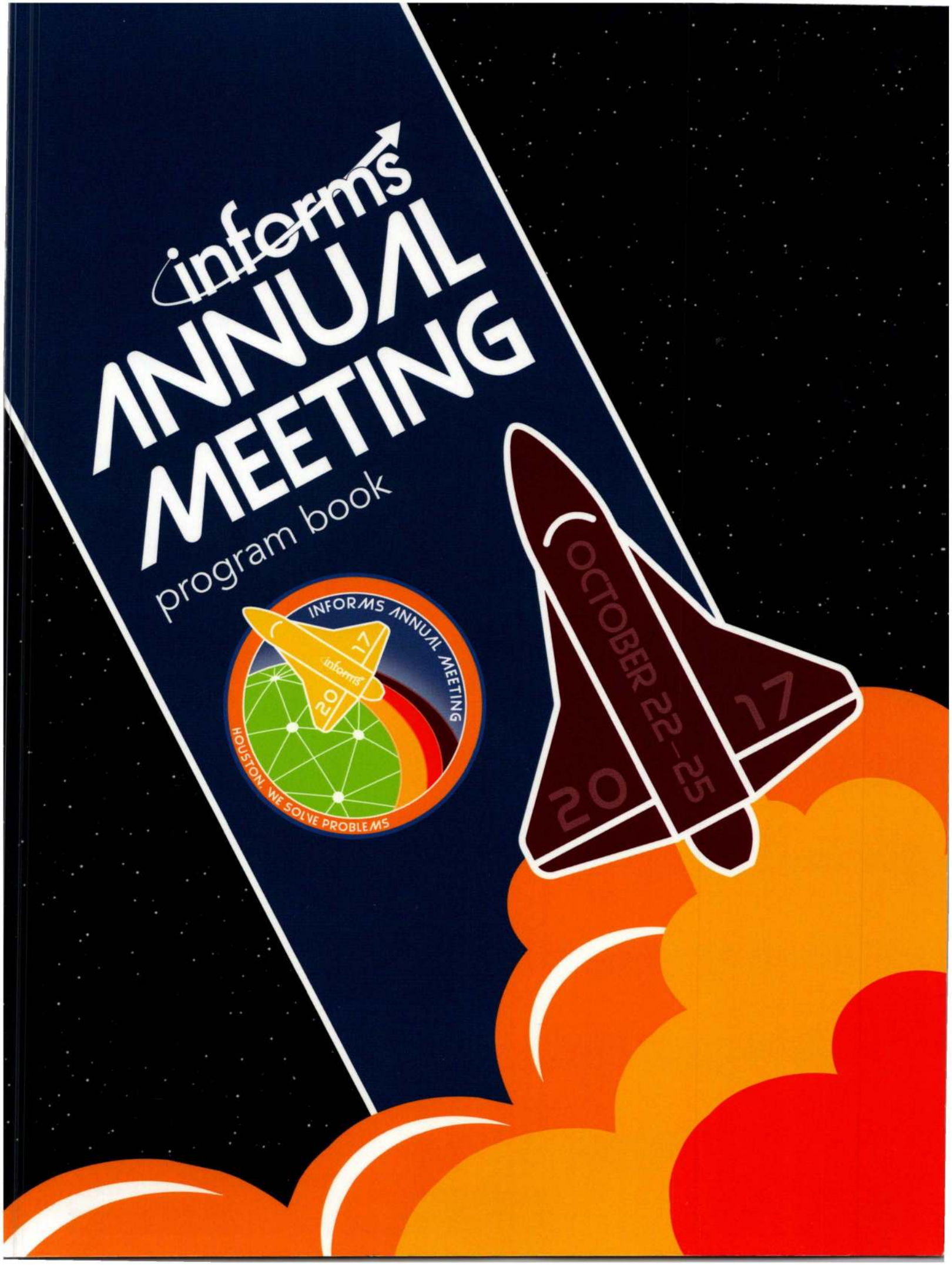

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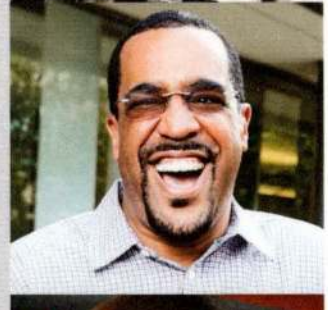
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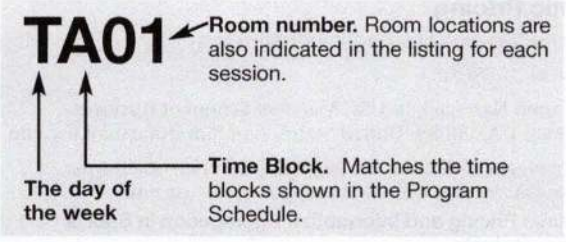


How to Navigate the Technical Sessions

There are four primary resources to help you understand and navigate the Technical Sessions:

- This Technical Session listing, which provides the most detailed information. The listing is presented chronologically by day/time, showing each session and the papers/abstracts/authors within each session.

The Session Codes



Time Blocks

Sunday - Monday

8:00am - 9:30am
10:00am - 10:50am
11:00am – 12:30pm
1:30pm – 3:00pm
3:10pm - 4:00pm
4:30pm – 6:00pm

Tuesday

7:30am - 9:00am
9:40am - 10:30am
10:30am - 12:00pm
12:05pm - 1:35pm
2:00pm - 3:30pm
3:40pm - 4:30pm
4:35pm – 6:05pm

Wednesday

7:30am - 9:00am
9:40am - 10:30am
10:30am - 12:00pm
12:30pm - 2:00pm

Rooms and Locations /Tracks

All tracks / technical sessions will be held in the George R. Brown Convention Center. Rooim numbers are shown on the Quick Reference and in the Technical session listings.

Monday and Tuesday Plenary talks will be held in Hilton- Ballroom of Americas, Level 2

Sunday, 8:00 - 9:30AM

■ SA02

310B

Decision Analytic Approaches to Green Infrastructure Solutions

Sponsored: Decision Analysis

Sponsored Session

Chair: Fengwei Hung, Johns Hopkins University, Baltimore, MD, 21218, United States, hfengwe1@jhu.edu

Co-Chair: Melissa A. Kenney, University of Maryland, College Park, MD, 20740, United States, kenney@umd.edu

1 - Needs Title

Snehasis Mukhopadhyay, IUPUI, Indianapolis, IN, United States, smukhopa@iupui.edu, Andrew Hoblitzell, Meghna Babbar-Sebens

WRESTORE is a stakeholder-driven design system that optimizes best management practices for the Eagle Creek Watershed in Indiana. The system provides resources on conservation programs and enables stakeholders to visualize the impacts of alternative practices on the watershed. The system utilizes fuzzy logic, neural networks, and deep learning for user modeling, and uses an interactive genetic algorithm with mixed initiative interaction for exploratory search and exploitative optimization. In this talk, we will provide a discussion of the current implementation of the system, as well as a brief discussion of ongoing work and future plans for the system.

2 - Understanding Residential Low Impact Development at the Home Owner Level

Domenico Amodeo, George Washington University, Washington, DC, 20052, United States, dcamodeo@email.gwu.edu

Environmental engineers and economist have studied the patterns of adoption for green technology. Many of these studies rely on regression and aggregated data. We developed a zero-truncated negative binomial regression model using parcel level data. However, we argue that regression is an inadequate method for predicting home owner adoption of LID. A graph based method is presented to identify configurations of LID emerging from residential property owners who are presented with a municipal incentive to adopt. We argue that understanding the configurations that emerge may provide insight into homeowners motivations and the effectiveness of incentive programs.

3 - A Two-stage Stochastic Programming Model for Adaptive Stormwater Management with Green Infrastructure

Fengwei Hung, Johns Hopkins University, 3400 N Charles St. Ames Hall 313, Baltimore, MD, 21218, United States, hfengwe1@jhu.edu

Adaptive management (AM) can be viewed as a multi-stage planning problem with the emphasis on learning by doing and uncertainty. The proposed model considers the decision maker's risk attitudes and the potential learning in latter stages. Risk is modeled in the form of conditional value of risk (CVaR) and learning is defined as the process of updating random distributions which are assumed to depend on the investment now (1st stage decisions). This method can explore the risk-expected value tradeoffs accounting for what we may be able to learn from doing. Finally, we show an example to demonstrate how this model works.

4 - Optimal Planning of Green Infrastructure Placement in an Urban Watershed under Precipitation Uncertainty

Masoud Barah, University of Tennessee, Knoxville, TN, United States, mbarah@utk.edu, Anahita Khojandi, Jon Hathaway, Xueping Li

Urbanization, infrastructure degradation, and climate change have overwhelmed most stormwater management systems across the nation or rendered them ineffective. Green Infrastructures (GIs) are low-cost strategies that can contribute to stormwater management. We develop a stochastic programming model to determine the optimal placement of GIs across a set of candidate locations in a watershed to minimize the excess runoff in medium-term precipitation uncertainties. We calibrate the model using rainfall projections and stormwater system's hydrologic responses to them. We provide optimal GI placement in a watershed and perform sensitivity and robustness analyses to provide insights.

■ SA03

310C

An Introduction to Two-Stage Stochastic Mixed-IntegerProgramming

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, United States, jopeng@Central.uh.edu

Co-Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, University at Buffalo (SUNY), Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - An Introduction to Two-Stage Stochastic Mixed-Integer Programming

Simge Kucukyavuz, University of Washington, Box 352650, Industrial & Systems Engineering, Seattle, WA, 98195, United States, simge@uw.edu, Suvrajeet Sen

This paper provides an introduction to algorithms for two-stage stochastic mixed integer programs. Our focus is on methods which decompose the problem by scenarios representing randomness in the problem data. The design of these algorithms depend on where the uncertainty appears (right-hand-side, recourse matrix and/or technology matrix) and where the continuous and discrete decision variables are (first-stage and/or second-stage). In addition we provide computational evidence that, similar to other classes of stochastic programming problems, decomposition methods can provide desirable theoretical properties (such as finite convergence) as well as enhanced computational performance when compared to solving a deterministic equivalent formulation using an advanced commercial MIP solver.

■ SA03A

Grand Ballroom A

Applied Probability in Finance

Sponsored: Applied Probability

Sponsored Session

Chair: Markus Pelger, Stanford University, Stanford, CA, 94305, United States, mpelger@stanford.edu

1 - Determinant of Clearinghouse Margins

Agostino Capponi, Columbia University, 500 W. 120th Street, New York, NY, 10027, United States, ac3827@columbia.edu

We analyze regulatory credit default swap (CDS) data to investigate drivers of clearinghouse margins, exploiting explicitly linked portfolio exposures and collateralizing assets. We document several stylized facts, including heterogeneity of clearing member portfolios, significant time variation in margin levels, and clustering of portfolio return on margins around the mean. Our results show that the advent of margin spirals relies on commonality in exposures, as shocks to common credit exposures can be destabilizing, whereas idiosyncratic shocks are stabilized by clearinghouse margining rules.

2 - Law of the Few: Economics of the Tipping Point

Nan Chen, Chinese University of Hong Kong, William M.W. Mong Engineering Bldg, Rm 609, Shatin N.T., Hong Kong, nchen@se.cuhk.edu.hk, Steven Kou, Yan Wang

Large regime switch due to social interaction, known as the tipping point, is of great interest in sociology and economics. Two empirical features related to this phenomenon are local conformity/global diversity and punctuated equilibrium effect. The former refers to that a significant conformity can be found within a given community but in other separate communities the same issue is approached by different ways. The latter feature means that the dynamics of a given community tend to have a long period of the dominance of one opinion, punctuated by bursts of opinion shifts. In this paper we propose a simple stochastic model to incorporate the above two features of an interacting population.

3 - Adaptive Learning and Stability of Equilibria in a Dynamic Model with Informed Investors

Yiwen Shen, Columbia Business School, New York, NY, United States, YShen21@gsb.columbia.edu, Paul Glasserman, Harry Mamaysky

We propose a dynamic model of securities trading between overlapping generations of informed and uninformed investors. We assume becoming informed is costly, and the quality of learnable information improves with the ratio of informed investors. Investors form beliefs about how price volatility depends on the quality of learnable information. We show the beliefs could be self-fulfilling in a low volatility market. With such beliefs, our economy is characterized by high and low information equilibria, both of which are locally stable but with periodic transitions between each other. We discuss the model's implications for trading volume, investors' welfare, and boom-bust cycles.

4 - Estimating Latent Asset-pricing Factors from Large-dimensional Data

Markus Pelger, Stanford University, 312 Huang Engineering Center, 475 Via Ortega, Stanford, CA, 94305, United States, mpelger@stanford.edu, Martin Lettau

We develop an estimator for latent factors in a large-dimensional panel of financial data that can explain expected excess returns. Statistical factor analysis based on Principal Component Analysis (PCA) has problems identifying weak factors that are important for asset pricing. Our estimator searches for high Sharpe-ratio factors that can explain both the expected return and covariance structure. We derive the statistical properties of the new estimator and show that it can find asset-pricing factors, which cannot be detected with PCA, even if a large amount of data is available. Our factors accommodate a large set of anomalies better than notable four- and five-factor alternative models.

■ SA03B

Grand Ballroom B

Dynamic Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Hamid Nazerzadeh, USC Marshall School of Business, Los Angeles, CA, 90089, United States, hamidnz@marshall.usc.edu

Co-Chair: Negin Golrezaei, University of Southern California, Pasadena, CA, 91106, United States, golrezae@usc.edu

1 - Dynamic Pricing and Information Aggregation in Sports Betting Markets

Adam Schultz, University of Chicago-Booth School of Business, 5532 South Kenwood Ave, Apt 208, Chicago, IL, 60637, United States, adam.schultz@chicagobooth.edu, John R. Birge, N. Bora Keskin

In this paper, we explore how market makers use dynamic pricing as a mechanism to aggregate information in a biased prediction market. We collect a novel data set of time series data to study a sports betting market, including Twitter data to control for breaking news events that lead to information changes in the market. After investigating how market makers adjust prices in this context, we present an approach to estimate potential bias in bettors' beliefs about game outcomes. This model allows us to perform a counterfactual analysis in which we characterize the optimal point spread for the market maker for each game. We use this model to analyze market makers' policies and expected profit performance.

2 - On the Efficacy of Static Prices for Revenue Management in the Face of Strategic Customers

Yiwei Chen, Singapore University of Technology and Design, Singapore, Singapore, yiwei_chen@sutd.edu.sg, Vivek Farias

We consider a RM problem wherein a monopolist seller seeks to maximize revenues from selling a fixed inventory of a product to customers who arrive over time. Customers are forward looking. We allow for multi-dimensional customer types. We allow for a customer's disutility from waiting to be positively correlated with his valuation. We show that static prices proposed by Gallego and van Ryzin [1994] that study a myopic customer RM problem continue to remain asymptotically optimal in the regime where inventory and demand grow large. Irrespective of regime, the optimal static price captures at least 63.2% of the seller's revenue under an optimal dynamic mechanism.

3 - Multidimensional Binary Search for Contextual Decision-making

Ilan Lobel, NY, United States, ilobel@stern.nyu.edu, Renato Paes Leme, Adrian Vladu

We consider a multidimensional search problem that is motivated by questions in contextual decision-making such as dynamic pricing. Nature selects a state from a d-dimensional unit ball and then generates a sequence of d-dimensional directions. After receiving a direction, we have to guess the value of the dot product between the state and the direction. Our goal is to minimize the number of times when our guess is more than away from the true answer. We construct a polynomial time algorithm that we call Projected Volume achieving regret O(d log d), which is optimal up to a log d factor. The algorithm combines a volume cutting strategy with a new geometric technique that we call cylindrification.

4 - Dynamic Pricing in High-dimensions

Adel Javanmard, USC Marshall School of Business, 300A Bridge Hall, University of Southern California, Los Angeles, CA, 90089, United States, ajavanma@marshall.usc.edu, Hamid Nazerzadeh

We study the pricing problem where a firm sells a large number of products, described via a wide range of features, to customers that arrive over time. The firm is oblivious to market values of products. However, it can gain information about valuations based on previous binary feedbacks on whether products were sold at the posted prices. This setting is motivated in part by the prevalence of online marketplaces that allow for real-time pricing. We propose a dynamic policy (RMLP) that leverages the sparsity structure of the demand space and provably achieves an asymptotically optimal revenue.

■ SA03C

Grand Ballroom C

Customer and Server Behavior in Queues

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Mirko Kremer, Frankfurt School of Finance and Management gGmbh, Frankfurt, 60314, Germany, m.kremer@fs.de

1 - Mismanaging the Quality-speed Tradeoff in Congested Environments

Mirko Kremer, Frankfurt School of Finance and Management, Frankfurt, 60314, Germany, m.kremer@fs.de, Francis de Véricourt

The tradeoff between diagnostic accuracy and speed permeates many manufacturing and service settings. We present the results from a set of controlled laboratory experiments designed to test the predictions of a formal sequential testing model that captures this tradeoff in a setting where the gathering of additional information (i.e., diagnostic testing) is likely to improve diagnostic judgments, but may also increase congestion in the system. We find that decision makers are insufficiently sensitive to congestion, with an aversion to stopping a diagnostic process in the face of increasing system congestion. On the other hand, decision makers are overly sensitive to diagnostic signals, with a tendency to stop a diagnostic process immediately after the first test result, even at low congestion levels that render additional testing inexpensive. As a result of these behavioral patterns, besides substantial heterogeneity in how they trade off quality and speed, the majority of decision makers manage their system with both lower-than-optimal diagnostic accuracy and higher-than-optimal congestion cost.

2 - The Effects of Discrete Work Shifts on Non-terminating Queues

Robert Batt, University of Wisconsin-Madison, Madison, WI, 53706, United States, bob.batt@wisc.edu, Diwas S.KC, Bradley R. Staats, Brian Patterson

We study an emergency department to see how the finite-length shift structure impacts productivity and quality. Using simulation, we show that policies thatprohibit starting new patients near the end of the shift can lead to improved system throughput.

3 - An Empirical Study of Customer Spillover Learning about Service Quality

Andres I. Musalem, Universidad de Chile, Beauchef 851, Santiago, 8370456, Chile, amusalem@duke.edu

We study social learning in a multi-arm bandit setting where each of a sequence of arriving customers chooses between alternative service providers with uncertain quality, observing only the outcomes from other customers' service experiences. In a series of experiments, we test the key theoretical prediction that the social learning process results in insufficient exploration, relative to a „centralized" benchmark regime where customers learn about the providers' quality from their own (previous) choices.

■ SA04

320A

Sustainable and Socially Responsible Operations

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Can Zhang, Georgia Institute of Technology, Atlanta, GA, 30309, United States, czhang2012@gatech.edu

Co-Chair: Atalay Atasu, Georgia Institute of Technology, Atlanta, GA, 30308, United States, atalay.atasu@scheller.gatech.edu

1 - Agricultural Support Prices in Developing Economies: Operational Analysis and its use in Policy Making

Tharanga Kumudini Rajapakshe, University of Florida, 10287, SW. 37th Place, Gainesville, FL, 32608, United States, tharanga@ufl.edu

In this paper, we offer analytically-supported insights on several fundamental aspects of the Guarenteed Support Price scheme by analyzing a Stackelberg game between a homogenous population of small farmers and a social planner. To understand the welfare implications of the GSP scheme on its main stakeholders, we characterizethe equilibrium operational decisions of the farmers and the equilibrium value of the GSP.

2 - The Value of Strategic Farmers, Social Entrepreneurs and For-profit Firms in Crop Planting Decisions

Wenbin Wang, Shanghai University of Finance and Economics, Shanghai, China, wang.wenbin@mail.shufe.edu.cn, Ming Hu, Yan Liu

We study how farmers of heterogeneous production costs make crop-planting decisions over time to maximize their incomes. We consider both strategic farmers, who rationally anticipate the near-future prices and naive farmers, who shortsightedly react to recent crop prices. We find self-interested behavior of strategic farmers alone can reduce price volatility and benefit all farmers. In the absence of strategic farmers, an optimally-designed pre-season procurement contract, offered by a social entrepreneur or for-profit firm, also brings benefit to farmers as well as to the firm itself. However, a poorly designed contract may distort the market and drive non-contract farmers out of business.

3 - Inter-dependency among Mitigation, Preparedness, and Response Decisions in Disaster Management Cycle

Shabnam Rezapour, Florida International University, Miami, FL, United States, srezapou@fiu.edu, Reza Zanjirani Farahani, Alfonso J. Pedraza Martinez

This research explores the interdependency between the stages of mitigation (fortifying stocks), preparedness (locating stocks), and response (distributing stocks timely) in disaster management cycle. Using a stochastic model, the focus is on minimizing the total logistics costs. We show that controlled decentralization, centralization, and decentralization are the best locating strategy to minimize logistics costs for expensive goods, for cheap goods, and in relief networks with high transportation cost. Stock fortification (in mitigation stage) makes it possible to have short response intervals (in response stage) and fulfill demand with less number of stocks (in preparedness stage).

4 - Perishable Inventory Sharing in a Two-location System

Can Zhang, Georgia Institute of Technology, 499 Northside Circle NW, Apt 315, Atlanta, GA, 30309, United States, czhang2012@gatech.edu, Turgay Ayer, Chelsea C. White

Motivated by a platelet inventory management problem in a local hospital network, we study an inventory sharing problem for perishable products in a two-location system. We derive structural properties of the optimal policy and present managerial insights that are significantly different from those in existing studies for traditional non-perishable products.

■ SA06

320C

Design and Evaluation of Differentiated Care Interventions

Sponsored: Health Applications

Sponsored Session

Chair: Diana Maria Negoescu, University of Minnesota, Minneapolis, MN, 55455, United States, negoescu@umn.edu

1 - Machine Learning Discovery of Longitudinal Patterns of Depression and Suicidal Ideation

Jue Gong, University of Washington, Industrial and Systems Engineering, MEB B14 BOX 352650, Seattle, WA, 98195, United States, gongjue@uw.edu, Gregory E. Simon, Shan Liu

Depression is often accompanied by thoughts of self-harm which are a strong predictor of subsequent suicide attempt and suicide death. We used artificial neural networks to extract latent structures from the trajectory data of depressive symptoms in an on-going treatment population from electronic health record. We discovered correlations between patients' depression symptoms (PHQ-8) and suicidal ideation (the 9th question of PHQ) through cross-correlation analysis. This work paves the way toward the development of personalized depression monitoring and suicide prevention strategies.

2 - Optimal Learning of the Tumor Response Parameters Distribution in Spatiotemporally Integrated Radiotherapy

Ali Ajdari, University of Washington, Seattle, WA, United States, ajdari@uw.edu, Archis Ghate

One of the key assumptions in the linear-quadratic formulation of the radiotherapy problem is that the distribution of uncertainty in tumor-response parameters is known to the treatment planner. Recent advances in imaging techniques however, have brought forth the possibility of relaxing this assumption and using tumor-images acquired over the treatment course to learn patient-specific parameter distributions. Therefore, the goal in this study is to learn the tumor's response while optimally dosing a patient over the treatment course.

3 - Response-adaptive Design of Dose-finding Trials

Amir Nasrollahzadeh, Clemson University, Clemson, SC, United States, snasrol@g.clemson.edu, Amin Khademi

In Clinical trials human participants are assigned to one or more interventions to evaluate the effects of those interventions on health-related outcomes. In a standard dose-finding trial, patients are randomly assigned to predetermined doses such that the number of patients assigned to each dose is roughly equal. Such a design may be inefficient. A better strategy is adaptive design in which modifications are made to dose assignments, while the study is in progress. We consider a response-adaptive dose-finding clinical trial where the decision maker is interested in identifying the optimal dose, and allocation of future patients to doses is based on knowledge gained from previous outcomes

4 - Personalized Prediction of Glaucoma Progression under Different Target Eye Pressure Levels

Pooyan Kazemian, Harvard University, 50 Staniford Street, 9th Floor, Room 930B, Boston, MA, 02114, United States, pooyan.kazemian@mgh.harvard.edu, Mariel Sofia Lavieri, Mark P. Van Oyen, Joshua Stein

Using perimetric and tonometric data from two randomized clinical trials, we developed and validated Kalman filter models for fast-, slow-, and non-progressing patients with glaucoma. Our models identify patient type and generate personalized and dynamically-updated forecasts of glaucoma progression under different target eye pressure levels. This approach can help eye doctors determine an appropriate treatment regimen and tailor care to individual patients.

■ SA07

322A

Medicaid Fraud Detection and Prevention

Sponsored: Health Applications

Sponsored Session

Chair: Elham Torabi, James Madison University, torabiex@jmu.edu

1 - Medicaid Fraud Detection and Prevention: A Systems Approach

Elham Torabi, Assistant Professor, James Madison University, 1933 Buttonwood Ct., Harrisonburg, VA, 22802, United States, torabiex@jmu.edu, Verbus Counts

Medicaid fraud and abuse result in significant waste of resources. Any dollar saved in the Medicaid program can be used in improving access for those who need care. Auditing Medicaid claims and investigating fraudulent activities is time and money consuming. Therefore, what is crucially needed more than ever is mechanisms that prevent fraud. We propose a systems approach for Medicaid fraud inspection and prevention that maximizes the risk of committing fraud for providers serving Medicaid population.

2 - The Lifecycle of Maturity for Organizations to Fight Fraud

Arnie Greenland, Robert H. Smith School of Business, 4342 Van Munching Hall, College Park, MD, 20742, United States, agreenland@rhsmith.umd.edu

Organizations that are faced with the daunting task of detecting, reducing and eventually eliminating fraud differ greatly in their capabilities to succeed in that endeavor. In this paper, the author will propose a natural lifecycle of development that organizations traverse in developing the data and capabilities to improve their ability to effectively fight fraud; and he will offer some examples, appropriately masked. While the paper will focus primarily on the data and organizational requirements, the author will also discuss the key analytical tools, capabilities and skill sets required as part of the organizational development process.

3 - What Indicators Matter for Fraud Identification in Healthcare and to what Extend do they Matter

Didem Egemen, PhD Candidate, Integrity Management Services Inc., Alexandria, VA, United States, didem@gwu.edu, Paulo Macedo, Sewit Araia

Detecting healthcare fraud is not a straightforward process since it requires outlier detection methods for large number of indicator. In this study, we recommend combining different methods, which are Mahalanobis distance, Singular Value Decomposition, and One Class Classification. Our goal is to obtain outliers within healthcare providers by taking into account the different information provided by these three methods and try to reduce the number of false positives. For this purpose, the observations flagged differently by these methods are compared by using Multivariate Lorenz curves and the equivalence of these Lorenz curves are tested by using the Bootstrapping method.

■ SA08

322B

Smart and Connected Health

Sponsored: Health Applications

Sponsored Session

Chair: Muge Capan, Christiana Care Health System, Wilmington, DE, 19801-3082, United States, mcapan@ncsu.edu

1 - Data-Driven Approach to Early Warning System Implementation

Stephen Hoover, MS, Christiana Care Health System, Value Institute, Newark, DE, United States, Stephen.Hoover@ChristianaCare.org

Early warning systems are designed to alert healthcare providers to changes in patient status. Despite good intentions, poor implementations can lead to an increase in alert burden and alarm fatigue. We will discuss the prospective analysis of the impact of early warning systems' on alerts prior to implementation from both an analytical modeling and information technology perspective. Post-implementation results will also be presented.

2 - Signaling Sepsis and Forecasting the Unexpected Transfer to Upgraded Resources in Sepsis

Muge Capan, Associate Director of Health Systems Optimization, Newark, DE, Muge.Capan@ChristianaCare.org, Kristen Miller

Signaling Sepsis, funded by the National Library of Medicine, creates an evidence-based framework to optimize sepsis clinical decision support. One of its quality improvement projects, FUTURE (Forecasting the Unexpected Transfer to Upgraded Resources in sepsis), uses gamification to elicit predicted patient outcomes from healthcare teams, thus enabling patient-level feedback, raising sepsis awareness, and identifying clinicians who best predict patient decompensation.

3 - Computer-aided Multimodal Health Monitoring System with Wearable Microfluidic Sweat Sensors

Daehan Won, Binghamton University, Vestal, NY, United States, dhwon@binghamton.edu

Quantitative, simple, and low-cost analysis of biofluids is essential to prevent and diagnosis variety of health conditions along with the understanding metabolisms of human physiology. Therefore, we introduce a new health-related information monitoring framework; various chemicals in human sweat will be measured and analyzed by a newly designed wearable sensors and the mobile application respectively. Our unified framework will hold great potentials for future applications.

4 - Patient-centered and Personalised Scheduling of Colonoscopy Appointment

Karmel Shehadeh, University of Michigan, Ann Arbor, MI, 48109, United States, ksheha@umich.edu, Amy Cohn

We consider the problem of scheduling colonoscopy patients in an endoscopy unit, recognizing the impact of the quality of the pre-procedure bowel preparation that the patient must undergo in the variability of procedure duration. High-quality preparation can lead to short procedure duration while poor preparation can make the procedure much longer. Combined with patient no-show and arrivals uncertainties, this duration structure contributes to a schedule with many outliers. We use simulation and stochastic programming to analyze and improve the scheduling of colonoscopy patients. Attention is paid to the competing schedule metrics, including patient waiting, provider idle and over times

■ SA09

330A

Minimizing Food Waste

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Dorothee Honhon, University of Texas at Dallas, Richardson, TX, 75080, United States, dorothee.honhon@utdallas.edu

Co-Chair: Xiajun Amy Pan, University of Florida, Gainesville, FL, 32611-7169, United States, amy.pan@warrington.ufl.edu

1 - Package Size and Pricing Decisions with a Bulk Sale Option

Ismail Kirci, University of Texas at Dallas, 800 West Campbell Road, Richardson, TX, 75080, United States, Ismail.Kirci@utdallas.edu, Dorothee Honhon, Alp Muharremoglu

We investigate the package size and pricing decisions of a retailer selling a perishable product to a population of heterogeneous consumers who differ in their valuation of the product. We also study the pricing decision when the retailer sells the product in bulk and compare bulk sale with package sale in terms of retailer's profit and consumers' waste.

2 - Food Distribution and Food Waste in Food for Education Programs

Debjit Roy, Indian Institute of Management, House Number 308, IIM. Ahmedabad, Vastrapur, Ahmedabad, 560078, India, debzitt@gmail.com, Elena Belavina

Mid-day meal schemes are popular government subsidized schemes run in developing economies, which incentivizes children to attend school. What factors can improve the effectiveness of such state-run food distribution schemes? We develop an empirical model to identify the factors and develop a daily demand estimation model for different school categories.

3 - Policies to Minimise Food Waste in Retail Environment

Emel Aktas, Cranfield University, School of Management, Bedfordshire, Cranfield, MK43 0AL, United Kingdom, emel.aktas@cranfield.ac.uk, Akunna Oledinma, Hafize Sahin, Zahir Irani, Amir Sharif, Samsul Huda, Zeynep Topaloglu, Mehran Kamrava

Food retail is one of the largest sectors both in the UK and the US. IGD predicts the UK food and grocery market to reach £200bn over the next five years. Supermarkets sell 60-90% of all fresh fruits and vegetables, with high levels of imported produce. We focus on fresh fruits and vegetables due to their high value and perishability. We build a causal loop of the fresh fruits and vegetables supply chain in Qatar, considering imported and locally grown produce, the demand, and the waste due to inefficient operational processes and consumer behavior. Using the deSolve library in R, we test inventory control policies based on service levels, lot sizes, and demand across a range of fresh produce categories.

4 - Shelf Space Optimization of Perishable Products

Arzum E. Akkas, Boston University, 100 Memorial Drive, 8-11C, Cambridge, MA, 02142, United States, aakkas@bu.edu

In practice, shelf lives within a product category can vary significantly due to product characteristics such as sugar content and pungency levels (e.g. 3 months versus 6 months); yet, shelf life information is not considered when configuring planograms. This paper examines the shelf space allocation problem from the perspective of the relationship between shelf life and expiration.

■ SA10

330B

Operational Issues in Organ Transplants

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Baris Ata, University of Chicago, Chicago, IL, 60637, United States, Baris.Ata@chicagobooth.edu

Co-Chair: Ali Cem Randa, The University of Chicago-Booth School of Business, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States, randa@chicagobooth.edu

1 - Optimizing Simultaneous-offering Mechanism of Cadaveric Organs

Tinglong Dai, Johns Hopkins University, 100 International Dr, Baltimore, MD, 21202, United States, dai@jhu.edu

In this study, we consider an OPO's problem of determining the optimal batch size of simultaneous offers made to transplantation centers. We model the strategic interaction among transplant centers both within and across batches, generating structural properties and computational insights.

2 - Patient Centered Organ Acceptance Decisions in Kidney Transplant

Sanjay Mehrotra, Northwestern University, Dept of I.E./ M.S.C246 Tech Inst., 2145 Sheridan Road, Evanston, IL, 60208-3119, United States, mehrotra@iems.northwestern.edu

It is not always clear if an offered kidney should be accepted by a patient. We will present results from a patient centered model for accepting an offered kidney that quantifies its benefits using a decision tree. The parameters of the tree are quantified using appropriate statistical models, which will also be presented.

3 - Personalized Wait Time Estimates for Kidney Transplant Offers

Nikolaos Trichakis, Massachusetts Institute of Technology, 100 Main Street, E62-576, Cambridge, MA, 02143, United States, ntrichakis@mit.edu, Chaithanya Bandi, Phebe T. Vayanos

We deal with the problem of estimating the wait time until a patient on the kidney national wait list is offered an organ of desired quality, based on the patient's own characteristics and knowledge of the wait list status. We discuss the unique challenges this estimation problem poses, and argue that existing estimation methods are inadequate. We use a maximum likelihood process to calibrate our method, based only on data that patients observe in practice. Using highly-detailed historical data, we conduct numerical experiments that show our method to significantly outperform existing ones.

4 - An Empirical Analysis of the Effect of Kidney Allocation Policies on Patient Behavior

A. Cem Randa, University of Chicago-Booth School of Business, 5807 S Woodlawn Avenue, Chicago, IL, 60637, United States, randa@chicagobooth.edu, Baris Ata

Organ Procurement and Transplantation Network (OPTN) allocates deceased donor kidneys to the patients based on an additive point system. The patients accumulate points for waiting time and other factors, and organs are offered to patients according to their points. The patients carry no obligation to accept any organ offers. OPTN continuously updates the weight of factors that are affecting contributing to point system, in order to have a more effective allocation policy. However, this effort excludes the patient behavior. We will develop an empirical model to capture the affect of patient behavior in this system and evaluate different counterfactual policies empirically.

■ SA11

332A

Behavioral Operations in Services

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Mor Armony, New York University, New York, NY, 10012, United States, marmony@stern.nyu.edu

1 - Experiment of Hospital Unit Admission Decision Behavior under Congestion

Song-Hee Kim, University of Southern California, Bridge Hall 307A, Los Angeles, CA, 90089, United States, songheek@marshall.usc.edu, Jordan Tong

Hospital inpatient units have limited capacity. We explore how physicians make admission decisions in order to understand how to improve this important decision-making process. Specifically, in a controlled laboratory experiment setting, we observe and compare admission decision-making behaviors based on current unit occupancy and severity of arriving patient conditions.

2 - Allocating Inpatient Beds to Off-service Patients: Tradeoffs and Consequences

Hummy Song, The Wharton School, University of Pennsylvania, 560 Jon M. Huntsman Hall, 3730 Walnut Street, Philadelphia, PA, 19104, United States, hummy@wharton.upenn.edu, Anita L. Tucker, Ryan Graue, Sarah Moravick, Julius J. Yang

Given a highly variable patient census at the service level yet a fixed allocation of inpatient beds to services, a significant portion of admitted patients become "off-service" patients. These patients are physically located in a bed that belongs to a different service (e.g., general surgery) while still being cared for by a physician of the service (e.g., cardiac medicine). We examine the tradeoffs and consequences of assigning incoming patients to an off-service bed as opposed to an on-service bed.

3 - The Influence of Customer Emotions in Chat Service Operations

Galit Yom-Tov, Technion - Israel Institute of Technology, Techbion City, Haifa, 32000, Israel, gality@technion.ac.il, Anat Rafaeli, Daniel Altman, Monika Westphal, Michael Natapov, Neta Barkay

We develop a sentiment analysis tool for objective assessment of customer emotions in interactions between service agents and customers. We then explore customer sentiment of real customer-agent interactions in three companies. Our analyses shed light on the presence of positive and negative emotion in customer service, and identify patterns of customer emotion over the course of an interaction. The analyses quantify the link between customer emotions, service quality measures, and agent behaviour. We discuss implications of using automated sentiment analysis tools for the management of service centers.

4 - Strategic Capacity Management in Outpatient Care with No-shows and Rescheduling

Yunchao Xu, New York University, 44 W 4th Street, KMC#8-152, New York, NY, 10012, United States, yxu4@stern.nyu.edu, Mor Armony, Nan Liu

An important factor that determines whether a patient will show up or not for his scheduled appointment is how easy to reschedule if he chooses not to show up. In this talk, we discuss how an outpatient care provider should manage her practice by considering such patient strategic behavior. While this work is motivated by healthcare, our models and insights can also be applied to appointment-based services in other settings.

■ SA12

332B

Empirical Studies of Supply Chains and Production

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Ken Moon, The Wharton School, Philadelphia, PA, 19104, United States, kenmoon@wharton.upenn.edu

1 - Impact of Order-fulfillment Service Levels on Customer Value

Nitish Jain, London Business School, Sussex Place, Regent's Park, London, NW1 4SA, United Kingdom, njain@london.edu, Karan Girotra, Andres I. Musalem

Faster fulfillment of an order is one of the key service components for online retailers. Based on a detailed transactional data on fulfillment performance (actual and promised) and on subsequent purchase patterns, we impute the economic value of faster and timely fulfillment to online retailers.

2 - Estimating the Operational Costs of Pricing

Ioannis Stamatopoulos, University of Texas at Austin, McCombs School of Business, 2110 Speedway B6000, Austin, TX, 78705, United States, yannis.stamos@mccombs.utexas.edu, Soheil Ghili

We leverage detailed data from an international retailer who adopted the electronic shelf label technology to some - but not all - of its stores to identify the underlying operational costs of pricing. We impose a simple model for pricing on that data and use the adoption shock to separate the effects of menu costs on prices from those of changes in demand trends. Our approach can be thought of as a structural implementation of the difference-in-difference identification strategy.

3 - Does Ration Gaming Drive the Bullwhip Effect?

Robert Louis Bray, 830 Hinman Ave, 2s, Evanston, IL, 60202, United States, robertlbray@gmail.com

We model a single-supplier, 73-store supply chain as a dynamic discrete choice problem. We estimate the model with transaction-level data, spanning 3,251 products and 1,370 days. We find two phenomena: ration gaming (strategic inventory hoarding) and the bullwhip effect (the amplification of demand variability along the supply chain). We estimate that the bullwhip effect would be 12% smaller in the counterfactual scenario without ration gaming incentives, confirming the long-standing hypothesis that ration gaming causes the bullwhip effect.

4 - Managing High Worker Turnover: Productivity & Peer Effects on Modern Production Lines

Ken Moon, The Wharton School, Philadelphia, PA, 19104, United States, kenmoon@wharton.upenn.edu

We study the drivers and consequences of high worker turnover in modern, large-scale production processes. Leveraging a uniquely rich dataset drawn from China-based final assembly, testing, and packaging (FATP) facilities producing millions of units of consumer electronic goods per week, we study the role of peer effects in worker turnover and quantify the effects of such turnover on production outcomes. We prescribe policies to both manage turnover and mitigate its effects: in practice, managers lack guidance on the optimal mix of control versus mitigation and often suspect that they may undervalue worker experience.

■ SA13

332C

Health Care, Strategy and Policy

Contributed Session

Chair: Ashlea Milburn, University of Arkansas, Fayetteville, AR, United States, ashlea.bennett@uark.edu

1 - The Impact of Bundled Payment Policy On Health Care Operations

Yiming Fan, University of Science and Technology of China, Hefei, 230026, China, jinkui0612@163.com

Healthcare reimbursements in China have been traditionally based on a fee-for-service (FFS) scheme, leading to the rapid increase in healthcare costs, since FFS provides incentives for high volume of care, rather than efficient care. During the healthcare reform, a new reimbursement scheme, called bundled payment (BP), is introduced in order to remove such incentives. In this paper, we aim to empirically study the impact of BP on the operational performances of a healthcare system using a data set from Anhui New Rural Cooperative Medical System.

2 - Comparative Two Types of the Value Co-creation Model of Long-term Care for the Elder in Taiwan

Ching-Fang Wu, PhD Student, Nation Cheng Kung University, No.1, University Road, Tainan City, Taiwan (R.O.C), 701, Taiwan, r48021037@mail.ncku.edu.tw, Shih-Chieh Fang, Ching-Ying Huang

The purpose of this research is to examine the elderly customers' satisfaction and well-being from customer Effort in Value Co-creation Activities point of view. Besides, we compare two different models of long-term care and try to find which factors affect customer satisfaction and quality of life. This study is a quantitative study conducted by questionnaires. There are two types of Subjects for the questionnaires, one is the elder who lives in the day-care center, the other one is in the hospital-based institution. Three parts of the questionnaires which are demographic and living characteristics, value co-creation activities, satisfaction, and life satisfaction scale.

3 - Multiple Chronic Condition Patterns in Baby Boomers, Generation X, and Early Millennials

Ajit Appari, University of Texas Health Science Center at Houston, 1200 Pressler Street, RAS.W-310, School of Public Health, Houston, TX, 77030, United States, ajit.appari@uth.tmc.edu, Maria Ukhanova, Robert O. Morgan

Multiple chronic conditions (MCC) in working-age adults pose enormous burden to the American economy. Critical gaps exist in our understanding of MCC patterns and their geographic variation among working-age adults. In this study we analyzed claims data on 451,694 individuals, continuously enrolled with a leading insurer in Texas during 2008-2013. Using Exploratory Factor Analysis, we determined five major patterns- Metabolic, Cardiovascular, Musculoskeletal, Liver-Immune Disorder, and Neurologic-Pain. Next, logistic regression was used to identify community socioeconomic factors (zip code) that correlate with MCC risk, adjusting for selection bias using Heckman's approach.

4 - A Study of the 2008 Subprime Mortgage Crisis' Impact on Taiwanese Pregnant Women and Their Children Development by an Epigenetic Approach

Jonathan Tong, PhD Program Student, National Taiwan University, 7F., No. 28, Ln.325, Zhungjing Rd., Taipei, 110, Taiwan, d03323003@ntu.edu.tw

Previous studies show that embryo will change functionally relevant to cellular and physiological phenotypic traits without involving a change in the nucleotide sequence, nor in DNA sequence, when pregnant women endure external/environmental impacts. This study will investigate Taiwanese children born in the period of economic crisis 2008 based an epigenetic approach and see if such changes also include some critical social cognitive capabilities.

5 - A Study of Co-occurrence of Multiple Chronic Conditions using Online Healthcare Forums

Juxihong Julaiti, PhD Student, Penn State University, 445 Waupelani Drive, Apt J1, State College, PA, 16801-4445, United States, jpj5196@psu.edu

In recent years participation in online forums to discuss health related issues is increasing. We study the on-line forums to study the relationship between multiple chronic conditions and resources allocation. We use linear, logistic regression, random forest to derive the relationships. The results indicate that: 1) patients with cancer and depression are more likely to participate in online forums; 2) patients with costly chronic conditions are more likely to use online forums; 3) whether a patient has cardiovascular disease, arthritis are significant variable to predict if the patient will have asthma etc.

6 - Dispensing Medical Countermeasures in Public Health Emergencies via Home Health Agencies and Points of Distribution

Ashlea Bennett Milburn, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States, ashlea.bennett@uark.edu, Anna Hudgeons, Charleen McNeill

A major concern regarding emergency preparedness at the state government level involves the handling and dispensing of the Strategic National Stockpile of medicinal supplies. This research utilizes simulation modeling to determine if using home health agencies (HHAs) in addition to Points of Distribution (PODs) to dispense SNS supplies can provide aid in a more timely fashion than using PODs alone. The comparative effectiveness of the two dispensing methods is demonstrated via a case study of pandemic influenza in Northwest Arkansas.

■ SA14

332D

Analytics and Incentives for Efficient Healthcare Delivery

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Hamsa Sridhar Bastani, Stanford University, Stanford, CA, 94305, United States, hsridhar@stanford.edu

1 - Yardstick Competition for Hospital Queues

Nicos Savva, London Business School, London, United Kingdom, nsavva@london.edu, Tolga Tezcan, Ozlem Yildiz

In this paper, we first show that the hospital reimbursement system currently used in practice does not incentivize hospitals to reduce waiting times. We then propose a modification which can achieve socially optimum investment without placing an onerous informational burden on hospital payers.

2 - Misaligned Incentives in Kidney Exchange

Itai Ashlagi, Stanford University, Department of Management Sci. and Engr., Stanford, CA, 94305, United States, iashlagi@stanford.edu

Growth of live-donor kidney exchange has stagnated although an increasing number of transplant centers are facilitating exchanges through large national exchanges, in isolation or in small consortiums with other centers. Using a novel dataset we document significant fragmentation and heterogeneity in participation by centers, an adversely selected and hard to match national exchange pool, and inefficient transplants outside the largest exchange. Using a simple supply and demand model we estimate the inefficiency and in the current market and calculate a rewards scheme that would be implemented by the optimal mechanism.

3 - Exploiting the Natural Exploration in Contextual Bandits

Hamsa Sridhar Bastani, IBM Thomas J. Watson Research Center, Yorktown Heights, NY, United States, hamsab@wharton.upenn.edu, Mohsen Bayati, Khashayar Khosravi

The contextual bandit literature focuses on an exploration-exploitation tradeoff because exploration-free greedy policies may yield poor performance in general. However, greedy policies are desirable when experimentation is costly or unethical (e.g., clinical settings). We posit a sufficient set of additional assumptions under which a greedy policy is asymptotically optimal. Next, we present Greedy-First, a new algorithm that uses observed data to determine whether to follow a greedy policy or to explore. This algorithm is asymptotically optimal without our additional assumptions, and significantly reduces experimentation in simulations.

4 - Dynamic Bandit Approach for Personalized Treatment

Yonatan Mintz, UC Berkeley, San Francisco, CA, United States, ymintz@berkeley.edu, Anil Aswani, Philip Kaminsky, Elena Flowers, Yoshimi Fukuoka

Personalized fitness tracking devices enable the implementation of data driven exercise programs intended to treat sedentary lifestyles. Despite the prevalence of these devices, many individuals have a hard time adhering to the recommended programs since they may be incompatible with an individual's schedule or provide ineffective motivation. In this talk, we address this problem by leveraging the data and infrastructure of mobile fitness tracking devices to personalize exercise programs for participating individuals. We develop a multi-armed bandit approach to adaptively learn each participant's exercise preferences to personalize their exercise programs and increase adherence.

■ SA15

332E

Demand Learning

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Yiangos Papanastasiou, University of California Berkeley, Berkeley, CA, 94720, United Kingdom, yiangos@haas.berkeley.edu

1 - Dynamic Selling Mechanisms for Product Differentiation and Learning

N. Bora Keskin, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, John R.Birge

We consider a firm that designs a menu of vertically differentiated products for a population of customers with heterogeneous quality sensitivities. The firm faces an uncertainty about production costs. We characterize the structure of the firm's optimal dynamic learning policy and construct simple and practically implementable policies that are near-optimal.

2 - Bayesian Dynamic Learning and Pricing with Strategic Customers

Xi Chen, New York University, 44 W. 4th St, NYU. KMC Room 8-50, New York, NY, 10012, United States, xchen3@stern.nyu.edu, Zizhuo Wang

In this talk, we study such a learning problem when the customer is aware of the seller's policy, and thus may behave strategically when making a purchase decision. We propose a randomized Bayesian policy (RBP), which updates the posterior belief of the customer in each period with a certain probability. We show that the seller can learn the customer type exponentially fast with the RBP even if the customer is strategic, and the regret is bounded by a constant. We also propose policies that achieve asymptotically optimal regrets when only a finite number of price changes is allowed.

3 - Dynamic Pricing with Online Product Reviews

Dongwook Shin, Hong Kong University of Science and Technology, Kowloon, Hong Kong, dwshin@ust.hk
Dongwook Shin, Columbia University, New York, NY, 10027, United States, dwshin@ust.hk, Assaf Zeevi

We investigate how the presence of product reviews affects a dynamic-pricing monopolist who strives to maximize its total expected revenue. To formulate the problem in tractable form, we first study a fluid model, which is a good approximation when the volume of sales is large. In the context of the fluid formulation, the optimal pricing policy can be characterized in a closed-form, which is leveraged to design pricing policies that perform well with respect to the underlying revenue maximization problem. Lastly, we discuss the impact of product reviews on learning when the monopolist operates without knowing the demand function a priori.

4 - A Tutorial on Thompson Sampling

Daniel Russo, Northwestern University, Chicago, IL, United States, dan.joseph.russo@gmail.com

Thompson sampling is an algorithm for online decision problems where actions are taken sequentially in a manner that must balance between exploiting what is known to maximize immediate performance and investing to accumulate new information that may improve future performance. The algorithm addresses a broad range of problems in a computationally efficient manner and is therefore enjoying wide use. I will present selected examples and insights from a recent tutorial on Thompson sampling. The talk will focus on applications in revenue management, and on practical challenges like nonstationarity, prior specification, and the need for approximate posterior inference.

■ SA16

332F

Inventory Management

Contributed Session

Chair: Sidika Tunc, University College London, London, United Kingdom, sidika.tunc.16@ucl.ac.uk

1 - The Need for Speed: Effects of Uncertainty Reduction in Patenting

Mike Horia Teodorescu, Doctoral Candidate, Harvard Business School, Soldiers Field Road, Wyss House, Boston, MA, 02163, United States, miketeod@hbs.edu

How does patent acceleration affect startup growth? Using a novel dataset obtained through a year-long government study, I look at the strategic implications of patent acceleration for startups and venture capital investors. The paper builds on the markets for technology literature. The empirical approach is a differences-in-differences regression to determine the effects of a previously unstudied executive policy change on the entrepreneurship ecosystem. A novel technique based on natural language processing is employed for firm matching.

2 - Multi-dimensional Proximity and Knowledge Networks of Product and Process Innovation

Owais Anwar Golra, Doctoral Researcher, University of Edinburgh, 29 Buccleuch Place, Edinburgh, EH89JS, United Kingdom, S1256783@sms.ed.ac.uk

Informal networks among manufacturing firms play important role in the transfer of knowledge in Industrial clusters. Proximity facilitates networking process, however our understanding is limited about the relationship between proximity dimensions and innovation networks. Particularly, it is unclear, how proximity dimensions shape the knowledge network of product and process innovations? We studied these networks in a textile cluster in Pakistan, and find significant influence of four proximity dimensions, excluding institutional proximity, on the network formation. Notably, the impact of proximity on process innovation network is stronger than the impact on product network.

3 - Strategic Information Technology Alignment, External Knowledge & Innovation Performance: An Empirical Study

Mahmoud Abdullah, PhD Student, Yuan Ze, Zong Li, Taiwan, elakhdary@gmail.com

This study draws on the strategic IT alignment perspective & the knowledge-based view (KBV) to explain the impacts of the alignment between IT strategy and external search activities on firm innovation performance. Since the focus of our study comprise both IT and business strategy. This study is using the key informant approach to collect data from senior IT executives and business strategic planners in the Taiwanese manufacturing firms.

4 - Technical Entrepreneurship in the Large Firm

Eliezer Geisler, Illinois Institute of Technology, Chicago, IL, 60661, United States, geisler@stuart.iit.edu, Giuseppe Turchetti

This paper explores the technical entrepreneurship (or "Intrapreneurship) in the large firm. We review the relevant literature with a focus on: what are the variables which impact the activities and the performance of entrepreneurs in a large firm? What are the barriers and facilitators to technical entrepreneurs as they pursue their endeavors in the large firm? These and similar questions are explored from a theoretical perspective by describing the state of the art in this topic. We explore the streams in the literature which explore these questions and we extract relevant propositions from this literature.

5 - Optimal Duration of Innovation Contests

Sidika Tunc, University College London, Level 38 One Canada Square, Canary Wharf, London, E14 5AA, United Kingdom, sidika.tunc.16@ucl.ac.uk, C.Gizem Korpeoglu, Ersin Korpeoglu

In an innovation contest, an organizer decides on the contest duration and award to elicit solutions to an innovation-related problem from a number of independent agents. Each agent exerts effort to develop her solution by incurring a cost. This cost of effort decreases with the contest duration, and the quality of her solution depends on the agent's uncertainty and productivity. We show that the agent's effort increases with the contest duration, but the organizer limits the contest duration to guarantee agents' participation in the contest. We also show that the optimal contest duration and award increase with the agent's uncertainty and decrease with the agent's productivity.

■ SA17

340A

Markov Decision Processes and Applications

Sponsored: Applied Probability

Sponsored Session

Chair: Daniel F. Silva, Auburn University, Auburn, AL, 36849, United States, silva@auburn.edu

1 - Optimizing the Interaction between Residents and Attending Physicians

Hayriye Ayhan, Georgia Institute of Technology, School of Industrial & Systems Eng, 755 Ferst Dr NW, Atlanta, GA, 30332-0205, United States, hayhan@isye.gatech.edu, Sigrun Andradottir

We analyze how attending physicians should allocate their time between the residents they supervise and their own responsibilities. Under the assumptions that the work of the attending physician can be preempted, and that a holding cost is incurred when residents and patients wait for a conference with the attending physician, we show that there are only two policies that could maximize the long-run average reward. Namely, it is optimal for the attending physician to start having consultations with the residents either when the residents can no longer examine new patients or as soon as there is a patient ready for conference. We then characterize when each of these policies is profitable.

2 - Control Policies for Queueing Systems with Time Windows

Tugce Isik, Clemson University, 112 Summey St. Unit 2, Clemson, SC, 29631, United States, tisik@clemson.edu, Bahar Cavdar

We focus on a queueing system where each job has a preferred time window for service. Every job in the system must be served by the end of the time window, and jobs may need to be outsourced if the capacity is not enough. Both early service and outsourcing are penalized. We show that the cost-optimal policy has a monotone structure and is of threshold-type when there is a single class of jobs. Based on these results, we develop a policy improvement heuristic and evaluate its performance.

3 - Discard or Install: Upgrading in the Presence of Spare Parts Stock

Joni Driessen, j.p.c.driessen@tue.nl, Alan Scheller-Wolf, Joachim Jacob Arts, Geert-Jan Van Houtum

We study how a company should manage an upgrade of a capital-intensive product when they have a number of old items (operating and spare parts) to be replaced by new items. The company must trade off the savings from exploiting the current old inventory versus the superior performance of the new items. We model this problem as a Markov Decision Process, and we decide in each period: (i) to replace any failed item by a new or old item, or not to replace it at all; (ii) and how many old item spare parts to salvage. We prove properties of the optimal policy, and generate insights into a replacement policy in general.

4 - Near-optimal Control of Complex Authentication Systems

Oguz Toragay, Auburn University, 257 S.Gay Street, Dexter Arms A208, Auburn, AL, 36830, United States, ozt0008@auburn.edu, Daniel F.Silva

We consider an authentication system, with several methods available, where requests arrive from users of several classes. The decision maker must dynamically assign each incoming request to a method, with the objective of maximizing security and minimizing latency and cost. We model the problem as a multi-class, parallel queueing system and solve it using MDP. The structure of optimal policies in systems with only one finite-capacity method is known. We use this structure to propose a new heuristic approach to construct near-optimal policies. Numerical experimentation shows that our approach offers near-optimal performance for a wide range of parameters.

■ SA18

340B

Stochastic Networks and Queueing in Applied Probability I

Sponsored: Applied Probability

Sponsored Session

Chair: Harsha Honnappa, Purdue University, West Lafayette, IN, 47906, United States, honnappa@gmail.com

1 - Analysis of Abandonments in Ticket Queues: A Bayesian Approach

Kaan Kuzu, University of Wisconsin-Milwaukee, Sheldon B. Lubar School of Business, P.O. Box 742, Milwaukee, WI, 53201-0742, United States, kuzu@uwm.edu, Refik Soyer

Ticket queues collect interval censored data for customer abandonment. The abandonment of a customer is only realized when the ticket for that customer is called for service and the customer does not show up. Using a modulated Poisson process model as the framework, we develop parametric and semi-parametric models and their Bayesian analysis to predict abandonment counts on any interval. We also explore the impact of covariates such as queue position, number of servers, and day of the week on predicted abandonment counts. The proposed models are implemented on a real ticket queue data set to provide managerial insights on server allocation.

2 - Delay Announcements with Customer Response

Rouba Ibrahim, University College London, MS&I Department, UCL, Gower Street, London, WC1E 6BT, United Kingdom, rouba.ibrahim@ucl.ac.uk, Mor Armony, Achal Bassamboo

We study the accuracy of the last-to-enter-service (LES) delay announcement in service systems where customers respond to the announcements.

3 - Optimal Production Rates for Large Scale Systems under Time-varying Demand

Chihoon Lee, Stevens Institute of Technology, Hoboken, NJ, 07030, United States, clee4@stevens.edu, Yunan Liu, Xin Liu, Ling Zhang

Continuous manufacturing has received much of recent attention both in academia and industry. We consider production systems with a time-varying demand, perishable inventory, and abandonment of backorders. The system incurs inventory-related costs of holding and perishment, and demand-related costs of waiting and abandonment. We study the finite-time production planning to minimize the sum of the demand and production related costs. We use fluid models to derive time-dependent production rates that are asymptotically optimal as the system scale increases; specifically, we prove a limit theorem to verify the asymptotic effectiveness of the optimal solution.

4 - Club Queues

Jamol Pender, Cornell University, 206 Rhodes Hall, Ithaca, NY, 14850, United States, jjp274@cornell.edu, Andrew Daw

In many stochastic systems, the arrival process may exhibit clustering behavior. This behavior is typically seen in financial markets and is also seen at nightclubs in New York City and Las Vegas. Using martingales, we derive exact moments and moment generating function for an infinite server queue that is driven by a Hawkes process and has phase type service. We show via simulation that the moments well approximate the simulated moments. As an application, we apply our results to study a queueing process described as the Club queue. As a result, we derive the optimal rate at which a bouncer should allow clubgoers to go inside the club using optimal control theory with the mean of our Hawkes queueing process.

■ SA19

342A

Disruption Risk Management

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Nitin Bakshi, University of Utah, Salt Lake City, UT, 84112-8939, United States, nitin.bakshi@eccles.utah.edu

1 - Disruption Risk and Optimal Sourcing in Multitier Supply Networks

Dan Andrei Iancu, Stanford University, 655 Knight Way, Stanford, CA, 94107, United States, daniancu@stanford.edu, Robert Swinney

We study sourcing in a supply chain with three levels: a buyer, tier 1 suppliers, and tier 2 suppliers prone to disruption from, e.g., natural disasters. The buyer may not directly dictate which tier 2 suppliers are used but may influence the sourcing decisions of tier 1 suppliers via contract parameters. We show that the buyer's optimal strategy depends critically on the degree of overlap in the supply chain: if tier 1 suppliers share tier 2 suppliers, resulting in a "diamond-shaped" supply chain, the buyer relies less on direct mitigation (procuring excess inventory and multisourcing in tier 1) and more on indirect mitigation (inducing tier 1 suppliers to mitigate disruption risk).

2 - Risky Suppliers or Risky Supply Chains

Yixin Wang, University of Michigan, 701 Tappan Street R4323, Ross School of Business, Ann Arbor, MI, 48104, United States, iriswang@umich.edu, Jun Li, Ravi Anupindi

Past research has focused on the interaction between a buyer and its immediate suppliers. Propagation of risks, however, can extend beyond a firm's direct linkages. The sub-tier supply network structure may also aid or prevent such risk propagation. This paper focuses on a particular sub-tier network structure, viz., sharing of tier-2 suppliers, empirically studies its prevalence, and quantifies its association with the financial risk of tier-0 firms in the high-tech industry.

3 - Mitigating Disruption Cascades in Assembly Networks

Shyam Mohan, London Business School, Baker Street, PhD Office, London, NW1 4SA, United Kingdom, smohan@london.edu, Nitin Bakshi

The losses from supply chain disruptions arise not only due to direct damage at firms (from idiosyncratic disruptions), but also from the interruption of normal operations because of lack of supply; that is, due to disruption cascades from suppliers in the adjacent tiers and beyond. To curtail such losses, firms can make ex-ante investments in mitigation and recovery strategies. In this paper, we examine a game-theoretic framework to characterize equilibrium investments and payoffs of firms in an assembly network. We show that limited information about the network structure suffices for firms to make optimal investments.

4 - Learning (or not) from Precursors to Disasters

Heikki Peura, Imperial College London, London, United Kingdom, h.peura@imperial.ac.uk, Nitin Bakshi

Disasters are invariably preceded by more frequent precursor events. These events embed valuable information about the root cause of a disaster, and thereby facilitate risk assessment. But to learn from precursors, a managing firm typically relies on the reports of a contractor, who is often also responsible for mitigating the occurrence of these incidents. We show how firms may fail to learn from precursor events due to the resulting intertwined problems of moral hazard (on risk mitigation) and hidden information (on reporting precursors).

■ SA20

342B

Management of Innovation, Technology and Services

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Juliana Hsuan, Copenhagen Business School, jh.om@cbs.dk

1 - The Impact on the Pricing of Hotel Rooms using New Technology

Eric Bentzen, Copenhagen Business School, Frederiksberg, Denmark, eb.om@cbs.dk

In this paper we will investigate the dynamic pricing of hotel rooms among customers who use online booking apps. Online booking apps allow you to start making reservations directly using apps on smartphones, ipads, and PCs. The empirical results based on data from 2016-2017 show that the pricing structure depends on the type of customer, time of the year, number of hotels and the number of days in advance a hotel is booked.

2 - Nescience: A Key Ingredient to Managing Innovation

Nitin Mayande, Nike, 6249 NE Carillion Drive, Unit 201, Hillsboro, OR, 97124-8097, United States, nitin.mayande@nike.com, Charles M. Weber, Rainer P. Hasenauer

Aristotle's dictum scio nescio (I know that I don't know) may serve as a source of enhanced performance for organizations. Awareness of nescience sets the direction for further inquiry, as managers tend to move in the direction that they believe will reduce nescience most. However, nescience is difficult to quantify, so, to date, managers have primarily relied on intuition. Observing business analytics practices in three industries—semiconductor manufacturing, medical diagnostics and social media analytics—suggests that nescience can be measured using metrics from information theory.

3 - Directionality in Online Social Networks
Nitin Mayande, Nike, 6249 NE Carillion Drive, Unit 201, Hillsboro, OR, 97124-8097, United States, nitin.mayande@nike.com, Charles M. Weber

Relationships within social networks have been treated as reciprocal relationships in most cases within extant theory (Burt, 1976, Burt and Doreian, 1982, Granovetter, 1973). There have been a few studies in which directionality has been taken as a factor (Allen, 1977, Roger, 1983). However, the impact of considering directionality in a social network has not been studied in detail. In order to understand the impact of considering directionality, this study bifurcates the process of interaction (reciprocal) into consumption phase and propagation phase. The early results show that within a directed network, the consumption and propagations phases can behave very differently from each other.

4 - Measuring the Modularization of Industrial Service Processes
Juliana Hsuan, Professor, Copenhagen Business School, Solbjerg Plads 3 B.5.27, Frederiksberg, DK-2000, Denmark, jh.om@cbs.dk, Thomas Frandsen

We examine how complex industrial service processes can be measured through the lenses of service modularization strategies. The measured degree of modularity sharpened our understanding of the role of standardization and component reuse on creating architecture flexibility. It also provided a foundation for analyzing the short- and long-term impact of service innovation.

■ SA21

342C

Appointment Scheduling with No-Show and Unpunctual Patients

Invited: InvitedHealthcare Systems and Informatics

Invited Session

Chair: Paul Brooks, Virginia Commonwealth University, Richmond, VA, 23284, United States, jpbrooks@vcu.edu

1 - Multimodularity in the Stochastic Appointment Scheduling Problem with Discrete Arrival EPOCHS
Christos Zacharias, Assistant Professor, University of Miami, 5250 University Drive, Room 401 K/E, Coral Gables, FL, 33146, United States, czacharias@bus.miami.edu, Tallys Yunes

We address the problem of designing appointment scheduling strategies that account for patients' no-show behavior, non-punctuality, emergency walk-ins and general stochastic service times. We demonstrate that the optimal scheduling strategy minimizes a multimodular function and how to perform local search in polynomial time.

2 - Overbooking Rules in Outpatient Clinics when Considering No-shows and Cancellations
Shannon Harris, The Ohio State University, 1005 W. 5th Avenue, Unit 535, Columbus, OH, 43212-3085, United States, harris.2572@osu.edu, Jerrold H. May, Luis G. Vargas

In this paper we propose rules for overbooking patients in an outpatient clinic over a scheduling horizon. We incorporate direct and indirect waiting time, overtime, no-shows, and cancellations to inform the overbooking decisions. Rules for overbooking up to two patients per day, when making a pair-wise decision between two days, are expressed analytically. Numerical solutions for overbooking greater than two patients are provided. The effect of no-shows and cancellations on overbooking is also discussed.

3 - Predictive Analysis of Missed Medical Appointments/no-shows
Asil Oztekin, University of Massachusetts Lowell, 333 1st Street, Unit 210, Lowell, MA, 01850-2580, United States, asil_oztekin@uml.edu

Patients not showing up for clinical appointments (No-Shows) is a huge drain on the healthcare resources and costs several millions nationwide. The dataset has 300,000 medical appointment records and 15 variables. The purpose of this analysis is to predict whether a patient would show up for his appointment or not and to investigate why patients miss their scheduled appointments. The CRISP-DM approach is adopted to provide a framework to ensure potentially-useful deliverables for medical practice. This study aims to recognize if there are any key patterns to this type of "no-show" behavior.

■ SA22

342D

Economic Models in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Dan Zhang, University of Colorado, Boulder, CO, 80309, United States, dan.zhang@colorado.edu

Co-Chair: Xiao Huang, John Molson School of Business, Concordia University, Montreal, QC, H3G 1M8, Canada, xiao.huang.2009@marshall.usc.edu

1 - An Analytical and Empirical Look at Hotel Standby Upgrades
Pelin Pekgun, University of South Carolina, Columbia, SC, 29208, United States, Pelin.Pekgun@moore.sc.edu, Ovunc Yilmaz, Mark Ferguson, Guangzhi Shang

In this research, we first develop an analytical model of premium room and standby upgrade pricing under an uncertain market size, and examine how and when standby upgrades can provide additional revenue for a hotel. We then follow up with an empirical study, utilizing a hotel chain's booking and standby upgrades data, to understand the decision-making process of a guest facing standby upgrades, and the extent of the strategic guest behavior. Our findings provide guidance for hoteliers to use standby upgrade programs more effectively based on the hotel type and guest behavior.

2 - Created Unequal Bundling with Crowdsourced Products
Lu Wang, University of Toronto, Rotman School of Management, 105 St. George Street, Toronto, ON, M5S.3E6, Canada, lu.wang12@rotman.utoronto.ca, Ming Hu

As consumer buying habits are trending toward more simple and hassle-free experiences, more and more companies are jumping into the innovative business model of subscription services. Subscription providers such as Spotify, Netflix and OneGo (an all-you-can-fly subscription service provider) crowdsource products/services from many vendors and bundle them for the price of one. The collected subscription fees for the bundle then are allocated according to the realized contributions by each crowdsourced product. We examine the incentive compatibility of different parties under various bundling strategies.

3 - Service Product Design and Consumer Refund Policies
Xiao Huang, John Molson School of Business, Concordia University, 1455 De Maisonneuve Blvd. West, Montreal, QC, H3G 1M8, Canada, xiao.huang@concordia.ca, Dan Zhang

We consider a firm serving heterogeneous consumers with imperfect signals on their quality valuations. The firm can customize offering qualities, customize refund rates, or customize both. We show that a wide range of menu can be optimal depending on valuation heterogeneity and signal quality. Even with the liberty of customization, the firm may still offer standard quality or refund policy. Interestingly, aggregate consumer surplus does not increase with generous refund, and the seller may not have incentive to improve the signal quality even if it is cost-less.

4 - Managing Hotel Cancellations
Dan Zhang, University of Colorado, Leeds School of Business, University of Colorado, Boulder, CO, 80309, United States, dan.zhang@colorado.edu, Xiao Huang, Jian Wang

We use hotel transaction data to investigate customer cancellation behavior. We show that cancellation rates are highly correlated with booking rates and the posted rates at the time of cancellation. We discuss the implications of our findings on hotel pricing policies.

■ SA23

342E

Using Field Experiments to Optimize Operations

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Spyros Zoumpoulis, Paris, 75005, France, spyros.zoumpoulis@insead.edu

Co-Chair: Ruomeng Cui, Bloomington, IN, 47401-7739, United States, cuir@indiana.edu

1 - The Value of Fit Information in Online Retail: Evidence from a Randomized Field Experiment

Santiago Gallino, Dartmouth College, 100 Tuck Hall, Hanover, NH, 03755, United States, santiago.gallino@tuck.dartmouth.edu, Antonio Moreno Garcia

Virtual fitting-room technologies can provide information about how a product fits a particular customer in a novel way and mitigate the stress that the existing information gap generates in the retailers supply chain. By implementing a series of randomized field experiments, we study the value of virtual fit information in online retail.

2 - Mobile Messaging for Offline Group Formation in Prosocial Activities: A Large Field Experiment

Tianshu Sun, University of Southern California, 3670 Trousdale Parkway, Bridge Hall, BR.I.310B, Los Angeles, CA, 90089, United States, tianshus@marshall.usc.edu, Guodong (Gordon) Gao, Ginger Zhe Jin

We study whether and how charities can use mobile messaging to leverage individuals' social ties and encourage offline prosocial activities in groups. In particular, we run a randomized field experiment with 80,000 blood donors and study how behavioral interventions and economic rewards motivate offline group formation. We find that commonly used interventions like reminder message and individual reward are ineffective in motivating group donation. In contrast, a newly proposed group reward is effective, and tends to attract different types of donors. Structural estimation further reveals mechanisms, and suggests group reward is 4 times more cost-effective than rewarding individual donors.

3 - Field Experiments with Restaurant Table-top Technology: How Do We Select What We Eat?

Dmitry Sumkin, INSEAD, Rue de Montebelo 10, Fontainebleau, 77300, France, dmitry.sumkin@insead.edu, Serguei Netessine

We conduct field experiments using tablet-based restaurant menus which allow us to randomize location of dishes and design of the menu. We identify menu designs that allow restaurants to increase sales by exploiting customer search patterns using table-top technology.

4 - Optimizing Promotion Targeting using Field Experiments

Spyros Zoumpoulis, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, spyros.zoumpoulis@insead.edu, Theodoros Evgeniou, Duncan I.Simester, Artem Timoshenko

We investigate how firms can use the results of field experiments to optimize marketing decisions, training and testing our policies on a series of two large scale field experiments. We discuss how to optimize the targeting of promotions, how to efficiently evaluate targeting policies, and how to optimally target non-responders (i.e., people who did not respond to past promotions) using the timing of the responses of responders.

■ SA24

342F

Ride-sharing Platforms 2

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States, ozan.candogan@chicagobooth.edu

Co-Chair: Daniela Saban, Stanford GSB, Palo Alto, CA, 94304, United States, dsaban@stanford.edu

1 - Surge Pricing and its Spatial Supply Response

Francisco Castro, Columbia University, New York, NY, United States, fcastro19@gsb.columbia.edu, Omar Besbes, Ilan Lobel

Our work seeks to understand the structure of ride-sharing platforms' pricing strategies in a geographical network with self-interested supply agents. We anchor our analysis on a Stackelberg game. The platform sets prices at every node and drivers react by choosing whether to relocate to different nodes. We establish that an equilibrium for the drivers' game always exists, and we give structural properties of this equilibrium. Surprisingly, to give the "right" incentives to drivers, the platform may need to set prices higher than those that would balance supply and demand. Our results show how flexible supply impacts the optimal pricing policy and how supply incentive constraints shape it.

2 - On-demand Service Platforms

Terry Taylor, University of California Berkeley, 545 Student Services #1900, 2220 Piedmont Avenue, Berkley, CA, 94720, United States, taylor@haas.berkeley.edu

An on-demand service platform (e.g., Uber, Instacart) connects waiting-time sensitive customers with independent service providers. This paper characterizes how two defining features of an on-demand service platform—congestion-driven delay and service provider independence—impact the platform's optimal per-service price and wage.

3 - Pricing and Optimization in Shared Vehicle Systems

Siddhartha Banerjee, Cornell University, 229 Rhodes Hall, Ithaca, NY, 14853, United States, sbanerjee@cornell.edu, Daniel Freund, Thodoris Lykouris

We develop a framework for optimizing shared-vehicle systems, modeled using closed queueing networks. Our approach gives the first efficient algorithms with rigorous guarantees for several common demand-supply balancing controls, including pricing, rebalancing and matching, in the process simplifying and extending several recent results. Moreover, our framework, which is based on a novel convex relaxation coupled with a new infinite-projection and pullback technique, may prove useful for proving approximation bounds in other settings.

4 - Spatial Pricing of Taxi Rides

Nasser Barjesteh, University of Chicago, 5242 S Kenwood Avenue, Apt 2, Chicago, IL, 60615, United States, barjesteh@chicagobooth.edu, Baris Ata, Sunil Kumar

We study the pricing of taxi rides based on their pickup location. We introduce a structural model that captures the Spatial and inter-temporal variations in demand and the distribution of the destinations of the customers, the distances between locations, and the strategic relocations of the taxis. The goal is to use the model with the estimated parameters to find the spatial pricing scheme that maximizes the consumer surplus.

■ SA25

350A

Innovation, Product, and Project Management

Invited: New Product Development

Invited Session

Chair: Morvarid Rahmani, Georgia Institute of Technology, Atlanta, GA, 30308-1149, United States, morvarid.rahmani@scheller.gatech.edu

1 - Procurement Contracting under Product Recall Risk

Yue Zhang, Duke University, 5507 Butterfly Lane, Apt 207, Durham, NC, 27707, United States, yueyue.zhang@duke.edu, Lauren Xiaoyuan Lu, Jayashankar M.Swaminathan, Gang Wang

Managing product quality and mitigating the financial impact of product recalls pose great challenges to manufacturers due to demand uncertainty and non-contractibility of suppliers' quality effort. To understand the interdependence of supply chain quantity and quality decisions, we develop a procurement contractual framework under both demand and recall risks. We consider a model in which a manufacturer outsources to a supplier the production of a component, which is subject to potential quality failure leading to a product recall. We analyze two settings: a pull system in which the supplier makes the quantity decision and a push system in which the manufacturer makes the quantity decision.

2 - Optimal Contracts in Decentralized Projects

Theodore D. Klastorin, University of Washington, ISOM.Department, Box 353226, Seattle, WA, 98195-3226, United States, tedk@u.washington.edu, Michael R.Wagner

We consider a serial stochastic decentralized project where a client subcontracts the work to an independent contractor. Using a Stackelberg game, we analyze several different types of contracts including incentive, fixed price, and cost plus contracts. We show that certain types of contracts maximize the expected client profit and derive conditions that define the optimal parameters for these contracts.

3 - Archetypes of Entrepreneurship: From Ideas to Products to Funding
Hyunwoo Park, The Ohio State University, Columbus, OH, 43210, United States, park.2706@osu.edu, Asifur Mehedi, Aleksi Aaltonen

We analyze a series of interviews with entrepreneurs using text mining to extract representative features. We focus on identifying different pathways of how entrepreneurs develop ideas into viable products or services. Since different products and services have different funding requirements, we further investigate the relationship between the idea-product pathways and funding types and amount by augmenting our sample with startup funding data.

4 - Incentives and Competition in Innovation Contests with Public Submissions: Can "Star" Power Help or Hurt Competition?
Anant Mishra, George Mason University, Fairfax, VA, United States, amishra6@gmu.edu, Jesse Bockstedt, Cheryl Druehl

Innovation contests allow firms to harness specialized skills of participants with diverse backgrounds for solving challenging business problems. We use detailed data on contest and contestant characteristics from a popular online logo-design contest platform with public submissions to examine the role of incentives on the competitive environment of contests.

■ SA26

350B

Applications and Innovations in DEA

Invited: Data Envelopment Analysis

Invited Session

Chair: Andrew L. Johnson, Texas A&M University, 3131 TAMU, 4033 Emerging Technologies Bldg, College Station, TX, 77843-3131, United States, ajohnson@tamu.edu

1 - Robust Benchmarking and Efficiency Estimation using Quantiledea (QDEA): Methodology and Statistical Properties
Joseph Atwood, Montana State University, Bozeman, MT, United States, jatwood@montana.edu, Saleem Shaik

LP DEA models can estimate efficiency metrics but suffer from sensitivity to outliers and data noise. Quantile-DEA (qDEA) enables the analyst to use LP while allowing up to q-percent of data points to lie external to the efficiency hull. Procedures utilized in qDEA are applicable to a broader class of "relaxed constraint" LP problems where the analyst wishes to allow up to a proportion of endogenously identified constraints to be violated. We present the theory of relaxed constraint LP models, the qDEA model, the statistical properties of qDEA estimators, and examples where qDEA is used to address data outliers and obtain quantile performance benchmarks.

2 - Nutrient Profiling using Data Envelopment Analysis
Thomas Raymond Sexton, Professor, Stony Brook University, 5 Linden Lane, Farmingville, NY, 11738-1154, United States, Thomas.Sexton@StonyBrook.edu, Christine Pitocco

Nutrient profiling models summarize the complex array of nutritional data associated with a food item to help consumers make better food purchasing decisions. Many models rely on somewhat arbitrary thresholds that change over time. We use Data Envelopment Analysis to develop a novel and highly flexible nutrient profiling model that requires no thresholds. We illustrate the model on purported "superfoods."

3 - Beyond DEA: How What We Learned from DEA Can Be Used in Analytics
Jose H. Dula, Virginia Commonwealth University, Richmond, VA, 23284, United States, jdula@vcu.edu

Much of today's big data is non-parametric. The concepts and tools used in DEA can be adapted and extended to many aspects of the analytics of such data. Familiarity with DEA means understanding sophisticated optimization duality relations widely used in computational geometry. DEA algorithms can be applied directly to all sorts of data to extract interesting information. The additive model in DEA involves the L1 norm, an intensely explored norm in analytics because of its desirable robustness properties. In this talk we discuss how knowledge of DEA can prepare researchers to make contributions in big data analytics.

4 - Lost Economies of Scope and Merger Gains in Norwegian Electricity Industry
Ørjan Myland, Inland Norway University of Applied Sciences, Lillehammer, Norway, Orjan.Mydland@inn.no

In 2016, the Norwegian Parliament amended the Energy Act, with changes taking effect from 2019. The amended legislation will introduce strict separation of all generation- and distribution companies within the electricity industry in Norway. Economies of scope studies from Norway shows evidence of large economies of scope. Further, the companies in the industry could utilize the economies of scale potential if they would merge. In this paper, I perform merger analysis to investigate best- and worst scenario outcomes regarding the cost effects on the industry from the amendments in the Norwegian Energy act.

■ SA27

350C

Social Media Analytics Best Student Paper Competition

Invited: Social Media Analytics

Invited Session

Chair: Michel Ballings, University of Tennessee, Knoxville, TN, 37996, United States, michel.ballings@utk.edu

1 - Social Media Analytics Best Student Paper Competition
Michel Ballings, University of Tennessee, University of Tennessee, Knoxville, TN, 37996, United States, michel.ballings@utk.edu

The section prize committee selected these finalists to come and present their student-led work.

■ SA28

350D

Market Design

Invited: Auctions

Invited Session

Chair: Martin Bichler, Technische Universitat Munchen, Munich, 85748, Germany, bichler@in.tum.de

1 - Core-Selecting Auctions in the Laboratory
Marion Ott, RWTH Aachen University, Templergraben 64/V, Aachen, 52062, Germany, marion.ott@rwth-aachen.de, Alexander Heczko, Thomas Kittsteiner

We experimentally analyze core-selecting auctions (CSA) and find that they perform better than Vickrey auctions. The proportions of efficient allocations are similar in both types of auctions, but the proportions of stable (core) allocations and the revenue are higher in the CSA. We observe this for two different informational setups, one in which theory predicts the better performance of the CSA and one in which it does not. We trace the causes of the performance differences back to patterns in bids and find that bidders in the CSA react to incentives to deviate from reporting truthfully in the predicted direction, though less pronounced than predicted.

2 - The Value of Sharing Intermittent Spectrum
Rakesh Vinay Vohra, University of Pennsylvania, Economics Department, 3718 Locust Walk, Philadelphia, PA, 19104, United States, rvohra@sas.upenn.edu, Randall Berry, Micheal Honig, Thanh Nguyen, Vijay Subramanian

Recent initiatives by regulatory agencies to increase spectrum resources available for broadband access include rules for sharing spectrum with high-priority incumbents. We study a model in which wireless Service Providers (SPs) charge for access to their own exclusive-use (licensed) band along with access to an additional shared band. The shared band is intermittently available with some probability, due to incumbent activity, and when unavailable, any traffic carried on that band must be shifted to licensed bands.

3 - On the Design of Combinatorial Exchanges
Martin Bichler, Technische Universitat Munchen, Department of Informatics, Boltzmannstr. 3, Munich, 85748, Germany, bichler@in.tum.de

Linear and anonymous competitive equilibrium prices are desirable in multi-item auctions, but unfortunately they do not always exist in non-convex markets. We discuss the market design for a large-scale combinatorial exchange for fishery access rights. The specifics of the allocation problem lead to different ways on how allocation and payments are computed. We analyze trade-offs of different payment rules relevant to an auction designer. Similar market design problems can be found in other parts of the world and other application domains.

4 - Reducing Congestion through Information Design
Sanmay Das, Washington University in St. Louis, Dept. of Computer Science & Engg., One Brookings Dr, CB 1045, Saint Louis, MO, 63130, United States, sanmay@wustl.edu, Emir Kamenica, Renee Mirka

We consider the problem of designing information structures in games of uncertain congestion, like road traffic networks where the level of traffic is unknown. Using the framework of Bayesian persuasion, we show that we can devise signal structures that mitigate congestion and improve social welfare.

■ SA29

350E

Methods and Models for Big Network Data

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Bin Zhang, PhD, University of Arizona, Tucson, AZ, 85721, United States, binzhang@arizona.edu

1 - When will a Repost Cascade Settle Down?
Chi Chen, Tsinghua University, Beijing, China, chenchi14@mails.tsinghua.edu.cn

Repost cascades play a critical role in information diffusion on social media. Substantial previous work has studied various aspects of repost cascades such as growth, burst and recur, however, when a repost cascade will settle down remains to be an open problem. Existing models cannot be directly applied to solve the problem because of sensitiveness of feature based models and assumption of point process based models. In this paper, we propose a novel definition "settling time" and develop a model to get rid of the restriction in previous studies. We conduct experiments on Sina Weibo dataset whose results show that our model achieves over 10% performance gain than the previous approaches.

2 - Estimating External Motivating Factors in Interorganizational Social Media: Peer Effects and Organizational Influences
Bin Zhang, Assistant Professor, University of Arizona, 1130 E. Helen St, Rm 430Z, Tucson, AZ, 85721, United States, binzhang@arizona.edu, Kexin Zhao, Xue Bai

Interorganizational social media (IOSM) enable professionals belonging to different organizations to share knowledge online. Knowledge sharing requires social interactions within and beyond the community boundary. Thus influences from external entities likely play an important role in encouraging individuals' participation. In this research, we study external motivating factors generated from peer effects and organizations. We apply a novel econometric identification method to analyze a unique dataset collected from an IOSM. We find that external motivating factors from peers and organizations are influential in determining community participation.

3 - Are Electronic Cigarettes a Safer Substitute for Cigarettes for Asthma Patients a Network Based Research
Wenli Zhang, University of Arizona, Tucson, AZ, United States, wenlizhang@email.arizona.edu, Sudha Ram

Asthma affects millions of US adults. Among all the asthma triggers, one of the biggest risk factors is smoking. However, smoking is one of the most difficult addictions to break. It is believed that the use of Electronic Nicotine Delivery Systems (ENDS) may be considered as a low risk substitute for tobacco use for asthma patients. Studies show that people exposed to an ENDS post on social media may be more easily persuaded if the message is from credible sources (e.g., friends or reliable news media), which may have influence on the adoption of ENDS. The research objective of this study is to explore the key conversations and the propagation of ENDS usage among asthma users on social media.

4 - A Model-free Solver for Arbitrary Graph Problems: Predicting Solutions with Deep Learning
Stefan Feuerriegel, University of Freiburg, Platz der alten Synagoge, Freiburg, 79098, Germany, stefan.feuerriegel@is.uni-freiburg.de, Nil-Jana Akpinar

Graph problems require extensive manual effort due to the mathematical derivation of exact solvers or heuristics. As an alternative, we propose a deep learning methodology that can approximate solutions without the need for a mathematical model of the problem. Our innovative approach merely requires problem-solution pairs, based on which it then learns the underlying mechanism in order to solve the problem. The key is here a memory network for making predictions from arbitrary data structures. This work studies its computational performance and derives bounds.

■ SA31

351A

Nicholson Student Paper Competition I

Invited: Nicholson Student Paper Prize

Invited Session

Chair: Hayriye Ayhan, Georgia Institute of Technology, School of Industrial & Systems Eng, 755 Ferst Dr NW, Atlanta, GA, 30332-0205, United States, hayhan@isye.gatech.edu

Co-Chair: Cole Smith, Clemson University, 110 Freeman Hall, Clemson, SC, 29634, United States, jcsmith@clemson.edu

1 - Dynamic Matching for Real-time Ridesharing
Erhun Ozkan, University of Southern California, Los Angeles, CA, United States, erhunozkan@gmail.com

In a ridesharing system such as Uber or Lyft, arriving customers must be matched with available drivers. We propose to base the matching decisions on the solution to a continuous linear program (CLP) that accounts for (i) the differing arrival rates of customers and drivers in areas of the city, (ii) how long customers are willing to wait for driver pick-up, and (iii) the time-varying nature of all the aforementioned parameters.

2 - Tractable Distributionally Robust Optimization with Data
Zhi Chen, National University of Singapore, Singapore, chenzhi.james@gmail.com

We present a framework for distributionally robust optimization that could encompass a variety of statistical information including constraints on expectation, conditional expectation, and disjoint confidence sets with uncertain probabilities defined by phi-divergence. We also show that the Wasserstein-based ambiguity set has an equivalent formulation via our ambiguity set, which enables us to tractably approximate a Wasserstein-based distributionally robust optimization problem with recourse.

3 - On Deterministic Reformulations of Distributionally Robust Joint Chance Constrained Optimization
Weijun Xie, Georgia Institute of Technology, Atlanta, GA, wxie33@gatech.edu

A joint chance constrained optimization problem (CCP) involves uncertain constraints that are jointly required to be satisfied with probability exceeding a prespecified threshold. In a distributionally robust joint CCP (DRCCP), the joint chance constraint is required to hold for all probability distributions of the stochastic parameters from a given ambiguity set. We consider DRCCP involving convex nonlinear uncertain constraints and an ambiguity set specified by convex moment constraints.

4 - Multi-agent Online Learning under Imperfect Information:Algorithms, Theory and Applications
Zhengyuan Zhou, Stanford University, Stanford, CA, zyzhou@stanford.edu

We consider multi-agent online learning under imperfect information, where the reward structures of agents are given by a general continuous game. After introducing a general equilibrium stability notion for continuous games, we examine the online mirror descent (OMD) algorithm and show that its last iterate converges to variationally stable Nash equilibria under certain assumptions. We also propose a delayed mirror descent algorithm that relies on the repeated leveraging of past information.

■ SA32

351B

Drone Delivery Systems – I

Invited: Invited Drone Delivery Systems

Invited Session

Chair: James F. Campbell, University of Missouri-St Louis, Saint Louis, MO, 63121-4499, United States, campbell@umsl.edu

1 - A Branch and Bound Approach to the TSP with Drone and Related Heuristics
Stefan Poikonen, PhD Candidate, University of Maryland-College Park, 3406 Tulane Dr., Apt. 22, Hyattsville, MD, 20783, United States, spoikone@math.umd.edu, Bruce L.Golden

The traveling salesman problem with a drone (TSP-D) is a hybrid truck and drone model of delivery. A drone may ride atop a truck. Trucks may deliver packages directly. Alternatively, the drone may carry a package from the truck to a customer then return to the top of the truck to swap batteries. This system benefits from the drone's use of the crow-fly metric and parallelization of work, yet mitigates concerns about limited drone range. Computational results, both exact and heuristic, will be shown. We greatly expand the size of problems that may be solved optimally. Comparisons to other solution methods in the literature will be made.

2 - Optimization of Parcel Delivery with a Truck and Drones Combination

Alice E. Smith, Auburn University, 3301 Shelby Center, Dept of Industrial/Sys Engineering, Auburn, AL, 36849, United States, smithae@auburn.edu, Mehmet Gulsen, Chase Murray

The use of drones in parcel delivery has the potential to lower delivery cost and shorten delivery times. Deploying multiple drones in parcel delivery will further speed-up the process, but this brings new challenges in terms of synchronizing the schedules of the drones and the truck. This research presents an operational framework of a multiple drone - truck integrated delivery system. Realistic technical constraints for the drones such as payload capacity and endurance limit are taken into consideration. With the objective of minimizing total delivery time, the routes for each drone and the truck are determined using an integrated optimization approach.

3 - Delivery with Trucks and Drones

James F. Campbell, University of Missouri-St Louis, College of Bus. Administration, One University Boulevard, Saint Louis, MO, 63121-4499, United States, campbell@umsl.edu

Delivery drones (unmanned vehicles) provide a new opportunity for delivery of small packages. The presentation considers continuous approximation models for three delivery options from a depot: single-stop drone trips, multi-stop truck tours, and multi-stop hybrid truck-drone tours where drones are launched from and return to trucks. Different tour time limits allow high service levels to be modeled and fixed costs for depots allow deign of multi-depot delivery systems with drones.

■ SA33

351C

Aviation Applications Section: Awards Finalists

Sponsored: Aviation Applications

Sponsored Session

Chair: Virginie Lurkin, Ecole Polytechnique Fédérale de Lausanne, Route Cantonale, Lausanne, 1015, Switzerland, vlurkin@ulg.ac.be

Co-Chair: Vikrant Vaze, Dartmouth College, 14 Engineering Drive, Murdough Center, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu

1 - Modeling Crew Itineraries and Delays in the National Air Transportation System

Keji Wei, Dartmouth College, Hanover, NH, United States, keiji.wei.th@dartmouth.edu, Vikrant Naze

We propose, optimize and validate a methodological framework for estimating the extent of the crew-propagated delays and disruptions (CPDD). We identify the factors that influence the extent of the CPDD, and incorporate them into a robust crew scheduling model. We develop a fast heuristic approach for solving the inverse of this robust crew scheduling problem to generate crew schedules that are similar to real-world crew scheduling samples. We develop a sequence of exact and heuristic techniques to quickly solve the forward problem within a small optimality gap for network sizes that are among the largest in robust crew scheduling literature. Computational results using four large real-world airline networks demonstrate that the crew schedules produced by our approach generate propagation patterns similar to those observed in the real world. Extensive out-of-sample validation tests indicate that the parameters calibrated for one network perform reasonably well for other networks. We provide new insights into the perceived tradeoff between planned costs and delays costs as reflected by actual airline crew schedules. Finally, we present a general approach to estimate the CPDD for any given network using our methodological framework under a variety of data availability scenarios.

2 - Service Improvement and Cost Reduction for Airlines: Optimal Policiesfor Managing Arrival and Departure Operations under Uncertainty

Heng Chen, University of Nebraska-Lincoln, CBA 250, 1240 R.Street, Lincoln, NE, 68588, United States, heng@unl.edu

We study four novel operational problems related to flight arrivals and departures at airports under the uncertainty of operating conditions, and demonstrate the potential dollar-based value that can be generated through stochastic models within the context of airline and airport operations. We derive both tactical and strategic policies to improve efficiency and sustainability for airlines and the society, which can enhance service quality and strengthen market position for the airlines involved.

■ SA35

351E

Supply Chain Management

Contributed Session

Chair: Francisco Brahm, University of Cambridge, Trumpington 10, Cambridge, CB2 1AG, United Kingdom, fb435@cam.ac.uk

1 - Assessing Inventory Performance via Warehouse Structural Embeddedness

Kedong Chen, University of Minnesota, Minneapolis, MN, United States, chen3548@umn.edu, Hung-Chung Su, Kevin W. Linderman

How a business entity is embedded in its network of the same others will affect its operational performance. Such an effect of structural embeddedness becomes further salient when supply and warehouse networks become increasingly complex due to business expansion. Through analyzing proprietary datasets from China's leading logistics management company, we identify the duality of the effect of a warehouse's structural embeddedness on its inventory performance. Specifically, a distribution center (DC)'s direct ties are negatively associated with the DC's inventory turnover and stockout rate, while the association becomes positive for the DC's indirect ties in its tier-1 ego network.

2 - A Dynamic Agent-based Model of Inter-firm Strategic Interaction

Duncan Robertson, Loughborough University, SBE, Loughborough, United Kingdom, d.a.robertson@lboro.ac.uk

We present a dynamic model of inter-firm strategic interaction where firms compete for customers within an competitive market. We develop an agent-based model where firms move in a strategic space in order to capture customers. The competitive landscape faced by a firm changes not only as the result of firm-firm interactions but also from the indirect interaction between firms and customers. We present results for different strategies and show when they should be used.

3 - A Contingency Framework for Disparate Tradeoffs in Manufacturing Strategy on a Duality Time Perspective

Zongjian Chen, Associate Professor, Huazhong University Of Science & Technology, Luoyu Road 1037, Wuhan, 430074, China, chenzjem@mail.hust.edu.cn

I introduce a contingency framework that relates digitization of manufacturing to the definitions of the performance frontier concept of a manufacturing unit, paying particular attention to the question of how to mix competitive priorities and competitive capabilities in manufacturing strategy. On a duality time perspective, this study investigates the assumptions, rationales and methodologies of the framework for disparate strategic tradeoffs.

4 - Acquisitions as Second Order Dynamic Capability: Understanding Indirect Contextual Impact

Vivek Peeraji Jirnal, PhD Student, XLRI, Room No 26 B.Block, GMP, XLRI, C. H. Area, Jamshedpur, 831001, India, jirnalvivek@gmail.com

We utilize the recent contributions in dynamic capability literature to identify acquisition learning as a second order dynamic capability. We build a model to understand the indirect impact that acquisition capability in its different forms (weak and strong) can cause, based on a) firms absorptive capacity, b) firms combinative capability, and c) the level of environmental dynamism. Our study goes beyond previous acquisition literature by designing comprehensive parameters to capture contextual multidimensionality and its contribution in impact variance of acquisitions, captured through six different forms of impact of acquisition capability.

5 - The Evolution of Productive Organizations

Francisco Brahm, University of Cambridge, Trumpington 10, Cambridge, CB2 1AG, United Kingdom, fb435@cam.ac.uk, Joaquin Poblete

We develop a evolutionary game-theory model to study the origins of partnerships, guilds, cooperatives, and other knowledge-based organizations. On every period, a population of agents adopts a technology that confers fitness but can be affected by environmental changes. These agents might display individual or social learning. We show that social learning does not enhance the fitness of the population. Then, we show that by organizing a portion of the population into a small group that has a lower cost of social learning the fitness of the population increases. The model provides several propositions regarding organization size, adaptation to uncertainty, who innovates, and the role of secrecy.

■ SA36

351F

Service Science Analytics

Sponsored: Service Science

Sponsored Session

Chair: Suchithra Rajendran, PhD, Pennsylvania State University, State College, PA, 16802, United States, sur205@psu.edu

1 - Minimizing Completion Time Variance in Service Industries using Heuristic Approaches

Chandrasekharan Rajendran, IIT.Madras, Dept. of Mgmt. Studies, IIT Madras-Chennai, Chennai, 600040, India, crajiitm@gmail.com

The problem of scheduling customers or jobs in a service system or in a manufacturing system is an important operational issue. Minimizing the completion-time variance (CTV) of customers is an important performance measure when customers require an uniform treatment, i.e., each customer spends approximately the same time in the system or waits for service as every other entity. In this work, an existing branch-and-bound algorithm is first analyzed for minimizing the CTV and a correction on the lower bound is presented. Based on this, a simple heuristic to solve the problem is proposed.

2 - Determining Risk Type of Customers at Financial Institutions using Machine Learning Algorithms

Suchithra Rajendran, Pennsylvania State University, 265 Blue Course Drive, Apt 3E, State College, PA, 16803, United States, sur205@psu.edu, Sharan Srinivas

Financial institutions are constantly facing the problem of approving loans to high-risk customers. It has been reported in the literature that there are several financial institutions becoming bankrupt due to loan defaulting. In this research, five machine learning approaches are developed to classify the customers as high risk and low risk based on several parameters such as age, salary and past history on defaulting. The methods are compared using several performance measures such as sensitivity, specificity and accuracy to determine the best performing rule.

3 - An Integrated Supplier Selection and Lot Sizing Policy Considering Total Quantity Discount and Quality Constraint

Sang Jin Kweon, PhD, Pennsylvania State University, Industrial and Manufacturing Engineering, 232 Leonhard Building, University Park, PA, 16802, United States, rossa1984@gmail.com, Xin Li, Jose Antonio Ventura, Barbara Venegas, Seong Wook Hwang

This paper studies a joint supplier selection and lot sizing problem with quality constraint. Suppliers are capacitated and offer total quantity discount (TQD). Under TQD, the product unit price depends on the total order quantity (TOQ) for the supplier over a certain time period. Order quantities can have integer or continuous values. For each case, given a supplier and the TOQ for it, a procedure to derive the optimal order quantities and number of orders is developed. A near-optimal algorithm that combines Lagrangian relaxation and dynamic programming is proposed to solve the problem.

4 - Preference Based Scheduling in a Healthcare Provider Network

Deepak Agrawal, Pennsylvania State University, 310 Leonhard Building, University Park, PA, 16802, United States, dua143@psu.edu, Guodong Pang, Soundar Kumara

Healthcare is delivered by a complex network of physicians, clinic facilities and patients with different priorities and preferences. Traditional appointment scheduling systems do not consider the network effect. Motivated by this, we study the advanced scheduling problem with multiple clinic locations and physicians where patients can visit any clinic location and provider of their preference. We develop theoretical bounds on the performance gap with respect to the best achievable policy and propose a performance improvement heuristic to solve the problem. Further, we conduct numerical experiments to show that our proposed model outperforms the scheduling policies used in practice.

■ SA37

352B

Best IBM Service Science Student Paper Award Competition I

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Pennsylvania State University, Malvern, PA, 19355, United States, robinqiu@psu.edu

Co-Chair: Aly Megahed, IBM Research-Almaden, San Jose, CA, 95123, United States, aly@gatech.edu

1 - Managing Market Thickness in Online B2B Markets

Wenchang Zhang, Robert H.Smith School of Business, 12001 Old Columbia Pike, Apt 811, Silver Spring, MD, 20904, United States, wzhang@rhsmtih.umd.edu, Kostas Bimpikis, Wedad J.Elmaghraby, Ken Moon

Platforms can obtain sizable returns by operationally managing their market thickness, i.e., the availability of supply-side inventory. Using data from a natural experiment on a major B2B auction platform specializing in the $424 billion secondary market for liquidating retail merchandise, we find that thickening the platform's market by consolidating the ending times of auctions to certain weekdays substantially increases its revenue by 6.5%, due primarily to the bidders' participation frictions. We study two complementary design levers to calibrate and control the platform's market thickness in the face of complex demand-side decision making: listing policy and a recommendation system.

2 - Examining Impacts of Clinical Practice Variation on Operational Performance: Implications for Bundled Payment Reform Models

Seokjun Youn, Texas A&M.University, 320 Wehner Building, 4217 Texas A&M.University, College Station, TX, 77840-4217, United States, syoun@mays.tamu.edu, Gregory R. Heim, Subdoha Kumar, Chelliah Sriskandarajah

Motivated by bundled payment policies that aim to reduce practice variation, this study examines whether and how lower variations in clinical practice relate to hospital operational performance. Analyzing six years of data from hospitals in NY and FL states, we provide our empirical findings. We believe better measurement and understanding of practice variation's antecedents and consequences can lead managers and policy-makers to better design bundled payment reform models, the target opportunity of which is to reduce waste by decreasing variabilities in care-delivery processes.

3 - Linking Delay Announcements, Abandonment, and Staffing: A Behavioral Perspective

Eric Michael Webb, eric.michael.webb@gmail.com, Kurt Bretthauer, Qiuping Yu

Using field data from a call center, we study the behavioral determinants of customers' queue abandonment decisions in the presence of delay announcements. We relax traditional behavioral assumptions on how customers should behave. Customers exhibit loss aversion with respect to time losses in queue, becoming much more likely to abandon if forced to wait longer than expected. Customers also exhibit a decreasing base hazard rate. Longer announced wait times increase customer abandonment behavior and customers are often strategic in their arrival decisions. By accounting for our insights, firms may significantly reduce their staffing levels without increasing customers' overall waiting time.

■ SA38

352C

Algorithms and Heuristics for Multiobjective Mixed-integer Optimization

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Daniel Jornada, Ford Motor Company, 15403 Commerce Drive South, Dearborn, MI, 48120, United States, danieljornada@gmail.com

1 - Bi-objective Mixed Integer Linear Programming for Managing Building Clusters with a Shared Electrical Energy Storage

Rui Dai, University of South Florida, Tampa, FL, United States, ruidai@mail.usf.edu

Building clusters allow buildings to collaborate and reduce their operational cost. However, since each building is treated as an independent decision maker, fairness havs to be addressed in these collaborative environments. We address these issues on building clusters with an electrical energy storage shared between two buildings with deterministic demand. We introduce three strategies, and develop a bi-objective mathematical formulation for each strategy with several linearization techniques such as piecewise McCormick relaxation. Experiment results demonstrate the efficacy of our proposed linearization techniques, and compare all three strategies in terms of fairness and freedom.

2 - The Box-Line Algorithm for Mixed Integer Biobjective Optimization

Diego Pecin, Georgia Tech, Atlanta, GA, United States, diegopecin@gmail.com

Recent years have seen a surge of new algorithms for solving multiobjective integer programs, especially for the pure integer case. The presence of continuous variables presents significant challenges to discovery of the nondominated frontier, and development of algorithms for the mixed integer case have lagged. Here, we present a new algorithm for mixed integer problems with two objectives, which generalizes the Balanced Box Method (BBM) for pure integer programs. The computational performance of the Box-Line Algorithm is compared with that of existing methods on benchmark problems, in terms of its overall run-time, and its ability to approximate the frontier if terminated early.

3 - Linear Programming Filtering Algorithms for a Class of Biobjective Optimization Problems over the Efficient Set
Daniel Jornada, Ford Motor Company, Dearborn, MI, United States, danieljornada@gmail.com

This presentation deals with a class of biobjective optimization problems over the efficient that is reformulated as a biobjective mixed binary linear program (BOMBLP).Two objective space search algorithms are proposed. Computational experiments suggest that both algorithms run faster than existing general purpose objective space search procedures.

■ SA39

352D

Analytics Society

Sponsored: Analytics

Sponsored Session

Chair: Matthew Lanham, Purdue University, 112 Eastland Drive, Lafayette, IN, 47905, United States, malanham@gmail.com

1 - Value of the Society and New Offerings
Stefan E. Karisch, Boeing Commercial Aviation Services, Seattle, WA, stefan.e.karisch@boeing.com

The President of the Analytics Society invites you to an open forum to share your recommendations and ideas for how the society grows with you and the industries we support to provide the value and relevant offerings. We will as well review the strategic goals and key initiatives of the Society this year and through 2018.

■ SA40

352E

2017 Edelman Finalists Reprise

Sponsored: The INFORMS Section on Practice

Sponsored Session

Chair: Anne G. Robinson, Verizon Wireless, Basking Ridge, NJ, 07920, United States, agrobins@gmail.com

1 - Analysis and Improvement of Blood Collection Operations
Turgay Ayer, Georgia Institute of Technology, School of Industrial and Systems Engineering, Groseclose 417, Atlanta, GA, 30332, United States, ayer@isye.gatech.edu, Can Zhang, Chenxi Zeng, Chelsea C. White, Kevin Lee, Mary Deck, V. Roshan Joseph

We describe a regional-level cryoprecipitate (cryo)-collection project at the American Red Cross Southern Region (ARC-SR). The implementation of our proposed solution resulted in a significant improvement: about 1,000 more cryo units at a slightly lower collection cost, resulting in an approximately 40% reduction in per-unit cryo collection cost. Based on the successful implementation at the ARC-SR, the ARC plans to implement our proposed model at its 10 other cryo production facilities.

2 - The New York City Off-Hour Delivery Program: A Business andCommunity-Friendly Sustainability Program
Trilce Encarnacion, Rensselaer Polytechnic Institute, 110 8th Street, Jonsson Engineering Center # 4049, Troy, NY, 12180, United States, encart@rpi.edu, José Holguín-Veras, Stacey Hodge, Jeffrey Wojtowicz, Caesar Singh, Cara Wang, Miguel Jaller, Felipe Aros-Vera, Kaan Ozbay, Michael Marsico, Andrew Weeks, Michael Replogle, Charles Ukegbu, Xuegang Ban, Matthew Brom, Shama Campbell, Ivan Sanchez-Díaz, Carlos Alberto Gonzalez-Calderon, Alain Kornhauser, Mark Simon, Susan McSherry, Xia Yang, Asheque Rahman, Diana Gineth Ramirez-Rios, Lokesh Kalahashti, Johanna Amaya, Michael Silas, Brandon Allen, Brenda Cruz

The New York City Off-Hour Delivery program, a private-public-academic partnership, implemented policy designed with the help of OR/MS, including behavioral micro-simulation. By successfully inducing more than 400 commercial establishments in NYC to accept OHD, economic benefits accrued are considerable: carriers reduced costs by 45%; receivers enjoy more reliable deliveries and reduce inventory; trucks reduced emissions up to 67%. Total economic benefits exceed $20 million per year.

■ SA42

360A

Funding Opportunities for OR and Advanced Manufacturing

Invited: Invited OR and Advanced Manufacturing

Invited Session

Chair: Yu Ding, Texas A&M University, College Station, TX, 77843-3131, United States, yuding@tamu.edu

1 - NSF
Georgia-Ann Klutke, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA, 22230, United States, gaklutke@nsf.gov

2 - DOE
Sudarsan Rachuri, Sudarsan.Rachuri@ee.doe.gov

3 - Moderator
Yu Ding, Texas A&M.University, Dept Industrial & Systems Engineering, ETB 4016, Ms 3131, College Station, TX, 77843-3131, United States, yuding@tamu.edu

Program directors from three federal agencies will discuss their program's scope, focus, opportunities and initiatives that may be of interest to researchers in OR and advanced manufacturing.

■ SA43

360B

Public and Nonprofit Applications

Sponsored: Public Sector OR

Sponsored Session

Chair: Ece Zeliha Demirci, Bilkent University, Merkez Kampus, Rektorluk Binasi EA325, Ankara, 06800, Turkey, edemirci@bilkent.edu.tr

1 - Decision Support for Choosing among Projects: Handling Multi-dimensional Efficiency and Equity Concerns
Özlem Karsu, Bilkent University, Ankara, 06800, Turkey, ozlemkarsu@yahoo.co.uk, Nur Kaynar

We develop interactive algorithms that will help policy makers make choices among a set of projects. The projects are evaluated based on their benefits to different population groups and there are multiple benefit types to consider. We assume that both efficiency and equity are relevant and hence the problem is a multicriteria decision making problem. Our computational experiments demonstrate the satisfactory performance of the algorithms. We believe that such decision support tools may be of great use in practice and help in moving towards fair and efficient service provision.

2 - Will Aging Voting Machines Cause Long Waiting Lines
Muer Yang, University of St. Thomas, 1000 Lasalle Avenue, TMH 451E, Minneapolis, MN, 55403, United States, yangmuer@stthomas.edu

As the majority of voting machines in use today approach or exceed their expected lifetime, there is an impending crisis from the increased number of voting machine failures expected in the upcoming elections. This study examines and quantifies the impact of aging machines on voter wait times via simulation. The reliability issue of aging voting machines might not be as serious as predicted.

3 - One- or Two-Channel Subsidies? Donor Funding for Drug Availability
Iva Petrova Rashkova, Washington University in St. Louis, Washington University in St Louis, St Louis, MO, 63130, United States, irashkova@wustl.edu

Abstract: We study the decision of a donor subsidizing health programs by allocating a limited budget between the commercial and non-commercial distribution channels. The two channels differ in their affordability to patients and quantity yield per-unit subsidy. We show that the variability of the random yield in the non-commercial channel generates inter-channel cannibalization and reduces total consumption. Thus, efforts of the donor should be focused on reducing this variability. We evaluate the consumption improvement of the optimal subsidy using historical data from three donor organizations.

4 - An Interdiction Model for Delaying Adversarial Attacks in Information Technology Supply Chains

Kaiyue Zheng, University of Wisconsin-Madison, 5002 Sheboygan Avenue, Apt 202, Madison, WI, 53705, United States, kzheng23@wisc.edu

IT supply chain risks from adversarial attacks are sophisticated, hard to detect, and likely to have severe consequences. We propose an interdiction model that prioritizes cost-effective security mitigations to maximally delay adversarial attacks in IT supply chains. We consider attacks originated from multiple adversaries with different capacities and perceptions of supply chain vulnerabilities, each of which aims to find a "critical path" through the attack surface to complete attack goals. We address uncertainty regarding mitigation effectiveness by incorporating random delaying times. A Lagrangian heuristic is proposed that identifies near-optimal solutions efficiently.

5 - Designing Intervention Scheme for Electric Vehicle Market

Ece Zeliha Demirci, Eindhoven University of Technology, De Lismortel 42-250, Rektorluk Binasi EA325, Eindhoven, 5612AR, Netherlands, edemirci@bilkent.edu.tr, Nesim K. Erkip

Real life examples indicate that a central authority needs to intervene to the supply chain of electric vehicle so that their adoption level is increased towards socially desirable levels. In this study, we consider an intervention scheme composed of investing in demand-increasing strategies and rebates. We introduce a model that determines a utility maximizing intervention scheme and further investigate the model. Also, we conduct a numerical study based on the available electric vehicle market data from California.

■ SA44

360C

Urban Transportation and Logistics in Public Sector OR

Sponsored: Public Sector OR

Sponsored Session

Chair: Sung Hoon Chung, Binghamton University, Binghamton, NY, 13902, United States, schung@binghamton.edu

1 - Congestion Reduction through Efficient Empty Container Movement

Santiago Carvajal, University of Southern California, 731 W. 30th Street, Apt 6, Los Angeles, CA, 90007, United States, scarvaja@usc.edu, Maged M.Dessouky

The optimization problem for efficiently routing multi-container trucks to better reposition both loaded and empty containers is studied. Our formulation adds the multi-container truck to the empty container reuse problem. Our aim is to efficiently route trucks by reducing the number of truck trips, thus decreasing transportation costs, and reducing the natural environmental impact of transporting goods.

2 - Vehicle Routing Problem for Smart Street Sweeping using GIS

EunSu Lee, New Jersey City University, 160 Harborside Plaza 2, #234H, Jersey City, NJ, 07311, United States, elee3@njcu.edu

Every city faces unique budget situation and public policy on the activities of street sweeping. This study assess the effectiveness of current system in Jersey City, NJ and proposes a smart street sweeping system using geographic information systems (GIS). The method minimizes citywide total operating costs while improving public services.

3 - Code Assignment for Parcel Distribution Network

Byung-In Kim, POSTECH, Industrial & Management Engineering, 77 Cheongam-Ro, Nam-Gu, Pohang, Kyungbuk, 37673, Korea, Republic of, bkim@postech.ac.kr, JaeSang Park

We consider a parcel distribution network consisting of multiple hubs and hundreds of spokes, in which the category code for each spoke is important. Parcels are collected at spokes, sorted based on their category codes, sent to hubs and sorted, and sent to their destination spokes. Parcels may go through multiple hubs. A spoke can send parcels to a given number of hubs and each hub has the sorting capacity and the limited number of connecting spokes. We propose a mathematical formulation and develop an algorithm of category code assignment to spokes and corresponding network flow design.

4 - Robust Ride-Sharing with Client Clustering under Travel Time Uncertainty

Sung Hoon Chung, Binghamton University, P.O. Box 6000, Binghamton, NY, 13902, United States, schung@binghamton.edu, Yinglei Li

We consider a ride-sharing system in which information on riders (clients) and drivers (servers) is updated and drivers' routes need to be calculated quickly. We assume travel times between pick-up locations are subject to uncertainty, and propose a robust optimization approach to handle it properly. To achieve computational tractability, we employ the insertion algorithm in conjunction with tabu search method, and propose a cluster-first-route-second approach to find heuristic solutions. In particular, the greedy algorithm and k-means algorithm are used to group the client nodes and their respective results, along with non-clustering case outcomes, are compared.

■ SA45

360D

JFIG Panel Discussion: Tips for Successful Publication from Journal Editors

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: Anahita Khojandi, University of Tennessee, UTK, Knoxville, TN, 1, United States, anahitakhojandi@gmail.com

1 - JFIG Panel Discussion: Tips for Successful Publication from Journal Editors

Anahita Khojandi, University of Tennessee, Knoxville, TN, United States, anahitakhojandi@gmail.com

The panelists consist of past and current editors from top journals, including Manufacturing & Service Operations Management (MSOM), Service Science, and IISE Transactions. The editors will share tips on how to get your paper successfully published, from selecting the right journal and preparing the manuscript, to revising the paper and responding to reviewers' comments. They will also answer questions pertaining to writing and publication.

2 - Panelist

Sheldon H. Jacobson, University of Illinois, Dept of Computer Science, 201 N.Goodwin Avenue MC258, Urbana, IL, 61801-2302, United States, shj@illinois.edu

3 - Panelist

Maria Esther Mayorga, North Carolina State University, 400 Daniels Hall, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu

4 - Panelist

Christopher S. Tang, University of California-Los Angeles, UCLA Anderson School of Management, Operations and Technology Management, Los Angeles, CA, 90095-1481, United States, chris.tang@anderson.ucla.edu

5 - Panelist

Alan Scheller-Wolf, Tepper School of Business, GSIA, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, awolf@andrew.cmu.edu

■ SA46

360E

Scheduling in Practice

Invited: Project Management and Scheduling

Invited Session

Chair: Emrah Cimren, Nike, 1 SW Bowerman Dr, Beaverton, OR, 97005, United States, Emrah.Cimren@nike.com

1 - Stable Matching and Sustainable Cost Allocation for Real-time Ride-sharing System

Pengyu Yan, University of Electrolic Sicence and Technology of Chnia, No.2006, Xiyuan Ave, West Hi-Tech Zone, 611731, Chengdu, 611731, China, yanpy@uestc.edu.cn, Cynthia Chen, Zhiqin Luo, Chengbin Chu

Ride-sharing, a sustainable transportation mode, allows drivers to flexibly share idle seats in their vehicles with others. This paper addresses a stable matching solution conception in a real-time ride-sharing system with considering the benefits of the self-interested users. We first formulate a stable matching model that generates an acceptable matching solution for most of the users. The loss of the system efficiency of four existing cost allocation methods are investigated. We propose a sustainable cost allocation method that guarantee the optimal system efficiency of a stable matching solution. The numerical experiment indicate the effectiveness of our proposed method.

2 - Speedscaling in Flow Shops with Lot Streaming
Kan Fang, Tianjin University, Tianjin, China, kfang@tju.edu.cn, Michael L.Pinedo

The variable frequency drives on electrical motors have become more attractive in manufacturing to save their energy. We consider using speed scaling techniques to solve the flow shop lot streaming problems. We investigate the structural properties of optimal schedules and the computational complexity of various scheduling problems.

3 - Optimality of a Priority Policy for a Server Scheduling Problem with a Deteriorating Server
Jefferson Huang, Cornell University, Ithaca, NY, 14853, United States, jefferson.huang@cornell.edu, Mark E. Lewis, Cheng-Hung Wu

We consider a server scheduling problem motivated by the control of semiconductor manufacturing systems, where the service rate depends on both the class of the job and the degree to which the server has deteriorated. Conditions are given under which a priority policy is optimal. The case where the server may be preemptively repaired is also considered.

4 - Scheduling for Map-reduce Jobs
Vaneet Aggarwal, Purdue University, 315 N. Grant St., West Lafayette, IN, 47906, United States, vaneet@purdue.edu, Tian Lan

The Map-Reduce computing framework rose to prominence with datasets of such size that dozens of machines on a single cluster were needed for individual jobs. The interesting aspect of map-reduce job scheduling is that the reduce jobs can start when all the map tasks have finished. We give competitive scheduling algorithms for such job scheduling procedures where the release times of jobs depend on completion times of others.

■ SA47

360F

Value of E-Businesses

Sponsored: EBusiness

Sponsored Session

Chair: Qizhi Dai, Drexel University, Philadelphia, PA, 19104, United States, qd24@drexel.edu

1 - Crowdfunding Lender Team Structure and Lending Behavior
Bin Wang, University of Texas Rio Grande Valley, Edinburg, TX, United States, bin.wang@utrgv.edu, Diego Escobari

The proliferation of crowdfunding in the last few years has drawn academic researchers' interest. Specifically, many have examined lending behavior and borrowers' success of person-to-person (P2P) lending. The current research proposes to examine how lender team structure affect lending behavior and campaign success. Using data collected from Kiva.com, a leading P2P platform connecting lenders and borrowers from around the world, we examine how the network positions of lending team captains and members affect their lending behavior and the success of crowdfunding campaigns.

2 - Evaluating Observational Learning in Competitive Two-sided Crowdsourcing Market: A Bayesian Inferential Approach
Emmanuel Ayaburi, PhD Candidate, The University of Texas at San Antonio, One UTSA Circle, San Antonio, TX, 78249, United States, emmanuel.ayaburi@utsa.edu, Zhechao (Charles) Liu, Yoris A. Au

This study examines the effect of observational learning by both buyers and creatives (suppliers) in the increasingly popular crowdsourcing market. Using a Bayesian framework, we estimate two structural models that capture buyers and creatives' utility. Our results show that both buyers and creatives actively exercise observation learning from various market signals, and such learning leads to a more accurate prediction of market outcome and strong network effects. Our findings provide important insights on how crowdsourcing market participants can leverage the influence of the information signals present in the market to enhance their utility and promote a sustainable growth of the market.

3 - Crafting Personalized Incentives: A Randomized Field Experiment in an Online Dating Platform
Ting Li, Erasmus University, T09-14, Burg Oudlaan 50, Rotterdam, 3000DR, Netherlands, tli@rsm.nl, Rodrigo Belo

Heterogeneity across consumers often leads to diverse responses to incentives. We develop a method that accounts for consumer heterogeneity and maximizes consumer life-time value (CLTV), by personalizing incentives in scenarios of multiple conversion outcomes. We use data from a real-world randomized experiment in an exclusive online dating platform to create uplift models that predict changes in consumer behavior. We apply these methods in a new out-of-sample randomized experiment and find considerable improvements in CLTV, when compared to randomly assigned incentives. We explore the effectiveness of personalized incentives across consumers and discuss implications for business.

■ SA48

361A

Behavioral Issues in Supply Chain and Service Management

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Tingliang Huang, Carroll School of Management, Boston College, Chestnut Hill, MA, 02467, United States, tingliang.huang@bc.edu

Co-Chair: Hang Ren, University College London, London, N12 8AQ, United Kingdom, hang.ren.13@ucl.ac.uk

1 - The Behavioral Promise and Pitfalls in Compensating Operations Managers
Shan Li, Assistant Professor, Baruch College, City University of New York, 55 Lexington Avenue, New York, NY, 10010, United States, shan.li@baruch.cuny.edu, Kay-Yut Chen, Ying Rong

We theoretically and behaviorally studied Profit-Sharing and Target-with-Bonus compensation schemes in an inventory management context. Our experimental data reveals behavioral promise and pitfalls of the two widely used incentive compensation schemes, and it further suggests systematic deviations from the theoretical benchmarks. Based on the experimental findings, we manipulate the behaviors and engineer the design of the compensation scheme through two additional treatments, to explore potential improvement of the mechanism. Our results have implications for the design of incentive schemes in practice.

2 - Service Systems with Unknown Quality and Customer Anecdotal Reasoning
Hang Ren, UCL.School of Management, Flat 52, Nansen Village, 21 Woodside Avenue, London, N12 8RW, United Kingdom, hang.ren.13@ucl.ac.uk, Tingliang Huang

We consider a service system where customers do not know the distribution of uncertain service quality and cannot estimate it fully rationally; instead, they form beliefs by taking the average of anecdotes. The sample size measures to what extent customers are boundedly rational. We characterize customers' joining behavior and the server's pricing, quality, and information disclosure decisions. As customers gather more anecdotes, the server may first decrease and then increase price, and the revenue is U-shaped. Interestingly, more anecdotes may induce a lower quality. Moreover, a low (high)-quality service provider may (not) disclose quality information if the sample size is small (large).

3 - Non-binding Goals in Teams: A Real-effort Coordination Experiment
James Fan, juf187@smeal.psu.edu

We experimentally investigate the efficacy of non-binding (wage-irrelevant) team goals. In our study, participants act as either team workers or managers. A manager can set a non-binding goal for the team production, which is determined by the minimum (or weak-link) performance of its workers. Consistent with our theory, we find evidence that the team production increases when managers are able to set goals. This effect is stronger when goals are challenging but attainable for weak-link workers. We also find evidence that many managers assign goals that are too challenging for weak-link workers, resulting in suboptimal team production and profits.

4 - Trust Among Executives
Yanchong Zheng, Massachusetts Institute of Technology, Sloan School of Management, 100 Main Street, E62-578, Cambridge, MA, 02139, United States, yanchong@mit.edu, Emily Choi, Ozalp Ozer

We integrate the results of a social network survey and a forecast information sharing experiment to determine whether and how trust and trustworthiness impact high-ranking executives' decisions in a dyadic supply chain. The members of our executive sample have on average 17 years of work experience. Over half of them hold C-level positions in world-leading organizations. We demonstrate that executives are significantly motivated by trust and are more cognizant of when to rely on trust in their business decisions than non-experienced individuals. These results offer valuable insights into how organizations can better leverage executives' trust intelligence to improve supply chain efficiency.

■ SA49

361B

Behavioral Aspects of Judgment and Forecasts

Invited: InvitedBehavioral Aspects of OR

Invited Session

Chair: Dilek Onkal, Bilkent University, Ankara, 06800, Turkey, onkal@bilkent.edu.tr

1 - The Effects of the Availability Bias on Facebook Users' Perception of Privacy Risks Over Time

Kathleen M. Whitcomb, University of South Carolina, Moore School of Business, Management Science Dept, Columbia, SC, 29208, United States, whitcomb@moore.sc.edu

Past studies have shown that a short-term increase in risk perception for an activity or event can be achieved by exposing individuals to a vivid image known to induce negative affect. This effect has been demonstrated even when the image is unrelated to the activity. It has been hypothesized that the increase in risk perception generated by a vivid image inducing negative affect persists longer when the image is relevant to the target activity. We report the results of an experiment which demonstrates that a relevant negative image results in both a more enduring and greater increase in risk perception than does an irrelevant negative image.

2 - Cognitive Debiasing Training in Judgmental Frecasting: An Experimental Study

Jorge Alvarado Valencia, PhD, Colombia, Pontificia Universidad Javeriana, Bogota, Colombia, jorge.alvarado@javeriana.edu.co, Jaime Vargas, Lina Merchan

In order to reduce well-known cognitive biases in judgmental time series forecasting (noise modelling, small unjustified adjustments and overoptimism) a short cognitive debiasing training was tested against forecasting techniques training and no training at all with students in a judgmental adjustment task . Results show that cognitive debiasing training reduced small unjustified adjustments, but did not reduce noise modelling and was no better than absence of training. Forecasting techniques training led to a reduction in accuracy, mainly due to unjustified adjustments.

3 - Effects of Scenario Tone on Judgmental Forecast Adjustments

Dilek Onkal, Bilkent University, Faculty of Business Administration, Ankara, 06800, Turkey, onkal@bilkent.edu.tr, Paul Goodwin, M. Sinan Gonul

When presented with forecasts, users typically respond by judgmentally adjusting these predictions to incorporate their experience, intuition, and informational asymmetries. However, such adjustments may not always improve forecast accuracy; hence the need for support tools to improve communication and information sharing between forecasters and decision-makers. This research investigates the effects of providing differently-toned scenarios as forecast advice on individual and group-based judgmental predictions. Findings suggest important directions for designing and implementing effective forecast management systems to support both the providers and users of forecasts.

■ SA50

361C

Large-scale Data Analytics in Urban Transportation Modeling I

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Shanjiang Zhu, George Mason University, Fairfax, VA, 22030, United States, szhu3@gmu.edu

Co-Chair: Zhen Qian, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, seanqian@cmu.edu

1 - Assessing Travel Behavior Responses to Washington Metro SafeTrack Project using Smartphone App Data

Shanjiang Zhu, George Mason University, Nguyen Engineering Building, Suite 1300, 4400 University Drive Ms 6c1, Fairfax, VA, 22030, United States, szhu3@gmu.edu, Zhuo Yang, Lei Zhang

This study investigates the behavioral reactions to the Washington Metro SafeTrack Project, a series of accelerated safety projects that required either single-track operations, or complete closure of a line segment. Longitudinal travel trajectories data were collected using a smartphone app among transit riders who used to use metro before the service disruptions. Algorithms were developed to infer the travel choices before, during, and after the network disruptions, which are crucial for assessing the impact of the unprecedented maintenance work at the Washington Metro. Findings from this study could help to inform agencies who are struggling with the aging infrastructure in the US.

2 - Spatio-temporal Analysis of Urban Mobility of Transit Users from Smart Card Transactions Data

Laiyun Wu, SUNY-Buffalo, 326 Bell Hall, University at Buffalo, Buffalo, NY, 14226, United States, laiyunwu@buffalo.edu, Jee Eun Kang, Samiul Hasan

Characterizing individual trajectories is critical to understand the dynamics of human mobility and design reliable mobility models. The recent availability of Automatic Fare Collection (AFC) data has diversified the ways to understand human mobility, especially for the patterns of different type of transit users (e.g., regular workers, students, seniors and disabled persons). In this paper, we measure travel distance, travel time and stay time at activity locations for various user groups and present the statistical distributions of these characteristics.

3 - Bayesian Optimization to Fuse Large Scale Transportation Data Sets into Simulation Models

Laura Schultz, George Mason University, Fairfax, VA, 22032, United States, lschult2@gmu.edu, Vadim Sokolov, Joshu Auld, Dominik Karbowski, Aymeric Rousseau

In this paper we present Bayesian optimization techniques for calibrating large scale transportation models. Specifically, we address the problem of updating integrated demand-network models using dynamic traffic flow data, collected on freeways. We present several Bayesian optimization techniques and a distributed data flow framework, that allows scalable execution on highly parallel architectures. We demonstrate our approach using empirical results from the calibration of Chicago's metropolitan area transportation model, with 10 million travelers and 28 million daily trips.

■ SA51

361D

The Structural Modeling and Machine Learning Applications for Issues in Information Systems

Sponsored: Information Systems

Sponsored Session

Chair: Lin Hao, University of Notre Dame, Notre Dame, IN, 46556, United States, lhao@nd.edu

1 - How Much is an Image Worth? Airbnb Property Demand Estimation Leveraging Large Scale Image Analytics

Shunyuan Zhang, Carnegie Mellon University, 5562 Hobart Street, Apartment 614, Pittsburgh, PA, 15217, United States, shunyuaz@andrew.cmu.edu, Dokyun Lee, Param Vir Singh, Kannan Srinivasan

We investigate the economic impact of images and lower-level image factors that influence demand in Airbnb. Using DiD analyses on a nine-month Airbnb panel data of 8211 properties, we find units with verified photos generate approximately 7% more demand. Leveraging computer vision techniques to classify image quality, we show 52.5% of this effect comes from high image quality. Next, we identify 12 human-interpretable image attributes and evaluate their economic impacts. Results suggest direct impacts of the attributes on demand. The study contributes to and bridges literature which traditionally ignored either demand side (photography) or systematic image characterization (marketing).

2 - A Dynamic Structural Model of Online Learning: Heterogeneous Studying Plan and the Peer Effect

Ruoxin Zhou, Peking University, Beijing, China, zhourx@pku.edu.cn, Fei Ren

This paper studies how online learning users dynamically adjust their learning plan every day given their preset deadlines, learning history, and peer effect. We develop a dynamic structural model in which users maximize utility considering the intertemporal trade-off between current and future learning amount. Theoretical properties enable us to distinguish forward-looking from myopic users, and we empirically test for forward-looking consumption patterns. We use a two-stage method to estimate structural parameters, and conduct counterfactual simulations to see how to help users learn better.

3 - Reward-based Crowdfunding Platform Design

Shahryar Doosti, University of Washington, Mackenzie Hall, Seattle, WA, 98195, United States, shahryar@uw.edu, Yong Tan, Shengsheng Xiao

With the emergence of reward-based crowdfunding platforms, there are a growing number of projects benefiting from crowd participation in their fund-raising process. With increasing competition, failed campaigns have been also increased. At the same time, there are multiple choices for entrepreneurs to design their campaigns in terms of design, reward scheme, and goal which can affect the success of the project. In this study, we use different methods of data mining to shed light on the important design questions in front of fund-seekers.

4 - Fostering Innovation: Exploration is not Everybody's Cup of Tea
Vipul Aggarwal, University of Washington, 5263 University Avenue NE, Apt 103, Seattle, WA, 98105, United States, aggarv@uw.edu, Elina Hwang

Innovation thrives on the creative application of existing and new ideas to create new products or concepts. The existing research on the ability of analogies to inspire innovative ideas treats the conceptual distance between the analogy and the target problem as a hammer. Our research aims to bring nuance to this hammer of problem-solving. We investigate the impact of analogical distance on the ability of users to ideate in an open innovation setting. We use state-of-the-art NLP techniques of paragraph vectors and structural topic models to construct our feature set. We find that the effects of analogy distance varies with user types and are also contingent upon the source of the analogies.

5 - Social Ties and the Quality of User-generated Content
Jin Yue, School of Economics and Management, Tsinghua University, Beijing, 100084, China, jiny.13@sem.tsinghua.edu.cn

The social networking mechanism is ubiquitous in content communities. However, the effect of social ties on user contribution behavior is unclear. This study explores how social ties influence the quality of user-generated content from the perspectives of social learning and motivation. Results from a social question-and-answer community reveal that the number of followings of a user enhances the quality of his/her future answers, whereas the number of followers diminishes the quality of such answers. Moreover, the influence of followings comes from their behaviors (i.e., number of answers) rather than their community status (i.e., number of followers and number of agrees).

■ SA52

361E

Storage, Handling, and Picking

Sponsored Session

1 - Sizing a Block Stacking Storage System
Hueon Lee, PhD Candidate, University of Arkansas, 4121 Bell Engineering Center, 1 University of Arkansas, Fayetteville, AR, 72701, United States, hueonlee@uark.edu, Kelly Sullivan, John A. White

Block stacking is a commonly used storage method for palletized loads. As the name implies, unit loads are stacked on top of each other. Stacks are arranged in storage rows having different depths. Given a set of adopted row depths and inventory cycles of product lots, the floor space required for a block stacking storage system is determined by staggering replenishment schedules of multiple lots and assigning a row depth to a product lot. We employ integer programming to obtain the replenishment schedule and assignment of products to row depths to minimize required space. Numerical results are provided for the heuristic algorithm we developed.

2 - Design Challenges and Performance Analysis of the AGV-pick System
Kaveh Azadeh, PhD Candidate, Rotterdam School of Management Erasmus University, Burgemeester Oudlaan 50, Mandeville Building T09-41, Rotterdam, 3062PA, Netherlands, azadeh@rsm.nl, Debjit Roy, Debjit RoyB.M. De Koster

Recently, an AGV-based pick system is developed to minimize the pickers travel time for filling large orders. In such systems, the AGV automatically go to the pick location to wait for the picker to arrive. Once the picker puts the item into a customer's tote carried by the AGV, the AGV goes to the next location. When the order is complete, the AGV brings it to the depot. Due to a parallel movement among the pickers and the AGVs, analysis of such systems is complex. In this research, we attempt to develop queuing network models to capture the realistic movement of the AGVs and the pickers in the system and develop solution methods for performance evaluation.

3 - Modeling Service Priority at Landside Terminal Resources: Exact Analysis and Approximations
Debjit Roy, Indian Institute of Management, Ahmedabad, India, debjit@iima.ac.in

We develop an exact approach to model service priority of train over truck containers by one automated stacking crane at landside container terminals using an imbedded Markov chain analysis. We further develop an approximate analysis approach to model service priority of train over truck containers with multiple automated stack cranes.

4 - Inbound Storage Block Stacking Optimization for Vehicle Assembly Factories
Yulian Zeng, Georgia Institute of Technology, 2618 Druid Oaks NE, Atlanta, GA, 30329, United States, yulian.zeng@gmail.com

We focus on optimizing inbound parts storage center configuration exploiting rack-less block stacking in vehicle assembly factories. Given parts storage and throughput requirements and stacking constraints, the objective is to determine the center size (rows, row length & depth) and to assign parts to stack locations, so as to minimize induced costs. We report on large-scale experimentation for a major-brand carmaker factory.

■ SA53

361F

Autonomous Vehicles: From Planning to Vehicle Control

Invited: TSL, Intelligent Transportation Systems (ITS)

Invited Session

Chair: Michael Levin, The University of Texas at Austin, 7205 Hart Ln, Apt 1002, Austin, TX, 78731, United States, michaellevin@utexas.edu

1 - Optimal Design of Autonomous Vehicle Zones in Transportation Networks
Zhibin Chen, University of Michigan, 2244 Saint Francis Drive, Apt 209, Ann Arbor, MI, 48104, United States, chipin@umich.edu, Fang He, Yafeng Yin, Yuchuab Du

It is envisioned that in the future government agencies will dedicate certain areas of road networks to autonomous vehicles (AVs) to facilitate the formulation of vehicle platoons. We present a mathematical framework for the optimal design of AV zones in a general network. Since AVs may apply different routing principles outside of and within the AV zones, a novel mixed routing equilibrium model is proposed to capture such behaviors. A mixed-integer bi-level programming model is then formulated to optimize the deployment plan of AV zones.

2 - Auction-based Reservations of Network Trajectories for Autonomous Vehicles
Michael Levin, The University of Texas at Austin, 7205 Hart Ln, Apt 1002, Austin, TX, 78731, United States, michaellevin@utexas.edu

Auctions have been proposed to determine vehicle access to road infrastructures. Although high value-of-time vehicles may be willing to pay tolls or auction bids, many would rather make a single payment that guarantees a travel time for their entire trip. We present a combinatorial assignment algorithm for reserving space-time trajectories with priority determined by auction. Traffic flow follows the cell transmission model. Reservation-based intersection control is used to ensure that reserved trajectories are followed. Winning vehicles tend to have lower travel times, although variability is high. In addition, the trajectory reservation system reduced overall congestion in the network.

3 - Optimal Geometric Design of Parking Facilities for Autonomous Vehicles
Mehdi Nourinejad, University of Toronto, 193 Silverlinden Drive, Toronto, ON, L4B4G6, Canada, mehdi.nourinejad@mail.utoronto.ca, Sina Bahrami, Matthew Roorda

Existing parking facilities are designed according to city guidelines without any accommodation for Autonomous vehicles (AV). With AVs, however, the geometric design of parking facilities will change for two reasons. First, AVs can be parked closer to each other and less space will be taken in total. Second, AVs can be relocated automatically within the parking lot. By optimally relocating the AVs, more vehicles can be packed into each parking facility. This paper addresses the following: (i) what is the optimal geometric design for AV parking facilities, (ii) how to relocate the vehicles within the facility, and (iii) how to stack the AVs in the facility to minimize the expected number of relocations.

4 - A Fuzzy Logic-based Approach for Determining Driving Mode under Partially or Highly Autonomous Vehicle
Lin Liu, Chongqing University, Chongqing, China, liulin@cqupt.edu.cn, Yong Hoon Kim, Yongfu Li, Srinivas Peeta

A partially or highly autonomous vehicle is capable of being operated in autonomous mode by an on-board self-driving controller, or in manual mode by a human driver. This study proposes a fuzzy logic-based approach to determine a competence level of the human driver and the on-board self-driving controller. The experimental validation shows the effectiveness of the proposed approach to determine the driving mode of autonomous vehicle.

■ SA54

362A

Agriculture Analytics at IBM Research

Invited: Agricultural Analytics

Invited Session

Chair: Robin Lougee, IBM Research, Yorktown Heights, NY, 10598, United States, rlougee@us.ibm.com

1 - Precision Agriculture leveraging IoT and Curated Satellite Data Analytics

Ranjini Guruprasad, IBM.Research India, Manyata Embassy Business Park, Bangalore, Karnataka, 560045, India, ranjinib@in.ibm.com, Jagabondhu Hazra

Increasing agricultural productivity is key to raising GDP growth in India, as well as lifting millions of people out of poverty. Digitization, mobile and cognitive technologies have the opportunity to play a pivotal role to enable this future. At IBM Research - India, we are combining multiple global satellite based information sources to compute agronomic insights at sub-acre level. Farmers can now tap the sophisticated output of cognitive analytics to get predictive insight at the right time to manage scarce groundwater-based irrigation, optimize the timing/amount of fertilizers & pesticides, minimize wastage, etc. This presentation will cover few use cases specific to India/SA.

2 - Modeling of Expert Knowledge for Crop Cultivation

Tatsuya Ishikawa, IBM Research - Tokyo, 19-21, Nihonbashi Hakozaki-cho, Chuo-ku, Tokyo, 103-8510, Japan, Ishikawa@jp.ibm.com, Yasuteru Kohda, Hironobu Takagi

We are facing a risk of losing skills of crop cultivation due to the retirements of aging expert farmers in Japan. Their key knowledge is adaptive decision-making such as appropriate temperature settings in greenhouses depending on stages of development in crops and environmental conditions. In this talk, we present a framework which combines (1) measurements of crop growth and environment, (2) simulation models of these dynamics with data assimilation, and (3) model-based adaptive control. We discuss the capability of our framework to model farmer's decision-making.

3 - Geospatial Analytics Powered by IBM Pairs Big-data Platform

Siyuan Lu, IBM, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States, lus@us.ibm.com, Marcus Freitag

The PAIRS geospatial analytics platform is a big-data service of IBM Research that aims at reducing the barrier for analytics or machine-learning on large-scale and disparate spatio-temporal data sources such as weather, satellite, land-classification, lidar, census, sensors, etc. Incoming data is curated on the unified nested PAIRS grid, and derived analytics layers, such as evapotranspiration, are automatically populated as new timestamps of the underlying data arrive. The users may upload their own data in additional layers of the same grid, and perform their analytics on a mix of open and proprietary layers. In this talk the PAIRS architecture and analytics on top of it will be discussed.

■ SA55

362B

Multi-Firm Decision Making

Sponsored: Financial Services

Sponsored Session

Chair: Daniel Mitchell, University of Minnesota, damitche@umn.edu

1 - Robust Portfolio Selection with Transaction Costs

Jingnan Chen, Singapore University of Technology and Design, 20 Dover Drive, Singapore, 138682, Singapore, jingnan_chen@sutd.edu.sg, Ning Zhang

We propose a robust and sparse portfolio selection model to obtain portfolios that are insensitive to parameter estimation errors and have low transaction costs. Two components of transaction costs, i.e., the broker'scommission and the market maker's spread, are both considered. We adopt a distributional robust approach to maximize the worst-caseexpected utility over a set of distributions with the same first- and second-order moment information, and impose l0 and l1 regularization to account for transaction costs. The inclusion of l0 norm results in a non-convex and non-smooth optimization program and we develop an efficient algorithm to find the optimal portfolio.

2 - A Hybrid Approach to the 1/n Portfolio Tracking Problem

Oliver Strub, University of Bern, Schuetzenmattstrasse 14, FM.Quantitative Methoden, Bern, 3012, Switzerland, oliver.strub@pqm.unibe.ch, Norbert Trautmann

The 1/N portfolio strategy corresponds to investing an equal amount in all N stocks from a given investment universe. This strategy exhibits desirable empirical risk-return properties, but causes substantial management costs if N is large. We consider the problem of tracking the 1/N portfolio's returns by investing in a small subset of the N stocks only. We propose a hybrid approach to this problem based on an iterated greedy heuristic and quadratic programming. In a computational experiment with real-world data, we demonstrate that the proposed approach leads to a high tracking accuracy.

3 - Pricing of Cyber Insurance Contracts in a Network Model

Kerstin Weske, Gottfried Wilhelm Leibniz Universität Hannover, Welfengarten 1, Hannover, 30167, Germany, weske@stochastik.uni-hannover.de, Matthias A. Fahrenwaldt, Stefan Weber

We investigate a novel approach for pricing cyber insurance. The considered cyber threats, such as viruses and worms, diffuse in a data network. The spread of the cyber infection is modeled by an interacting Markov chain. Conditional on the underlying infection, the occurrence and size of claims are described by a marked point process. We develop a novel mean-field approach to compute prices of cyber insurance contracts. Several numerical case studies illustrate the impact of the network topology.

4 - Regulation of Financial Networks

Dan Mitchell, University of Minnesota, 111 Church Street SE, Minneapolis, MN, 55455, United States, damitche@umn.edu, Stathis Tompaidis

We consider a financial system in which individual institutions are organized in a directed network representing random payoffs from financial instruments and a regulator is able to set capital requirements for each firm in the network. The regulator sets these capital requirements to reduce the risk of systemic failure to the whole system.

■ SA56

362C

Advances in Location Theory

Sponsored: Location Analysis

Sponsored Session

Chair: Oded Berman, University of Toronto, Toronto, ON, M5S 3E6, Canada, berman@rotman.utoronto.ca

1 - Maximal Collaborative Cover Problems with an Application to Hazardous Materials Emergency Response and a Case Study from China

Jiahong Zhao, McMaster Unviersity, Hamilton, ON, Canada, zhaoj77@mcmaster.ca, Peng Hu, Vedat Verter

An efficient emergency system can reduce the risk derived from hazmat network. We restrict our attention to reducing the waiting time and propose a methodology of optimizing multiple emergency sources. We generate the hazmat network based on urban road, and calculate the response time for different hospitals and fire stations. A new model is modified to decide the locations of multiple sources, where the locations are optimized according to minimizing the gap of each hospital and fire station. To solve this model, a solution procedure is designed from generic algorithm. This methodology is applied to the problem in Chengdu, China, and the results provides a significant reduction in waiting time.

2 - Location and Pricing of a Mobile Food Vending Facility using Public Data

Rajan Batta, University at Buffalo, Buffalo, NY, United States, batta@buffalo.edu, Rishabh Bhandawat

The aim of this talk is to formulate a location problem for a market entrant mobile food vendor to maximize profits based only on public data. Specifically, the model suggests dynamic location and service quality decisions (cuisine, price and other service criteria) from online yelp reviews, customer's proximity to the facility along with geographic and demographic data. The error in prediction is reduced by including other facilities and reviews.

3 - Generalised Facility Location and Design Problem

Dmitry Krass, University of Toronto, Rotman School of Management, 105 St George Street, Toronto, ON, M5S.3E6, Canada, krass@rotman.utoronto.ca, Robert Aboolian, Oded Berman

We present a general problem that can be used to represent a wide variety of known location and design models, including models with elastic demand, competitive facilities, different customer allocation rules, etc. While the general model has non-linearities in both the objective and the constraint, these can be removed by exploiting the special structure. This leads to a solvable MIP formulation.

4 - Modeling Global Facility Decisions for a Supply Chain Coordinator

Ram Gopalan, Rutgers, The State University of New Jersey, 227 Penn Street, Camden, NJ, 08102, United States, ram.gopalan@gmail.com, Snehamay Banerjee, Damodar Golhar

A Supply Chain Coordinator (SCC) is an intermediary between raw material suppliers, contract manufacturers and retailers. The SCC does not own plant capacity or raw material, but performs a disintermediating role in supply chain finance by orchestrating the contract manufacturing of customized products for various globally dispersed retailers. The SCC exploits differences in manufacturing costs at various candidate facilities, but also bears the operational risk if demand at end retailers is significantly different from forecasts. This research addresses a facility choice and capacity selection (FC-CS) problem for a SCC who is customizing a product with pronounced counter-seasonal demand.

■ SA57

362D

Advances in Simulation Optimization and its Applications

Sponsored: Simulation

Sponsored Session

Chair: Loo Hay Lee, National University of Singapore, Singapore, 119260, Singapore, iseleelh@nus.edu.sg

1 - Improving Ordinal Transformation by Combining Multiple Low-fidelity Models

Si Zhang, Shanghai University, Shang-Da Road No. 599, Shanghai, 200444, China, zhangsi817@sina.com, Chun-Hung Chen, Jie Xu, Edward Huang

Simulation optimization problems are usually large-scaled and reqire a very high computing cost to solve them. Previous works on a new framework known as ordinal transformation (OT) provides a method that makes use of a low-fidelity approximate model to speed up optimization. In this work we study how to improve the quality of using low-fidelity models when there are two or more low-fidelity models.

2 - Efficient Nested Simulation for Risk Management of Variable Annuities

Ben Feng, University of Waterloo, Waterloo, ON, Canada, ben.feng@uwaterloo.ca

Variable annuities are popular insurance products that enable policyholders to enjoy both insurance protections and investment returns.Dynamic hedging for variable annuities requires computationally intensive nested Monte Carlo simulation experiments. We propose, analyze, and examine efficient simulation procedures to estimate the expected shortfall of the hedging errors for different variable annuities.Our procedure first infers the ranking of hedging losses from a baseline simulation model then concentrate the simulation budget on the inferred "tail scenarios". As shown by our numerical experiments, such concentration of simulation effort greatly improves efficiency.

3 - Machine Learning and Sample Path Analysis for Large Scale Ranking and Selection

Giulia Pedrielli, Arizona State University, Tempe, AZ, 85281, United States, giulia.pedrielli.85@gmail.com, John W. Fowler

The advancement of machine learning methods as well as computing capabilities has opened possibilities to solve discrete optimization problems over large sets. We propose an algorithm that uses unsupervised learning to support ranking and selection when a large number of solutions are present. Paired comparisons are used to provide a three level scoring to individual solutions for clustering and then optimally allocate computational budget to the solutions for estimation. The comparison uses sample path information relying on memory availability on the machine, while trying to minimize the amount of new observations required.

4 - Exploring an Input Parameter Space with a Limited Simulation Budget

Xilun Chen, Arizona State University, 600 S Dobson Road, Unit 110, Mesa, AZ, 85202, United States, Xilun.Chen@asu.edu, K. Selcuk Candan

Complex simulators, such as for predicting epidemics, require a large number input parameters and generate a large space of observations. Consequently, simulation ensembles are expensive to generate and difficult to explore. In practice, given a simulation budget, one needs to identify an ensemble that includes the most informative simulations to help explore the simulation space. Recognizing this challenge, we propose a novel SimExplorer method that uses partial observations to guide the selection process for new simulations to execute. We show that this process can effectively identify new interesting simulations to run, while balancing the overall fit against the partial observation.

■ SA58

362E

Energy and Climate Themes in Transportation

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Benjamin Leibowicz, The University of Texas-Austin, Graduate Program in Operations Research and Indust, Austin, TX, United States, bleibowicz@utexas.edu

1 - Hydrogen Supply Chain Analysis for Fuel Cell Vehicles using Wind Energy in Texas

Kazunori Nagasawa, University of Texas-Austin, Austin, TX, United States, nagasawa@utexas.edu, F. Todd Davidson, Michael E. Webber

This work will develop methods to help private and public stakeholders better assess the opportunity for manufacturing, transmitting, and distributing renewable hydrogen, and will use Texas as a case study. This work will include identifying potential locations for hydrogen production via electrolysis and wind power, while accounting for the spatial variance in future consumption centers, and the trade-offs in different infrastructure solutions.

2 - Shared Autonomous Electric Vehicle (SAEV) Operations and Emissions Savings

Krishna Gurumurthy, University of Texas-Austin, Stop C1700, Austin, TX, 78712, United States, Kara Kockelman

Shared Autonomous Vehicles (SAVs) will offer new travel options, with smaller vehicles and better engine use delivering lower emissions. Use of electric vehicles can further reduce energy demands and human exposure to pollution. These studies simulate SAV and SAEV vehicle use around Austin for emissions and cost estimates. One uses different battery-range, fleet-size and charging-speed scenarios to assess fleet profitability and customer service times. While a gasoline hybrid-electric (HEV) SAV fleet typically performs better than EV fleets. SAEVs come close with longer ranges and fast-charging. Higher gas prices, carbon taxes and environmental policies may stimulate their demand.

3 - Policy Recommendations for a Transition to Sustainable Mobility Based on Historical Diffusion Dynamics of Transport Systems

Benjamin D.Leibowicz, University of Texas-Austin, ETC 5.128D, 204 E. Dean Keeton St. C2200, Austin, TX, 78712-1591, United States, bleibowicz@utexas.edu

This study analyzes historical data on the diffusion dynamics of transport systems in the United States. The methodology systematically compares the relative timing of diffusion processes for infrastructure, vehicles, and travel. A striking regularity observed across transport systems is that the diffusion of infrastructure precedes the adoption of vehicles, which precedes the expansion of travel. On the "chicken-and-egg conundrum" of infrastructure provision, findings thus support the view that infrastructure comes first.

■ SA59

362F

Airport Capacity Management

Sponsored: Aviation Applications

Sponsored Session

Chair: Konstantinos G. Zografos, Lancaster University, Lancaster, LA1 4YX, United Kingdom, k.zografos@lancaster.ac.uk

1 - Airport-centric vs Airline-centric Approaches in Demand Management

Alexandre Jacquillat, Carnegie Mellon University, 5000 Forbes Avenue, Office 2118J, Pittsburgh, PA, 15213, United States, ajacquil@andrew.cmu.edu, Vikrant Vaze

Airport scheduling interventions can mitigate, or control, congestion through limited changes in flight schedules. However, significant flexibility exists regarding the design of the underlying schedule optimization. The outcomes of centralized (airport-centric) approaches may not coincide with the distributed (airline-centric) objectives. This talk presents two advances: (i) scheduling approaches that balance centralized objectives of efficiency and reliability with distributed objectives of inter-airline equity, and (ii) game-theoretic approaches that identify opportunities of airline strategic behaviors, or lack thereof. Theoretical and computational results are shown.

2 - Integrating Series in the Simultaneous Allocation of Slots on a Network of Airports

Paola Pellegrini, IFSTTAR, Villeneuve d'Ascq, France, paola.pellegrini@ifsttar.fr, Tatjana Boli , Lorenzo Castelli, Raffaele Pesenti

Airport capacity of many airports is managed through the airport slots. SOSTA is an integer linear programming formulation for the simultaneous allocation of slots at all European airports, considering aircraft turnaround. It reproduces the current process by bringing optimization into it, improving the resulting slot allocation. The original formulation however cannot be used to allocate slots for the entire scheduling season since it does not consider the allocation of a series of slots. In this work, we study possible approaches for overcoming this limitation.

3 - Modelling Efficiency, Fairness and Acceptability in Airport Slot Scheduling Decisions

Jamie Fairbrother, Centre for Transport and Logistics (CENTRAL), Lancaster University Management School, Fylde College, Mathematics and Statistics, Lancaster, LA1 4YW, United Kingdom, j.fairbrother@lancaster.ac.uk, Konstantinos G. Zografos

We propose and solve a slot scheduling model which optimizes efficiency and considers fairness and airline acceptability. We introduce a new congestion based fairness measure and we allow airlines to express their preferences regarding the satisfaction of their slot requests. We apply the proposed model to a medium size congested airport to assess the impact of existing and modified IATA slot scheduling guidelines on fairness and efficiency.

4 - Multimarket Contact and Capacity: Evidence from the United States Airline Industry

Hao Su, University of Maryland-College Park, Robert H. Smith School of Business, College Park, MD, 20742, United States, haosu@rhsmith.umd.edu, Martin E.Dresner

This paper will examine the relationship between multimarket contact (MMC) and airline capacity. Based on the literature, we hypothesize that: (1) MMC negatively affects capacity and (2) MMC has a more negative effect on a carrier's capacity when that market is not important to the carrier. Based on U.S. air carrier traffic data with carefully defined markets, we hypothesize that MMC will be associated with lower route capacity and that this effect is greater on less important routes. Our findings may provide evidence for the mutual forbearance hypothesis, suggesting that MMC may facilitate tacit collusion on the supply of capacity.

■ SA60

370A

Case Competition I

Sponsored: INFORMEd

Sponsored Session

Chair: Palaniappa Krishnan, University of Delaware, Newark, DE, 19716-2130, United States, baba@udel.edu

1 - Staffing at the Strategic Advisory Consulting Group: the "S" Word

Elliott Weiss, University of Virginia, Charlottesville, VA, United States, WeissE@Darden.virginia.edu

Staffing at the Strategic Advisory Consulting Group: The "S" Word" is a field-based case that requires deterministic and stochastic modeling for a staffing problem. The case can be used to reinforce quantitative topics related to simulation analysis, newsvendor thinking and optimization. Managerial judgment and creativity are required with respect to implementation of solutions. The case is intended for use in introductory courses in OM and DA/QA or in elective courses in Management of Service Operations or Optimization. It can be used to cover optimization techniques and applied modeling.

2 - Glitz Investments

Srinivas Krishnamoorthy, Simon Fraser University, Vancouver. BC, Canada, srinivas_krishnamoorthy@sfu.ca, Shelly Bajaj

Rylee Smith - an investment manager - wishes to identify the factors that explain successful movies in Bollywood. She uses log linear and quantile regression to arrive at her conclusions. The case can be used in an elective course in a BBA or MBA program or a core course in a MS in Analytics program.

■ SA61

370B

MIF Paper Competition

Sponsored: Minority Issues

Sponsored Session

Chair: Lauren Berrings Davis, North Carolina A&T State University, Greensboro, NC, 27411, United States, lbdavis@ncat.edu

Co-Chair: Sean Barnes, University of Maryland-College Park, College Park, MD, 20742, United States, sbarnes@rhsmith.umd.edu

1 - Minority Issues Forum Award

Karen T.Hicklin, University of North Carolina at Chapel Hill, B-24 Hanes Hall, Chapel Hill, NC, 27599-3260, United States, khicklin@email.unc.edu

The annual MIF Paper Competition features paper submissions covering an array of topics from members of the MIF community. The prize committee evaluated submissions based on importance of the topic, appropriateness of the approach, and impact of the paper within its respective area. Four finalists have been selected to present their research: Alp Akcay and Canan Corlu (Simulation of inventory systems with unknown input models: A data driven approach), Michelle Alvarado and Lewis Ntaimo (Chemotherapy appointment scheduling under uncertainty using mean-risk stochastic integer programming), Esra Buyukhtahtakin and Joseph C. Hartman (A mixed-integer programming approach to the parallel replacement problem under technological change) and Maria Mayorga, Emmett Lodree, and Justin Wolczynski (The optimal assignment of spontaneous volunteers).

2 - Simulation of Inventory Systems with Unknown Demand Models

Canan Corlu, Eindhoven University of Technology, Eindhoven, Netherlands, na, Alp Akcay

Assuming the availability of limited demand data, we consider the stochastic simulation of an inventory system with unknown demand distributions. Building on a nonparametric Bayesian approach, we propose a simulation replication algorithm that estimates a service level for the inventory system without making any assumptions on the functional form of the demand models. We illustrate our approach in a single-product inventory simulation.

3 - Chemotherapy Appointment Scheduling under Uncertainty using Mean-Risk Stochastic Integer Programming

Lewis Ntaimo, Texas A&M.University, 3131 TAMU, College Station, TX, 77843, United States, ntaimo@tamu.edu, Michelle Alvarado

Chemotherapy involves a series of appointments over several weeks and the timing of these appointments is critical to the patient's healing process. However, oncology clinics often find it very challenging to schedule large volumes of cancer patients for chemotherapy due to limited resources and data uncertainties such as nurse availability, patient acuity levels and appointment durations. In this work, we develop risk-averse stochastic integer programming models and algorithms towards solving this problem. Computational results based on real data show that the new approach significantly reduces patient waiting times and nurse overtime.

4 - A Mixed-Integer Programming Approach and New Cutting Planes for the Parallel Replacement Problem under Technological Change

Esra Buyuktahtakin, New Jersey Institute of Technology, Newark, NJ, United States, esratoy@njit.edu, Joseph Hatrman

The parallel replacement problem under economies of scale (PRES) determines minimum-cost keep-and-replace decisions for a group of assets. We study the MIP formulation of PRES under technological change (PRES-T), such that newer, technologically advanced assets have higher capacity than assets purchased earlier. We provide optimal solution characteristics and insights into the economics of the problem and derive new cutting planes for optimizing it. Computational experiments on the USPS fleet management case illustrate that the inequalities are quite effective in solving PRES-T instances.

5 - The Optimal Assignment of Spontaneous Volunteers

Maria Esther Mayorga, North Carolina State University, 400 Daniels Hall, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu, Emmett Lodree, Justin Wolczynski

In this presentation, a queuing model is formulated to accurately represent the dynamics of assigning spontaneous volunteers to tasks (or jobs) in a post-disaster setting. In particular, we model volunteers as servers with not only stochastic arrivals but also with stochastic abandonment times. We formulate a continuous-time Markov decision process and find an optimal policy for volunteer allocation under the relatively stable recovery phase of post-disaster management. We then test the optimal policy against heuristic policies using a simulation model. We also test the performance of these policies under relaxed assumptions.

■ SA62

370C

Advanced Maintenance Models

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Yisha Xiang, Lamar University, Beaumont, TX, United States, yxiang@lamar.edu

1 - Bayesian Degradation Based Reliability Growth with Uncertain Effectiveness of Corrections

Cesar Ruiz Torres, University of Arkansas, Fayetteville, AR, 72701, United States, caruizto@email.uark.edu, Haitao Liao, Edward A. Pohl

Modern products continue to be made increasingly complex meanwhile are still expected to be more reliable. To meet the increasing reliability requirements, reliability growth tests must be conducted in a fast and effective way. We propose a Bayesian reliability growth method to estimate and improve the reliability of a product based on multiple degradation processes of the product. We assume that each degradation process can be modeled by an Inverse-Gaussian process, but the initial degradation and the parameters of corrective actions are unknown. A Copula approach is utilized to model the dependencies between the multiple failure modes. A simple case study is provided to demonstrate the model.

2 - Reliability Analysis of Repairable Systems with Incomplete Failure Time Data

Wujun Si, Wayne State University, 4815 Fourth Street, Room 2167, Detroit, MI, 48202, United States, wujun.si@wayne.edu, Qingyu Yang, Leslie Monplaisir, Yong Chen

In many real situations, the failure time data of a repairable system may not be fully observed. Most existing reliability studies concerned with missing failure time data assume the system repair is either perfect or minimal. In this paper, we conduct reliability analysis of repairable systems subject to missing failure time data when the repair is general. A maximum likelihood estimation method is developed for the model parameter estimation. Simulation and case studies are conducted to illustrate the developed methods.

3 - Spare Parts Prediction Considering Uncertain Installed Base: A Review and Future Study

Tongdan Jin, Texas State University, 601 University Drive, Ingram School of Engineering, San Marcos, TX, 78666, United States, tj17@txstate.edu, Jose F.Espiritu, Heidi Taboada

Maintenance and spares inventory model are often studied based on a static installed base. When a new product is released, the installed base is likely to increase due to the market growth. As a result, the demand for spare parts turns to be nonstationary. This talk discusses the recent advances in spare parts provisioning in a non-stationary setting. We introduce superposition renewal theory, review spares forecasting model, characterize lead-time demand, and discuss the future research opportunities.

4 - Condition Based Maintenance for Wind Turbines Considering Complex Conditions

Zhigang Will Tian, University of Alberta, 5-8J Mechanical Engineering Building, Department of Mechanical Engineering, Edmonton, AB, T6G 2G8, Canada, ztian@ualberta.ca, Fangfang Ding, Hao Xu

Condition based maintenance strategy aims to develop predictive maintenance schedules based on equipment health conditions. Wind turbines are subject to varying load due to changing wind speed and directions. In this study, wind turbine component health conditions are predicted considering complex varying external conditions, and condition based maintenance schedules are developed based on the predicted future health conditions.

5 - Opportunistic Preventive Maintenance Scheduling for a Multi-unit Series System

Yisha Xiang, Lamar University, 2626 Cherry Engineering Building, Beaumont, TX, United States, yxiang@lamar.edu, Zhicheng Zhu, Bo Zeng

In a complex multi-unit system, opportunistic maintenance is an effective way to reduce system maintenance cost. The center problem of opportunistic maintenance is to decide which component should be maintained in a decision point under the uncertainty of the components' life time. In this research, we consider a stochastic opportunistic preventive maintenance for a multi-unit series system, and develop a two-stage deterministic equivalent problem for approximation. Numerical example is given to illustrate the proposed model. Our results show that potential saving can be achieved from optimal opportunistic preventive maintenance.

■ SA63

370D

State-of-the-Art Renewable Energy Modeling and Analysis

Invited: Energy and Climate

Invited Session

Chair: John Bistline, Electric Power Research Institute, Electric Power Research Institute, Jbistline@epri.com

Co-Chair: Delavane Diaz, Electric Power Research Institute, Electric Power Research Institute, Washington, DC, 20005, United States, ddiaz@epri.com

1 - Advanced Methods for Modeling the Integration of Variable Resource Renewable Energy Technologies in the Electric Power Sector

Kelly Eurek, National Renewable Energy Laboratory, Golden, CO, United States, Kelly.Eurek@nrel.gov

Because renewable power is a rapidly growing component of the electricity system, robust representations of renewable technologies should be included in capacity-expansion models. This is a challenge because modeling the electricity system—and, in particular, modeling renewable integration within that system—is a complex endeavor. This presentation highlights the major challenges of incorporating renewable technologies into capacity-expansion models and shows examples of how NREL's Regional Energy Deployment System (ReEDS) model address those challenges.

2 - The Economic Geography of Variable Renewable Energy

John Bistline, Electric Power Research Institute, Los Angeles, CA, United States, john.bistline@gmail.com

Regional differences in electric sector capacity mixes, wind and solar resource potentials, and markets have important implications for resource planning and policy design, especially for variable renewable energy. Despite the proliferation of state-based policies, capacity planning models have only recently incorporated the temporal and spatial resolution necessary to evaluate economic and environmental effects from such regional market linkages. This talk will summarize novel treatments of these areas in EPRI's US-REGEN energy-economic model and will describe analyses of renewables-focused policies, which underscore the importance of capturing the spatial dependence of impacts.

3 - Representing Energy Storage in Power System Models with Variable Renewable Energy

Audun Botterud, MIT, Argonne National Laboratory, Cambridge, MA, 02140, United States, audunb@mit.edu

We discuss the representation of energy storage in modeling of power systems and electricity markets with increasing shares of renewable energy. In particular, we focus on modeling of electrochemical batteries with improved representation of degradation, losses, and power limits. We present examples of short- and long-term analysis of energy storage applications in the power grid, including energy arbitrage, unit commitment, and generation expansion planning.

■ SA64

370E

Data Mining Best Paper Award I

Sponsored: Data Mining

Sponsored Session

Chair: Tong Wang, University of Iowa, Pappajohn Business Building, 21 East Market Street, Iowa City, IA, 52245, United States, tong-wang@uiowa.edu

1 - Learning Cost-Effective and Interpretable Treatment Regimes

Himabindu Lakkaraju, Stanford University, Escondido Village, 119 Quillen Court, Stanford, CA, 94305, United States, himalv@cs.stanford.edu

Decision makers, such as doctors, make crucial decisions such as recommending treatments to patients on a daily basis. These decisions typically involve weighing the potential benefits of taking an action against the costs involved. In this work, we aim to automate this task of learning cost-effective, interpretable and actionable treatment regimes from observational data. We formulate this as a problem of learning a decision list - a sequence of if-then-else rules - that maps characteristics of subjects (eg., diagnostic test results of patients) to treatments. We propose a novel objective to construct this decision list which maximizes outcomes for the population, and minimizes overall costs. Since we do not

observe the outcomes corresponding to counterfactual scenarios in observational data, we use techniques from causal inference literature to infer them. We model the problem of learning a decision list as a Markov Decision Process (MDP) and employ a variant of the Upper Confidence Bound for Trees (UCT) strategy which leverages customized checks for pruning the search space effectively. Experimental results on real world observational data capturing judicial bail decisions and treatment recommendations for asthma patients demonstrate the effectiveness of our approach.

2 - Data Science Based Simulation and Optimization of Soybean Variety Selection

Durai Sundaramoorthi, Washington University in Saint Louis, St. Louis, MO, 63131, United States, dsundaramoorthi@gmail.com

Humanity is facing the greatest challenge of feeding itself. The World Food Programme estimates that about 795 million people do not have adequate food to have a healthy life. About 3.1 million children die every year because of poor nutrition. As a small part of addressing this great humanitarian challenge, this research proposes an analytics framework for growing the optimal soybean varieties. Selecting soybean varieties for planting is an important decision that has significant implications for the yield of the farm. With many soybean varieties available along with the data on yield performance collected over several years at various farm locations, the seed-mix selection is a highly intriguing decision to modern day farmers. To aid soybean-mix selection, this research evaluates five data mining models - Regression Trees (RT), Random Forest (RF), Boosted Trees (BT), Multivariate Adaptive Regression Splines (MARS), and Artificial Neural Network (ANN) - as the predictive algorithms for the soybean yield. Using a data set collected between 2008 and 2014 by Syngenta, an agribusiness, we evaluate these models and choose RT as the most suitable algorithm to inform simulation of soybean yield under different weather conditions. We formulated a simulation-based optimization problem to determine the optimal soybean-mix to minimize the risk associated with the yield. As a result, Syngenta is equipped to make soybean-mix recommendations to the farmers.

3 - Tensor Mixed Effects Model with Applications in Nanomanufacturing Inspection

Xiaowei Yue, Georgia Institute of Technology, 755 Ferst Drive NW, ISYE, Atlanta GA, 30332, United States, xwy@gatech.edu"

Raman mapping technique has been used to do in-line quality inspections of nanomanufacturing process. In such an application, a massive high dimensional Raman mapping data with mixed effects are generated. In general, fixed effects and random effects in the multi-array Raman data are associated with different quality characteristics such as fabrication consistency, uniformity, defects et al. The existing tensor decomposition methods cannot separate mixed effects, and existing mixed effects model can only handle matrix data instead of high dimensional multi-array data. In this paper, we propose a tensor mixed effects (TME) model to handle massive in-line high dimensional Raman mapping data with complex structure. The proposed TME model can (i) separate fixed effects and random effects in a tensor domain; (ii) exploit the correlations along different dimensions; and (iii) realize efficient parameter estimation by a proposed iterative double Flip-Flop method. Properties of the TME model and existence and identifiability of parameter estimation are investigated. Numerical analysis demonstrates the efficiency and accuracy of the parameter estimation in the TME model. Convergence and empirical asymptotic properties are discussed in the simulation and surrogate data analysis. The Real case study shows an application of the TME model in quantifying the influence of alignment on carbon nanotubes buckypaper.

4 - Dynamic Multivariate Functional Data Modeling via Sparse Subspace Learning

Chen Zhang, National University of Singapore, Singapore, 117576, Singapore, zhangchen@u.nus.edu

Though multivariate functional data are common in many applications, they have not been comprehensively investigated yet, with several challenges to be solved. In particular, they are naturally high-dimensional and have complex cross-correlation structure. Some functions are strongly correlated with similar features, while some others may have almost no correlations with quite diverse features. Furthermore, the cross-correlation structure may even change over time due to the system evolution. With this regard, this paper presents a dynamic subspace learning method for multivariate functional data modeling. In particular, we consider different functions come from different disjoint subspaces, and only functions of the same subspace have correlations with each other. The subspaces can be automatically identified and learned by formulating the problem as a sparse regression. By allowing but regularizing the regression change over time, we can describe the cross-correlation dynamics. The model can be efficiently estimated by the fast iterative shrinkage-thresholding algorithm (FISTA), and the features of every subspace can be extracted using the smooth multi-channel functional PCA. Numerical studies together with case studies demonstrate the efficiency and applicability of the proposed methodology.

■ SA65

370F

Interpretable Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Berk Ustun, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, ustunb@mit.edu

1 - Optimized Risk Scores

Berk Ustun, Massachusetts Institute of Technology, 20 Highland Avenue 2, Cambridge, MA, 02139, United States, ustunb@mit.edu, Cynthia Rudin

Risk scores are simple models to quickly assess risk by adding and subtracting a few small numbers. Such models are widely used in healthcare and criminal justice, but are built ad hoc. We present a new approach to learn risk scores that are optimized for feature selection, integer coefficients, and operational constraints. We formulate the risk score problem as a MINLP, and design a new cutting plane algorithm to solve it efficiently. Our approach can fit optimized risk scores in a way that scales linearly in the sample size, provides a proof of optimality, and addresses complex constraints without parameter tuning. We illustrate its benefits by building customized risk scores for medical applications.

2 - Interpretable and Interactive Approximations of Black Box Models

Himabindu Lakkaraju, Stanford University, Escondido Village, 119 Quillen Court, Stanford, CA, 94305, United States, himalv@cs.stanford.edu, Ece Kamar, Rich Caruana, Jure Leskovec

We propose Black box Explanations through Transparent Approximations, a novel framework for constructing global explanations of any black-box classifier. We develop a novel objective function which learns a small number of compact decision sets each of which explains black box model behavior in unambiguous, well-defined regions of feature space. Our framework also allows users to interactively explore how the black box model behaves in different subspaces. To our knowledge, this is the first approach which produces explanations of black box classifiers via joint optimization of unambiguity, fidelity, interpretability, while allowing users to explore its behavior based on their preferences.

3 - Interpretable Two-level Boolean Rule Learning

Dennis Wei, IBM Thomas J. Watson Research Center, Yorktown Heights, NY, 10598, United States, dwei@us.ibm.com, Guolong Su, Kush R. Varshney, Dmitry M. Malioutov

We develop a novel optimization framework for learning two-level Boolean rules for classification, in both conjunctive (AND-of-ORs) and disjunctive (OR-of-ANDs) normal forms. Two objective functions are introduced to trade off classification accuracy and interpretability, where we use 0-1 error and Hamming loss to characterize accuracy and sparsity to characterize interpretability. We propose efficient optimization procedures based on linear programming relaxation, block coordinate descent, and alternating minimization. Experiments show that our algorithms based on Hamming loss provide good tradeoffs between accuracy and sparsity with improvements over the state-of-the-art.

■ SA66

371A

Vehicle Routing with Service Network Design Considerations

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Marco Schutten, University of Twente, Faculty of Management and Governance, P.O. Box 217, Enschede, 7500 AE, Netherlands, m.schutten@utwente.nl

Co-Chair: Ali Alyasiry, The University of Queensland, Brisbane, Australia, a.alyasiry@uq.edu.au

1 - A Hub Location and Vehicle Routing Problem with Time Windows

Jeremy Castaing, Llamasoft Inc, Ann Arbor, MI, 48104, United States, jeremy.castaing@llamasoft.com, Duyi Li

A common extension of the vehicle routing problem (VRP) in real-life transportation system is to model hubs. Hubs are facilities that consolidate shipments between distribution centers and customers. We discuss an approach to extend a classic VRP algorithm to consider hubs and also time windows. The algorithm is integrated in Supply Chain Guru software developed by Llamasoft Inc.

2 - Large Neighborhood Heuristics for the Two-echelon Multi-depot Vehicle Routing Problem Arising in City Logistics
Jiang Da-Pei, Tongji University,School of Economics and Management, Tongji Building A, Siping Road 1500, Shanghai, China, 56jdp@tongji.edu.cn

Two-echelon distribution systems are quite common in city logistics under electronic commerce. First-level vehicles located in the depots carry the demands from depots to the satellites, then demands are transfer to the second-level vehicles, then delivery to customers and fulfillment the time windows. In this paper, we introduce a two-echelon multi-depot vehicle routing problem with tasks synchronization problem (2E-MDVRP-TS). We propose an adaptive large neighborhood search to solve this problem. Our method used existing operators that in the literature and developed some new operators designed specifically for the problem considered, later evaluated on some benchmarks.

3 - An Exact Algorithm for the Pickup and Delivery Problem with Time Windows and its Variants
Ali Alyasiry, The University of Queensland, St. Lucia Campus, Brisbane, 4072, Australia, a.alyasiry@uq.edu.au, Michael Forbes

Research on exact methods to solve the pickup and delivery problem with time windows (PDPTW) and its variants has mainly focused on branch and price and cut algorithms. We propose a novel exact approach based on fragments - a series of pickup and delivery requests starting and ending with an empty vehicle. Using fragments, we formulate an optimistic network flow model with side constraints and use lazy constraints to cut off any illegal solutions generated while solving the resultant integer program. Results confirm that this approach is competitive with existing methods.

4 - Multi-hop Driver-parcel Matching Problem with Time Windows
Marco Schutten, University of Twente, Enschede, Netherlands, m.schutten@utwente.nl, Wenyi Chen, Martijn Mes

Crowdsourced shipping can result in significant economic and social benefits (e.g., faster deliveries and congestion reduction). With the aim of using the spare capacities along the existing transportation flows of the crowd to deliver small-to-medium freight volumes, we introduce the multi-driver multi-parcel matching problem and propose a general ILP formulation, which incorporates drivers' maximum detour, capacity limits, and the option of transferring parcels between drivers. The numerical study shows that crowdsourced shipping can be an economic viable and sustainable option.

■ SA67

371B

Analysis of Complex Manufacturing Data

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Zhou Qiang, University of Arizona, zhouq@email.arizona.edu

Co-Chair: Jianguo Wu, University of Texas-El Paso, El Paso, TX, 79968, United States, jwu2@utep.edu

1 - Multivariate Profile Monitoring using Gaussian Process Models
Salman Jahani, Research Assistant, University of Wisconsin-Madison, Madison, WI, 53706, United States, jahani@wisc.edu

Recently, considerable attention has been paid to profile monitoring. While most of the research is focused on monitoring univariate profiles, this study focuses on multivariate profile monitoring using a multivariate Gaussian process (MGP) model. In this regards, first, using MGP the structure of profiles is determined; then based upon this baseline structure, a distance-based statistic is proposed to monitor the stability of profile over time.

2 - Size Distribution Estimation of 3D Particle Clusters in Metal Matrix Nanocomposites Considering Sampling Bias
Jianguo Wu, University of Texas-El Paso, 500 W University Ave, Engineering Building, Room A-244, El Paso, TX, 79968, United States, jwu2@utep.edu

Nanoparticle clustering phenomenon is a critical quality issue in metal matrix nanocomposites manufacturing. Accurate estimation of the 3D cluster size distribution based on the 2D cross-section images is essential for quality assessment, quality control, and process optimization. The existing studies often draw conclusions with observable samples, which are inherently biased because large clusters more likely to be intersected by SEM images compared with small ones. This paper takes into account this sampling bias and proposes two statistical approaches, namely, the maximum likelihood estimation (MLE) and the method of moments (MM), to estimate the distribution parameters accurately.

3 - Diagnosis of Multi-scale Spatial Point Interaction
Qiang Zhou, University of Arizona, Rm314, 1127 E James E. Rogers Way, Tucson, AZ, 85721, United States, q.zhou@arizona.edu

We propose a novel diagnosis method for spatial point data in manufacturing, based on decomposition of a K function-based T2 statistic. The method can independently analyze point interactions at multiple spatial scales, which is particularly useful for fault diagnosis when the process is out-of-control.

■ SA68

371C

QSR Best Student Paper Award Competition

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Xinwei Deng, Department of Statistics, Virginia Tech, Blacksburg, VA, 24061, United States, xdeng@vt.edu

1 - Nonparametric Modeling and Prognosis of Condition Monitoring Signals: A Transfer Learning Approach Based on Multivariate Gaussian Convolution Processes
Raed Al Kontar, University of Wisconsin-Madison, 1513 University Avenue, Room 3255, Madison, WI, 53706, United States, alkontar@wisc.edu

In this paper, an alternative view on modeling condition monitoring signals is proposed. This view draws its roots from transfer learning and is based on sharing convolved latent functions between training and testing units. The advantageous features of our method are highlighted with a case study for automotive lead-acid batteries.

2 - S3T: An Efficient Score-statistic for Spatio-Temporal Surveillance
Junzhou Chen, Georgia Institute of Technology, Atlanta, GA, United States, na@tbd.org

We present an efficient score statistic to detect the emergence of a spatially and temporally correlated signal, which is called the S3T statistic. The signal may cause a mean shift, and (or) a change in the covariance structure. The score statistic can capture both spatial and temporal change and hence is particularly powerful in detecting weak signals. Our score method is computationally efficient and statistically powerful. The main theoretical contribution is an accurate analytical approximation on the false alarm rate of the detection procedure, which can be used to calibrate a threshold analytically. Simulated and real-data examples demonstrate the good performance of our procedure.

3 - Adaptive Importance Sampling for Determining Resistance Levels in Reliability-based System Design
Qiyun Pan, University of Michigan, 1205 Beal Avenue, Department of IOE, Ann Arbor, MI, 48109-2117, United States, qiyun@umich.edu

In order to design reliable systems, resistance level determination becomes crucial in many applications. At the design stage, resistance level can be estimated using stochastic simulations. However, estimation results using the crude Monte Carlo sampling are highly uncertain. We present a new adaptive algorithm to improve the estimation accuracy.

4 - Bayesian Sequential Calibration using Detailed Sample Paths
Bo Wang, Rensselaer Polytechnic Institute, Troy, NY, United States, wangb13@rpi.edu

Simplified simulation models are often used to guidethe decision-making for complex stochastic systems. To faithfullyassess the mean performance of the real system, we developa new calibration approach incorporating the detailed output-sample paths in a sequential manner, that can efficiently use thesimulation resources and achieve better accuracy.

■ SA69

371D

Elements Toward a Smart City

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Victoria Chen, University of Texas, vchen@uta.edu

1 - Design and Analysis of Computer Experiments Approach for Green Building

Shirish Rao, The University of Texas-Arlington, Arlington, TX, United States, shirish.rao@mavs.uta.edu

Building structures have significant impact on environment and energy consumption. Buildings can be designed so that their energy consumption is reduced by using energy efficient materials. The "cradle-to-grave" cycle is a criterion for the environmental effects of materials, and minimizing this effect along with energy consumption is of great interest. The goal of the research is to compare different experimental designs and statistical modeling methods to help inform our approach for a multivariate, multi-response green building framework. The results of the experiments are studied by using Treed regression and Multi Adaptive Regression Splines techniques to find influential factors.

2 - Using Approximate Dynamic Programming to Control an Electric Vehicle Charging Station System

Victoria C.P. Chen, University of Texas-Arlington, Industrial, Manufacturing, & Systems Engr., Campus Box 19017, Arlington, TX, 76019-0017, United States, vchen@uta.edu, Ying Chen, Jay Michael Rosenberger, Wei-jen Lee

Electric vehicle charging stations system assumed to locate in Dallas Fort-Worth area integrate wind power, solar power and main electricity grid to supply electricity for the demand from the electric vehicles. Design and analysis of computer experiments based infinite-horizon approximate dynamic programming (ADP) algorithm is used to generate a high-quality policy to control this 31 dimensional system over a continuous-state space. A specified 45-degree line correspondence stopping rule is utilized to identify the high-quality ADP policy at early DP iterations. The results demonstrate with the selected ADP policy, the system has a better control performance than using the greedy policy.

3 - Optimizing Location of Electric Vehicle Charging Stations

Ukesh Chawal, The University of Texas at Arlington, Arlington, TX, United States, ukesh.chawal@mavs.uta.edu, Jay Rosenberger, Victoria Chen, Wei-Jen Chen, Raghavendra Punugu, Mewan Wijemanne

Due to the economic and environmental concerns associated with fossil fuels and the growing need for sustainability, the use of electric vehicles (EVs) is a viable solution. In this paper, a Mixed-Integer Linear Programming (MILP) model and a Design and Analysis of Computer Experiments (DACE) based system design optimization approach have been used to optimize the locations of the EV Charging stations and the number of slots to be opened to maximize the profit, meeting the customers demand.

4 - A Simulation Framework for Police Patrol Deployment: A Decision Support Tool

Khan Md. Ariful Haque, The University of Texas at Arlington, Arlington, TX, United States, khanmdariful.haque@mavs.uta.edu

Evaluating dynamic deployment strategies and determining the best one is a real challenge to a police department without reforming the current practice that costs money and time without any result. A flexible discrete-event simulation framework has been proposed that can facilitate any police department in city level for evaluating possible dynamic policing strategies without spending significant resources. From available data, estimated input parameters considering randomness of Call arrivals and service times of different priority levels are using into the model that will enable police department in decision making based on the output.

■ SA70

371E

Big Data

Contributed Session

Chair: Harshad Rai, University of Illinois at Urbana-Champaign, Champaign, IL, United States, hrrai2@illinois.edu

1 - Looking Inside Your Shopping Bag the use of Retail Data to Capture Health Lifestyles

lichung Jen, National Taiwan University, Taipei, Taiwan, lichung@ntu.edu.tw, YiChun Liu

When a patient goes to a clinic, the doctor can only see the results from all the medical examinations and then infer what is wrong about his/her health without knowing what exactly is the behavior of his/her daily nutrition intake. Due to the recent development of Big Data technology, the transactions data collected by retailers can reveal the details of consumer purchase behavior illustrating their health lifestyle. In this study, we construct an index of calories activity (CAI) of food consumption based on the customer transaction database of a supermarket. Through the index, we are able to identify customers with health risks.

2 - The Optimal Bootstrap and its Applications

Bradley E. Sturt, Massachusetts Institute of Technology, Cambridge, MA, United States, bsturt@mit.edu, Dimitris Bertsimas

The bootstrap is a randomized method for calculating quantities, such as confidence intervals (CI), directly from data. Since the variability from randomization can lead to inaccurate outputs, we take a deterministic approach. In this talk, we present the first efficient deterministic approximation algorithm (FPTAS) for the bootstrap method. In experiments, the algorithm quickly produces CIs that are substantially more accurate and trustworthy than those from traditional methods. Finally, we present several new computational complexity results related to the bootstrap and probability theory.

3 - Internet of Things

Michael Chuang, SUNY New Paltz, 1 Hawk Drive, New Paltz, NY, 12561, United States, mikeychuang@gmail.com

Internet of Things, a global infrastructure enabling services by interconnecting physical and virtual things based on interoperable information and communication technologies, has emerged in business applications in various industrial areas, and will reshape tomorrow's business and technology development.

4 - GPU Supported Large Scale Simulation Models for Influenza Pandemic Outbreaks

Shalome Hanisha Anand Tatapudi, University of South Florida, 4202 E. Fowler Avenue, ENB 118, Tampa, FL, 33620-5350, United States, tatapudi@mail.usf.edu, Walter Silva, Tapas K. Das

Influenza pandemics are a serious concern and researchers are trying to understand its patterns. One such tool to effectively understand the disease characteristics is through an agent-based (AB) simulation model, which is versatile, yet has computational limitations when it comes to simulating larger populations. This study integrates the flexibility of AB simulation with computational efficiency of a graphical processing unit (GPU) to create models for pandemic outbreaks in large areas comprising of hundreds of millions of people.

5 - NYC Traffic Collision Analysis to Mine Patterns in Traffic Fatalities

Harshad Rai, Graduate Student, University of Illinois at Urbana-Champaign, 107, East Springfield Ave., Apt. 317, Champaign, IL, 61820, United States, hrrai2@illinois.edu, Anirudh Madhusudan

This project focuses on the use of Machine Learning algorithms to analyze traffic collisions. In the future, there is likely to be a lot more data about cities. Vehicle-to-vehicle and vehicle-to-infrastructure is likely to provide transformative changes in mobility. Cities are breeding grounds for emergent behavior, so this provides a lot of interesting challenges. The DBSCAN algorithm, a density based clustering method; is used to cluster traffic fatalities to recognize possible danger zones. Spatio-temporal visualization and analysis is carried out to find patterns in traffic collisions. Random forest is used to predict the recurrence of accidents and fatalities.

■ SA71

371F

Black-box or Simulation Optimization

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Zelda B. Zabinsky, University of Washington, Seattle, WA, 98195-2650, United States, zelda@u.washington.edu

1 - Simulation Optimization of Risk Measures with Adaptive Risk Levels

Enlu Zhou, Georgia Institute of Technology, 755 Ferst Drive NW, Atlanta, GA, 30332-0205, United States, enlu.zhou@isye.gatech.edu, Helin Zhu, Joshua Hale

Optimizing risk measures such as Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) of a general loss distribution is usually difficult, because 1) the loss function might lack structural properties such as convexity or differentiability since it is often generated via black-box simulation of a stochastic system; 2) evaluation of risk measures often requires rare-event simulation, which is computationally expensive. We extend the recently proposed gradient-based adaptive stochastic search (GASS) to the optimization of risk measures VaR and CVaR, and incorporate an adaptive updating scheme on the risk level.

2 - Trust Based Optimization with Adaptive Restart: A Family of Global Optimization Algorithms

Logan Michael Mathesen, Arizona State University, 699 S. Mill Ave, Tempe, AZ, 85281, United States, lmathese@asu.edu, Giulia Pedrielli

The field of simulation optimization has seen many algorithms proposed for local optimization drawing upon locally convergent search methods, and numerous global optimization algorithms with differing strategies to achieve convergence. Globally we look into meta-model based algorithms that stochastically drive global search through an optimal sampling criteria evaluated over a predicted response and its uncertainty. We propose Trust Region Based Optimization with Adaptive Restarts (TBOAR), a family of algorithms that dynamically restarts a trust region based local search method via an optimal sampling criteria derived upon a meta-model based global search approach.

3 - Martingale Search Algorithms for Simulation Optimization

Seksan Kiatsupaibul, Chulalongkorn University, 65 Soi Sukhumvit 7, Bangkok, 10110, Thailand, seksan@cbs.chula.ac.th, Robert L. Smith, Zelda B. Zabinsky

We propose a class of adaptive random search algorithms for simulation optimization that generalizes a number of algorithms in the literature. In the course of the algorithm, design points are sequentially sampled from the design space, according to an adaptive sampling probability function. Objective function values are estimated via shrinking balls, which satisfies a martingale property in a continuous domain. We extend the martingale property to discrete domains, noting that we only make a single observation for each sample point in each iteration, although later returns to the same point will accumulate a collection of observations for the same design point.

■ SA72

372A

Emerging Applications in Network Optimization

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Robert Mark Curry, Clemson University, Central, SC, 29630, United States, rmcurry@g.clemson.edu

1 - A Centrality Study of Protein-protein Interaction Networks

Saeid Rasti, North Dakota State University, Fargo, ND, United States, saeid.rasti@ndsu.edu, Chrysafis Vogiatzis

One of the main objectives of Systems biology is to reveal fundamental, architectural principles that provide us with better insight on the underlying structure and functionality at the cellular level. In this talk, we present the state-of-the-art of using centrality indices to analyze and interpret protein-protein interaction networks (PPINs). We then proceed to discuss a series of novel group centrality metrics and their implications for PPINs. Of particular interest to us is a membership centrality index, that builds upon standard centrality metrics. Our results showcase that group centrality enables us with an efficient and effective way to detecting essentiality in the proteome.

2 - Solution Methods for the Interdependent Network Flow Problem

Negin Enayaty Ahangar, Industrial Engineering, University of Arkansas, nenayaty@email.uark.edu, Kelly Sullivan, Sarah G. Nurre

We formulate a multi-layered network flow problem in which the flow of each layer is dependent on the flow of other layers. The formulation can be considered as an extension of the minimum cost flow problem to a multi-layered network. This problem has applications in identifying and mitigating vulnerabilities in interdependent infrastructure systems. We identify valid inequalities to tighten the model's LP relaxation. We propose a solution methods using these valid inequalities to solve this NP-Hard problem. Computational results are presented to compare the proposed solution method with the traditional branch and bound method.

3 - On Routing Unmanned Aerial Vehicles for Surveillance and Reconnaissance Activities

Cai Gao, University at Buffalo, Bell 316, University at Buffalo, Buffalo, NY, 14260, United States, caigao@buffalo.edu, Jose Luis Walteros, Chase Murray

We tackle a variation of the close-enough traveling salesman problem in which the salesman is accounted of visiting a node if he traverses a pre-calculated optimal distance through each circular area surrounding the node. This variation arises in the context of unmanned aerial vehicle routing, where a vehicle must cross an area collecting information form a set of targets, while minimizing the detection risks. We consider two approaches for modeling the tradeoff between the amount of collected information and the observed risk and test them by solving a collection of instances adapted from the literature.

4 - An Augmenting Flow Algorithm for a Class of Node-capacitated Maximum Flow Problems

Robert Mark Curry, Clemson University, 111 Woodside Lane, Central, SC, 29630, United States, rmcurry@g.clemson.edu, Cole Smith

We consider a class of maximum flow problems having node- and arc-capacity constraints, in which each unit of flow on arc (i,j) consumes a non-negative amount of capacity at node i. Rather than solving a linear program for these problems, we present an augmenting flow algorithm. In this algorithm, we augment flows along a path having positive residual capacities among all arcs and nodes along the path. When no such paths exist, we find and augment flow along flow-cycles that increase the residual capacity at an incapacitated node. We prove the optimality and computational complexity of our algorithm and apply it to solve various problems in wireless sensor network settings.

■ SA73

372B

Time-Expanded Models and Integer Programming

Sponsored: Computing

Sponsored Session

Chair: Natashia Boland, Georgia Institute of Technology, Atlanta, GA, 30332, United States, natashia.boland@gmail.com

1 - Pickup and Delivery with Synchronized Transfers

Monireh Mahmoudi, Arizona State University, Tempe, AZ, United States, mmahmou2@asu.edu, Xuesong Zhou

In this paper, we consider complex assignment-routing constraints corresponding to the pickup and delivery problem with time windows and synchronized transfers by constructing multi-dimensional networks. More specifically, we introduce a multi-vehicle state-space-time network in which only non-dominated assignment-based hyper paths are examined. Then, we reach optimality for local clusters derived from a large set of passengers on real-world transportation networks. Extensive experiments over the standard instances and real-world data set show the solution optimality, as well as computational efficiency of our developed algorithm.

2 - Solving Stochastic Scheduled Service Network Design Problems

Mike Hewitt, Loyola University Chicago, 370 Grandview Ave, Glen Ellyn, IL, 60137, United States, mhewitt3@luc.edu

Consolidation carriers transport shipments that are small relative to trailer capacity. To be cost-effective, a carrier must consolidate shipments, which requires coordinating shipment paths in both space and time. However, they often must determine these shipment paths before all information (e.g. size, times available and due) regarding a shipment is known. In this talk, we present an extension of an iterative refinement algorithm designed to solve Scheduled Service Network Design Problems to stochastic variants.

3 - Inventory Routing in Continuous Time using Time-Expanded Models

Natashia Boland, Georgia Institute of Technology, Ferst Drive, Atlanta, GA, 30332, United States, natashia.boland@gmail.com, Felipe Lagos, Martin W. P.Savelsbergh

Inventory routing is the problem of routing vehicles in space and time to deliver product to customers whose demand is a function of time, so that customers are never short of product and so that the sum of delivery and/or inventory costs are minimized. To date, research on inventory routing problems has focused on discrete time settings. Here we treat continuous time: customers demand is a continuous function of time. We show how integer programming models based on time discretization can be constructed so as to yield both primal and dual bounds on the value of the continuous-time problem, leading to a solution procedure, for which we present computational results.

■ SA74

372C

Bilevel Optimization

Sponsored: Computing

Sponsored Session

Chair: Juan Borrero, University of Pittsburgh, Pittsburgh, PA, 15260, United States, jsb81@pitt.edu

Co-Chair: Hosein Zare, University of Pittsburgh, Pittsburgh, PA, 15260, United States, moz3@pitt.edu

1 - Solving Facility Location Problem through Robust Bilevel Optimization

Liang Xu, University of Pittsburgh, 3700 O'Hara Street, 1048 Benedum Hall, Pittsburgh, PA, 15261, United States, lix21@pitt.edu, Bo Zeng

We study facility location problem through robust bilevel optimization, a novel model as well as solution procedure is proposed. Computational demonstrations based on practical system will also be discussed in the talk.

2 - Asymmetric Bilevel Linear Programming with Incomplete Information and Learning

Juan Borrero, Oklahoma State University, 322 Engineering N, Stillwater, OK, 74078, United States, jsb81@pitt.edu, Oleg A. Prokopyev, Denis R. Saure

We consider an asymmetric bilevel linear problem where the leader and follower interact repeatedly. At each period the leader implements an upper-level solution after which the follower reacts by solving the lower-level problem. The leader has incomplete information about the cost function of the follower's problem, and learns about it from observing his reaction to her actions. Given that the leader's objective is to find an optimal solution of the full-information bilevel problem, we study a set of greedy and 'best'-case decision policies that are able to find an optimal solution in finite time periods, and can provide a real-time certificate of optimality to the leader.

3 - A New Bilevel Market Based Capacity Expansion

Bo Zeng, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall, Pittsburgh, PA, 15260, United States, bzeng@pitt.edu

Bilevel optimization has been used to build capacity expansion models for power grid. Considering multiple market clearing responses, we build a new model for market based capacity expansion. Numerical results will be reported.

4 - Optimal Strategies in Pediatric Vaccine Pricing Problem

Hosein Zare, University of Pittsburgh, 4200 Fifth Avenue, Pittsburgh, PA, 15260, United States, moz3@pitt.edu, Oleg A. Prokopyev, Osman Yalin Ozaltin

We consider pediatric vaccine pricing problem in an oligopolistic market and explore the optimal pricing approach in a bilevel setting. Given that the customer in the lower-level problem selects a subsets of available vaccines to minimize the cost of vaccination, the vaccine manufacturer in the upper-level problem sets the price of vaccines to compete with other manufacturers and maximize her profit. We study the problem under different assumptions and provide the optimal pricing strategy in each situation.

■ SA75

372D

Algorithms for Structured Optimization Problems I

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Shiqian Ma, The Chinese University of Hong Kong, Shatin, Hong Kong, sqma@se.cuhk.edu.hk

1 - Value-function Based Non-cooperative Games

Tianyu Hao, PhD Student, University of Southern California, 3715 McClintock Avenue, GER240, Los Angeles, CA, 90089-0193, United States, tianyuha@usc.edu, Jong-Shi Pang

Inspired by the family of network interdiction games which are proposed by Andrew Liu and his collaborators, we studied a two-stage non-cooperative game. The objective function of each player's optimization problem contains a value function of a second-stage linear program, which is dependent on the first-stage variables in a way that a point-wise linear function upper bounds the second-stage decision variable. We first establish results regarding the existence of solution. Then we show that under Slater's conditions and some other conditions, Lemke's method can compute a solution to such games.

2 - Difference of Convex Approaches to Statistical Learning

Miju Ahn, University of Southern California, Los Angeles, CA, United States, mijuahn@usc.edu

We discuss a difference-of-convex (dc) programming approach to the sparsity representation problem in statistical learning. We present a unified formulation of many existing surrogate sparsity functions that are employed as approximations of the L-0 function, summarize optimality and sparsity results of the resulting dc optimization problem using such sparsity functions, discuss a LASSO based algorithm for solving the latter problem, and present numerical results on two sets of sparse statistical estimation problems: least square regression and logistic classification.

3 - Linear Convergence of Randomized Feasible Descent Methods under the Weak Strong Convexity Assumption

Chenxin Ma, Lehigh University, Bethlehem, PA, United States, chm514@lehigh.edu, Martin Takac, Rachael Tappenden

In this paper we generalize the framework of the Feasible Descent Method (FDM) to a Randomized (R-FDM) and a Randomized Coordinate-wise Feasible Descent Method (RC-FDM) framework. We show that many machine learning algorithms, including the famous SDCA algorithm for optimizing the SVM dual problem, or the stochastic coordinate descent method for the LASSO problem, fits into the framework of RC-FDM.We prove linear convergence for both R-FDM and RC-FDM under the weak strong convexity assumption. Moreover, we show that the duality gap converges linearly for RC-FDM, which implies that the duality gap also converges linearly for SDCA applied to the SVM dual problem.

■ SA76

372E

Advances in General Purpose Cutting Planes

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Matthias Koeppe, University of California-Davis, Davis, CA, 95616, United States, mkoeppe@math.ucdavis.edu

1 - Interactive Software for Cut-generating Functions and Beyond

Yuan Zhou, University of California-Davis, 1 Shields Avenue, Department of Mathematics, Davis, CA, 95616, United States, yzh@math.ucdavis.edu, Matthias Koeppe

We present software for investigations with cut-generating functions in the Gomory-Johnson model and extensions, implemented in the computer algebra system SageMath.

2 - V-polyhedral Cuts

Aleksandr M. Kazachkov, Carnegie Mellon University, Pittsburgh, PA, United States, akazachk@cmu.edu, Egon Balas

Generating cutting planes for mixed-integer programs from valid general disjunctions, containing multiple inequalities per term, has been an active topic of inquiry in recent years. We investigate this idea from the V-polyhedral perspective, using a properly selected set of points and rays to generate cuts. Our framework, called V-polyhedral cuts, can be viewed as a strict extension of the generalized intersection cut paradigm, which only applies to generating cuts from convex sets. We discuss theoretical properties of V-polyhedral cuts and the results from an implementation of one variant of the method.

3 - Computer-assisted Discovery and Certification of Next-generation Cutting Planes for Mixed Integer Programming
Matthias Koeppe, University of California-Davis, One Shields Avenue, Dept of Mathematics, Davis, CA, 95616, United States, mkoeppe@math.ucdavis.edu, Yuan Zhou

The revival of Gomory's classic general purpose cutting planes in the mid-1990s enabled the development of powerful branch-and-cut software. Challenging new applications and increased data sizes prompt us to develop next-generation general-purpose cutting plane systems. We revisit Gomory and Johnson's infinite-dimensional relaxations of integer programs. We overcome the difficulties in studying the "facet-defining" valid inequalities of these relaxations by making use of computer-assisted discovery and certification. The goal is to develop a large library of parametric families of such "facets" as the foundation of learning-based cutting-plane systems.

4 - Cutting Planes from Extended Formulations
Sanjeeb Dash, IBM T.J.Watson Research Center, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States, sanjeebd@us.ibm.com

We discuss how to use extended formulations of the LP relaxation of a mixed-integer program to obtain stronger split cutting planes than those that can be obtained from the original LP relaxation. We analyze a few different approaches to building extended formulations, and the effectiveness of split cuts in each case. In particular, we consider the Lovasz-Schrijver and Sherali-Adams lift-and-project operator hierarchies, and also discuss extended formulations of mixed-integer programs obtained by replacing integral variables by weighted sums of binary variables.

■ SA77

372F

Dynamic Optimization for Allocation Problems

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Viswanath Nagarajan, University of Michigan, Ann Arbor, MI, 48109, United States, viswa@umich.edu

1 - Pricing in Dynamic Two-sided Markets with Service Guarantees
Kamesh Munagala, Professor, Duke University, P.O. Box 90129, Department of Computer Science, Durham, NC, 27708-0129, United States, kamesh@cs.duke.edu, Reza Alijani, Siddhartha Banerjee, Sreenivas Gollapudi, Konstantinos Kollias

We consider dynamic two-sided markets, where buyers and sellers arrive over time following Poisson processes. Each agent has private value and patience level for receiving/providing service, and a known location in an underlying metric space. The platform posts prices and wages at nodes in the metric space, as well as choose agents for matching to simultaneously ensure three orthogonal objectives: 1) maximizing profit; 2) minimizing maximum metric distance of any match; and 3) minimizing abandonment probability of an accepted agent. We consider a natural class of scheduling policies, and develop LP rounding techniques that find approximately optimal policies.

2 - Exact Competitive Ratios for Online Edge-weighted Bipartite Matching with a Known Set of Edge Weights
Will Ma, Massachusetts Institute of Technology, 71 School Street, Cambridge, MA, 02139, United States, willma353@gmail.com, David Simchi-Levi

In this paper we obtain tight competitive ratios for the online edge-weighted bipartite matching problem, as a function of the set of potential edge weights, which is assumed to be given in advance. We obtain corresponding results for the Adwords problem under the small bids assumption, and the stochastic matching setting if each fixed node can be matched a large number of times. Our results are for the adversarial arrival model, and based on our optimal "tradeoff function" for online budgeted allocation in general, when each budget, or resource, could be converted to reward at multiple rates. Our analysis is primal-dual, and uses a randomly-initialized tradeoff function to handle the multiple rates.

3 - Closing the Gaps: An Online Learning Algorithm for the Lost-sales Inventory System with Lead Times
Huanan Zhang, University of Michigan, 2133 Glencoe Hills Drive, Apt 10, Ann Arbor, MI, 48108-1094, United States, zhanghn@umich.edu, Xiuli Chao, Cong Shi

We develop an improved nonparametric learning algorithm for periodic-review lost sales inventory systems with positive lead time, where the firm does not know the demand distribution a priori but makes the replenishment decision in each period based only on the past sales (censored demand) data. It is known that the optimal policy is hard to compute even with full information, hence in this paper we focus on finding the best base-stock policy. We establish a square-root convergence rate of the proposed learning algorithm, which is the best possible rate for this class of problems.

4 - Adaptivity Gaps for Stochastic Probing Problems
Viswanath Nagarajan, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States, viswa@umich.edu, Anupam Gupta, Sahil Singla

We consider a general class of stochastic probing problems with submodular or subadditive objectives. Each element is active independently with some known probability, but we know the status of an element only after "probing" it. There is also a constraint on the sequence of elements that may be probed. The goal is to find a policy for probing elements so as to maximize the expected function value on the active elements. Such problems arise in many applications, eg. influence maximization, Bayesian mechanism design and path planning. We show that the gap between optimal adaptive and non-adaptive policies is small, which also leads to good approximation algorithms for these stochastic probing problems.

■ SA78B

380B

Energy

Contributed Session

Chair: Emre Çelebi, Kadir Has University, Istanbul, Turkey, ecelebi@khas.edu.tr

1 - Efficient Allocation of Benefits in Multinational Transmission Expansion Planning using Cooperative Game Theory
Martin Kristiansen, PhD Student, NTNU, Nedre Mollenberg gate 23A, Trondheim, 7014, Norway, martin.kristiansen@ntnu.no

There are multiple countries involved in, or affected by, multinational grid investments. Although cooperative investment strategies always result in nonnegative aggregate net-benefits, benefits for individual parties can be asymmetric and, in some cases, negative. In this talk, we present a methodology to determine an efficient and fair allocation of benefits using Shapley Value from cooperative game theory. Moreover, we verify numerically that our case study of the North Sea Offshore Grid yields a convex cooperative game, meaning that the computed allocation is in the core and, consequently, provides a higher payoff to all countries than under any other possible subcoalition.

2 - Enhanced Representative Days and System States Modeling for Energy Storage Investment
Diego Alejandro Tejada Arango, Research Assistant, Universidad Pontificia Comillas, C/ Santa Cruz de Marcenado 26, Madrid, 28015, Spain, dtejada@comillas.edu, Sonja Wogrin, Efraim Centeno

In this work, we analyze the impact of different options to represent the operation decisions in the study of energy storage (ES) investment for long-term planning models. We compare the representative days and the system-states approaches for the representation of these operation decisions. We proposed enhanced versions of these approaches to improve the ES investment approximation. An Spanish case study is evaluated and the results are used to identify the potential profits that energy storage investment can obtain.

3 - Investment Plan Against Malicious Attacks on Power Networks: Multilevel Game-theoretic Models with Shared Cognition
Hamzeh Davarikia, PhD Candidate, Research Assistant, University of Arkansas, 2801 S.University Avenue, Little Rock, AR, 72204, United States, hxdavarikia@ualr.edu, Mustafa Alassad, Yupo Chan

We developed a tool for utility transmission planners to protect power network from potential attacks. An extended tri-level mixed-integer linear-programming interdiction-model returns the best protecting strategy. Deception is an integral part of the mathematical model, accomplished by releasing misinformation based on shared cognition theory. In addition, the multi origin-destination model allows the impact of disabled facilities to become transparent. The results from IEEE 24 and 118 Bus Test Systems show the viability of the model, including its capacity to impute the worth of deception.

4 - Nested Decomposition Algorithm for Electric Power Infrastructure Planning
Cristiana Lara, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, cristianallara@cmu.edu, Ignacio E.Grossmann

We propose a Nested Benders Decomposition algorithm for mixed-integer problems arising in the planning of electric power systems. Our decomposition, which extends previous nested Benders methods by handling integer and continuous state variable, targets large-scale multi-period problems and allows us to investigate the impact of the number of representative days per year in the planning strategy over a long time horizon. The proposed algorithm is applied to a case study in the ERCOT region for a 30 year planning horizon, and demonstrate massive computational savings from our decomposition. Additionally, we compare the results for the different numbers of representative days.

5 - Integrated Models for Transmission/generation Investments and Market-clearing Equilibrium in Electricity Markets

Emre Çelebi, Kadir Has University, Kadir Has Caddesi, Cibali, Istanbul, 34083, Turkey, ecelebi@khas.edu.tr

Investments in transmission/generation assets and market-clearing equilibrium are interrelated and influenced by a variety of factors including strategic behavior of the generation firms and uncertainties in demand and generation assets. Integrated investment/market-clearing models are formed as bi-level programming problems and they are reformulated by using a method for discretely constrained mixed complementarity problems. The proposed models are demonstrated using a realistic 9-node Turkish electricity market model. These models will be useful in planning generation/transmission investments and analyzing the relations among these investments and the market outcomes.

■ SA79

381B

Power System Resilient Design and Optimization

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Amir Mousavian, Clarkson University, amir@clarkson.edu

1 - Closed-loop Distribution Grid Restoration for Natural Disaster Recovery

Jianhui Wang, Southern Methodist University, Dallas, TX, United States, jianhui@smu.edu

We present a closed-loop distribution system restoration decision support model to assist distribution utility operators in making optimal and effective decisions during distribution system restoration under extreme weather events. The modeling framework consists of four modules: data fusion, advanced controls, multi-objective optimization and crew and resource dispatch.

2 - Storage Investment Model Considering Energy and Reserves Markets

Hrvoje Pandzic, Faculty of Electrical Engineering and Computing University of Zagreb, Unska 3, Zagreb, 10000, Croatia, hrvoje.pandzic@fer.hr, Yury Dvorkin, Miguel Carrion

We present an investment model for a merchant storage investor who is trying to maximize its profit in energy and reserves market.

3 - Communication-constrained Resilient Distribution Grid Design

Geunyeong Byeon, University of Michigan, Ann Arbor, MI, United States, gbyeon@umich.edu, Russell Bent, Pascal Van Hentenryck, Harsha Nagarajan

Several extreme weather events have revealed potential risks to electric power grids and motivated the need for upgrades that improve the resilience of grids to these events. Moreover, the increased functional dependencies between a power grid and its associated communication network have also added a new layer of risks to grid reliability. Hence, we consider the problem of designing resilient distribution grids in combination with its dependencies on communication systems. We pose the problem as a two-stage mixed-integer stochastic optimization problem and develop decomposition-based algorithms to analyze practically relevant test cases.

4 - Evaluating the Impact of Renewable Generation on Transmission Expansion Planning

Ebrahim Mortaz, Auburn University, 115 N.debardeleben St. Apt 29, Auburn, AL, 36830, United States, emortaz@auburn.edu, Jorge F. Valenzuela

In this talk, we study the impact of renewable generation on transmission expansion planning (TEP). We solve the TEP problem considering two prominent sources of renewable energy, wind and solar, and assess the effects of harvesting locations and installed capacity on the transmission network expansion plan. In solving the TEP problem, the hourly fluctuations of demand and RES over time are considered. We run all of our simulations on the IEEE 24-bus test system for a planning horizon of ten years. The simulation results provide alternative investment plans for expanding the transmission network that includes high penetration of RES.

■ SA80

381C

Decisions in Energy Markets using Extended Concepts of Equilibrium

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Sauleh Ahmad Siddiqui, Johns Hopkins University, Baltimore, MD, 21218, United States, siddiqui@jhu.edu

1 - Solving Problems with Equilibrium Constraints with an Application to Energy Markets

Sauleh Ahmad Siddiqui, Johns Hopkins University, 3400 N Charles Street, Baltimore, MD, 21218, United States, siddiqui@jhu.edu

We provide a new set of complementarity-based algorithms for solving mathematical programs with equilibrium constraints and extend them to solve equilibrium problems with equilibrium constraints. We apply these algorithms to provide insights into energy markets with hierarchical structures. We conclude with policy insights and recommendations on how this approach can be extended.

2 - Carbon Emissions Forensic in Energy Sector: Is it Necessary?

Yihsu Chen, University of California Santa Cruz, Santa Cruz, CA, 95060, United States, yihsuchen@ucsc.edu

Climate policy has mostly focused on regulating power suppliers. There is a growing interest to explore regulating emissions from the demand side by forcing consumers to reduce their energy consumptions or to purchase power from cleaner sources. One possible approach is to impose a carbon tax on power consumption through network flow tracing. This paper analyzes the market outcomes under supplier- and demand-based approaches. We conclude that both approaches likely lead to the same market outcomes while consumer-based approach is likely to be inferior owing to its significant transaction cost.

3 - Phasing Out the U.S. Federal Helium Reserve: Policy Insights from a World Helium Model

Olivier Massol, IFP School, 228-232 Avenue Napoleon Bonaparte, Rueil-Malmaison, 92852, France, olivier.massol@ifpen.fr, Omer Rifaat

We propose a market equilibrium model to study the effects of the recently decided rapid phase out of the U.S. Federal Helium Reserve (FHR), a strategic stockpile accumulated during the 1960s. The model treats both helium producers and the FHR as profit maximizing players in a dynamic non-cooperative game (formulated as a MCP). Evidences gained from our market simulations indicate that, compared to the currently implemented policy, a slower depletion of the U.S. FHR stockpile would systematically increase the financial return to the U.S. federal budget, lower helium venting into the atmosphere, and would also augment the global welfare.

■ SA81

382A

Advances in Stochastic Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: David Brown, Duke University, Durham, NC, 27708, United States, dbbrown@duke.edu

Co-Chair: Santiago Balseiro, Duke University, Durham,NC, United States, santiago.balseiro@duke.edu

1 - Static Routing in Stochastic Scheduling: Performance Guarantees and Asymptotic Optimality

Chen Chen, Duke University, 100 Fuqua Drive, Box 90120, Durham, NC, 27708, United States, cc459@duke.edu, Santiago Balseiro, David Brown

We study stochastic scheduling with the weighted sum of expected completion time objective and processing times that may vary across both jobs and machines. We analyze static routing policies that route each job to a particular machine upfront and then sequence jobs on each machine via the WSEPT rule. A good routing can be found by solving a convex quadratic program that only uses expected job processing times. We provide an additive performance bound on the sub-optimality of this static routing policy that implies asymptotic optimality in the regime of many jobs. The key to this result is a lower bound on the performance of an optimal adaptive scheduling policy via a penalized information relaxation.

2 - Learning Preferences with Side-information: Near Optimal Recovery of Tensors
Andrew A. Li, MIT, Cambridge, MA, 02139, United States, aali@mit.edu, Vivek Farias

Many recent problems in e-commerce can be cast as large-scale problems of tensor recovery. Thus motivated, we study the problem of recovering tensors from their noisy observations. We provide an efficient algorithm to recover structurally 'simple' tensors given noisy observations of their entries; our version of simplicity subsumes low rank tensors for various definitions of tensor rank. Our algorithm is practical for massive datasets and provides a significant performance improvement over incumbent approaches to Tensor recovery. Further, we show a near-optimal recovery guarantee. Experiments on music streaming data demonstrate the performance and scalability of our algorithm.

3 - Stochastic Online Scheduling on Unrelated Machines
Varun Gupta, University of Chicago, guptav@uchicago.edu, Benjamin Moseley, Marc Uetz, Qiaomin Xie

We derive the first performance guarantees for a combinatorial online algorithm that schedules stochastic, nonpreemptive jobs on unrelated machines to minimize the expectation of the total weighted completion time. Prior work on unrelated machine scheduling with stochastic jobs was restricted to the offline case, and required sophisticated linear or convex programming relaxations for the assignment of jobs to machines. Our algorithm is purely combinatorial, and therefore it also works for the online setting.

4 - Robust Markov Decision Processes under Non-rectangular Uncertainty
Julien Grand-Clement, Columbia University, New York, NY, United States, jg3728@columbia.edu, Vineet Goyal

Markov decision processes are a common paradigm for modeling dynamic optimization problems. We consider a robust approach to Markov decision processed where the uncertainty in probability transitions is modeled using an uncertainty set. Most prior works consider the case of uncoupled uncertainty (or rectangular uncertainty) between different states, potentially resulting in highly conservative policies. The general coupled uncertainty set leads to intractable formulations. In this work, we consider a natural low-rank coupled uncertainty between different states and show that this leads to a tractable approach and overcomes the conservativeness of using uncoupled uncertainty sets.

■ SA82

382B

New Directions in Stochastic Inventory Control

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Cong Shi, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48105, United States, shicong@umich.edu

1 - Inventory Management with Opaque Products
Yeqing Zhou, Columbia University, 550 W. 120th St, New York, NY, 10027, United States, yz2714@columbia.edu, Adam Elmachtoub, David D.Yao

We study the use of opaque products in a multi-item inventory system. An opaque product is defined as a product where some specific attributes are not revealed to customers until after payment. We derive the optimal opaque fulfillment policy which minimizes the long run average inventory costs and show that a simple heuristic is near-optimal for managing opaque products. We also quantify the cost savings achieved by having opaque products (versus not having them) using a connection to the balls-into-bins framework.

2 - Nonparametric Learning Algorithms for Stochastic Inventory Systems with Random Capacities
Weidong Chen, PhD Student, Michigan Engineering, Ann Arbor, MI, 48105, United States, aschenwd@umich.edu

We propose a nonparametric learning algorithm for the single-product, periodic-review, backlogging inventory systems with random production capacities. We assume that the firm has no prior information on the demand distribution nor the capacity distribution and only has access to past demand and supply data (which can be referred to as censored capacity information). We propose a cyclic gradient-descent type of algorithm whose running average cost asymptotically converges to the clairvoyant optimal costWe prove that the rate of convergence guarantee of our algorithm is O(\sqrt{T}), and conduct numerical experiments to demonstrate the effectiveness of our proposed algorithms.

3 - Online Algorithms for Stochastic Inventory Systems
Yuchen Jiang, University of Michigan, Ann Arbor, MI, 48109, United States, ycjiang@umich.edu

We study stochastic inventory systems by designing online algorithms to determine optimal inventory decisions before the realization of any future demands. Our online algorithm uses up-to-date demand information and hence can be carried out in practice. Moreover, our competitive analysis shows that the algorithms we proposed preform well even in the adversarial setting, where the worst case demand realization is considered.

■ SA83

382C

Sequential Decision Making under Uncertainty

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Belleh Fontem, University of Mary Washington, Fredericksburg, VA, 22407, United States, bfontem@umw.edu

1 - Multi-objective Sequential Stochastic Assignment Problems
Ge Yu, University of Illinois, Champaign, IL, United States, geyu3@illinois.edu, Sheldon Jacobson

We provide an asymptotic analysis of multi-objective sequential stochastic assignment problems (MOSSAP). In MOSSAP, a fixed number of tasks arrive sequentially, with an n-dimensional value vector revealed upon arrival. Each task is assigned to one of a group of known workers immediately upon arrival, with the reward given by an n-dimensional product-form vector. The objective is to maximize each component of the expected reward vector. We provide expressions for the asymptotic expected reward per task for each component of the reward vector, under three classes of Pareto optimal policies. We also compare the convergence rates of these three classes of Pareto optimal policies.

2 - Concentration Inequality Approach to Variance-Constrained Bivariate Optimal Stopping
Belleh Fontem, University of Mary Washington, Fredericksburg, VA, United States, bfontem@umw.edu

Under a certain payoff structure, we consider the problem of finding an optimal stopping time for a bivariate random walk subject to a constraint on the stopping variance of one of the state variables. The non-linearity of the variance constraint gives rise to time-inconsistency in the sense that traditional Bellman optimality is inapplicable. We employ two concentration inequalities to prove optimality of the first-exit time of the relevant state variable from either a control band, or a half-space (depending on the how we interpret optimality). The motivating application is determining an optimal selling policy for a risk-averse rental car firm that also serves purchasing customers.

Sunday, 10:00 - 10:50AM

■ Sunday Plenary

GBCC- General Assembly B, Level 3

The Final Step in the Remarkable Journey of the Isoperimetric Problem: The Completion of Euler's Approach

Plenary

Invited Session

1 - The Final Step in the Remarkable Journey of the Isoperimetric Problem: the Completion of Euler's Approach
Richard Tapia, Rice University

In this presentation we give a brief overview of the remarkable life of the impactful isoperimetric problem. We identify three distinct classes of solution approaches that have been used throughout history: the Cartesian coordinate representation approach of Euler, the synthetic geometry approach of Steiner, and the parametric representation approach of Weierstrass. We say that one of our three classes of approaches has been completed when an appropriately short sufficiency proof for the isoperimetric problem has been constructed that belongs to this class of proofs. In a legendary work from 1744, Euler presented his contribution, establishing neither necessity nor sufficiency for this problem. This failure led Steiner in 1838 to propose his approach that gave only necessity and not sufficiency as he believed. The Steiner path was completed by Lawlor in 1998. Euler's and Steiner's failures led Weierstrass in 1879 to propose his approach, which did indeed lead to sufficiency but required a somewhat elaborate theory. The Weierstrass approach was completed in 1934 by Littlewood, Hardy, and Polya. The major contribution in this presentation is our completion of Euler's approach. Our proof uses elementary tools.

Sunday, 11:00AM - 12:30PM

■ SB01

310A

Game Theoretical Models in Strategic Managament

Sponsored: Decision Analysis

Sponsored Session

Chair: Wenxin Xu, University of Illinois at Urbana-Champaign, 1206 S Sixth Street, (217) 503-8779, IL, 61820, United States, wenxin.v.xu@polyu.edu.hk

1 - Uncertain Innovation, Spillovers, and First and Second Mover Advantages

Jovan Grahovac, Purdue University, 403 W State Street, West Lafayette, IN, 47907, United States, jgrahov@purdue.edu, Dharma Kwon, Wenxin Xu

We use a game theoretic duopoly model to examine the impact of spillovers and uncertain R&D expenditures and completion times on firm outcomes. We characterize the Nash equilibrium of the model and we find that spillovers may or may not diminish the profit of the firm that is more capable in R&D. In other words, the technological leader may wish to commit to imitability of its innovation under certain conditions. Moreover, we find that the technological leader does not always invest earlier than the laggard, and we discuss implications of these results for firm strategy and the resource-based view.

2 - Exit Strategy under Uncertainty and Incomplete Information

Dharma Kwon, University of Illinois at U-C, 350 Wohlers Hall, 1206 S Sixth Street Mc-706, Champaign, IL, 61820, United States, dhkwon@illinois.edu

We examine a duopoly exit game between two firms where the the flow profits are stochastic and the exit cost of each firm is private information, and we characterize the Markov perfect Bayesian equilibria.

3 - Innovation Effort, Spillovers and Patent Licensing Strategy

Benoit Chevalier-Roignant, King's College London, London, United Kingdom, benoit.chevalier-roignant@kcl.ac.uk

In this paper, we endogenize the choice between licensing a technology or keep it proprietary. An innovator decides on the innovation effort to achieve a process innovation, on whether (and under which conditions) to license the technology and, when demand is known, on supply. We examine the growth and volatility conditions which drive the choice of licensing contracts and the level of innovation effort.

4 - R & D Competition with Spillovers and Uncertain Completion Times

Wenxin Xu, The Hong Kong Polytechnic University, wenxu@polyu.edu.hk

We examine a game-theoretic model of two firms that are competitively engaged in research and development (R &#38 D) projects. We investigate the impact of imitability on R&D investment strategies when the R &#38 D completion times are uncertain and either firm can receive spillover from the other.

■ SB02

310B

Panel: The Journey to Organizational Decision Quality

Sponsored: Decision Analysis

Sponsored Session

Chair: Carl S. Spetzler, Strategic Decisions Group, Palo Alto, CA, 94301-2411, United States, cspetzler@sdg.com

1 - Moderator

Carl S. Spetzler, Strategic Decisions Group, 745 Emerson Street, Palo Alto, CA, 94301-2411, United States, cspetzler@sdg.com

In this session we will review what it means to reach ODQ (organizational decision quality) using the assessment instrument that has been generated by the board of examiners for the Raiffa-Howard Award. The panel members will then discuss the challenges they faced and currently face on the journey to ODQ and share lessons that have been learned along the way.

2 - Panelist

Bill K. Klimack, Chevron, BillKlimack@chevron.com

3 - Panelist

Dinesh Cheryan, Hess Corporation, Houston, TX, United States, dinesh.cheryan@Hess.com

4 - Panelist

Eric Bickel, University of Texas, Austin, TX, United States, ebickel@mail.utexas.edu

5 - Panelist

James R. Driscoll, Intel Corp., Beaverton, OR, United States, james.r.driscoll@intel.com

■ SB03

310C

Operations Research Approaches for Building Demand Response

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, !, United States, jopeng@Central.uh.edu

Co-Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, University at Buffalo (SUNY), Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Operations Research Approaches for Building Demand Response in a Smart Grid

Miguel Anjos, Polytechnique Montreal, Montreal, QC, United States, miguel-f.anjos@polymtl.ca, Juan Gómez

Electric power systems need to ensure that production and demand of electricity are continuously in balance. With fundamental changes taking place in the power grids of many countries due to a variety of technological and policy developments, there is a need to obtain additional flexibility to achieve this essential power balance. Demand response refers to the collection of all the means to obtain this flexibility from the demand side of the balance. We present a selection of contributions of operations research to the provision of demand response by the residential, commercial and institutional sectors of the economy. The aspects covered include electricity tariffs, building energy management systems, load estimation, local generation, electric vehicles, energy storage, and building-level aggregation. We conclude with a brief discussion of current opportunities for operations research to support the development and realization of the potential of demand response.

■ SB03A

Grand Ballroom A

Joint Session RMP/APS: Topics in Revenue Management and Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: N. Bora Keskin, Duke University, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu

1 - Revenue Management in Systems of Reusable Resources

David Simchi-Levi, Massachusetts Institute of Technology, Dept of Civil and Environmental Engineering, 77 Massachusetts Avenue Rm 1-171, Cambridge, MA, 02139, United States, dslevi@mit.edu

We first consider personalized assortment optimization in systems of reusable resources. When the manager is not privy to real-time utilization data we show that the optimal policy can be computed efficiently. When real-time utilization data is available, we propose effective heuristic policies. We further consider the joint pricing and assortment problem and show that non-discriminatory policies can be developed in special cases despite theoretical hardness. Motivated by practical considerations we extend these techniques to settings in which demand varies periodically over time.

2 - Less Can be More in Price Experimentation

Divya Singhvi, Massachusetts Institute of Technology, Cambridge, MA, United States, dsinghv@mit.edu, Georgia Perakis

We consider a dynamic pricing problem where a monopolist is selling a single product but has no knowledge of the demand curve. Further, there is a cost on price experimentation. The monopolist seeks to efficiently learn the demand curve and keep the cost of price experimentation low. We propose an approach for price experimenting and learning which is simple and mimics industry practice. We provide bounds on the number of price experimentations needed to achieve a threshold revenue level. We show that with few price experimentations (aka 4) we can be within 18% of the optimal.

3 - Matching or Not Matching: Strategic Pricing in a Competitive Airline Environment
Alexandre Jacquillat, Carnegie Mellon University, Pittsburgh, PA, United States, ajacquil@andrew.cmu.edu, Michael Benborhoum, Maxime Cohen

A common practice in the airline industry involves matching competitors' lead-in fares, which may lead to missed revenue opportunities. This talk presents a complete approach to assess how airlines can strategically react to competitors' pricing decisions. We study a game-theoretic model of capacitated Bertrand competition that identifies conditions under which deliberately deviating from competitors' prices can increase revenues.

4 - On Incomplete Learning and Certainty-equivalence Control
N. Bora Keskin, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Assaf Zeevi

Motivated by dynamic pricing applications, we consider a dynamic control-and-estimation problem. The decision-maker sequentially chooses controls and observes responses that depend on both the chosen controls and an unknown parameter. The decision-maker uses a certainty-equivalence policy, and we characterize the asymptotic accuracy performance of this policy.

■ SB03B

Grand Ballroom B

Multi-Item and Multi-Location Revenue Management Models

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Candace Arai Yano, University of California-Berkeley, Berkeley, CA, 94720-1777, United States, yano@ieor.berkeley.edu

1 - Dynamic Pricing of Omnichannel Inventories
Joline Uichanco, University of Michigan, Ross School of Business, 701 Tappan St, Room 4418, Ann Arbor, MI, 48109-1234, United States, jolineu@umich.edu, Pavithra Harsha, Shivaram Subramanian

We develop a dynamic pricing model for omnichannel retail which accounts for cross-channel interactions in demand (channel substitution) and supply (cross-channel fulfillment). The model combines ideas from dynamic pricing and capacity control to address the novel features of an omnichannel setting. We propose two computationally tractable pricing policies based on partitioning the channel agnostic inventories. A markdown optimization system based on our models was developed and implemented at a major US retailer. Causal model analysis of the pilot data show 12% improvement due to the new system.

2 - Product Quality, Service and Pricing
Ruxian Wang, The Johns Hopkins Carey Business School, Baltimore, MD, Shiliang Cu

We develop a unified framework to investigate firms' joint decisions on product quality, price and ancillary service, when they offer a line of products to consumers in a variety of monopolistic and competitive environments.

3 - Marginal Estimation+Price Optimization" with Robust Choice Models
Karthik Natarajan, Singapore University of Technology and Design, Singapore University of Technology and Design, 20 Dover Drive, Singapore, 138682, Singapore, karthik_natarajan@yahoo.com, Chung-Piaw Teo, Zhenzhen Zen, Cong Chen

We develop an estimation and optimization framework for the multi-product pricing problem by exploiting properties in a new class of choice models. The pricing problem under this new choice model is a convex optimization problem when the marginal distributions of the utilities are log-concave. We develop a data-driven second order conic/linear program to estimate a robust choice model, and to find the corresponding optimal prices. Mixed Integer Linear Programming models can be used to find the prices when side constraints are present.

■ SB03C

Grand Ballroom C

M&SOM Student Paper Competition I

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Tunay Tunca, Unversity of Maryland, Silver Spring, MD, 20910, United States, ttunca@rhsmith.umd.edu

1 - Truthful Mechanisms for Medical Surplus Product Allocation
Can Zhang, Georgia Institue of Technology, Atlanta, GA, czhang2012@gatech.edu

2 - An IV Tree Approach for Personalized Health Care Outcome Analysis
Guihua Wang, University of Michigan, Ann Arbor, MI, guihuaw@umich.edu

3 - Risky Suppliers or Risky Supply Chains? An Empirical Analysis of Sub-tier Supply Network Structureon Firm Risk in the High-Tech Sector
Yixin Wang, University of Michigan, Ann Arbor, MI, iriswang@umich.edu

■ SB04

320A

Operational Innovations with Social and Environmental Benefits

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Erica Plambeck, Stanford University, Stanford, CA, 94305-5015, United States, elp@stanford.edu

Co-Chair: Dan Andrei Iancu, Stanford University, Stanford, CA, 94107, United States, daniancu@stanford.edu

1 - Consumer Education and Reverse Logistics in a Social Enterprise
Andre Du Pin Calmon, INSEAD, Boulevard de Constance, Fontainebleau, 77300, France, andre.calmon@insead.edu, Gonzalo Romero

We study the problem faced by a social enterprise that distributes new life-improving technologies in a developing market. Its goal is to profitably increase the adoption of a product that is sold through a small retailer. The retailer sells to budget-constrained consumers that have an uncertain product valuation. The distributor considers two strategies: (i) improve the information accuracy provided to consumers, and (ii) improve its reverse logistics. We show that if the distributor highly values product adoptions, it prefers reverse logistics rather than improving information accuracy.

2 - Pay it Forward: A Sustainability Incentive in Smallholder Commodity Supply Chains
Joann De Zegher, Stanford University, dezegher@stanford.edu, Dan Andrei Iancu, Erica Plambeck

Batched payments in commodity supply chains burdens the cash flow management of small suppliers in developing economies. We formulate a dynamic model of consumption-maximizing, cash-constrained farmers to analyze the supply chain consequences of batched payments. Building on this, we propose a novel incentive and sourcing policy for buyers to achieve their no-deforestation commitments in commodity supply chains of developing economies. Our proposed incentive increases farmer welfare and buyer profits. A one-size-fits-all policy achieves no-deforestation most often, but a tailored policy minimizes deforestation. The palm oil supply chain starting in Indonesia motivates our study.

3 - Off Grid Electricity at the Bottom of the Pyramid
Bhavani Shanker Uppari, INSEAD, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, BhavaniShanker.Uppari@insead.edu, Manuel Barron, Rowan Clarke, Serguei Netessine, Martine Visser, Ioana Popescu

We report results of a large-scale randomized controlled trial in Rwanda whose goal was to understand off-grid electricity adoption at the bottom of the pyramid. We focus on different business models designed to stimulate transition from kerosene to electric lamps. These experiments demonstrate behavioral barriers to adoption of electricity and ways to overcome them.

4 - Truthful Mechanisms for Medical Surplus Product Allocation
Can Zhang, Georgia Institute of Technology, 499 Northside Circle NW, Apt 315, Atlanta, GA, 30309, United States, czhang2012@gatech.edu, Atalay Atasu, Turgay Ayer, Beril L. Toktay

We analyze resource allocation problems faced by medical surplus recovery organizations (MSROs) that recover reusable medical products to fulfill the healthcare needs of under-served regions/countries. We present strategies to improve MSROs' value provision when recipient needs are private information, and validate our results using historical data from a partner MSRO.

■ SB05

320B

Pierskalla

Sponsored: Health Applications

Sponsored Session

Chair: Hamsa Sridhar Bastani, Stanford University, Stanford, CA, 94305, United States, hsridhar@stanford.edu

Co-Chair: Mohsen Bayati, Stanford University, Stanford, CA, 94305, United States, bayati@stanford.edu

1 - An Examination of Early Transfers to the ICU Based on a Physiologic Risk Score
Wenqi Hu, Columbia Business School, New York, NY, United States, wh2274@columbia.edu, Carri Chan, José R. Zubizarreta, Gabriel J. Escobar

Unplanned transfers of patients from the ward to the Intensive Care Unit (ICU) can occur due to rapid deterioration and may increase the patients' risk of death and lengths of stay in hospital. A new predictive model, the EDIP2, was developed with the intent to identify patients at risk of deterioration, which in some cases could trigger proactive transfers to the ICU. This work examines the potential costs and benefits of preventive ICU admissions based on this new dynamic warning system. We find that preventive ICU admissions have the potential to improve patient outcomes, and physicians' fears of needlessly clogging the ICU may not be as dire as initially feared.

2 - Optimal Timing of Drug Sensitivity Testing for Patients on First-line Tuberculosis Treatment
Sze-chuan Suen, University of Southern California, 3715 McClintock Ave, GER 240, Los Angeles, CA, 90089, United States, ssuen@usc.edu, Margaret L. Brandeau, Jeremy D. Goldhaber-Fiebert

Tuberculosis (TB) patients who are not responsive to first-line treatment should be triaged to appropriate treatment alternatives. Treatment response can be monitored using inexpensive but noisy sputum-smear (SS) tests or expensive but accurate drug sensitivity tests (DST). We use a partially observed Markov decision process (POMDP) to determine whether and when DST should be administered. We apply our model to TB in India to identify patterns of SS test results that should prompt DST. We find an optimal DST policy that would save India approximately $1.9 billion.

3 - Outcomes-based Reimbursement Policies for Chronic Care Pathways
Saša Zorc, INSEAD, Fontainebleau, France, sasa.zorc@insead.edu, Stephen Chick, Sameer Hasija

We develop an outcomes-based model of contracting in care for chronic patients, using data from United Kingdom's NHS. The government contracts with healthcare providers in effort to maximise population health minus the cost. We consider the decision of whether to contract with individual healthcare providers or groups of such providers, as well as which contract type to use. Individual contracts fail to provide the desired incentives if providers under such contracts cooperate (collusion), however so do group contracts if group members fail to coordinate (free-riding). We demonstrate that individual outcomes-adjusted capitation contracts are the most resistant to these adverse effects.

4 - Optimal Risk-based Group Testing in Public Health Screening
Hrayer Y. Aprahamian, Virginia Tech, 1145 Perry Street, Blacksburg, VA, 24060, United States, ahrayer@vt.edu, Douglas R. Bish, Ebru K. Bish

Public health screening so as to classify subjects as positive or negative for a binary characteristic (e.g., an infection) is an essential tool that can save lives and reduce suffering. We study optimal group testing designs, in which multiple subjects are tested with a single test, considering subject-specific risk characteristics, and accuracy- and equity-based objectives, and characterize structural properties of optimal testing designs. These properties allow us to develop efficient algorithms and derive insights on equity versus accuracy trade-off. We demonstrate the value of risk-based testing through a case study on chlamydia screening in the United States.

5 - Non-Stationary Bandits with Habituation and Recovery Dynamics
Yonatan Mintz, UC Berkeley, San Francisco, CA, 94103, United States, ymintz@berkeley.edu, Anil Aswani, Philip Kaminsky, Yoshimi Fukuoka, Elena Flowers

Abstract Not Available.

■ SB06

320C

Drug Shortages

Sponsored: Health Applications

Sponsored Session

Chair: Emily Tucker, University of Michigan, Ann Arbor, MI, 48105, United States, eltuck@umich.edu

1 - Identifying Critical Components of a Multi Agent Drug Supply Chain
Rozhin Doroudi, Northeastern University, 360 Huntington Ave, Boston, MA, 02115, United States, doroudi.r@husky.neu.edu, Ozlem Ergun, Jacqueline Griffin, Rana Azghandi

The growing epidemic of drug shortages in the US indicates the fragility of drug supply chain in the face of disruptions. Identifying most critical components in the supply chain can assist policy makers in mitigating these shortages. In this study we propose a node criticality measure for underlying network of a drug supply chain in which nodes are agents and arcs are material flow between them. Unlike most node criticality measures in network science literature this measure does not abstract away domain-specific functions of network components. Therefore, it can be used in predicting the effect that disruption of one node can have on the overall supply chain performance.

2 - Evaluating Flexible Inventory Policies for Robust Pharmaceutical Supply Chains
Rana Azghandi, Northeastern University, 360 Huntington Avenue, Boston, MA, 02115, United States, rana.azghandi@gmail.com, Jacqueline Griffin

Despite efforts to increase robustness of pharmaceutical supply chains, they remain vulnerable to supply disruptions and, correspondingly, drug shortages continue to be common. Designing a system which is robust for these disruptions is complex and requires adaptive decision process that dynamically changes over time. We use a stochastic optimization model to characterize the effects of the inventory policy parameters (cycle service level) for varying supply disruption profiles. Additionally, we study the effects of flexibly inventory policies via a system dynamics simulation.

3 - Mitigating U.S. Drug Shortages through Supply Contracts
Hui Zhao, The Pennsylvania State University, 419 Business Building, Smeal College of Business, University Park, PA, 16802, United States, huz10@psu.edu, Justin Jia

Drug Shortage is a major challenge facing the US pharmaceutical industry and the government. We propose to mitigate shortage through Pareto-improving supply contracts that consider the manufacturer's and GPO's profits, the government spending, and the hospital's cost. We show that price increases must be paired with strengthened failure-to-supply clauses (IPS) to achieve consistent and significant shortage reduction as well as Pareto improvement. With realistic data, a 30% price increase under IPS can lead to an average of 53% shortage reduction. We also show the impacts of IPS on different parties in the supply chain.

4 - Incentivizing Resilient Pharmaceutical Supply Chains to Prevent Drug Shortages
Emily Tucker, PhD Candidate, University of Michigan, 1205 Beal Ave. Ann Arbor, MI, 48109, United States, eltuck@umich.edu, Mark S. Daskin, Burgunda V. Sweet, Wallace J. Hopp

A substantial portion of drug shortages are caused by manufacturing issues. While these can be mitigated through redundancy and safety stock, many companies choose to maintain lean supply chains for drugs with low profit margins. We present a stochastic programming approach to solving the pharmaceutical supply chain design problem under disruption. We discuss potential policies to incentivize companies to maintain more resilient supply chains and reduce the impact of shortages.

■ SB07

322A

Medical Decision Making

Sponsored: Health Applications

Sponsored Session

Chair: Zlatana Dobrilova Nenova, University of Denver, Denver, CO, United States, Zlatana.Nenova@DU.edu

Co-Chair: M. Reza Skandari, University of Chicago, 5454 South Shore Drive, 914, Chicago, IL, 60615, United States, skandari@uchicago.edu

1 - Preference-sensitive Management of Post-mammography Decisions in Breast Cancer Diagnosis

Mehmet Ayvaci, University of Texas at Dallas, Richardson, TX, United States, Mehmet.Ayvaci@utdallas.edu, Oguzhan Alagoz, Mehmet Eren Ahsen, Elizabeth Burnside

Decision models representing the clinical situations where treatment options entail a significant risk of morbidity or mortality should consider the variations in risk preferences of individuals. In this study, we develop a stochastic modeling framework that optimizes risk-sensitive diagnostic decisions after a mammography exam. Using a risk-sensitive finite-horizon MDP model, we provide medical/policy insights. We empirically validate our model and demonstrate that the current medical practice of breast biopsies resemble risk-seeking behavior.

2 - Optimal Fractionation in Radiotherapy with Two Modalities

Sevnaz Nourollahi, University of Washington, 6322 5th Avenue NE, Lower Unit, Seattle, WA, 98115, United States, sevnaz@uw.edu, Minsun Kim, Archis Ghate

We present a formulation and a solution method for the optimal fractionation problem with two modalities using the standard linear-quadratic modelof dose-response. Numerical experiments and sensitivity analyses will be described to provide insight into the resulting dosing decisions.

3 - Optimal Strategies for Monitoring and Prediction of Chronic Kidney Disease Demand-for-care

Zlatana Dobrilova Nenova, University of Denver, 2720 Shady Avenue, Apt 2, Denver, CO, 15217, United States, znenova@katz.pitt.edu, Jennifer S.Shang

Chronic disease monitoring strategies involve understanding patient's overall health state. In this research, we design a framework for optimizing such strategies, which consists of three models: two parameter estimation models (Case-based Reasoning and Survival Analysis) and one optimization model (MDP). We showcase our framework using chronic kidney disease, which is selected due to its complexities, prevalence and cost of care. Furthermore, we demonstrate how the proposed MDP model can be used to predict medium-term appointments' demand, which is important when making staff hiring and patient recruitment decisions.

4 - Optimal Decision Making in a Markov Model with Parameter Uncertainty: the Case of Chronic Kidney Disease

Mohammad Reza Skandari, University of Chicago, 5454 South Shore Drive, 914, Chicago, IL, 60615, United States, skandari@uchicago.edu, Steven Shechter

We investigate a Markov decision process whose unknown transition parameters are revealed partially through state observation. Decisions are made as the state evolves. We use the model to study the optimal time to start preparing a type of vascular access for chronic kidney disease patients who will need dialysis.

■ SB08

322B

Simulation in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Michael W. Carter, University of Toronto, Toronto, ON, M5S 3G8, Canada, carter@mie.utoronto.ca

1 - Cost-effectiveness Analysis of Nalmefene to Treat Alcoholism

Greg Zaric, London, ON, Canada, gzaric@ivey.ca, Estefania Ruiz Vargas, Richard Zur

We developed a microsimulation model to estimate the cost-effectiveness of nalmefene plus psychosocial support in an alcohol dependent population with high or very high drinking risk levels. The model simulates a large cohort from age 17 to age 110 in 1-year time steps. In each time step individuals are classified as being in one of three drinking states Among current drinkers, changes in consumption are based on age, sex, and current drinking status. Transition rates were estimated using three large databases, and treatment efficacy was modeled based on clinical trial results.

2 - Modelling Surge Across Emergency Department, Operating Room, and Inpatient Beds with Generic, Data-driven, Discrete Event Simulation Model

Carolyn Busby, University of Toronto, Toronto, ON, L6J.2W5, Canada, carolyn.busby@mail.utoronto.ca, Michael W. Carter

Canadian hospitals routinely operate, at, near or over capacity. To manage beds, and serve patients when full, hospitals have written surge protocols that outline what actions should be taken to alleviate the congestion. However, although these protocols are routinely employed, they have not been fully captured in hospital models. Additionally, as the hospital fills up, capturing the interaction of operating rooms, the emergency department, and inpatient beds become critical. A data-driven, generic, discrete-event-simulation model is presented that captures these interaction and the process changes that occur when in surge.

3 - Coordinated Response of Hospitals in Disaster

Bahar ShahVerdi, George Mason University, Washington, DC, United States, bshahver@masonlive.gmu.edu, Elise Miller-Hooks, Marcedeh TariVerdi

A discrete event simulation framework is presented for assessing the benefits of coordinated response of hospitals in a disaster incident involving area-wide damage and mass casualties. Impacts on critical resources, physical spaces and demand are modeled. Findings from numerical experiments show the potential of joint capacity modification strategies.

■ SB09

330A

Mobile and Operations in the Digital Economy

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Jose A Guajardo, University of California-Berkeley, Berkeley, CA, 94720-1900, United States, jguajardo@berkeley.edu

Co-Chair: Vibhanshu Abhishek, Carnegie Mellon University, Pittsburgh, PA, 19104, United States, vibs@cmu.edu

1 - Business Models in the Sharing Economy: Manufacturing Durable Goods in the Presence of Peer-to-Peer Rental Markets

Jose A.Guajardo, University of California-Berkeley, Haas School of Business, 545 Student Services Bldg, Berkeley, CA, 94720-1900, United States, jguajardo@berkeley.edu

Business models that focus on providing access to assets rather than on transferring ownership of goods have become an important industry trend. Motivated by this trend, this research analyzes the interaction between a manufacturer of durable goods and a peer-to-peer marketplace, characterizing market outcomes under alternative market structures.

2 - Product Heterogeneity and Externality of Sponsored Search on Online Marketplaces

Siddhartha Sharma, Carnegie Mellon University, 4800 Forbes Avenue, 3024 Hbh, Pittsburgh, PA, 19104, United States, na, Vibhanshu Abhishek, Param Vir Singh

E-commerce marketplaces like Amazon, Ebay and Flipkart have gained significant prominence in the last decade. In this paper, we examine a new phenomenon used by these marketplaces called Product Listing Ads (PLA) which allow third party sellers to promote their listings via an ad. Using a large scale randomized field experiment we measure the impact of PLA on the marketplace and on competing advertisers.

3 - Motivating Effective Mobile App Adoption in Multi-channel Shopping: A Large Field Experiment

Tianshu Sun, University of Southern California, 3670 Trousdale Parkway, Bridge Hall, BR.I.310B, Los Angeles, CA, 90089, United States, tianshus@marshall.usc.edu, Lanfei Shi, Siva Viswanathan, Elena Zheleva

Using a randomized field experiment involving 250,000 customers from a large ecommerce platform, we investigate i) whether and how a firm can motivate customers to adopt mobile apps and ii) the causal effect of induced mobile app adoptions on customers' purchase behaviors. We find that i) both providing information and monetary incentive can lead to significant increase in customers' app adoption; ii) the effect of mobile app adoption varies greatly depending on how customers are motivated. Although providing monetary incentives may lead to larger increase in mobile app adoption, such induced adoption does not result in more purchases in the long run. In contrast, providing information leads to effective mobile adoption that sustainably increases customers' purchases, and overall profits of the firm. We further examine customers' multichannel behavior and explore how induced app adoptions affect customers' purchases.

4 - Putting a Dollar Sign to Retweets – How Startup External Social Capital Improves VC Funding
Fujie Jin, Kelley School of Business, Indiana University, Bloomington, IN, Veeresh Thummadi

This project looks at how startups can leverage external social capital from social media platforms to improve their VC funding outcomes. We focus on firm social media activities, to see whether retweets or mentions from investors and other established firms serve as quality signals to attract VC funding. Our findings suggest that external social capital from social media platforms provide another source of relevant information for venture capitalists funding decisions and that startups should employ social media strategies that enhance their external social capital on these platforms.

■ SB10

330B

Supply Chain Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Canan Savaskan, SMU Cox School of Business, Dallas, TX, 75275, United States, csavaskan@cox.smu.edu

1 - Enabling Healthcare Delivery through Vehicle Maintenance
Li Chen, Cornell University, 321 Sage Hall, Ithaca, NY, 14853, United States, li.chen@cornell.edu, Sang-Hyun Kim, Hau Leung Lee

Difficulties in healthcare delivery in developing economies arise from poor road infrastructure of rural communities, where the bulk of the population reside. Riders for Health, a nonprofit social enterprise, has developed specialized capabilities that enable significant enhancements in vehicle maintenance for healthcare delivery. The organization has engaged with the governments and provided its services using different contract schemes. In this paper we develop an analytical model based on reliability theory to compare the outcomes of these contracts, and relate the findings to data collected from a 2.5-year implementation by Riders for Health in Zambia.

2 - A Model of Interplay between Regulation, Time-to-Market, and Quality in New Drug Development
Canan Savaskan, SMU. Cox School of Business, P.O. Box 750333, Dallas, TX, 75275, United States, csavaskan@cox.smu.edu, Vishal Ahuja

In this paper, we study the interplay between Prescription Drug User Fee Act, firm choice of product innovation, FDA's product review quality and the product time to market. While the FDA regulation on PDUFA has had positive impact on product approval times, the effect on final product quality has been mixed. IN this paper, using game theoretic modeling, we capture the impact of improved product review times on drug quality in the market.

3 - Optimizing Local Content Requirements under Technology Gaps
Lauren Xiaoyuan Lu, University of North Carolina at Chapel Hill, Kenan-Flagler Business School, CB #3490, McColl Building, Chapel Hill, NC, 27599, United States, lauren_lu@unc.edu, Shiliang Cui

We study how the government of a developing country optimizes its Local Content Requirement (LCR) policy to maximize social welfare in a setting where foreign OEMs produce and sell final products in the host country and the OEMs' sourcing costs for components are higher from local suppliers than from global suppliers due to technology gaps. We characterize and compare the optimal product-level and component-level LCR policies imposed on multi-component products. Such policies have not been well studied in prior research but are practically relevant given that most real-world LCR policies regulate multi-component products.

4 - The Impact of Category Captainship on the Retail Competition
Alper Nakkas, The University of Texas at Arlington, Arlington, TX, United States, alper.nakkas@novasbe.pt, Mumin Kurtulus

Category captainship is a retailing practice where a retailer relies on a leading manufacturer (referred to as captain) on improving the category performance. This paper studies category captainship in the context of retail competition. We find that category captainship can be beneficial for not only the collaborating retailer but also for the competing retailer.

■ SB11

332A

Buyer Valuation Uncertainty

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Rachel Rong Chen, University of California-Davis, Davis, CA, 95616, United States, rachen@ucdavis.edu

Co-Chair: Jane Gu, University of Connecticut, jane.gu@uconn.edu

1 - When do Givers Take and Takers Give? Reciprocity Styles and Student Interaction on MOOCs
Aravinda Garimella, University of Washington, Seattle, WA, United States, aravinda@uw.edu

MOOCs are platforms of collaborative learning that heavily rely on student interaction. We show that students are heterogeneous in their reciprocity styles and identify three distinct styles. We show that incentives have different effects on students based on their intrinsic reciprocity styles. Our analysis is conducted on three years of daily interaction data between students on Khan Academy.

2 - Pricing Strategies under Service Competition and Uncertainty
Vashkar Ghosh, vashkar.ghosh@warrington.ufl.edu, Janice Ellen Carrillo, Kyung Sung Jung, Young Kwark

We analytically examine the service competition between two online retailers in the presence of consumers' uncertainty. We consider the impact of online reviews on the profits of the parties in the channel and show their preferences toward agency and reselling models.

3 - Returns, Rebates and Restocking Fee
Rachel Rong Chen, UC Davis, Davis, CA, United States, rachen@ucdavis.edu, Paolo Roma

Buyers are often uncertain of the product valuation before their purchase. As a result, they might return the product to the retailer. This paper examines the possibility of using product rebates to deter consumer returns, and compare the effectiveness of rebates vs. restocking fee at reducing returns.

4 - Strategic Store Design in a Vertical Channel
Jane Gu, University of Connecticut, Storrs, CT, United States, jane.gu@uconn.edu

We investigate the strategic implications of a big retailer's store organization when the retailer sells competing manufacturers' products. We model consumers' shopping behavior at the big retailer as a dynamic process of consideration set formation, and investigate how consumers' consideration set evolves in the battle between a well-known manufacturer's effort to induce consumers to search for its own product at the retailer's store and the retailer's effort to motivate consumers to search for other product alternatives through its store design. Our results show that the retailer has an incentive to withhold from improving store organization as long as its store is not poorly organized.

5 - Product Upgrades under Innovation Uncertainty
Yiwei Wang, willwangyiwei@gmail.com, Shuya Yin, Vidyanand Choudhary

Firms constantly invest on the development of prospect technologies hoping to improve the performance. However, a potential risk is that the new technologies may be unstable and their performance could be inconsistent from time to time. This project aims to provide conditions under which firms should or should not adopt the prospect technology. These conditions are affected by a number of driving forces, such as the characteristics of the technologies and cost structures.

■ SB12

332B

Marketplace Design

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Itai Ashlagi, Stanford University, Stanford, CA, 94305, United States, iashlagi@stanford.edu

1 - Communication Requirements and Informative Signaling in Matching Markets

Itai Ashlagi, s, Stanford, CA, 94305, United States, iashlagi@stanford.edu, Mark Braverman, Yash Kanoria, Peng Shi

We study how much communication is needed to and a stable matching in a two-sided matching market with private preferences. Segal (2007) and Gonczarowski et al. (2015) showed that in the worst case, any protocol that computes a stable matching requires the communication cost per agent to scale linearly in the total number of agents. In real-world markets with many agents, this communication requirement is implausibly high. This casts doubts on whether stable matchings can arise in large markets. We study markets with realistic structure on the preferences and information of agents, and show that in "typical" markets, a stable matching can be found with much less communication effort. Our protocols have good incentive properties and give insights on how to mediate large matching markets to reduce congestion.

2 - The Reverse Economics of (thin) Centralized Matching Markets

Afshin Nikzad, Stanford University, 741A Homer Ave, Stanford, CA, 94301, United States, afshin.nikzad@gmail.com

We study the monopoly and duopoly equilibria of centralized matching markets where there is externality for thickness. When these markets are "thick", their equilibria are governed by the usual economic laws, e.g. the higher the demand, the higher the price. However, when these markets are "thin", their economics could be very different. In particular, we characterize the Reverse Law of Demand, according to which, the wage paid to workers may go up when the labor supply goes up. We also characterize the Adverse Effect of Competition in the duopoly equilibrium, according to which, customers may face higher price (and therefore lower average welfare) under a duopoly than under a monopoly.

3 - Dynamic Reserve Prices for Repeated Auctions: Learning from Bids

Hamid Nazerzadeh, CA, United States, nazerzad@marshall.usc.edu, Yash Kanoria

A large fraction of online advertisements are sold via repeated second-price auctions. In these auctions, the reserve price is the main tool for the auctioneer to boost revenues. In this work, we investigate the following question: How can the auctioneer optimize the reserve prices by learning from the previous bids, while accounting for the long-term incentives and strategic behavior of the bidders? To this end, we consider a seller who repeatedly sells ex ante identical items via a second-price auction. Buyers' valuations for each item are drawn i.i.d. from a distribution F that is unknown to the seller. We find that if the seller attempts to dynamically update a common reserve price based on the bidding history, this creates an incentive for buyers to shade their bids, which can hurt revenue. When there is more than one buyer, incentive compatibility can be restored by using personalized reserve prices, where the personal reserve price for each buyer is set using the historical bids of other buyers. Such a mechanism asymptotically achieves the expected revenue obtained under the static Myerson optimal auction for F. Further, if valuation distributions differ across bidders, the loss relative to the Myerson benchmark is only quadratic in the size of such differences. If up-front fees are permitted, we show how the seller can determine such payments based on the bids of others to obtain an approximately incentive compatible-mechanism that extracts nearly all the surplus.

■ SB13

332C

Health Care, Strategy and Policy

Contributed Session

Chair: Hamideh Anjomshoa, IBM Research Australia, Carlton, Victoria, Australia, hamideh.a@au.ibm.com

1 - Evaluating the Effects of the Implementation of Variances to the Current Allocation System on the State of Georgia

Monica Gentili, University of Louisville, JB Speed Building, Room 304, Louisville, KY, 40292, United States, monica.gentili@louisville.edu, Shanthi Muthuswamy, Mohsen Mohammadi, Vinod Venkata Naga Sai

The U.S. transplant community has long been concerned about disparities in access to and outcomes of transplantation. One of the alleged causes of disparity is administratively determined organ allocation boundaries that limit organ sharing across regions. To overcome these issues members of the Organ Procurement Transplant Network can propose a modification (i.e., a variance) to the current allocation system to allocate organs differently than the OPTN Policies. In this study, using optimization and simulation, we investigate how the implementation of the Statewide Sharing variance would affect access to and outcomes of transplantation for the state of Georgia over time.

2 - Comparison of Particle Filter Methods for the Estimation of Reproduction Number of Influenza Epidemics

Xi Chen, University of Texas at Austin, 3500 Greystone Drive, Apt 271, Austin, TX, 78731, United States, carol.chen@utexas.edu

Accurately estimating the parameters of the infectious disease progression model can efficiently help organizations determining the progression and severity of the disease and response properly and quickly. We propose a Posterior particle filter and two Single Statistic Posterior particle filters and compare them with Bootstrap Filter and Auxiliary Particle Filter to show their ability of accurately and consistently estimating the parameters in infectious disease progression models which are non-linear in nature. Besides, we show the importance of the re-sampling algorithm in helping improving the consistency of particle filters.

3 - Identifying Temporal Disease Progression Patterns using Electronic Medical Records

Xiaochen Wang, PhD Student, Yale University, 300 George Street, Suite 503, New Haven, CT, 06511, United States, xiaochen.wang@yale.edu, Hongyu Zhao

Wide availability of electronic medical records nowadays allows for a more comprehensive understanding about disease progression patterns and their associations with patients' outcomes. We will describe a multi-layer continuous-time hidden Markov model to learn the hidden states of a disease and their progression on patients receiving different treatment. Our disease progression model can explicitly include demographic information and characterize treatment effects under different treatments. We will show how our model parameters can be estimated using the EM-based algorithms, and illustrate its usefulness through its application to a congestive heart failure patient cohort.

4 - Minimizing Health Compromising Behaviors via School-based Programs: An Application of Linear Programming

Banafsheh Behzad, Assistant Professor, California State University, Long Beach, 1250 Bellflower Blvd., MS.850, CBA 440, Long Beach, CA, 90840, United States, banafsheh.behzad@csulb.edu, Niloofar Bavarian, Sheena Cruz

We aimed to examine the minimum curriculum delivery levels of a school-based social-emotional and character development program needed to observe an impact on youth's internalizing and externalizing behaviors and outcomes, while controlling for known barriers to implementation fidelity by using a linear programming model.

5 - Considering Efficacy-based Objective Functions for Dorfman Style Pooling using a Combo Assay

Evan Mullins, Virginia Tech, 966 Nellie's Cave Road, Blacksburg, VA, 24060, United States, evanm@vt.edu, Ebru Korular Bish, Doug Bish

We derive performance metrics for a two-infection combo assay and develop an optimization model to capture classification accuracy with respect to a testing budget constraint and an optimization model that minimizes total cost to the testing center. We consider performance metrics influenced by the dilution effect and then modify them for the special case of no dilution effect. We propose three hypothetical sensitivity functions to quantify that quantify the dilution effect and analyze their effect on the performance metrics. The methodology is then evaluated by a numerical study based on for four distinct sub-groups.

6 - Optimal Budget Allocation for Infectious Disease Control

Hamideh Anjomshoa, IBM.Research Australia, 204 Lygon Street, Carlton, Victoria, 3124, Australia, hamideh.a@au.ibm.com, Manoj Gambhir, Roslyn Hickson, Olivia Jayne Smith

There are typically multiple possible intervention combinations that can be applied to control infectious disease outbreaks. We simulate the spatiotemporal disease transmission dynamics and subsequent impacts of intervention applications. We identify the optimisation framework to optimally allocate resources given the budgetary constraints which we demonstrate with a case study of dengue fever. The key challenge in this work is the nonlinear dynamics, combined with budget allocations between spatial regions.

■ SB14

332D

Stochastic Modeling in Healthcare Operations

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Carri Chan, Columbia Business School, New York, NY, 10027, United States, cwchan@columbia.edu

Co-Chair: Vahid Sarhangian, Columbia University, vs2573@columbia.edu

1 - Managing Patient Flow Dynamics in Internal Wards

Jing Dong, Northwestern University, 2145 Sheridan Road, Room C210, Evanston, IL, 60208, United States, jing.dong@northwestern.edu, Ohad Perry

We introduce a new class of queueing models that take into account the most salient features of patient flow dynamics in Internal Wards. We also develop efficient approximation techniques for long-run performance analysis, which greatly facilitate evaluating the effect of various operational policies.

2 - Data-driven Appointment-scheduling under Uncertainty: The Case of an Infusion Unit in a Cancer Center

Nikolaos Trichakis, MIT, 100 Main Street, E62-576, Cambridge, MA, 02143, United States, ntrichakis@mit.edu, Avishai Mandelbaum, Petar Momcilovic, Sarah Kadish, Ryan Leib, Craig Bunnell

We consider appointment scheduling under a time-varying number of servers, in a data-rich environment where service durations and punctuality are uncertain. Our data-driven approach, based on infinite-server queues, yields tractable and scalable solutions that accommodate hundreds of jobs and servers. We successfully test our approach against near-optimal algorithms, which exist for merely single-servers. To test for practical performance, we leverage a unique dataset from a cancer center, that combines real-time locations, electronic health records and appointments log. Focusing on one of the center's infusion units (~90 daily appointments, 25+ infusion chairs), we reduce cost by 30%.

3 - Designing Personalized Anticoagulation Therapy

Rouba Ibrahim, University College London, MS& I.department, UCL, Gower Street, London, WC1E 6BT, United Kingdom, rouba.ibrahim@ucl.ac.uk, Vedat Verter, Beste Kucukyazici, Michel Gendreau, Mark Blostein

We develop an analytical framework for personalizing the anticoagulation therapy of patients who are taking warfarin, and present results from a case study using data collected at the anticoagulation clinic of the Jewish General Hospital in Montreal.

4 - Dynamic Server Assignment in a Multiclass Queueing System with Shifts, with Application to Nurse Staffing in Emergency Departments

Vahid Sarhangian, University of Toronto, Toronto, ON, Canada, sarhangian@mie.utoronto.ca, Carri Chan

Nurse staffing decisions in emergency departments (EDs) are typically assigned weeks in advance, which can create staffing imbalances as patient demand fluctuates. In this work, we consider the potential benefits of assigning nurses to different areas within an ED at the beginning of each shift. We study the problem of optimal reassignment of nurses to areas by considering a multiclass queueing model of the system. We analyze an associated fluid control problem and use the solution to develop policies that achieve asymptotically optimal performance under fluid-scaling for the original stochastic system. We find this additional flexibility can substantially reduce waiting times for patients.

■ SB15

332E

Empirical Supply Chain Research

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Nitish Jain, London Business School, London, NW1 4SA, United Kingdom, njain@london.edu

1 - Estimating Consumer Preferences for Pooled Transportation

Kashish Arora, INSEAD, Fontaniebleau, France, kashish.arora@insead.edu, Karan Girotra, Fanyin Zheng

Marketplace operators run aggressive incentive schemes to achieve scale, that is key to the efficacy, survival and eventual domination of a marketplace. This study quantifies and compares the effect of incentives given to the "buyer" side and "seller" side using data from a leading ride-hailing market. We build a structural model to accurately capture the driver and passenger response to incentives, and the nature of incentives. Driver effort on the platform is unobserved, for which we devise a novel local matching model based imputation method. We find that in short-term (current week) passenger incentives are more effective while the opposite is true in the long-term (next 3 months).

2 - (DIS)Value of Information in a Supply Chain of Perishable Products

Ming Hu, University of Toronto, Rotman School of Management, 105 St. George Street, Toronto, ON, M5S.3E6, Canada, ming.hu@rotman.utoronto.ca, Peng Luo, Jiahua Wu

Our study is based on a data set from a fast-food restaurant chain. During the observation window, this restaurant chain switched from third-party POS systems to their own system, which allows them to gather real-time sales information from stores. We study store managers' adjustment of operational decisions in response to this change, as well as the resulting impact on customer satisfactions.

3 - Behavioral Drivers of Routing Decisions: Evidence from Restaurant Table Assignment

Fangyun Tan, Southern Methodist University, 6212 Bishop Blvd, Dallas, TX, 75275, United States, ttan@cox.smu.edu, Bradley R. Staats

In many settings, humans make routing decisions dynamically, either because algorithms don't exist, decision support tools have not been implemented, or existing rules are not enforced. Understanding how individuals make decisions creates the opportunity to identify both positive deviances, as well as suboptimal decision making that can be improved. In this paper we theoretically identify the factors that may impact decision making before empirically examining a large operational data set in a casual restaurant setting to research whether and how hosts deviate from their predefined round-robin rule to seat customers to servers.

4 - Empirical Analysis of Supply Network Relationship Concentration, Structure, and Firm Performance

Marcus A. Bellamy, Boston University, Rafik B. Hariri Building, 595 Commonwealth Avenue, Boston, MA, 02215, United States, bellamym@bu.edu, Soumen Ghosh, Manpreet Singh Hora

We examine the concentration and structural configuration of a firm's supply chain as drivers of its performance using supply chain relationship data from the Bloomberg database. We demonstrate how firm performance may be influenced by such drivers and how the industry context within which a firm operates augments their influence.

■ SB16

332F

Inventory Management

Contributed Session

Chair: Mustafa Hekimoglu, Isik University, Istanbul, Turkey, mustafa.hekimoglu@isikun.edu.tr

1 - Joint Replenishment and Transshipment for Three Locations - Asymptotics and Bounds

Weifen Zhuang, Associate Professor, School of Management, Xiamen University, Xiamen, 361005, China, wfzhuang@xmu.edu.cn

We study the problem of joint replenishment and transshipment for a retailer who sells seasonal products through three physical stores. The decisions involve the one-shot stocking at the beginning of the season and the supply/transshipment decision throughout the season. Applying an MDP formulation with compound Poisson demand processes, we identify the optimal policies. We then study two downward transshipment models and develop bounds, which are shown to be asymptotically optimal. We develop effective heuristics by making use of the bound solution. The bounds and heuristics can be extended to deal with the problem of multiple-location.

2 - Ordering and Transshipment Policies for a Healthcare System with Two Hospitals

Erhun Kundakcioglu, Ozyegin University, Faculty of Engineering, Nisantepe mah. Orman sok., Istanbul, 34794, Turkey, erhun@alumni.ufl.edu, Hamed Shourabizadeh

One of the most important challenges in healthcare systems is managing inventory. Depending on available capacity and average expiration dates, hospitals typically determine replenishment cycles without mathematical optimization. Our study focuses on determining optimal inventory levels that minimize the sum of inventory holding, ordering, and transshipment costs for a system of two hospitals. Hospitals can collaborate in the form of stock transfer and joint replenishment. Due to uncertain demand, hospitals are expected to benefit from a collaborative inventory model that increases the quality of care for patients (drug accessibility) and time between consecutive orders.

3 - Warehouse Storage Layout Optimization using Community Detection and Mathematical Modeling

Husam Dauod, PhD Student, Binghamton University, 99 Main Street, Apt 5, Binghamton, NY, 13905, United States, hdauod1@binghamton.edu, Sung Hoon Chung, Sang Won Yoon

This research presents a community detection approach to analyze and optimize warehouse storage layout in order picking environments. Storage layout is a key warehouse management function that greatly affects the overall performance. However, storage layout optimization is challenging because it requires the analysis of large amounts of orders data. To analyze this data efficiently, networks community detection is used to extract association relationships between items. These relationships are then used in a mixed integer programming model to determine optimal inventory locations. Results indicate that the proposed approach provide good results with short computational time.

4 - Dynamic Substitution Policy for Selling Multiple Products with Supply Uncertainty

Chengzhang Li, Purdue University, 2367 Edison Dr, West Lafayette, IN, 47906, United States, li1392@purdue.edu, Qi Feng, J. George Shanthikumar

We study a firm selling multiple substitutable products over a planning horizon of multiple periods. The firm faces replenishment cycles of fixed lengths with uncertain supply. In each period, when the random demands materialize, the firm may substitute one product with another in meeting the demands. Extending the notion of stochastic linearity, we show that the replenishment problem is concave via transformation. We design an efficient algorithm to decide the substitution policy that delivers close-to-optimal performance. We also show that restricting substitutions between products with adjacent characteristics can yield a benefit close to allowing full substitution among all products.

5 - Optimum Pricing and Inventory Control for Spare Parts in Existence of Secondary Markets

Mustafa Hekimoglu, Assistant Professor, Isik University, Sile Campus, Sile, Istanbul, 34980, Turkey, mustafa.hekimoglu@isikun.edu.tr, Rommert Dekker, Erwin Van der Laan

Secondary markets for spare parts are online platforms where Original Equipment Manufacturers (OEMs), distributors, customers can obtain spare parts with short lead times and for cheaper prices or they can dump their excess inventory. From an OEM's perspective, pricing against secondary market while controlling inventory is critical as higher prices may lead customers to secondary markets or even early phase-outs of their capital products. In this study, optimum policy for single period problem of pricing and inventory control is developed under linear demand model assumption. Also, we developed insights for multi-period problem under discounter cost criterion.

■ SB17

340A

Healthcare/Service Systems in Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Song-Hee Kim, University of Southern California, Los Angeles, CA, 90089, United States, songheek@marshall.usc.edu

1 - Dynamic Decision Making in a Queueing System with Secondary Service

Wanyi Chen, wanyic@live.unc.edu

Motivated by operational practices in emergency departments, we consider a queueing model where each job is one of two types. Type 1 jobs need only a primary service given by a single server. Type 2 jobs need an additional secondary service. Secondary service is conducted by infinitely many servers. Primary servers cannot serve a new job until secondary service of a job is over. Jobs incur waiting costs and there is an option of starting primary and secondary services together with an extra cost. The decision is whether or not to use that option for each job given the probability that the job is type 1. We show the optimal policy is of threshold-type and numerically test the performance of heuristic methods.

2 - Improving Itinerary Completion at a Destination Healthcare Institution

Jonathan Helm, Indiana University, Kelley School of Business, 1309 East Tenth Streeet, Bloomington, IN, 47405, United States, helmj@indiana.edu, Mark P.Van Oyen

At a destination hospital, patients travel long distances to receive treatment. For these patients, itinerary completion - defined as the completion of their treatment segment before the weekend - is an important metric. Motivated by itinerary completion, we present a new methodology for modeling and optimizing flows in a network of outpatient clinic visits to minimize flow times of priority patients within a queueing network with hard deadlines for service completion.

3 - A Real-time Risk Prediction and Discharge Optimization Framework for Inpatient Flow and Patient Outcomes

Pengyi Shi, Purdue University, 403 W. State St, Krannert School of Management, Kran 472, West Lafayette, IN, 47907, United States, shi178@purdue.edu, Jonathan Helm, Jivan Romain Deglise-Hawkinson, Julian Pan

Hospital discharge processes are critical to quality and access. Inpatient congestion can be mitigated by early discharge, which, however, carries risks of adverse events for individual patients. In collaboration with a healthcare analytics company, we develop a real time risk prediction model for readmission risk on each day of a patient's hospital stay. We integrate this prediction with a discharge optimization framework that balances the risk of early discharge for individual patients with the risks of inpatient congestion. In this talk, we present our methodology and discuss our joint implementation efforts at a partner hospital.

4 - Analysis of Hospital Networks via Time-Varying Fluid Models with Blocking

Noa Zychlinski, Technion - Israel Institution of Technology, Haifa, 3200003, Israel, noazy@tx.technion.ac.il, Avishai Mandelbaum, Petar Momcilovic, Izack Cohen

This research focuses on modeling, developing and analyzing time-varying fluid networks with blocking. These models are motivated by two applications. The first is patient flow analysis between hospitals and geriatric institutions in order to improve their joint operation. The second application includes analysis of tandem flow lines with blocking and finite waiting rooms before the first station, and between stations. The finite capacity of the first station leads to customer loss, and therefore, requires reflection analysis. We demonstrate that our models yield operational insights on network performance.

■ SB18

340B

Stochastic Networks and Queueing in Applied Probability IV

Sponsored: Applied Probability

Sponsored Session

Chair: Maria Vlasiou, Eindhoven University of Technology, P.O. Box 513, Eindhoven, 5600MB, Netherlands, m.vlasiou@tue.nl

Co-Chair: Bert Zwart, Eindhoven, 5629RD, Netherlands, Bert.Zwart@cwi.nl

1 - Effect of Presorting on the Delay in Multiclass Queues with a Global FCFS Service Discipline

Willem Mélange, Ghent University, Ghent, Belgium, Willem.Melange@UGent.be, Joris Walraevens, Dieter Claeys, Herwig Bruneel

We study the effect of presorting on the delay of a random customer in a continuous-time queueing system with two types of customers and dedicated servers. In this system, all arriving customers are accommodated in a single FCFS queue. All customers, except for the first P are served in a FCFS order, regardless of their types. The first P customers however can overtake customers of the other type in order to be served. The motivation for this work comes from traffic. Our results can be used to determine optimal lengths of filter lanes.

2 - Dynamic Control of Service Systems with Teams

Junqi Hu, Georgia Institute of Technology, Atlanta, GA, 30332, United States, hujunqi1210@gatech.edu, Sigrun Andradottir, Hayriye Ayhan

Consider a Markovian queueing network with two stations in tandem,flexible servers, finite intermediate buffer, and infinite supply of jobs in front of the first station. We assume that the servers always work in teams and allow the team service rates to be general. Our objective is to maximize the long-run average throughput by dynamically assigning servers to teams and teams to stations. We first establish sufficient criteria for eliminating inferior teams, and then we show how to find the optimal policy among the remaining teams. Finally, we investigate special cases with constraints on team formation and with structured team service rates.

3 - Strategic Customers in Systems with Batch Arrivals: On How to Protect Your Party

Olga Bountali, Southern Methodist University, 4210 Fairmount Street, Apartment 3063, Dallas, TX, 75219, United States, obountali@smu.edu, Apostolos Burnetas, Lerzan Ormeci

Customers in batch-arrival systems that are served individually vacillate upon the "join-balk" dilemma: should each member decide under the objective of maximizing his revenue or should they all aim to maximize the batch welfare? We consider a Markovian queue and address the question above under two rules with regards to the decision framework: the 0-1 case, where the whole batch decides to join or balk, and the partial case, where only a fraction of the customers joins. We analyze and compare the equilibrium behavior in both cases and the corresponding implications on the social welfare.

4 - Queueing Processes on a Random Graph
René Bekker, PhD, VU Amsterdam, Netherlands, r.bekker@vu.nl, Nicos Starreveld, Michel Mandjes

During this presentation we attenpt to develop a queueing model on a random graph. The queueing process at each node is following the dynamics of an infinite-server queue. The links between nodes (or the nodes themselves) evolve between up and down states according to some background process. Alternatively, the model can be interpreted as a network of infinite-server queues. The performance measures we study are the number of links that are up and the queue content at the nodes. We explicitly determine their moments, give a functional central limit theorem for the number of nodes that are up, and present more detailed results for fully symmetric random graphs.

■ SB19

342A

Empirical Research at OM/Finance Interface

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Volodymyr O. Babich, Georgetown University, Washington, DC, 20057, United States, vob2@georgetown.edu

1 - Supply Chain Implications of Shock Propagation and Systematic Risk
Jing Wu, City University of Hong Kong, Hong Kong, jing.wu@cityu.edu.hk, John R.Birge

In this talk, by leveraging supply chain data that is unstructured, incomplete, and highly complex, we show empirically the spill-over effects of moderate shocks transmitted to other connected firms in supply chains. We also show the systematic risk implications of the self-organized supply chain structure which cannot be explained by common risk factors.

2 - Stock Market Reaction to the 2015 Volkswagen Diesel Emission Scandal
Brian W. Jacobs, Michigan State University, 632 Bogue Street. Rm N370, East Lansing, MI, 48824, United States, jacobsb@bus.msu.edu, Vinod R. Singhal

Responsible sourcing is of increasing research interest, but what happens if your customer is not socially responsible? We examine the propagation of changes to shareholder value that emanated from the 2015 VW diesel emissions scandal, spread upstream in the supply chain, and horizontally to competitors and the diesel industry.

3 - Supply Chain Contagion in Credit Default Swap Market
Volodymyr O. Babich, Georgetown University, 37th & O.St NW, McDonough School of Business, Washington, DC, 20057, United States, vob2@georgetown.edu, Senay Agca, John R. Birge, Jing Wu

We present evidence for the existence of the supply-chain contagion channel in the Credit Default Swap (CDS) market, using event studies and diff-in-diff regressions, based on CDS, supply chain, and firm data from 2004 to 2014. The CDS spread up- (down-) jump in a supply chain is associated with CDS spread increase (decrease) for the reference firm. Supply-chain contagion extends to higher supply-chain tiers. We identify firm and supply chain attributes that contribute to CDS supply chain contagion. For example, older SC links, and links with stronger financial ties between customers and suppliers amplify contagion. We confirm results with robustness tests, e.g., placebo test with inactive links.

4 - Optimal Term Design for Supply Chain Finance
Xiaobo Ding, Johnson School, Cornell University, Ithaca, NY, United States, xd72@cornell.edu

Small suppliers are often cash-strapped due to long payment collection cycles and high credit rates. Supply chain finance, also known as reverse factoring (RF), is a popular instrument used in practice to address this problem. In this paper, we study the supplier's cash management problem under RF, and also quantify the value of RF to the supplier. We show that the optimal policy for the multi-period cash management problem is a modified (L,U) policy. We explain how RF creats a win-win-win situation for the supplier, the buyer and the bank. Moreover, our model can be used to inform the design of the optimal term for supply chain finance.

■ SB20

342B

Computational Research Methods and Applications in TIMES

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Hyunwoo Park, Ohio State University, 2100 Neil Ave, Columbus, OH, 43210, United States, park.2706@osu.edu

1 - A Bicentric Diagram Approach to Manage Interdependencies when Designing Complex Systems
Hyunwoo Park, The Ohio State University, Columbus, OH, United States, park.2706@osu.edu, Manuel Sosa, Rahul C. Basole

Complex systems are conceived as network of interconnected components. An important challenge for engineering managers is to identify the components that could potentially be affected if design changes affect two interdependent components. We introduce a novel approach, based on bicentric diagrams, to manage design changes of pairs of interdependent components of complex systems. We illustrate the use of our approach by applying it to the management of various critical technical interfaces during the development of large commercial aircraft engine.

2 - Prediction of Patient Activation During Technology Enabled Continuity of Care Intervention
Nitin Joglekar, Boston University, 595 Commonwealth Ave, Boston, MA, 02215, United States, joglekar@bu.edu, Carolyn Queenan, Kellas Ross Cameron

Patients' skills, knowledge, and motivation to actively engage in their healthcare are assessed with the Patient Activation Measure (PAM). We predict PAM as a function of the strength of information signals associated with telemedicine technology enabled care using a machine learning methodology. Predictions are shown to be subject to under/over estimation biases, consistent with the behavioral concept of system neglect in signal detection theory.

3 - Visual Business Ecosystem Intelligence: A Computer Vision Based Approach
Rahul C.Basole, Georgia Institute of Technology, School of Interactive Computing, 85 5th Street Nw, Atlanta, GA, 30332, United States, basole@gatech.edu

This study presents the application of computer vision, pattern recognition, and data visualization techniques for extracting, analyzing, and understanding image-based data of emerging business ecosystems.

4 - Business Model Innovation Feature Extraction and Application to the Lean Startup Framework
Christophe Pennetier, INSEAD, 6 Marina Boulevard, # 27-15, Singapore, 018985, Singapore, christophe.pennetier@insead.edu, Serguei Netessine, Karan Girotra

Using a new curated dataset with more than half a million startups, we use state-of-the-art text mining and machine learning techniques to identify business model innovations and study their effects on startups' success. We are the first to empirically study the lean startup approach.

■ SB21

342C

Computer Aided Medical Diagnosis

Invited: InvitedHealthcare Systems and Informatics

Invited Session

Chair: Juri Yanase, Complete Decisions, LLC, Baton Rouge, LA, 70810, United States, jurijuriy@aol.com

Co-Chair: Evangelos Triantaphyllou, Louisiana State University, Baton Rouge, LA, 70803, United States, etriantaphyllou@yahoo.com

1 - Translating Prediction to Decision: A Framework to Tackle Risk Identification and Presentation Challenges in Sepsis
Muge Capan, Christiana Care Health System, 902 N. Market Street, Apt 527, Wilmington, DE, 19801-3082, United States, Muge.Capan@ChristianaCare.org, Julie Simmons Ivy, Stephen Hoover, Kristen Miller, Jeanne Marie Huddleston, Ryan Arnold

Rising incidence and mortality rate make sepsis, a spectrum of acute organ dysfunction secondary to an infection, a significant burden on the healthcare system. While predicting sepsis-induced deterioration using electronic health records promises enhanced risk detection, translating findings into decisions is challenging. We present a framework to reengineer the risk presentation associated with sepsis and in-hospital mortality in septic patients.

2 - Computer-Aided Diagnostic Models for Breast Cancer Screening
Oguzhan Alagoz, University of Wisconsin-Madison, 3242 Mechanical Engineering Building, 1513 University Avenue, Madison, WI, 53706, United States, alagoz@engr.wisc.edu

Mammography is used for early breast cancer diagnosis however similarities between early signs of breast cancer and normal structures in images make diagnosis a difficult task. We have developed computer-aided diagnostic models and tested them using real-life mammography data. In this presentation, we describe our experiences, list the limitations of the existing CADx models, and provide possible future research directions.

3 - Constraint Relaxation Extensions for Imbalanced Classification
Talayeh Razzaghi, Assistant Professor, New Mexico State University, MSC 4230, P.O. Box 30001, Department of Industrial Engineering, Las Cruces, NM, 88003-8001, United States, talayehr@nmsu.edu, Onur Seref, Petros Xanthopoulos

In this work, we study several algorithmic modifications of relaxed support vector machines to tackle a number of disease diagnosis problems with imbalanced datasets in the presence of outliers. We provide computational evidence proving better performance for the combined use of cost sensitive learning with constraint relaxation compared to bagging-based algorithms, which treat imbalanced-ness and outliers separately.

4 - Current Trends and Challenges of Computer-Aided Medical Diagnosis
Juri Yanase, Complete Decisions, LLC, 10517 Springbrook Ave., Baton Rouge, LA, 70810, United States, jurijuriy@aol.com, Evangelos Triantaphyllou

Computer-aided diagnosis is already more than 50 years old and has entered a maturity stage. It offers certain advantages for employing information from big data and being consistent. It finds applications in a wide range of areas. However, some serious challenges persist and include the need to analyze ultra large volumes of data, and algorithmic, security, and legal liability issues.

■ SB22

342D

New Problems in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Georgia Perakis, Massachusetts Institute of Technology, Cambridge, MA, 02142-1347, United States, georgiap@mit.edu

1 - Optimizing Over Tree Based Ensemble Objective Functions
Max R. Biggs, Massachusetts Institute of Technology, 77 Massachusetts Ave NE49-40497, Apartment 2, Cambridge, MA, 02139, United States, maxbiggs@mit.edu

In many real world applications, there is an unknown relationship between decisions and outcomes. For example, we might have data on previous actions taken in different situations, and observe outcomes. Using this data, there are powerful machine learning algorithms which can be used to build a predictive model. However, there has been little attention on how to make decisions if we fit a tree based ensemble model and use it as our objective function. We will show that this optimization problem can be modeled as a MILP, and present tractable decompositions and heuristics. We apply this methodology to a jury selection problem, where there is uncertainty as to how a juror will influence the jury.

2 - Stochastic Probing to Maximize the Value of Diagnostic Information
Mathieu Dahan, MIT, Cambridge, MA, United States, mdahan@mit.edu, Saurabh Amin, Georgia Perakis

We consider an adaptive probing problem to maximize the detection of failures in infrastructure networks. We study a stochastic programming model which accounts for the spatial distribution of alerts, including relative distances between locations and predictive accuracy of failure events within each location. Our result shows how to optimally sequence the probing of locations based on the tradeoff in exploiting a given location versus exploring other locations. We connect our work with recent literature on stochastic orienteering. Finally, we apply our approach to improve the value of diagnostic information for a regulated gas utility who invests in leak surveys to detect network failures.

3 - Submodular Batch Scheduling for Warehouse Picking
Daniel Chen, Massachusetts Institute of Technology, Cambridge, MA, United States, dcchen@mit.edu, Retsef Levi, Georgia Perakis

We describe theoretical and data-driven work in collaboration with an online retailer. In a warehouse, multi-item orders take up capacity on a wall until all items are picked. To avoid exceeding capacity, the retailer must balance picking efficiency with completing orders quickly. Motivated by this, we model an NP-hard batch scheduling problem to minimize average order completion times, where the processing time of each batch is given by a submodular function, generalizing previous problems in the literature. We provide integer programming formulations and approximation algorithms, and testing on a data-driven simulation suggests a potential 15% reduction in the time orders stay at the wall.

■ SB23

342E

New Models in Pricing and Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Sandun Perera, PhD, University of Michigan-Flint, 2200 Riverfront Center, 303 East Kearsley Street, Flint, MI, 48502, United States, sperera@umich.edu

1 - Multi-product Pricing with Stockouts and Satisficing Customers
Varun Gupta, Penn State Erie, The Behrend College, 5101 Jordan Rd, Burke 281, Erie, PA, 16563, United States, vxg15@psu.edu, Metin Cakanyildirim

Stockouts for high inventory turnover products lead to loss of sales as customers may substitute their preferred product (stocked out) with another product (available). We study centralized pricing for a retailer and equilibrium prices for competing retailers selling to satisficing customers with stockout-based substitution under lost sales and backorders.

2 - Dynamic Pricing and Replenishment for Seasonal and Regular Products
Oben Ceryan, LeBow College of Business, Drexel University, 2040 Market St. Apt. 801, Philadelphia, PA, 19103, United States, oceryan@drexel.edu

We consider a firm that offers two substitutable products that differ in how their inventories are managed, a seasonal product with a fixed initial quantity that allows dynamic price adjustments but no replenishments, and a regular product with a static price that can be periodically replenished. We study the impact of these asymmetries on optimal dynamic pricing and replenishment decisions.

3 - Dynamic Pricing to Explore Markets with Customer- and Time-heterogeneity
Meng Li, Rutgers University, 227 Penn Street, Camden, NJ, 08102, United States, meng.li@rutgers.edu, Bora Keskin

Consumers are often heterogeneous in their preferences for product quality, and companies usually face uncertainty about consumer preferences when they sell differentiated products to such heterogeneous consumers. We study this problem in a situation where a company dynamically optimizes its prices.

4 - Optimizing Starvation to Avoid Cannibalization: Retailer's Strategies for Markets in Crisis
Sandun Perera, School of Management, The University of Michigan-Flint, 2200 Riverfront Center, 303 E. Kearsley Street, Flint, MI, 48502-1950, United States, sperera@umich.edu, Syagnik Banerjee, Metin Cakanyildirim

At times of crisis and disaster, donors often pay for necessary commodities distributed via local retailers. Retailers need to set prices that balance the tradeoffs between vulnerable customer needs and their ability to pay. We study this pricing problem under different market conditions.

■ SB24

342F

Pricing and Consumer Experience in Behavioral and Service Settings

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Sami Najafi-Asadolahi, Santa Clara University, Santa Clara, CA, 95053, United States, snajafi@scu.edu

1 - Why Markdown as a Pricing Modality? the Role of Threat of Entry
Elodie Adida, University of California Riverside, Riverside, CA, United States, elodieg@ucr.edu, Ozalp Ozer

Markdown as a pricing modality is ubiquitous in retail. Despite its practical advantages everyday-low-price is rarer. We explore whether and why either of these pricing modalities is an effective defense against a firm that enters the market with the alternative pricing modality when consumers are heterogeneous, strategic and regret-prone.

2 - Patient's Waiting Experience in an Urban Emergency Department
Sina Ansari, Northwestern University, McCormick School of Engineering, 2145 Sheridan Road, Evanston, IL, 60208, United States, sinaansari2013@u.northwestern.edu, Seyed Iravani, Laurens G.Debo

Excessive wait time is the most common reason patients become unsatisfied and leave the emergency department before being treated. In this study, we aim to study the impact of announcing patient's waiting times and operational transparency on patients satisfaction and Left-Without-Being-Seen (LWBS) rate.

3 - How Freemium Gets Consumers to Pay a Premium: The Role of Loss-Aversion
Sami Najafi Asadolahi, Assistant Professor, Santa Clara University, Leavey School of Business, 500 El Camino Real. Lucas Hall, Santa Clara, CA, 95053, United States, snajafi@scu.edu, Nishant Mishra, Sajjad Najafi, Andy A.Tsay

We consider a firm offering two versions of a single product: a basic version for free and a premium version at a positive price. Consumers are heterogeneous and loss-averse with, stochastic and endogenous reference points. Each consumer first uses the free version, which enables him to understand the value of both the free and premium versions; he then decides whether to buy the premium version. The firm maximizes its expected profits by setting the best price for the premium. We show that after using the free version, the consumer is less likely to buy the premium version if the realized free version's value is unexpectedly high but more likely to buy if the realized free version's value is unexpectedly low.

■ SB25

350A

Managing Incentives in Collaborative New Product Development

Invited: New Product Development

Invited Session

Chair: Timofey Shalpegin, University of Auckland, Auckland, 1010, New Zealand, t.shalpegin@auckland.ac.nz

1 - Incentivizing R&D for Neglected Diseases
Rongrong Luo, SUTD, SIngapore, Singapore, rongrong_luo@mymail.sutd.edu.sg

Many developing countries grapple with neglected diseases due to a lack of effective/safe biopharmaceutical treatments. The world health organization calls on non-government organizations (NGOs), and biopharmaceuticals to act in concert to eliminate neglected diseases. We model the interaction between an NGO, an Innovator and a Marketer. First, we characterize the conditions for a disease to be neglected in the absence of incentives. Subsequently, we evaluate the effectiveness of different incentive mechanisms in inducing collaboration to bring products targeting neglected diseases to market.

2 - Rights of First Negotiation and Rights of First Refusal in New Product Development Partnerships
Shantanu Bhattacharya, Singapore Management University, Lee Kong Chian School of Business, 50 Stamford Road, Singapore, 178899, Singapore, shantanub@smu.edu.sg, Guangyu Wan, Sameer Hasija, Niyazi Taneri

This paper considers a new product partnership between a pharmaceutical firm (Pharma) and a biotechnology firm (Biotech). The partnership involves collaboration in the early phase of the R&D process, when uncertainty about valuation makes designing a licensing contract challenging. In practice, right of first negotiation (ROFN) and right of first refusal (ROFR) contracts are used to manage future uncertainty that can be resolved over time. We build a principal-agent model where the Biotech as the principal designs a contract including a possible upfront fixed fee and a ROFN or ROFR clause for the future licensing of the drug candidate, and identify the situations where each clause is appropriate.

3 - Effect of Incentive Design on of Location Decision of Product Development of Teams
Sara Rezaee Vessal, HEC Paris, Paris, 91570, France, sara.rezaee-vessal@hec.edu, Svenja C. Sommer

To successfully compete on an international scale, multinationals increasingly turn towards globally dispersed product development teams, both to draw on a diverse set of expertise and to access more accurate local knowledge. However, dispersion also creates additional challenges for collaboration, which can have negative effects on project performance. In this study, we compare dispersed and co-located teams and address the question how to incentivise them. We show that despite the current trend among firms, geographically dispersed teams are not always the optimal structure, especially when collaboration is in the form of information sharing.

4 - Outsourcing Component Development for New Products to External Suppliers
Timofey Shalpegin, University of Auckland, ISOM, Business School, The University of Auckland, Auckland, 1010, New Zealand, t.shalpegin@auckland.ac.nz

New products sometimes fail due to failure of their key components developed by external suppliers. We find that some common contracts between manufacturer and suppliers cannot provide sufficient incentives for the suppliers to ensure high (first-best) component quality. We propose a contract that creates right incentives for the suppliers.

5 - Risk Taking in Organisations: An Evolutionary Approach
Antoine Feylessoufi, University of Cambridge, Christ's College, Cambridge, CB2 3BU, United Kingdom, af545@cam.ac.uk, Daniel Ralph, Stylianos Kavadias

Through social interactions, the behaviour of an individual is affected by the population but also influences the other members within that population. In a new approach to capture this effect on risk taking in organisations, we incorporate notions of prospect theory into an evolutionary game theoretic model widely used in biological ecosystems. We find that unexpected and extreme levels of risk taking behaviour (or lack thereof) can emerge in organisations through this mechanism. Moreover, it may drive all employees to risk taking behaviour even when this is discouraged through a firm's reward system. We describe how some successful ventures and collapses can be explained by this model.

■ SB26

350B

Stochastic Approaches: Methods and Application

Invited: Data Envelopment Analysis

Invited Session

Chair: Andrew L. Johnson, Texas A&M University, College Station, TX, 77843-3131, United States, ajohnson@tamu.edu

1 - Markup Size, Export Tax Rebates, and Resource Misallocation
Mahmut Yasar, myasar@uta.edu

The paper provides an analysis of the allocation effects of the export tax rebate policy. We first add a tax rebate to the Melitz and Ottaviano (2008) model and examine the impact of this policy on firms' markup size and resource allocation. We then use customs transactions, tax administration, and firm-level data to measure the effect of variation in export tax rebates. We find that an increase in tax rebates shifts production to eligible firms and that "more fully" refunding export VATs increases allocative efficiency.

2 - Models with Ratio Measures & Potential Ratio Inefficiency
Ole Bent Olesen, University of Southern Denmark, Odense, Denmark, ole@sam.sdu.dk, N.C. Petersen, Victor Podinovski

In a recent, the authors developed a methodology that allows the incorporation of ratio inputs and outputs in the variable and constant returns-to-scale DEA models. Practical evaluation of strong and weak efficiency of decision making units (DMUs) in such models generally goes beyond the application of standard linear programming techniques. In this paper we discuss how the DEA models with ratio measures can be solved and introduce a new type of potential ratio (PR) inefficiency. It characterizes DMUs that are strongly efficient in the model of technology with ratio measures but become inefficient if the volume data used to calculate ratio measures become available.

3 - Estimating Firm Specific Efficiency in Stochastic Frontier Models
John Ruggiero, University of Dayton, Dayton, OH, United States, jruggiero1@udayton.edu

Production frontiers are estimated using either maximum likelihood or the method of moments when errors are composed of statistical noise and inefficiency. Firm level efficiency has been estimated using a conditional expectation of inefficiency given observed overall error. In this paper we discuss the limitations of this measure and provide an alternative estimator.

4 - Shape Constrained Estimation of Production Functions
Andrew L. Johnson, Houston, TX, 77030, United States, ajohnson@tamu.edu

Nonparametric estimation methods avoid functional form misspecification. However, the flexibility of nonparametric methods often cause difficulties in interpreting production function estimates. However, microeconomic theory provides additional structure for modeling a production or cost function which can be interpreted as shape constraints. Several nonparametric shape constrained estimators have been proposed that combine the advantage of avoiding functional misspecification with improving the interpretability of estimation results. We will review the recent work by our research team in this area.

■ SB27

350C

Behavioral Analytics

Invited: Social Media Analytics

Invited Session

Chair: Tauhid Zaman, MIT, Cambridge, MA, 02114, United States, zlisto@gmail.com

1 - Building a Location-based Set of Social Media Users

Tauhid Zaman, MIT, 6 Whittier Place, Apt 8M, Boston, MA, 02114, United States, zlisto@gmail.com, Christopher Marks

We introduce a method for producing a set of social media users from a specified location. Building on existing methods for identifying user locations, network search, and community detection, we propose an expand-classify methodology which recursively collects users based on their connections, and then classifies the users according to a factor graph model. This factor graph model accounts for the implications of both observed user profile features and social network connections in inferring location. Using geo-located Twitter data for evaluation, we find that our method typically outperforms Twitter's native user search in producing a location-based set of users.

2 - Determining Group Membership using Social Media Activity Patterns

Matthew Robert Webb, US.Army, 361 Beacon Street, Apt.1, Boston, MA, 02116, United States, mrwebb@mit.edu

We propose a novel classification algorithm to determine a user's group membership based on the time series of his or her social media posts and the user's location. We do this by comparing the user's pattern of activity to that of a known group. We apply our method to the class of Muslim users whose prayer activity is determined by the position of the Sun in relation to the horizon at a location. By assuming Muslim users do not utilize social media during these prayers, we are able to infer the religious affiliation of unknown user accounts.

3 - Predicting Performance under Stressful Conditions using Galvanic Skin Response

Tauhid Zaman, PhD, MIT Sloan, Cambridge, MA, United States, zlisto@mit.edu, Carter Mundell, Juan Pablo Vielma

We show that the biological signal known as galvanic skin response (GSR) allows one to predict a subject's performance under stress. We conduct an experiment where subjects answer arithmetic questions under different stress conditions while having their galvanic skin response monitored. Using only the GSR measured under low stress conditions, we are able to predict which subjects will perform well under high stress conditions, achieving an area under the curve of 0.76. Without using GSR, we do no better than random guessing.

4 - Modeling Dynamic user Engagement for Online Gamers

David Scott Hunter, MIT, dshunter@mit.edu

We propose a new model for user engagement based on online gameplay data. Our model clusters users into varying groups, where each group corresponds to differing gameplay behaviors. Using these clusters, we are able to construct an engagement score that allows us to accurately predict whether or not a user will buy the next version of the game.

■ SB28

350D

Mechanism Design and Applications

Invited: Auctions

Invited Session

Chair: Brian Baisa, Amherst College, Amherst, MA, 01002, United States, bbaisa@amherst.edu

1 - Post Efficient Auctions and English Auctions for Bidders with Non-Quasilinear Preferences

Brian Baisa, Amherst College, Converse Hall, Office 211, Amherst, MA, 01002, United States, bbaisa@amherst.edu

We study efficient auction design for a single indivisible object when bidders have interdependent values and non-quasilinear preferences. When the object being sold is a good, there is an efficient ex post implementable mechanism if there is an efficient ex post implementable mechanism in a corresponding quasilinear setting. This result extends results on efficient ex post equilibria of English auctions with quasilinearity to our non-quasilinear setting. However, in procurement settings there is no mechanism that has an ex post efficient equilibrium if the level of interdependence between bidders is sufficiently strong.

2 - Optimal Quantity Caps in Discriminatory Price Auctions with Resale

Justin Burkett, Wake Forest University, 1834 Wake Forest Road, Department of Economics, Winston-Salem, NC, 27106, United States, burketje@wfu.edu, Brian Baisa

We present a model of a discriminatory price auction in which a large bidder competes against many small bidders, followed by a post-auction resale stage in which the large bidder is endogenously determined to be a buyer or a seller. We extend first-price auction with resale results to this setting and give a tractable characterization of equilibrium behavior. We use this to study the policy of capping the amount that may be won by large bidders in the auction. Despite being used in the US Treasury auction among others, this policy has received little attention in the auction literature.

3 - Optimal Auction Design in the Presence of Competition

Mallesh Pai, Rice University, Department of Economics, MS-22, Rice University P.O. Box 1892, Houston, TX, 77251-1892, United States, mallesh.pai@rice.edu

I study the design of the optimal auctions in the presence of competition. Using the theory of mathematical programs with equilibrium constraints, I study the problem of a seller whose competitors have committed to using second price auctions. I provide necessary conditions on the distribution of buyer values for this seller's optimal auction to be a second price auction with a reserve. The conditions are strict weakenings of Myerson's increasing virtual value condition.

4 - Sample Complexity of Multi-item Profit Maximization

Tuomas W. Sandholm, Carnegie Mellon University, Gates Center for Computer Science, Pittsburgh, PA, 15213, United States, sandholm@cs.cmu.edu, Maria-Florina Balcan, Ellen Vitercik

In multi-item settings, it is typically unrealistic to assume the designer has a prior over buyers' valuations. We analyze revenue-maximizing sales mechanisms when the designer has samples from the prior, introduced by Likhodedov and Sandholm in AAAI-04. We provide generalization guarantees that bound the difference between profit on the sample and profit over the prior. Our overarching theorem uses Rademacher complexity to measure intrinsic complexity of widely-studied single- and multi-item auction classes. It also applies to linear and non-linear single- and multi-item pricing. Furthermore, it enables one to determine the optimal complexity in mechanism hierarchies.

■ SB29

350E

New Methods and Algorithms in Artificial Intelligence

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Bradley Walls, University of Arizona, Tucson, AZ, 8, United States, blwalls@email.arizona.edu

1 - Machine Learning Methods to Tease Out Hidden Patterns in Hierarchical Data

Praveen Pathak, University of Florida, 8325 SW. 16th Place, Gainesville, FL, 32607, United States, praveen@ufl.edu

We use Machine Learning methods to tease out hidden patterns in hierarchical data and forecast an outcome characterized by high dimensionality. Our methods outperform comparable statistical models and are robust in dealing with sparse data. We offer insights on extending the technique problem domains were the outcome is based on a model of effects characterized by high dimensionality.

2 - Optimal Regression Trees

Jack Dunn, Massachusetts Institute of Technology, 24 Hardwick St, Unit 1, Cambridge, MA, 02141, United States, jackdunn@mit.edu, Dimitris Bertsimas

Decision tree methods are widely used for regression problems, but one must choose between methods that are interpretable (such as CART) and those with high accuracy (random forests or boosting). We introduce a new approach for constructing Optimal Regression Trees based on mixed-integer optimization, and develop high-performance heuristics for these problems that offer significant improvements over traditional greedy approaches and run in comparable times. We show in a collection of synthetic and real-world instances that our Optimal Regression Trees improve substantially over CART and related methods such as Random Forests, delivering high-accuracy solutions that are interpretable.

3 - Fuzzification of Sorting for Multiple Combinatorial Optimization Applications

Paul Eugene Coffman, Technical Leader, Ford Motor Company, 6100 Mercury Drive, Dearborn, MI, 48126-2746, United States, gcoffman@ford.com, Stephany Coffman-Wolph

Many efficient heuristics for combinatorial algorithms (e.g., bin packing, knapsack, and queueing) rely on fast sorting algorithms. Using an established three-step framework for the fuzzification of algorithms, sorting algorithms can be converted into fuzzy sort algorithms. These "fuzzy" sort algorithms often provide computational improvements with minimal acceptable trade-offs, yielding "good enough" solutions. Extending selected traditional heuristic algorithms with fuzzy sorting should generate acceptable solutions faster than the base algorithms for these problems types.

■ SB30

350F

Social Media Analytics for Healthcare Improvement I

Invited: Social Media Analytics

Invited Session

Chair: Shu He, University of Illinois at Urbana-Champaign, Urbana, IL, 61802, United States, shuhe2@illinois.edu

1 - Big Data Analytics for Text-based Data in Healthcare: A Review and Research Directions

Priya Nambisan, University of Wisconsin - Milwaukee, Northwest Quadrant Building B, Rm #6410, 2025 East Newport Avenue, Milwaukee, WI, 53201, United States, nambisap@uwm.edu

Many recent studies have focused on developing algorithms for analyzing text based health data such as patient postings on social media, physician notes, etc. However, it is not clear whether these studies are contributing to healthcare research or to research on algorithm development. In this study, 40 papers in this topic were systematically analyzed to evaluate the effectiveness of the algorithms to analyze text based data and to determine the relevance of the findings for the healthcare domain. Based on the analysis, several limitations of these studies are identified and future research directions are discussed.

2 - The Effectiveness of Social Media-enabled Patient Communities on Health Goal Attainment: An Approach of Survival Analysis

Jiahe Song, Assistant Professor, Western Michigan University, Kalamazoo, MI, United States, carrie.song@wmich.edu, Pei Xu

This study explores how social media-enabled patient communities affect health goal attainment. Applying social cognitive theory, we studied the online antecedents of goal attainment from the respects of social support and self-reflection. A survival analysis was applied to a unique dataset of patients' interactions and goal progress. Findings indicate that the two social support factors, informational and emotional support, have opposite effects (direct and buffering) on goal attainment. The two self-reflection factors, verbal and leisure update, also affect the possibility of goal attainment oppositely. The research provides important implications to online disease self-management.

3 - Expanding the Reach of Humanitarian Organizations on Social Media

Eunae Yoo, Arizona State University, Tempe, AZ, United States, eunae.yoo@asu.edu, Elliot Rabinovich, Bin Gu

Humanitarian organizations have been using social media to broadcast important messages to their stakeholders. On social media, a user's follower count typically represents the user's audience size, or reach. We explore the mechanisms that drive follower growth for organizations involved with disaster relief using a large data set from Twitter during the 2016 Ecuador earthquake. Our data capture the dynamic nature of the user network one week before and after the disaster, and we find that the follower bases of the organizations in our sample increase dramatically after the earthquake.

4 - The Nature of Connections on Twitter and its Dynamics

Youngsoo Kim, Singapore Management University, School of Information Systems, 80 Stamford Road, Singapore, 178902, Singapore, yskim@smu.edu.sg

Twitter is one of the leading social network sites (SNS). Prior studies have mainly focused on social networking behavior or information diffusion process on Twitter. By contrast, this study explores (1) the network formation (link connection with the focus on the network structural format), (2) the nature of link (online versus offline relationship) and its impact on communication frequency, and (3) the dynamics of homophily and interaction over time.

■ SB31

351A

Nicholson Student Paper Competition II

Invited: Nicholson Student Paper Prize

Invited Session

Chair: Cole Smith, Clemson University, 110 Freeman Hall, Clemson, SC, 29634, United States, jcsmith@clemson.edu

Co-Chair: Hayriye Ayhan, Georgia Institute of Technology, School of Industrial & Systems Eng, 755 Ferst Dr NW, Atlanta, GA, 30332-0205, United States, hayhan@isye.gatech.edu

Co-Chair: Sergiy Butenko, Texas A&M University, 4037 Emerging Technologies Building, Mail Stop 3131, College Station, TX, 77843-3131, United States, butenko@tamu.edu

1 - Minimizing Multimodular Functions and Allocating Capacity in Bike-sharing Systems

Daniel Freund, Cornell University, 109 Lake St, Ithaca, NY, 14850, United States, df365@cornell.edu

We consider the strategic question of how to (re-)allocate dock-capacity in bike-sharing systems. We develop mathematical formulations for variations of this problem and exhibit discrete convex properties in associated optimization problems. This allows us to design a polynomial-time allocation algorithm that can handle constraints such as a limit on the number of docks moved in the system. We apply our algorithm to data sets from Boston, New York City, and Chicago.

2 - Learning Preferences with Side-information

Andrew A. Li, Massachusetts Institute of Technology-ORC, 77 Massachusetts Avenue, Bldg. E40-149, Cambridge, MA, 02139, United States, aali@mit.edu

Product and content personalization is now ubiquitous in e-commerce. Companies seek to use a variety of information on the interactions between a product and a customer to drive personalization decisions. We formalize this problem as one of recovering a large-scale matrix, with side information in the form of additional matrices of conforming dimension. We provide an efficient algorithm that is practical for massive datasets and demonstrate its performance on data from a music streaming service.

3 - Tight Weight-dependent Competitive Ratios for Online Edge-weighted Matching, with Application to Revenue Management

Will Ma, Massachusetts Institute of Technology, Cambridge, MA, Contact: willma353@gmail.com

Online bipartite matching is a classical problem in the study of online algorithms. These problems can be abstracted as follows: there are fixed resources that must be allocated on-the-fly, without knowledge of future demand. This talk studies the generalizations of these problems when each resource could be sold at multiple, known prices. We show how to generalize the algorithms to accommodate multiple prices, and achieve a tight competitive ratio under the integral or asymptotic settings.

4 - Computationof the Bootstrap: Complexity, Exact Algorithms, and Deterministic Approximations

Bradley E. Sturt, Massachusetts Institute of Technology, Somerville, MA, Contact: bsturt@mit.edu

The bootstrap is a randomized method for calculating quantities, such as confidence intervals, directly from data. Because variability from randomization can lead to inaccurate outputs, we propose a deterministic approach. We present computational complexity results for the bootstrap method and the first FPTAS for the bootstrap method. We demonstrate that the algorithms run fast in practice and produce bootstrap confidence intervals that are more accurate compared to traditional methods.

■ SB32

351B

Drone Delivery Systems - II

Invited: InvitedDrone Delivery Systems (tentative title)

Invited Session

Chair: Chase Murray, University at Buffalo, Amherst, NY, 14260-2050, United States, cmurray3@buffalo.edu

1 - Establishing Energy Efficient Paths for Delivery Drones in Direction Dependent Uniform Wind-Fields

Abhishake Kundu, Texas Tech University, Dept of Ind Eng, Box 43061, Lubbock, TX, 79409-3061, United States, abhishake.kundu@ttu.edu, Tim Matis

The purpose of this research is to propose an efficient minimum-energy path planning algorithm that combines global and local waypoints for parcel delivery using drones. Constraints on turn rate and turn acceleration is considered for the vehicle with limited battery power, flying in a uniform wind-field on the horizontal plane. The minimum energy path of the delivery drone pursues Dijkstra's arcs subject to curvature constraints for transitional headings, in contrast to minimum time traversal route that follows a Dubins path.

2 - The Customer-centric Vehicle Routing Problems with Drones

Mohammad Moshref-Javadi, PhD Candidate, Purdue University, 315 N. Grant St., Room 324E, West Lafayette, IN, 47907, United States, moshref@purdue.edu, Seokcheon Lee

This research proposes a new drone delivery system that focuses on minimizing the total waiting time of recipients. In this delivery system, a single truck takes drones and supplies and follows a route to visit some demand locations or dispatch the drones to customers for package delivery. The truck and drones can work in parallel, that is, the truck does not have to wait for the drones to return to the truck at the same location. We also compare this system with a static system in which the truck has to wait for the drones to return to the truck at the same location. This drone delivery system is specifically useful for disaster relief logistics and customer-oriented commercial systems.

3 - Augmenting a Truck with a Drone for Parcel Delivery

John Gunnar Carlsson, University of Southern California, 3750 McClintock Avenue, Los Angeles, 90089, United States, jcarlsso@usc.edu

Abstract We determine the efficiency of a delivery system in which an unmanned aerial vehicle (UAV) provides service to customers while making return trips to a truck that is itself moving. In other words, a UAV picks up a package from the truck (which continues on its route), and after delivering the package, the UAV returns to the truck to pick up the next package.

4 - Drone Delivery with Time Dependent Travel

Chase Murray, University at Buffalo, Dept of Industrial & Systems Engineering, 309 Bell Hall, Amherst, NY, 14260-2050, United States, cmurray3@buffalo.edu

A new variant of drone delivery problems is presented. In this problem, multiple drones are available to support last-mile delivery of small parcels. The drones coordinate with a single delivery truck. Travel times for the truck are time-of-day dependent. A mathematical programming formulation is described, as well as a heuristic approach for solving this problem.

■ SB33

351C

AAS Best Student Presentation Competition I

Sponsored: Aviation Applications

Sponsored Session

Chair: Virginie Lurkin, Ecole Polytechnique Fédérale de Lausanne, Route Cantonale, Lausanne, 1015, Switzerland, vlurkin@ulg.ac.be

Co-Chair: Peng Wei, Iowa State University, Ames, IA, 50011, United States, pwei@iastate.edu

1 - Predicting Performance of Traffic Management Initiatives

Alexander Estes, University of Maryland, 3802 Calverton Blvd, Apartment 25, Beltsville, MD, 20705, United States, aestes@math.umd.edu

The Federal Aviation Administration uses traffic management initiatives to manage excess demand for resources in the national airspace system. We present methods for estimating the performance that a given traffic management initiative will produce under a given set of weather and traffic conditions. These methods combine a weighting scheme from Geographic Weighted Regression with forest-based regression methods. Estimates of the conditional density can be produced along with standard regression estimates.

2 - Probabilistic Modeling of Airline Network Evolution

Reed Harder, Dartmouth, 14 Engineering Drive, Hanover, NH, 03755, United States, reed.haseltine.harder.TH@dartmouth.edu

Airline networks evolve as airlines enter and exit segments, based on the profitability of the routes related to this segment, competitive considerations, and the function of a given segment in the overall network. However, forecasting such segment entry and exit remains challenging due to the complexity of the air transportation system and the relative sparsity of entry and exit data. We present and compare probabilistic methods for predicting segment entry and exit by an airline, using data on past airline operations, network structure, and regional demographics.

■ SB34

351D

Operations Research and Cyber

Sponsored: Military Applications

Sponsored Session

Chair: Andrew Oscar Hall, United States Military Academy, West Point, NY, 10996, United States, andrew.hall@usma.edu

1 - A Sequential Weighted Laplacian Regularized Optimal Design of Experiments for Response Surface Modeling of Expensive Tests

Stanford Martinez, Graduate Research Assistant, University of Texas at San Antonio, San Antonio, TX, United States, ddfe530tx@gmail.com, Adel Alaeddini

In the design of experiments, space-filling methods can be used to reduce the number of tests needed to learn the response surface intrinsic to an experiment. Classical methods include preset designs that only take into account currently measured samples. Laplacian regularization adds a penalty term that will allow the learning of the interconnectivity of both measured and unmeasured data. In addition, further weighting can be applied using weighted regression techniques to mitigate effects of outliers present in an experiment. The effects of these two additions to the classical form of optimal experimental design will be compared to other methods in terms of performance and practicality-of-use.

2 - Critical Nodes in Interconnected Networks

Venkat Venkateswaran, Georgia Institute Of Technology, Room 4143, 800 West Peachtree, NW, Atlanta, GA, 30308, United States, venkat.venkateswaran@scheller.gatech.edu

We consider a system of interconnected networks. Initial damage to nodes can have far-reaching effects through cascading failures. We develop the methodology to identify nodes that may produce various levels of network degradation through such cascading. Computational results from sample test problems are presented.

3 - Queue Inference with Uncertain Observations

Andrew Keith, PhD Student, USAF, Dayton, OH, 45433, United States, andrew.keith@afit.edu, Darryl K. Ahner

Although the effect of various queue types on system performance has been well studied, the internal structure and parameters of a queuing system of interest may be completely unobservable in military and competitive commercial applications. Furthermore, external input and output information may be observable but subject to substantial uncertainty due to measurement error in the adversarial environment. This analysis quantifies the uncertainty in arrival and departure times, which are then used to estimate the number of servers and service rates of an internally unobservable GI/G/c queue.

■ SB35

351E

Supply Chain Management

Contributed Session

Chair: Juhi Bhardwaj Sapra, Rensselaer Polytechnic Institute, Troy, NY, United States, bhardj@rpi.edu

1 - The Interactive Effects of User Generated Contents on the Determinants of Tourist Destinations Strategies

Jinjin Xu, Tianjin University, Tianjin, China, x_jinjin@outlook.com, Liming Zhao

Vigorous development of tourism industry and sharing economy has led to fierce competition among China's tourist destinations, which accelerates tourism organizations to re-evaluate their competitive strategies. This study conducted from a strategy perspective and contributes both theoretically and practically to the tourism literature by validating artificial neural network model to investigate the relationships among user generated content and tourist destinations strategies. The empirical findings reveal four hidden nodes that have a significant impact on tourist destination performance.

2 - A Perspective of Managerial Cognitive Capability on Orchestration of Corporate Brand

Tzu-Hsuan Lin, PhD Student, National Taiwan University, Taipei, Taiwan, D00724004@ntu.edu.tw, Ming-Huei Hsieh

Through the perspective of managerial cognitive capability, this paper contributes to the hanging paradox of corporate branding - continuity versus change. It presents a process model regarding the interplay between the CEO's managerial cognitive capabilities and organizational strategic change based on 21 brands launching in four case studies - Franz Collection, Gloria Hotel, Johnson Health Tech., and Tayohya Home Fashion. The findings underscore the criticality of the CEO's dominant logic on sculpting and leveraging the corporate brand identity in concerto with product brand to achieve evolutionary fit.

3 - Diversification and Diagonal Integration: New Strategies for the Internet-of-things Landscape

Suri Gurumurthi, Hong Kong University of Science and Technology, 10707 Flaxton Street, Culver City, CA, 90230, United States, suri.gurumurthi@gmail.com

The supply chain strategy literature provides terminology and a conceptual framework for firms as they navigate towards positions of greater competitive advantage within their industry, sector, and value chain. However, these frameworks and models for the most part are based on the relationship and network dynamics of the firms within that value chain. New models are needed to guide firms as they make investment and diversification decisions within a network structurally and operationally defined by consumers, and their interactions with other consumers. Conceptual frameworks and strategy models are presented in the context of the so-called Internet-of-things landscape.

4 - Post Entry Mode Performance of Non-equity Based Entry Modes under Exogenous Shock

Johann Schessl, Research Assistant, EBS.Business School University for Business and Law, Rheingaustraße 1, Oestrich-Winkel, 65375, Germany, johann.schessl@ebs.de

This study examines post entry mode performance of non-equity based and equity based entry modes immediately after an exogenous shock. Using a sample of car manufacturers in European markets during the crisis of 2008, we attempt to determine if entry modes have an effect of performance immdiately after an exogenous shock. We theorize tat non-equity based are more responsive to the new business environment after an exogenous shock and therefore outperform equity based entry modes in the short term.

5 - Impact of Managerial Incentives Alignment on Marketing Strategies Evidence from SEO Context

Juhi Bhardwaj Sapra, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY, 12180, United States, bhardj@rpi.edu, Nithya Shankar

Studies have shown that manager's compensation incentivizes a myopic management behavior which involves cutting of marketing expenses that leads to higher profits in the short term but lower long term firm valuation. Our study explores this phenomenon in the context of seasoned equity offering (SEO) where firms behave myopically. We investigate the moderating effects of the change of compensation post SEO on firm's spending decisions. We contribute to the agency theory where alignment of compensation play an important role in firms performance post SEO. We attempt to explore the implications of SEO and managerial incentives that could mitigate myopic management and improve firm value.

■ SB36

351F

Service Science in the Emerging Economy

Sponsored: Service Science

Sponsored Session

Chair: Qiang Qiang, Penn State, Malvern, PA, 19355, United States, qzq10@psu.edu

1 - The Structure and Influencing Factors of Trade Network About BRICS

Shaowei Chen, Xi'an University of Finance and Economics, Xi'an, China, 516329356@qq.com

In the past two decades, the emerging countries developed rapidly, became to play important roles in the world. Especially Brazil, Russia, India, China and South Africa, which were called BRICS, made a great contribution to the world economy. Recent years, the development speed of BRICS was lower than before. Based on the bilateral trade data of BRICS during the period 2005~2015, this paper analyzed the characteristics by using the complex network method. It focused on the change about the network statistics of BRICS's trade network, especially after the time that China proposed "One Belt and One Road".

2 - Study on Social Security, Infrastructure and Rural Household Consumption Behavior

Wei Wang, Xi'an University of Finance and Economics, No. 2 Weichang Road, Chang'an District, Xi'an, Shaanxi Province, China, wangwei_871020@126.com

Rural household consumption is affected by factors at different levels. The factor of rural infrastructure is concerned in this paper. Factors influencing rural household consumption are divided into individual ones and organizational ones. The result shows that the causing effect of social insurance to household consumption is significant but small. Other household consumption characteristics factors, such as marital status, income, family size, also have a significant impact. Community-level factors on household expenditure have strong explanatory power, while transportation, water infrastructure has a significant positive impact.

3 - A Study on the Untrue Information Transmission in Subway Emergency

Ting Wang, Tongji University, 1 Zhangwu Road, Shanghai, 200092, China, 787084787@qq.com, Haifeng Zhao

Once in subway emergency , due to its closed, high traffic characteristics, the impact and harm may be amplified. In view of the fact that information dissemination in emergencies has a strong similarity with the spread of infectious diseases. In sudden events in subway, the SI model is established for the dissemination of untrue information by referring to the model of infectious diseases. The law of change in individual passenger groups were analyzed. In controlling the number of passengers who believe untrue information and hesitant person, the optimal control model is derived.Emergency decision-makers can establish the optimal control model and effectively control untrue information.

■ SB37

352B

Best IBM Service Science Student Paper Award Competition 2

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Penn State, Malvern, PA, 19355, United States, robinqiu@psu.edu

1 - When Psychology Meets Operations: the Influence of Cognitive and Emotional Loads on the Efficiency of Customer-Service Employees

Daniel Altman, Technion - Israel Institute of Technology, Haifa, Israel, altmand@campus.technion.ac.il, Anat Rafaeli, Galit Tom-Tov

We introduce the concept of Psychological Load, integrating predictions of psychological theories regarding two types of such load: Cognitive and Emotional Loads that customers offer to service agents. We measure both loads and test their effects on agent Response Time and customer Length of Stay using 145,995 service interactions. We find that Cognitive Load increases agent Response Time, and is positively related to Length of Stay. Emotional Load has a U-shaped effect on agent Response Time; high levels of positive or negative emotion relate to high Response Time. Time-based analyses support the causality of the effects. The paper offers novel insights into the study of agent efficiency.

2 - Dynamic Network Revenue Management for a Cloud Provider Hosting Interactive Applications

Hossein Jahandideh, University of California-Los Angeles, Los Angeles, CA, 90034-6473, United States, hs.jahan@gmail.com, Kevin McCardle, Julie Ward, Filippo Balestrieri

We consider a cloud provider which hosts interactive applications such as websites or mobile apps. Depending on the traffic of users for an application, the provider commits a subset of its resources (hardware capacity) to serve the application. The provider uses dynamic pricing to indirectly select the applications hosted and maximize revenue. We model the problem as a large-scale stochastic dynamic program, and decompose it into single-resource sub-problems by exploiting structural properties of optimal Lagrangian variables. We combine the solutions to the sub-problems to define a dynamic pricing policy, and propose novel upper bounds on the optimal revenue to evaluate our pricing mechanism.

3 - Service Design with Acclimation and Non-homogeneous Memory Decay

Yifu Li, Hong Kong University of Science and Technology, Room 3208 , Lift 21, Clear Water Bay, Kowloon, 999077, Hong Kong, ylick@connect.ust.hk, Tinglong Dai, Xiangtong Qi

In today's "experience economy," service providers increasingly emphasize creating memorable, delightful service experiences, a crucial driver of which is the schedule of activities in a service package. Empirical literature shows the most engaging activity should be scheduled neither at the beginning nor the end of the package. Theoretic literature, on the other hand, points to a U-shaped schedule. The paper closes this gap between empirical and theoretic literature and provides a foundation for advanced analytics that is called for in developing next-generation operating models.

■ SB38

352C

Recent Advances in Approximations for Multi-objective Integer Programs

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Hadi Charkhgard, University of South Florida, USF, Tampa, FL, 33559, United States, hcharkhgard@usf.edu

1 - A Feasibility Pump and Local Search Based Heuristic for Biobjective Pure Integer Linear Programming

Hadi Charkhgard, University of South Florida, Tampa, FL, 33559, United States, hcharkhgard@usf.edu, Aritra Pal

We present a new heuristic algorithm to approximately generate the nondominated frontier of bi-objective pure integer linear programs. The proposed algorithm employs a customized version of several existing algorithms in the literature of both single-objective and bi-objective optimization. Our proposed method has two desirable characteristics: (1) There is no parameter to be tuned by users other than the time limit; (2) It can naturally exploit parallelism. A computational study shows the efficacy of the proposed method and also the value of parallelization on that.

2 - A Feasibility Pump and Local Search Based Heuristic for Solving Multiobjective Mixed Integer Linear Programs

Aritra Pal, University of South Florida, 4202 E. Fowler Avenue, Tampa, FL, 33620, United States, aritra1@mail.usf.edu, Hadi Charkhgard

We present a new heuristic algorithm to approximately generate the nondominated frontier of multiobjective mixed integer linear programs. The proposed algorithm employs a customized version of several existing algorithms in the literature of both single objective and multiobjective optimization. Our proposed method has two desirable characteristics: (1) There is no parameter to be tuned by users other than the time limit; (2) It can naturally exploit parallelism. An extensive computational study shows the efficacy of the proposed method on some existing standard test instances in which the true frontier is known.

3 - A New Algorithm to Optimize a Function Over the Set of Efficient Solutions for Biobjective Mixed Integer Linear Programming

Alvaro Sierra, University of South Florida, 4411 Shady Terrace Lane, Unit A, Tampa, FL, 33613, United States, amsierra@mail.usf.edu, Hadi Charkhgard

We present a new criterion space search algorithm for optimizing a function over the set of efficient solutions of a biobjective mixed integer linear program. The algorithm is easy to implement and because it maintains a lower and an upper bound on the value of the linear function at any point in time, it can be used to quickly generate a provably high-quality approximate solution. An extensive computational study shows that the efficacy of the algorithm.

4 - Goal Programming - A Comparison with Other MCDM Methods

Nilakantan Sundara Raman Narasinganallur, K.J. Somaiya Institute of Management Studies & Research, B.602 Tulip Rachna Garden, Mulund Colony, Mumbai, 400082, India, nilakantan@somaiya.edu

For solving multi-criteria decision problems, different schools of thought have developed around different methodologies. Goal Programming is an elegant multi-objective programming technique using the structure of mathematical programming and extending it beyond its confines of single objective situations. Due to its simplicity and structure, it is much better than other multi-objective, multi-criteria decision-making techniques like Analytical Hierarchy Process, Fuzzy Theory etc. The presentation will discuss a few examples of Goal Programming and evaluate its merits vis-à-vis other MCDM techniques.

■ SB39

352D

Remembering Harvey Wagner

Invited : INFORMS Special Sessions

Invited Session

Chair Jayashankar M. Swaminathan, University of North Carolina, Kenan-Flagler Business School, Operations, Chapel Hill, NC, 27599-3490, United States, msj@unc.edu,

Co-Chair: Vinayak Deshpande, University of North Carolina, UNC, Chapel Hill, NC, United States, Vinayak_Deshpande@kenan-flagler.unc.edu

1- Remembering Harvey Wagner

Jayashankar M. Swaminathan, University of North Carolina, Chapel Hill, NC, msj@unc.edu

Harvey Wagner (1931-2017) had a profound impact on the field of Operations Research and Management Science during his lifetime. In this session, presenters will share their experiences with Harvey Wagner and how those influenced their thinking.

■ SB40

352E

INFORMS Undergraduate Operations Research Prize

Invited: Undergraduate Operations Research Prize

Invited Session

Chair: Murat Kurt, Merck & Co., Inc., 2306 Sherbrook Street, Apt: 2, Pittsburgh, PA, 15217, United States, murat.kurt7@gmail.com

1 - Fluid Optimal Control of Polling Systems with Large Switchover Times

Yue Hu, Northwestern University, Evanston, IL, United States, yuehu2017@u.northwestern.edu, Ohad Perry, Jing Dong

We study the optimal-control problem of stochastic polling systems with large switchover times. Under proper scaling, the stochastic system can be approximated by a Hybrid Dynamical System (HDS). For the HDS, we analyze two classes of controls, and prove that any (periodic) stationary behavior can be achieved by one of those controls. We employ this latter result to prove that the exhaustive policy is optimal among all stationary controls with respect to long-run average holding costs.

2 - A Generalized Markov Chain Model to Capture Dynamic Preferences and Choice Overload

Agathe Soret, Columbia University, New York, NY, United States, acs2298@columbia.edu, Vineet Goyal

Modeling preferences is a key problem in many settings. Many random utility based parametric models have been considered, but all suffer from two limitations: failure to capture i) dynamic preferences that depend on the offered assortment, and ii) the choice-overload phenomenon (where the probability of purchase decreases with the number of available options). We propose a generalization of the MNL model that addresses both these limitations. We show that our model can be estimated efficiently and also present a near-optimal algorithm for constrained assortment optimization.

3 - Optimization Strategies to Support Analyses and Decisions to Increase the Coverage of Cervical Cancer Screening Tests in Rural Areas of Cundinamarca, Colombia

Maria Camila Patino Torres, Universidad de los Andes, Bogota, Colombia, mp.patino10@uniandes.edu.co, Ivan Mura, Camilo Gomez

The barriers in the access to diagnosis and treatment of cervical cancer in Colombia are illustrative of the inequalities among population groups in the country. Through data analysis, the implementation of network flow and vehicle routing models, and economic evaluations, we assess the coverage of existing facilities in a large rural area, and propose alternatives to improve it. Our results show that cost-effective alternatives exist to provide access to screening for vulnerable populations.

4 - A Two-Stage Vehicle Routing Algorithm Applied to Disaster Relief Logistics after the 2015 Nepal Earthquake

Stephanie Allen, The State University of New York at Geneseo, New York, NY, United States, stephanie.a.allen95@gmail.com, Caroline Haddad

After the 2015 Nepal Earthquake, the Himalayan Disaster Relief Volunteer Group distributed supplies to affected areas. We model the organization's operations as a vehicle routing problem using Fisher and Jaikumar's two-stage method, which allocates locations to vehicles via an assignment integer program and then uses heuristics to route the vehicles. Our results illustrate the open nature of the VRP and the computational necessity of heuristics.

5 - Contract Tracing Protocol

Chungjae Lee, Georgia Institute of Technology, Atlanta, GA, United States, clee384@gatech.edu, Jason Bermudez, Kevin Desprez, Alex Kehres, Leah Patterson, Suphaphat Petlerkwang, Yuntong Zhu, Pinar Keskinocak, Brian Gurbaxani

Contact tracing is a protocol that prevents disease transmission by identifying disease-carriers. The Center for Disease Control and Prevention (CDC) suspects that the protocol is improperly estimating the number of contacted individuals and incurring excessive cost. Mathematical models and a decision tool are developed to design cost-effective protocols with quantitative justification for respiratory diseases. Through the tool, the CDC can reduce cost at most by $360,000 per protocol.

■ SB41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Xiaoli Duan, Northeastern University, Boston, MA, United States, duan.xi@husky.neu.edu

1 - Improving Outpatient Scheduling with Simulation

Michelle Rose Hribar, Oregon Health & Science University, Portland, OR, United States, hribarm@ohsu.edu, Sarah Read-Brown, Leah Reznick, Lorinna Lombardi, Mansi Parikh, Winston Chamberlain, Thomas Yackel, Michael F. Chiang

Clinicians today face increased patient loads, decreased reimbursements and negative productivity impacts from using electronic health records (EHR), but have no guidance on how to improve clinic efficiency. This study evaluates novel scheduling strategies using simulation and EHR data before their implementation in outpatient ophthalmology clinics. Key findings from this study are: 1) EHR timestamp data in simulation models represents clinic workflow, 2) simulations provide critical information for schedule creation and resource allocation, 3) scheduling long appointments last reduces patient waits, and 4) new schedule implementation challenges limit efficiency improvements.

2 - Establishing Staffing Levels and Surge Planning for the Emergency Department of the Children's Hospital of Pittsburgh using Simulation

Kiatikun Louis Luangkesorn, University of Pittsburgh, 1028 Benedum Hall, 3700 Ohara St, Pittsburgh, PA, 15261, United States, lluangkesorn@pitt.edu, Anna Svirsko, Bryan A. Norman, Jayant Rajgopal, John Rossi

An urban hospital emergency department experiences high variability in arrivals over the course of a day, from day to day, and from season to season. To handle this variable demand, Children's Hospital uses both a standard staffing level and a surge team for when the standard staffing level is not able to keep up with the patient demand. We present a simulation model to jointly analyze staffing levels and the surge plan in this environment. This simulation is used to evaluate the effects of staffing on ED length of stay and the need to implement the surge plan over the course of the year.

3 - Ophthalmology Benchmarking using Data Envelopment Analysis

Timothy R.Anderson, Portland State University, Mail Code ETM, P.O. Box 751, Portland, OR, 97201, United States, tim.anderson@pdx.edu, Daria Spatar

A benchmarking study of the electronic medical records adoption and usage by ophthalmology practices was conducted using data envelopment analysis.

4 - Agent-based Models of Opioid Use Spread

Xiaoli Duan, Northeastern University, Boston, MA, United States, duan.xi@husky.neu.edu, James Benneyan, Iulian Ilies

We developed several agent-based models of the spread of opioids abuse to help understand and mitigate this worsening national epidemic. Models varied in stochasticity, scale (individual to region), and topology (geographical to social) and were tested on several sociodemographic populations. Results indicated that different models work better in different settings and can help identify the magnitudes and combinations of interventions and investments (e.g., reduced prescription availability, education initiatives, or increased recovery services) necessary to effectively reduce the epidemic.

■ SB42

360A

Journal Editors Session

Invited: Invited OR and Advanced Manufacturing

Invited Session

1 - Journal Editors Panel

Satish Bukkapatnam, Texas A&M.University, 3131 TAMU, 4020 Emerging Technologies Building, College Station, TX, 77843, United States, satish@tamu.edu

This session will feature three panelists representing prominent journals in the manufacturing area to discuss opportunities to communicate research at the intersection of advanced manufacturing and operations research in these journals.

2 - Focus Issue Editor, IIE Transactions on Design and Manufacturing

Shiyu Zhou, University of Wisconsin-Madison, 3254 Mech Eng Bldg, 1513 University Avenue, Madison, WI, 53706-1572, United States, szhou@engr.wisc.edu

3 - Department Editor, Production and Operations Management

Chelliah Sriskandarajah, Texas A&M.University, 320q Wehner Building, 4217 Tamu, College Station, TX, 77843-4217, United States, chelliah@mays.tamu.edu

4 - Associate Editor, Journal of Manufacturing Science and Engineering

Satish Bukkapatnam, Texas A&M.University, 3131 TAMU, 4020 Emerging Technologies Building, College Station, TX, 77843, United States, satish@tamu.edu

■ SB43

360B

Advances in Healthcare Analytics

Sponsored: Public Sector OR

Sponsored Session

Chair: Van-Anh Truong, Columbia University, New York, NY, 10027, United States, vt2196@columbia.edu

1 - A Fluid Model for an Overloaded Bipartite Queueing System with Heterogeneous Matching Utilities

Yichuan Ding, UBC, 2053 Main Mall, Vancouver, BC, V6T1Z2, Canada, daniel.ding@sauder.ubc.ca, S. Thomas McCormick, Mahesh Nagarajan

We consider a bipartite queueing system (BQS) with multiple types of servers and customers, where different customer-server combinations may generate different utilities. Whenever a server is available, it serves the customer with the highest index, which is the sum of a customer's waiting index and the matching index. We develop a fluid model to approximate the behavior of such a BQS system, and show that the fluid limit process can be computed over any finite horizon. We prove that the fluid limit process converges to a unique steady state, which can be efficiently computed. We illustrate the use of our machinery by analyzing the public housing assignment in the city of Pittsburgh using a real data set.

2 - Learning Personalized Treatment Regimes from Observational Data

Nathan Kallus, Cornell University, New York, NY, United States, kallus@cornell.edu

In this talk I will describe several recent advances in learning personalized decision policies from observational data and its application to personalized medicine using electronic health records, including new methods, problems, and applications.

3 - Conspicuous by its Absence: Diagnostic Expert Testing under Uncertainty

Tinglong Dai, Assistant Professor, Johns Hopkins University, Baltimore, MD, 21202, United States, dai@jhu.edu, Shubhranshu Singh

Motivated by prevalent—albeit little explored—under-provision in the US healthcare setting, we study a scenario in which costly diagnostic testing is needed to acquire customers' true conditions and the expert's accuracy of diagnosis is unknown to customers. Our work is the first to formally link diagnostic uncertainty and information asymmetry.

4 - The Zocdoc Effect: How Does Online Information Impact Appointment Availability in Out-patient Care?
Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, United States, yxu@stern.nyu.edu, Mor Armony

In this paper, we propose a queueing model to study the impact of online healthcare channels. We analyze the impact of in-clinic service time and the number of offered appointments on patient joining decisions. We consider doctor's revenue maximization problem with these two service rates. We show that when the market size is large, the doctor uses partial market coverage strategy; while when the market size is small, the doctor uses full market coverage strategy. We then extend our model into a multiple doctors setting and show that (i) in small markets, each additional doctor induces each doctor to slow down further; (ii) otherwise, the market is large enough that each server acts as a local monopolist.

■ SB44

360C

Facility Location in Humanitarian and Disaster Response Logistics

Sponsored: Public Sector OR

Sponsored Session

Chair: Felipe Aros-Vera, Ohio University, Athens, OH, 45701, United States, aros@ohio.edu

1 - A Model for Strategic Facility Location and Tactical Resources Allocation under Uncertainty for Natural Disaster Response
Adan Rodriguez, Universidad Complutense de Madrid, Facultad de CC. Matematicas, Plaza de las Ciencias, 3, Madrid, 28040, Spain, adanro01@ucm.es, Begona Vitoriano, Laureano F. Escudero, Juan F. Monge, M. Teresa Ortuno

A strategic preparedness facility location and tactical preparedness resource allocation model is presented for a multi-period stochastic problem to manage natural disaster's response. That preparedness consists of warehouses location and capacity assignment and extension planning over years, and annual planning for procurement and allocation of commodities to warehouses. Uncertainty is taken into account including different scenarios of natural disasters in each season into a year, affecting operations management and costs. The model is being developed for public managers, but it also could be extended to other type of organisations.

2 - Facility Location and Allocation of Resources in Post-disaster Humanitarian Logistics
Felipe Aros-Vera, Ohio University, 277 Stocker Center, 1 Ohio University, Athens, OH, 45701, United States, aros@ohio.edu, Nick Loree

This presentation introduces a facility location model that explicitly accounts for deprivation costs incurred by survivors in post disaster environments. It provides realistic measures of disaster response logistics by allowing for multiple sourcing, number of facilities as a model output, capacity limitations, and inventory allocation decisions.

3 - Transportation of Hazardous Materials under a Disaster Settings Considering Risk Perception
Ruben Yie, Universidad el Norte, Km 5 Antigua via Puerto Colombia, Barranquilla, Colombia, ryie@uninorte.edu.co, Ana M. Bedoya, Fabian Betancur

This research has two main stages: stage 1 focuses on measure how people perceive risk within a network that transport hazardous materials, and how this perception of risk affects their decision making process. Stage 2 tries to develop a mathematical model to route this hazardous materials in order to minimize risk of the cargo but also the risk perception of the people sharing the network. Both stages are under a natural disaster settings (static or dynamic). Also an evolutive algorithm with learning machine properties (ant controlled genetic algorithm) was created to solve this problem.

4 - Location, Allocation and Prepositioning of Stock and Preparation and Response to Natural Disasters
Pamela Alvarez, Universidad Andres Bello, Manquehue sur 1076, dpto NA 1002, Santiago, AL, Chile, palvarez@unab.cl, Andrés Bronfman

The effects of natural disasters are unpredictable and emergency plans must be adapted to each situation. This work proposes a methodology in stages to address the problem of preparation-response. Phase 1 generates the base response plan with a multiobjective model that determines the location of shelters and warehouses, and assigns the population to this facilities. It seeks to minimize evacuation and supply times, and costs. Phase 2 (post disaster) considers the base plan and, with a new model, locates new shelters and warehouses, and reassigns the population according to the new configuration. The methodology was applied in the city of Iquique, Chile.

5 - A Humanitarian Logistics Inventory Management Model for Post-disaster
Azadeh Sadeghi, 2nd Andover Rd., Apt B11, Athens, OH, 45701, United States, as262914@ohio.edu

This presentation focuses on inventory management and control policies for post disaster humanitarian logistics. A mathematical model is proposed in which both traditional inventory and logistics costs and the cost of human suffering as a consequence of late delivery of the supplies are considered. The proposed model is also applicable to facility location humanitarian logistics problem.

■ SB45

360D

JFIG Panel Discussion: Tips for Writing CAREER Propsals

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: Jose Luis Walteros, University at Buffalo, SUNY, 413 Bell Hall, Buffalo, NY, 14260, United States, josewalt@buffalo.edu

1 - JFIG Panel Discussion: Tips for Writing CAREER Proposals
Jose Luis Walteros, University at Buffalo, SUNY, 413 Bell Hall, Buffalo, NY, 14260, United States, josewalt@buffalo.edu

The panelists consist of past NSF CAREER awardees. The panelists will share their experience in the process of getting their awards. They will discuss failures, successes and provide some tips on how to properly plan and consolidate a solid proposal. They will also answer questions from the attendees.

2 - Panelist
Changhyun Kwon, University of South Florida, 4202 E. Fowler Ave. ENB118, Tampa, FL, 33620, United States, chkwon@usf.edu

3 - Panelist
Esra Buyuktahtakin, New Jersey Institute of Technology, Industrial and Manufacturing Engineering Dept, Newark, NJ, United States, esratoy@njit.edu

4 - Panelist
Alejandro Toriello, Georgia Institute of Technology, 765 Ferst Drive NW, Atlanta, GA, 30332, United States, atoriello3@isye.gatech.edu

■ SB46

360E

Latest Developments in Scheduling

Invited: Project Management and Scheduling

Invited Session

Chair: Zhi-Long Chen, University of Maryland, College Park, MD, 20742-1815, United States, zchen@rhsmith.umd.edu

1 - Online Scheduling of Ordered Flow Shops
Kangbok Lee, Pohang University of Science and Technology, Pohang, Korea, Republic of, kblee@postech.ac.kr, Feifeng Zheng, Michael L. Pinedo

This work considers online over-list scheduling of ordered flow shops with the makespan as objective. We focus on ordered flow shops, in particular proportionate flow shops with different speeds and proportionate flow shops with different setup times. We derive several results on the worst case performance of the Greedy Algorithm in the online setting.

2 - Subcontracting Operations with Production Costs
George Vairaktarakis, Case Western Reserve University, Dept of OR and OM, 10900 Euclid Avenue, Cleveland, OH, 44106-7235, United States, gxv5@case.edu, Ke Fu, Vernon Hsu

We consider multiple manufacturers subcontracting part of their workload at a third party (3P) production facility with the rest of the work processed in-house. Production costs are customer-specific, both at their own facility as well as at 3P. We explore structural properties of optimal production plans and in propose fast polynomial time algorithms for several cases of the problem.

3 - Parallel Algorithms for Flow Shop Scheduling Subject to Limited Machine Availability

Yumei Huo, City University of New York, Staten Island, NY, United States, Yumei.Huo@csi.cuny.edu

In this paper, various parallel ant colony algorithms (PAC) and parallel tabu search algorithms (PTS) are presented and applied to Permutation Flowshop Scheduling Problem subject to limited machine availability. The objective is to minimize total flowtime criterion. This problem is proved to be NP-complete in a strong sense for more than one machine even when machines are always available. PACs and PTSes are based on the classical ant colony and tabu search algorithms. Various platforms are considered, including Message Passing and shared memory. All parallel algorithms will be compared with monte carlo algorithm and will be compared with each other in terms of both performance and CPU times.

4 - Integrated Production and Two-stage Delivery Scheduling: Offline and Online Algorithms

Zhi-Long Chen, University of Maryland, Robert H. Smith School of Business, Dept of Decision, Operations & Info Tech, College Park, MD, 20742-1815, United States, zchen@rhsmith.umd.edu, Lixin Tang, Feng Li

We study integrated production and distribution scheduling problems that arise in practical make-to-order settings in several industries. In these problems, make-to-order products are first processed in a plant, and then delivered to customer sites through two stages of shipping: first, from the plant to a pool point (e.g., a port, a distribution or a consolidation center), and second, from the pool point to customer sites. We consider both offline and online problems, propose several heuristics, and analyze their worst-case and asymptotic performance ratios. The heuristics are tested computationally using both real data from a company and randomly generated data.

■ SB47

360F

Economics of Digital Channels

Sponsored: EBusiness

Sponsored Session

Chair: Yi-Chun Ho, George Washington University, Washington, DC, 20052, United States, chadho@gwu.edu

1 - The Impact of the Sharing Economy on Household Finance

Tingting Nian, University of California, Irvine, Irvine, CA, United States, tnian@uci.edu

Powered by digital technologies, many peer-to-peer platforms or what is called the sharing economy have emerged in the past decade. While the impact of the sharing economy has received a great deal of attention in the past couple of years, extant research hasn't fully documented the impact of the sharing economy on consumers, workers, industry and the society as a whole. In this study, we exploit the geographic and temporal variation in Uber's entry to examine the impact of Uber's entry on the personal bankruptcy rate as well as other consumer credit default rates.

2 - Reward on User Generated Content

Zixuan Meng, University of Washington, 2021 NE 90th St Apt A501, Seattle, WA, 98115, United States, zxmeng@uw.edu

The value of user-generated content has been heatedly discussed and strongly emphasized in the past few years. However, most of the studies attribute such value to social capital gain and few studies have been conducted on how the value of content could be monetarized. Using a unique setting where readers can voluntarily provide monetary reward to content-generators, we intend to analyze how monetary incentive influences content-generators' behavior. We further analyze how change in rewarding policies would change users' content generation and rewarding behavior.

3 - The Impact of Verification in Online Matching Markets: Evidence from a Randomized Field Experiment

Lanfei Shi, University of Maryland, College Park, MD, United States, lanfeishi@rhsmith.umd.edu, Siva Viswanathan

Online matching markets suffer from significant information asymmetries. Online dating, in particular, has been challenged by fake profiles and scams, and markets have resorted to verification as a mechanism to mitigate such issues. While it is generally believed that verification is beneficial, it is not clear what type of users would choose to verify their credentials given an option, and what are the outcomes of such choices. In collaboration with one of the leading online dating platforms in the US, we design and conduct a randomized field experiment to answer these questions. Our findings provide insights on how to effectively leverage verification.

4 - Crowding-out Effect Mitigation through Intervention Strategies

Shun-Yang Lee, University of Connecticut, Storrs, CT, United States, shun-yang.lee@uconn.edu, Dandan Qiao, Qiang Wei, Andrew Whinston

Monetary incentives are often used to motivate individuals' pro-social behaviors. However, incentives are known to result in the crowding-out effect, which dampens individuals' intrinsic motivation and leads to lower contribution quality, typically exemplified in the form of information bias. In this paper, we conduct randomized experiments to investigate ways to overcome the crowding-out effect of monetary incentives. Our results suggest that monetary incentives, when combined with appropriate intervention strategies such as goal-setting and challenge-seeking, can motivate users to increase their contribution quantity without hurting the quality. Additional experimental results suggest that the moderating effect of these intervention strategies is heterogeneous, with low-altruistic individuals benefiting the most from the intervention. Our research contributes to the study of incentive provision and pro-social behaviors and has significant theoretical and practical implications.

■ SB48

361A

Bringing Behavioral Operations Into the Classroom

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Ryan Buell, Harvard Business School, Morgan Hall 429, Boston, MA, 02163, United States, rbuell@hbs.edu

1 - Exercise Exploring Behavioral Ideas in Service Ops

Michael Dixon, Utah State University, Logan, UT, United States, mike.dixon@usu.edu

Services are a ripe area to use to teach, apply, and consider multiple behavioral principles. This in-class exercise introduces students to a berth of such principles and challenges students to consider how different service industries apply, or could apply these principles. The exercise allows students to appreciate the importance of behavioral concepts in the management and design of service operations and introduces them to a wide array of ideas in behavioral research. The exercise can be used as an introduction to the importance of behavioral ideas in and operations management or services management course.

2 - Breakfast at the Paramount: A Case Study on Queuing Dynamics

Ryan Buell, Harvard Business School, Morgan Hall 429, Boston, MA, 02163, United States, rbuell@hbs.edu

The Paramount is a 44-seat diner on Charles Street in the Beacon Hill neighborhood of Boston. A frequent "Best of Boston" award winner, the restaurant is a perennial favorite among locals and tourists, particularly for brunch on the weekends, when lines often stretch down the street. The case focuses on the restaurant's interesting seating policy and a recent increase in the popularity of carryout orders, which poses a threat to the service experiences of customers and the sustainability of the operation. The session will introduce the multimedia case study, and how it can be used to teach the analytical and behavioral dynamics of queues in courses on operations management and service operations.

3 - Sharing the Risk: A Classroom Experiment for Teaching About Supply Chain Contracts

Karen L.Donohue, University of Minnesota, SCO.Department, 321 19th Street Avenue S, Minneapolis, MN, 55455, United States, donoh008@umn.edu, Yinghao Zhang

We describe an activity for introducing students to issues that can arise in using risk-sharing contracts (e.g., buyback and revenue sharing). The activity consists of two exercises where students take on the role of a supplier, first choosing what contract to offer, and second setting contract parameters for one of the contract types. In discussing the outcomes, students discover that the profit margin of a product (whether it is high versus low margin) leads to differences in contract preferences and performance. This provides an opportunity to introduce two important behavioral factors, loss aversion and prospective accounting, that help explain these results.

4 - Behavioral Drivers of Learning

Bradley R. Staats, University of North Carolina at Chapel Hill, Campus Box 3490, McColl 4721, Chapel Hill, NC, 27599-3490, United States, bstaats@unc.edu

Pal's Sudden Service is a quick service restaurant that has created a unique operating model that focuses on process control and improvement. The company treats the restaurant business like a manufacturing operation and was the first restaurant to win the Baldrige Quality award. At the same time the company has high employee engagement and together this has lead to excellent operating and financial performance. The case examines how it has architected an organization to learn and grow. This session will introduce the case and how it can be used to teach about behavioral drivers of learning.

■ SB49

361B

Behavioral Collaboration

Invited: InvitedBehavioral Aspects of OR

Invited Session

Chair: Leroy White, Professor, Warwick Business School, Warwick Business School, United Kingdom, Leroy.White@wbs.ac.uk

1 - The Problems of Collaborative Behaviour and Operations Research: An Overview

Leroy White, University of Bristol, School of Eonomics Finance and Accounting, 12 Priory Road, Bristol, BS8 1TU, United Kingdom, leroy.white@bristol.ac.uk

Abstract not available.

2 - Affordances for Collaborative Behavior Operations Research Interventions: A Practice-based View

Katharina Burger, University of Portsmouth, Business School, OSM, Portland Street, Portsmouth, PO1 3DE, United Kingdom, katharina.burger@port.ac.uk

Theorizing from practice-based OR interventions is a critical task for behavioral operations researchers who aim to understand how collaborative performance can be scaffolded. A micro-level lens to realize theory-based empirical studies of affordances is proposed. Drawing on data from a low-tech facilitated modelling workshop, three key dimensions of behavior with OR performance scaffolds are highlighted: trust, entrenchment and sharedness.

3 - Building the Multiplex: An Agent-Based Model of Formal and Informal Network Relations

Duncan Robertson, Loughborough University, SBE, Loughborough, United Kingdom, d.a.robertson@lboro.ac.uk, Leroy White

We present a new agent-based model of group decision making, where links are made in hierarchical organizational structures. Our model presents a trade off between deliberate organizational hierarchical planning and allowing organizational 'short cuts' to form spontaneously. We present results showing when organizations should be planned and when emergent designs can offer higher performance.

■ SB50

361C

Large-scale Data Analytics in Urban Transportation Modeling II

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Shanjiang Zhu, George Mason University, Fairfax, VA, 22030, United States, szhu3@gmu.edu

Co-Chair: Zhen Qian, Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, seanqian@cmu.edu

1 - Statistical Inference of Probabilistic Origin-destination Demand using Day-to-day Traffic Data

Zhen Qian, Carnegie Mellon University, 4800 Forbes Avenue, Pittsburgh, PA, 15213, United States, seanqian@cmu.edu, Wei Ma

Our research develops a novel framework for estimating the mean and variance/covariance of Origin-Destination demands considering the route choice variation and statistical equilibrium simultaneously. The observability and non-uniqueness property of the estimated probabilistic O-D demand are discussed. The framework is evaluated in a small and a large-scale network to provide insights and to demonstrate computational efficiency.

2 - How Does Social Media Infer the Longitudinal Travel Behavior?

Qing He, University at Buffalo, The State University of New York, 313 Bell Hall, Buffalo, NY, 14260, United States, qinghe@buffalo.edu, Zhenhua Zhang, Shanjiang Zhu

This paper proposes a sequential model-based clustering method to group the high-resolution Twitter locations and extract the Twitter displacements. Further, this study compares the displacement-based results from Twitter data with the results from traditional household travel survey. Our study demonstrates the potentials of employing social media to infer longitudinal travel behavior and to support travel demand modeling for a metropolitan area.

3 - Optimizing Paratransit Operations to Serve Demand of Passengers with Disabilities in Urban Areas

Eric Gonzales, University of Massachusetts-Amherst, 130 Natural Resources Way, Civil and Environmental Eng, Amherst, MA, 01003, United States, gonzales@umass.edu, Mahour Rahimi

Demand responsive transit service for people with disabilities is typically provided in the United States with paratransit services managed by transit agencies, as required by the Americans with Disabilities Act (ADA). The cost of operating a dedicated fleet of vans and cars for these customers is rising as more people become eligible for ADA service. Demand and operations data for NJ Transit support models and analysis to optimize zoning strategies, garage locations, and transfer policies. An opportunity now exists to further improve costs and mobility by coordinating ADA service with transportation network companies, which has been piloted by the MBTA in Boston.

4 - Inferring Origin-Destination Demand Matrix and Utility-Based Travel Preferences in Multi-Modal Travel Environment using Automatic Fare Collection Data

Laiyun Wu, SUNY-Buffalo, 326 Bell Hall, Buffalo, NY, 14226, United States, laiyunwu@buffalo.edu

We develop inference methods for understanding and expressing public transit system utilization based on travelers' origins/destination (OD) and ensuing behavior. The presented methodology infers both the preference vector and true OD-pair demand by analyzing Automatic Fare Collection (AFC) data, as travelers make their multi-modal route choice decisions in the time-dependent travel environment.

■ SB51

361D

Digital Advertising

Sponsored: Information Systems

Sponsored Session

Chair: Manmohan Aseri, The University of Texas at Dallas, Richardson, TX, 75080, United States, manmohan.aseri@utdallas.edu

1 - Block the Ad-block Users? Not Always

Manmohan Aseri, University of Texas-Dallas, 2200 Waterview Parkway, Apt 1738, Richardson, TX, 75080, United States, manmohan.aseri@utdallas.edu, Milind Dawande, Ganesh Janakiraman, Vijay S.Mookerjee

Ad-Blockers are the software or the plug-ins which remove ads from the users' browsers when they access a website on the internet. Companies which are heavily dependent on the advertisement revenue dislike the ad-blocker usage due to the loss of the ad revenue. We address the problem from the perspective of those publishers (websites) which rely heavily on the ad revenue and provide insights about how these companies should react to ad-block users. We solve the problem using a game theoretic model. Our results suggest that the network effect plays a critical role in the reaction of a publisher to the ad-block users. These results are consistent with the current practice.

2 - When are Two Machines Better than One? A Model to Reduce Rental Cost in Cloud Computing

Leila Hosseini, Information Systems, The University of Texas at Dallas, Richardson, TX, 75080, United States, leila.hosseini@utdallas.edu, Vijay S.Mookerjee, Chelliah Sriskandarajah

Amazon Web Services (AWS), a major cloud provider in the cloud infrastructure market, offers a diverse set of computing resources called virtual machines (VM). All VMs are priced based on their capabilities such that VMs whose prices are higher perform better than those which have lower prices. In this setting, AWS users receive a lot of flexibility to select their desired VMs. However, it is difficult to encounter to this much flexibility without being confused at the same time. Therefore, it is a must for users to find an efficient solution to transform this confusing market into a beneficial one. We study AWS cloud user's problem of renting VMs to minimize rental cost in the presence of a time constraint.

3 - Measuring Channel Complementarities in an Online Advertising Supply Chain

Changseung Yoo, The University of Texas at Austin, Austin, TX, 78712, United States, csyoo@utexas.edu, Anitesh Barua, Genaro J. Gutierrez

In the empirical literature on testing complementarities, no distinction has been made between the existence of complementarity and recognizing and acting upon such complementarity. To address this gap, we analyze how a decision maker's understanding of complementarities can affect the empirical evidence of complementarities or substitutabilities within a structural model.

4 - CPV vs CPC in Internet Video Advertising

Zhen Sun, Information Systems, The George Washington University, Washington, DC, 20052, United States, zhens@email.gwu.edu, Sameer Mehta, Vijay S. Mookerjee

This study is aim to conduct an economical analysis on the two pricing models in Internet video advertising.

■ SB52

361E

Network Design

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Mohammad Marufuzzaman, Mississippi State University, Dept of Industrial & Systems Engineering, P.O. Box 9542, Starkville, MS, 39762, United States, maruf237@gmail.com

1 - Optimizing Electric Vehicle Charging Station Expansion Decisions with an Integration of Renewable Energy and Vehicle-to-grid Sources

MD Abdul Quddus, Mississippi State University, 319 North Jackson Street, Apt 3E, Starkville, MS, 39759, United States, mq90@msstate.edu, Mohannad Kabli, Mohammad Marufuzzaman

This study proposes a novel formulation for designing and managing electric vehicle charging stations, considering both long-term planning decisions and short-term hourly operational decisions over a pre-specified planning horizon and under stochastic power demand. We propose a highly customized hybrid algorithm that combines Sample Average Approximation (SAA) with an enhanced Progressive Hedging Algorithm (PHA). A case study based on a road network around Washington, D.C. is present to visualize and validate the modeling results. Our computational results provide a number of managerial insights to the decision makers while indicating the robustness of the proposed algorithm.

2 - The Location Decision Revisited: Empirical Findings from the Automotive Sector

Ioannis Siskos, Kuhne Logistics University, Grosser Grasbrook 17, Hamburg, 20457, Germany, ioannis.siskos@the-klu.org Ioannis Siskos, Vlerick Business School, Reep 1, Gent, 9000, Belgium, ioannis.siskos@the-klu.org, Ann Vereecke, Luk N. Van Wassenhove, Matthias Holweg

In this paper we empirically test location factors in the automotive context, using de facto location decisions car firms have taken, i.e Vehicle Assembly Plant openings and closures. The main research question here is whether the location factors identified in the literature have the same effect in both openings and closures of Vehicle Assembly Plants.

3 - Optimal Planning of Swapping Station Network with Customer Satisfaction

Fang Guo, Huazhong University of Science and Technology, Hongshan District, 1037 Luoyu Road, WuHan, 430074, China, fang_guo@hust.edu.cn, Jun Yang

Key to the mass adoption of electric vehicles is the establishment of a sufficient battery service infrastructure network on the basis of customer behavior and psychology. Motivated by EV service infrastructure network design under the battery leasing/electric car sharing service business models,we present an electric vehicle battery service network design problem considering a customer's satisfaction related to "range anxiety" and "loss anxiety". The problem is formulated as a linear integer programming model under deterministic and fuzzy scenarios. A Tabu Search heuristic is proposed to solve the problem. Finally, we conduct parametric analysis on real-world road networks.

4 - Strategic and Tactical Planning in Dimension Stone Industry

Gangaraju Vanteddu, Associate Professor, Southeast Missouri State University, Harrison College of Business, One University Plaza, MS.5815, Cape Girardeau, MO, 63701, United States, gvanteddu@semo.edu

Supply Chain network design and tactical planning in dimension stone industry present certain unique challenges, in the presence of highly variable demand and material availability related constraints. In this research, generic linear programming based models are proposed for the strategic and tactical level planning to optimize the cost of developing a supply chain network and for medium term production planning.

■ SB53

361F

Advanced Vehicle Control and Traffic Operations with Connected Vehicles

Contributed Session

Chair: Lili Du, Illinois Institute of Technology, 3201 South Dearborn Street, Chicago, IL, 60616, United States, ldu3@iit.edu

1 - Facilitating the Emergency Response Vehicles' Movement Through a Transportation Network Link in the Connected Vehicle Environment

Gaby Joe Hannoun, Graduate Student, Virginia Polytechnic Institute and State University, 7054 Haycock Rd, Falls Church, VA, 22043, United States, gabyjoe@vt.edu, Pamela Murray-Tuite, Kevin Heaslip

Due to the increased traffic especially in urban areas and the risky maneuvers that Emergency Response Vehicles (ERVs) are forced to perform, a new mathematical program leveraging the vehicle to vehicle communications is proposed to facilitate the movement of the ERVs. The integer linear program finds the fastest passage for the ERV along a transportation link while avoiding conflict with nearby vehicles. It can be adapted to different road types, ERV characteristics, and surrounding conditions. When compared to current practices, the proposed formulation offers the same or faster ERV passage along with increased safety since it limits confusion and unexpected incidents caused by human factors.

2 - Multi Vehicle Coordination Strategy for Vehicles Approaching Signalized Intersection to Reduce Emissions using Connected Vehicles Technology

Vaibhav Rungta, Graduate Assistant, Rochester Institute of Technology, Rochester Institute of Technology, James E. Gleason Building, 81 Lomb Memorial Drive, Rochester, NY, 14623, United States, vr2002@g.rit.edu, Katie McConky

The connected vehicles technology allows vehicles and traffic infrastructure to exchange information. This information can be used to provide vehicles with optimal speed profiles which reduce emissions and fuel consumption. However for vehicles with different characteristics a single speed may not be optimal for all the vehicles while maintaining the traffic flow. This research aims to generate speed profiles which may be sub-optimal for a single vehicle, but result in lower emissions and fuel consumption at the system level for a group of vehicles.

3 - Non-Connected Vehicle Detection using Connected Vehicles

Yong Hoon Kim, Purdue University, 2335 Hokins Dr., West Lafayette, IN, 47907, United States, kim523@purdue.edu, Lin Liu, Srinivas Peeta

This study proposes a hidden Markov model, which is a probabilistic inference approach, to identify non-connected vehicle location/trajectory using connected vehicle trajectories under mixed traffic streams of connected vehicles. This methodology is integrated with a cooperative-situation awareness framework. The proposed model is analyzed using real-world vehicle trajectory data to aid the situational awareness of connected vehicles under low market penetration rates.

4 - Constrained Model Predictive Control and Distributed Computation based Car-Following Control for a Platoon mixed with CAVs and Human-Drive Vehicles

Siyuan Gong, Illinois Institute of Technology, Chicago, IL, 60616, United States, sgong1@hawk.iit.edu, Lili Du

The study developed a car-following control mechanism for a platoon mixed with human-drive vehicles and CAVs on a straight highway. Specifically, the movement of human-drive vehicles is modeled by the Newell car-following model and the aggregated response delay anticipated by a machine learning algorithm. By utilizing the connectivity between CAVs, a constrained MPC combined a distributed computation approach is developed to generate optimal control law for individual CAVs so that the desired traffic smoothness and stability are ensured in the system level. Last, the performance of our approaches is validated by simulation experiments.

■ SB54

362A

Models for the Management of Agriculture Industry

Invited: Agricultural Analytics

Invited Session

Chair: Foad Iravani, University of Washington, Foster School of Business, Seattle, WA, 98195, United States, firavani@uw.edu

1 - Transfer Price and Yield Risk-sharing Contracts for Cotton Supply Chains

Guang Xiao, Hong Kong Polytechnic University, Hong Kong, guang.xiao@polyu.edu.hk, Panos Kouvelis, Li Jian

Motivated by the practices from cotton supply chains, we propose a stylized model to study the contracting interactions among a ginner and its farmers with the presence of crop diversification and side selling. We propose a yield risk-sharing contract to better align the yield and price risks in the supply chain.

2 - Farmland Allocation with Crop Rotation Benefits

Javad Nasiry, Hong Kong University of Science and Technology-HKUST, Hong Kong Uni. of Sci. and Tech., ISOM.Dept.,, Lee Shau Kee Business Building, Room 4079, Hong Kong, nasiry@ust.hk, Onur Boyabatli, Yangfang Zhou

We examine a farmer's decision on how to allocate the available farmland between two crops when the crops have rotation benefits across growing seasons. The allocation decision is subject to revenue uncertainty in commodity markets. We characterize the optimal dynamic allocation policy. We then calibrate our model using the data from the United States Department of Agriculture to represent a typical Iowa farmer growing corn and soybean.

3 - Pulses Supply Chains in India: Issues and Solutions

Bin Hu, UNC Chapel Hill, McColl Building CB3490, Kenan-Flagler Business School, Chapel Hill, NC, 27599, United States, bin_hu@unc.edu, Liying Mu, Srinagesh Gavirneni

Pulses are a vital source of plant-based protein for the large number of vegetarians in India. Unpredictable domestic yields and limited import availability in times of need have recently caused crises for India. Many solutions (e.g., export restrictions, minimum support prices, long-term contracts) have been proposed to address the issues inherent to pulses supply chains and there is widespread debate on which to pursue. We evaluate the role of long-term contracts in resolving these supply chain problems and specifically evaluate the impact of contract timing, uncertainty, budget constraints, and salvage value.

4 - An Analysis of Price vs. Revenue Protection Government Subsidies in the Agriculture Industry

Foad Iravani, University of Washington, Foster School of Business, ISOM.Department, Box 353226, Seattle, WA, 98195-3226, United States, firavani@uw.edu, Saed Alizamir, Hamed Mamani

We develop models to analyze the effects of government subsidy programs in the agriculture industry on consumers, farmers, and the government. We provide insights about the impacts of crop and market characteristics on the relative performance of subsidies.

■ SB55

362B

Statistics and Probability in Finance

Sponsored: Financial Services

Sponsored Session

Chair: Agostino Capponi, Columbia University, Columbia University, New York, NY, 10027, United States, ac3827@columbia.edu

1 - The Optional Sampling Theorem

Philip Ernst, Rice University, Houston, TX, United States, philip.ernst@rice.edu

Suppose you have one unit of stock, currently worth 1, which you must sell before time T. The Optional Sampling Theorem tells us that whatever stopping time we choose to sell, the expected discounted value we get when we sell will be 1. Suppose however that we are able to see a units of time into the future, and base our stopping rule on that; we should be able to do better than expected value 1. But how much better can we do? And how would we exploit the additional information? The optimal solution to this problem will never be found, but in this paper we establish remarkably close bounds on the value of the problem, and we derive a fairly simple exercise rule that manages to extract most of the value of foresight.

2 - Risk-sensitive Cooperative Games for Human-Machine Systems

Matthew Stern, Columbia University, New York, NY, United States, mns2141@columbia.edu

Autonomous systems can substantially enhance a human's efficiency and effectiveness in complex environments. Machines, however, are often unable to observe the preferences of the humans that they serve. Though the human's and machine's objectives are aligned, asymmetric information, along with heterogeneous sensitivities to risk by the human and machine, make their joint optimization process a game with strategic interactions. We propose a framework based on risk-sensitive dynamic games to model applications including self-driving taxis and robo-financial advising.

3 - Strategic Dynamic Pricing with Network Effects

Ali Makhdoumi, MIT, 77 Massachusetts Ave. , 32D-640, Cambridge, MA, 02139, United States, makhdoum@mit.edu, Azarakhsh Malekian, Asu Ozdaglar

We study the optimal pricing policy of a committed monopolist selling durable goods in a dynamic pricing game with multiple rounds. Customers are forward-looking and experience a (positive) network effect. The monopolist announces and commits to a price sequence and strategic buyers decide on when (if ever) to buy the good in a perfect Bayesian equilibrium. We explicitly find the optimal pricing policy and show that it is linearly increasing in time, where the slope of the price path is described by a single network measure: sum of the entries of the inverse of network effects matrix.

4 - Reducing Bias in Event Time Simulation VIA Measure Changes

Alexander Shkolnik, University of California-Berkeley, Berkeley, CA, 94720, United States, ads2@berkeley.edu

Stochastic point process models of event timing are common in many areas, including finance, insurance and reliability. Monte Carlo simulation is often used to perform computations in these models. The standard sampling algorithm, which is based on a time-scaling argument, is widely applicable but generates biased simulation estimators. This article develops a measure change technique for reducing the bias and accelerating the algorithm. We prove the existence of a broad class of measure changes that yields martingales of independent interest. The result ensures that our algorithm has the same scope as the standard time-scaling scheme. Numerical results illustrate our approach.

■ SB56

362C

Applications of Location Analysis

Sponsored: Location Analysis

Sponsored Session

Chair: Sibel Alumur Alev, University of Waterloo, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, sibel.alumur@uwaterloo.ca

1 - Risk Aware Capacitated Facility Location Problems

Stefan Nickel, Karlsruhe Insitute of Technology, Institute for Operations Research, Karlsruhe, 76131, Germany, stefan.nickel@kit.edu, Tanya Gonser, Iris Heckmann, Francisco Saldanha-da-Gama

In this talk we present a new exact algorithmic framework for solving multi-stage stochastic mixed 0-1 problems based on a branch-and-bound approach. The approach can be applied to multi-stage problems with mixed-integer variables and uncertainty in each time stage.We describe the underlying scenario tree with a unique set of indices that enables an easy reformulation of the deterministic equivalent model.Computational results are presented for risk-aware capacitated facility location problems with multiple stages as well as uncertain demand and capacities. The results show that the presented method leads to the optimal solution for all considered instances with a good performance.

2 - A Mathematical Model for Point-to-point Based Airline Network Design Problems

Mihiro Sasaki, Nanzan University, 18 Yamazato, Showa, Nagoya, 466-8673, Japan, mihiro@nanzan-u.ac.jp, Takehiro Furuta

We consider an airline network design model for passenger transportation based on point-to-point services in which hubs are not necessarily required. We formulate the problem as an integer programming problem and propose a dynamic programming heuristic method to solve large-sized problems. We report some analytical results from passengers' perspectives.

3 - Shipment Scheduling in Hub Location Problems

James H. Bookbinder, University of Waterloo, 421 Richview Avenue, Toronto, ON, M5P.3G7, Canada, jbookbinder@uwaterloo.ca, Mobina Masaeli, Sibel Alumur Alev

We incorporate shipment scheduling decisions into hub location problems. We determine optimal hub locations, hub network structure, the number of vehicles to operate in the network, and the time period of dispatching each vehicle from a hub. We develop three MIP models for different problem versions, depending on whether holding costs are incorporated and whether the vehicles are of different types. We investigate the impact of shipment scheduling on hub network configurations, routing decisions, and total network costs. We solve the models on instances from a new dataset with real data.

4 - Heuristic Solutions for a Class of Stochastic Uncapacitated p-hub Median Problems

Francisco Saldanha-da-Gama, University of Lisbon, Deio-Fcul, Bloco C6, Lisbon, 1749016, Portugal, fsgama@ciencias.ulisboa.pt, Ángel Corberán, Rafael Marti, Juanjo Peiró

We extend the r-allocation p-hub median problem by including fixed allocation costs, non-stop services and uncertainty in traffic and costs. However, even for small instances of the problem, a compact optimization model for the new problem becomes too large for being tackled by a general solver. This fact motivates the development of an approximate procedure whose starting point is the determination of a feasible solution to every (deterministic) single-scenario problem. Such solutions are then embedded into an iterative process rendering feasible solutions for the overall problem. We discuss the results of the numerical experiments performed using instances build from well-known data sets.

■ SB57

362D

Advances in Stochastic Simulation

Sponsored: Simulation

Sponsored Session

Chair: Henry Lam, khlam@umich.edu

1 - Efficient Rare-event Simulation for Heavy-tailed Processes VIA Principle of Multiple Big Jumps

Chang-Han Rhee, Centrum Wiskunde & Informatica, Jakoba Mulderplein 164, Amsterdam, 1098 XG, Netherlands, rhee@cwi.nl, Jose Blanchet, Jose Blanchet, Bohan Chen, Bert Zwart, Bert Zwart

We propose a new class of strongly efficient rare event simulation estimators for heavy-tailed random walks and compound Poisson processes. The new estimators are straightforward to implement, has bounded relative errors, and are "universal" in the sense that a single importance sampling scheme applies to a very general class of rare events. In particular, our estimators can deal with rare events that are provoked by multiple big jumps (hence, beyond the usual principle of a single big jump) as well as multidimensional processes such as the buffer content process of a queueing network. We illustrate our new method with examples in mathematical finance, simulation optimization, and queueing theory.

2 - Input Model Averaging

Barry L. Nelson, Northwestern University, Dept of Industrial Eng and Mgmt Sciences, 2145 Sheridan Road, Room C216, Evanston, IL, 60208-3119, United States, nelsonb@northwestern.edu, Alan T. Wan

Input uncertainty is an aspect of simulation model risk that arises when the input distributions are derived or "fit" to real-world, historical data. While there has been significant progress on quantifying and protecting against input uncertainty, there have been few direct attempts to reduce it. We show that frequentist model averaging can be a provably effective way to create input models that better represent the true, unknown input distributions, thereby reducing model risk. We provide theoretical and empirical support for our approach.

3 - Ranking and Selection with Covariates

Haihui Shen, City University of Hong Kong, Kowloon, Hong Kong, haihui.shen@my.cityu.edu.hk, Jeff Hong, Xiaowei Zhang

We consider a new ranking and selection problem in which the performance of each alternative depends on some observable random covariates. The best alternative is thus not fixed but depends on the values of the covariates. Assuming a linear model that relates the mean performance of an alternative and the covariates, we design selection procedures producing policies that represent the best alternative as a function in the covariates. We prove that the selection procedures can provide certain statistical guarantee, which is defined via a nontrivial generalization of the concept of probability of correct selection that is widely used in the conventional ranking and selection setting.

4 - Bagging-based Estimation of Simulation Input Uncertainty

Huajie Qian, University of Michigan, Ann Arbor, MI, United States, hqian@umich.edu, Henry Lam

We study resampling-based methods for estimating input-induced variance in stochastic simulation as a means to construct output confidence intervals under nonparametric input uncertainty. We revisit two unbiased bootstrap estimators and investigate their efficiencies. We then investigate an infinitesimal jackknife estimator on a bagging prediction that closely connects to the input uncertainty problem. We demonstrate that the bagging-based approach is more efficient for single-run simulation experiments. We also present a subsampling technique that significantly reduces the simulation effort required by the methods.

■ SB58

362E

Disaster/Disruption/Hazmat Logistics

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Elise Miller-Hooks, miller@gmu.edu

1 - Facility Location and Item Prepositioning under Demand Uncertainty and Road-Facility Vulnerabilities

Melih Celik, Middle East Technical University, ODTU. Endustri Muh. Bolumu, Universiteler Mh. Dumlupinar Bl. No: 1, Ankara, 06800, Turkey, cmelih@metu.edu.tr, Ece Aslan

This study proposes a multi-echelon humanitarian supply chain network design by incorporation of demand uncertainty and road-facility vulnerabilities. In the frame of the study, a two-stage stochastic programming model is formulated to make decisions on warehouse locations and item prepositioning in the first stage, and relief distribution in the second stage. As an extension, concurrent road repair decisions are also considered. A sample average approximation scheme is developed for the solution of the proposed model, which is executed under efficiency- and equity-based objectives.

2 - Network Operations Against Attacks: A Tri-Level Model in Oil & Gas Production and Distribution

Mustafa Alassad, University of Arkansas, Little Rock, AR, United States, mmalassad@ualr.edu, Yupo Chan, Hamzeh Davarikia

Oil and gas are distributed via pumps and pipelines that are exposed to threats. Hardening strategies against malicious attacks are needed. A tri-level leader-follower-operator game determines the optimal fortification tactics to protect the critical assets. There exist dimensions of gaming beyond outright fortification, including tactics often adapted in the "fog of war," such as deception. This is modeled mathematically under the shared cognition concept. Our computational results show that the deception concept is much more effective than fortification, where the cost of attacker's damages diminished significantly without substantial resource commitment on the part of the defender.

3 - A Spectral Risk Measure in Hazardous Materials Transportation

Liu Su, University of South Florida, ENG 302, Tampa, FL, 33620, United States, liusu@mail.usf.edu, Longsheng Sun, Mark Henry Karwan, Changhyun Kwon

Due to catastrophic consequences of accidents by hazardous materials (hazmat) transportation, risk-averse approach for routing is needed. In this paper, we consider spectral risk measures, which are coherent and more general than existing approaches such as conditional value-at-risk. We develop a mixed integer programming model in hazmat routing to minimize a special class of spectral risks and propose an efficient algorithm to solve the problem. For general spectral risk measures, we approximate the spectrum function using step functions. By applying spectral risk measures to hazmat routing, we protect the road network from undesirable route choices that may lead to severe consequences.

4 - Optimizing Disaster Resilience of the Built Infrastructure

Elise Miller-Hooks, Professor, George Mason University, 208 Rosalie Cove Ct, Silver Spring, MD, 20905, United States, miller@gmu.edu, Mersedeh Tariverdi, Hossein Fotouhi, Seksun Moryadee

A multi-stage stochastic, mixed integer program is presented for quantifying and maximizing disaster resilience of the built infrastructure to multiple probabilistic hazard events. Dependencies on interdependent societal lifelines, including transportation, water and power, which are themselves subject to failure, are explicitly modeled. The model is applied on a case study.

■ SB59

362F

Joint Session RAS/Practice: Education Programs in OR/MS for Railways

Sponsored: ORinformed Healthcare Policies

Sponsored Session

Chair: Steven Harrod, Technical University of Denmark, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark, stehar@dtu.dk

1 - Railway Education Programs at the Technical University of Denmark and Other European Universities, and Related Careers

Steven Harrod, Technical University of Denmark, Room 132, Building 424, Kgs. Lyngby, 2800, Denmark, stehar@dtu.dk

Railway agencies, infrastructure managers, and operators nearly all desire formal university education today. This presentation summarizes the education programs available in Europe and some of the typical career paths available at European railways.

2 - OR/MS Education in Railways in China

Xy Yin, Beijing Jiaotong University, Beijing, China, xyyin@bjtu.edu.cn

This paper introduces the development process of the theory of Operations Research and Management Science in the education of the railway transportation in Beijing Jiaotong University. Beijing Jiaotong University has been established for 120 years. The major of railway transportation management is the earliest major in the school, and the theory of Operations Research and Management Science has been adopted in the major-related courses, including the organization of train operation and the organization of railway freight transportation. Such theory makes teaching level improved, helps to train a large number of qualified staffs in the fields of China railway transportation management.

3 - Railway Operations Education at the University of Illinois at Urbana-champaign

C. Tyler Dick, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, ctdick@illinois.edu

The Rail Transportation and Engineering Center (RailTEC) at the University of Illinois at Urbana-Champaign is home to the strongest academic program in railroad engineering of any university in North America, complimented by the largest and most diverse program of research on the topic. After many years of decline, railways have reemerged as an area of interest to North American academicians. This presentation will describe how RailTEC uses a combination of coursework, research, industry internships and international collaboration to meet the challenge of educating the next generation of railway operations and engineering professionals.

4 - OR Careers in Railways at BNSF

Pooja Dewan, Chief Data Scientist, BNSF Railway, 2650 Lou Menk Drive, #2, Fort Worth, TX, 76131, United States, pooja.dewan@bnsf.com

As one of the largest freight railroads in North America, BNSF moves goods and commodities that feed and clothe millions of people; help build roads and buildings; and provide a critical link that connects consumers with the global marketplace. Railroads carry more than 40 percent of freight in the U.S. by volume and provide the most fuel-and cost-efficient means for moving freight over land. Behind the scenes helping equip BNSF leaders with the research necessary to make decisions on is the company's Operations Research team. The team's mission is to leverage advanced analytics to provide innovative tools and insights that help support and enhance the decisions made by company's leaders.

■ SB61

370B

MIF Early Career Award

Sponsored: Minority Issues

Sponsored Session

Chair: Julie Simmons Ivy, North Carolina State University, North Carolina State University, Raleigh, NC, 27695-7906, United States, jsivy@ncsu.edu

1 - Choice-based Optimization in Transport, Mobility and Logistics

Shadi Sharif Azadeh, Erasmus University Rotterdam, Rotterdam, Netherlands. Contact: sharifazadeh@ese.eur.nl

Combining customer behaviour models in optimization provides a better understanding of the preferences of clients to policy makers while planning for their systems. These preferences are formalized with discrete choice models. However, their complexity leads to mathematical formulations that are highly non-linear and non convex in the variables of interest. On the other hand, we are also interested in discrete optimization models where supply and demand closely interact, which is typically the case in transportation. Such models are associated with (mixed) integer optimization problems, whose discrete variables are used to design and configure the supply. The goal of this research is to develop a general methodology which integrates both supply and demand under the framework of discrete choice models whose associated mixed integer linear problems are scalable and solvable within reasonable time.

2 - Integrated Computational and Theoretical Scheme for Linking Quality Control and Stochastic Modeling in Bioenergy Supply Chain Network Design

Krystel Castillo, University of Texas-San Antonio, San Antonio, TX, Contact: Krystel.Castillo@utsa.edu

In recent years, industry has seen the advent of highly complex, large-scale supply chains (SCs), whichhave become increasingly difficult to analyze and optimize using conventional modeling techniques and solutionprocedures. A particularly relevant example is found in the emerging second-generation biofuel industry, whichfaces unique, unaddressed challenges such as: (1) understanding the biomass quality/availability and quantifying howthese variables impact the design of technologies, and (2) assessing the impact of uncertainties related to thebiomass quality/availability on the supply chain design and planning. This presentation will include a discussion on a unified computational and theoretical scheme that links qualitycontrol, twostage stochastic modeling and tractable optimization algorithms to (1) enable the conversion of largequantities of biomass into marketable products, (2) better represent the random nature of the biomass quality, and (3)assess the impact of these uncertainties on the system's design. These computational tools are being integrated into science-as-service platform. This alpha version of a cloud-based Decision Support System aims to facilitate the adoption of experimental and field data as well as computational models..

■ SB62

370C

Big Data and Institutional Research

Sponsored: INFORMS Special Sessions

Sponsored Session

Chair: Grace Lin, Institute for Information Industry, 1F, No. 133, Sec. 4, Minsheng E. Rd., Taipei, na, Taiwan, gracelin.ny@gmail.com

1 - Big Data Analytics-Based Pricing and Revenue Management

Roger Gung, University of Phoenix, Phoenix, AZ, roger.gung@phoenix.edu

Using big data for better pricing is a critical strategy for revenue management. Nowadays commodity and service industries have been developing big data analytics-based pricing systems to optimize profit or return on investment. In this talk, we present a general methodology for pricing and revenue management using big data analytics. The methodology includes statistical models for predicting customer buying behavior and an optimization framework for optimizing profit or return on investment. The talk also presents a method to normalize variable impacts and rank the importance of the variables.

2 - An AI-based Framework for IR Decision-making

Grace Lin, Institute for Information Industry, 1F, No. 133, Sec. 4, Minsheng E. Rd., Taipei, Taiwan, gracelin.ny@gmail.com, Jeffrey Tsai, Ya-Hui Chan, Jianian Cheng, Yang Tinying, Ct Lee

In this talk, we will present a framework for a self-learning IR decision-making system that incorporates internal information from an institution as well as external big data information such as market and emerging technology trends and job market in order to bridge the gap between industry talent needs and university education.

■ SB63

370D

Redesigning Electricity Markets and Pricing to Account for Uncertainty

Invited: Energy and Climate

Invited Session

Chair: Ramteen Sioshansi, The Ohio State University, 240 Baker Systems Engineering Building, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, sioshansi.1@osu.edu

Co-Chair: Antonio J. Conejo, The Ohio State University, 286 Baker Systems Engineering Building, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, conejonavarro.1@osu.edu

1 - Price Formation with an Evolving Resource Mix

Congcong Wang, MISO, 720 City Center Dr, Carmel, IN, 46032, United States, cwang@misoenergy.org

With an evolving resource mix including increasing renewable penetration and demand-side participation, pricing needs have changed and will continue to change as resources are operated to balance variations and uncertainties in net demands throughout the day. This talk tries to provide a holistic view of the price formation challenges and how MISO is preparing for the low-carbon future. Numerical examples will be presented to illustrate the pricing challenges and potential solutions, including but not limited to sustainability of traditional resources facing prices driven down by low-marginal costs renewables and flexibility of resources that must be maintained for reliability needs.

2 - Pricing Methods in ISO Day-ahead and Real-time Auction Markets

Richard O'Neill, Chief Economist, Federal Energy Regulatory Commission, 12601 Meadowood Drive, Silver Spring, MD, 20904, United States, richard.oneill@ferc.gov

We examine four pricing methods for non-convex auctions markets comparing the properties of each including transparency, make-whole payments, entry price signals, price signals for price-responsive demand.

3 - A Market Design Integrating the View of Stochastic Producers

Antonio J. Conejo, The Ohio State University, Department of Integrated Systems Engineering, 210 Baker Systems Building, Columbus, OH, 43210, United States, conejonavarro.1@osu.edu, Ramteen Sioshansi

The goal of this presentation is to reexamine the design of electricity markets in light of the fundamental changes that electric power systems are undergoing, while account for the two decades of experience we have with restructured electricity markets. This includes increasing use of non-dispatchable, uncertain, and variable weather-dependent renewable energy, the use of distributed energy resources, and novel uses of electricity by end consumers.

■ SB64

370E

Data Mining Best Paper Award II

Sponsored: Data Mining

Sponsored Session

Chair: Tong Wang, University of Iowa, Pappajohn Business Build, 21 East Market Street, Iowa City, IA, 52245, United States, tong-wang@uiowa.edu

1 - Wasserstein Distributional Robustness and Regularization in Statistical Learning

Rui Gao, Georgia Institute of Technology, 755 Ferst Drive NW, ISyE Main Building, Atlanta, GA, 30332-0205, United States, rgao32@gmail.com

A central problem in statistical learning is to design algorithms that not only perform well on training data, but also generalize to new and unseen data. In this paper, we tackle this problem by formulating a distributionally robust stochastic optimization problem, which minimizes the worst-case expected loss over a family of distributions that are close to the empirical distribution in Wasserstein distances. We establish a relation between such Wasserstein distributionally robust stochastic optimization and the gradient-norm regularization. In particular, we identify a broad class of loss functions, for which the worst-case expected loss is upper and lower bounded by some gradient-norm regularization problems. Moreover, we show that the gap between the upper and lower bounds is asymptotically zero with probability one. The relation between Wasserstein distributional robustness and regularization has the following important implications: (i) It provides new interpretations for problems involving regularization, including a great number of statistical learning problems, and several discrete choice models such as the multinomial logit. (ii) It enables a new method to derive generalization error bounds for statistical learning problems, by leveraging tools from distributionally robust optimization. For example, we derive an optimal generalization error bound for linear prediction with Lipschitz loss. (iii) It suggests a novel and systematic way to regularize problems in deep learning. As an example, we demonstrate superior performance on training generative adversarial networks (GANs) using our new regularization scheme.

2 - A Cluster Fusion Penalty for Grouping Response Variables in Multivariate Regression Models

Brad Price, West Virginia University, College of Business and Economics, P.O. Box 6025, Morgantown, WV, 26506, United States, brad.price@mail.wvu.edu

We propose a method for estimating coefficients in multivariate regression when there is a clustering structure to the response variables. The proposed method includes a fusion penalty, to shrink the difference in

fitted values from responses in the same cluster, and an L1 penalty for simultaneous variable selection and estimation. The method can be used when the grouping structure of the response variables is known or unknown. When the clustering structure is unknown the method will simultaneously estimate the clusters of the response and the regression coe cients. Theoretical results are presented for the penalized least squares case, including asymptotic results allowing for p n. We extend our method to the setting where the responses are binomial variables. A coordinate descent algorithm is proposed for both the normal and binomial likelihood, which can easily be extended to other glm settings. Simulations and data examples from business operations and genomics are presented to show the merits of both the least squares and binomial methods.

3 - Statistical Degradation Modeling and Prognostics of Multiple Sensor Signals via Data Fusion: A Composite Health Index Approach

Changyue Song, University of Wisconsin-Madison, Rm 3221, Mechanical Engineering Building, 1513 University Ave, Madison, WI, 53715, United States, csong39@wisc.edu

Nowadays multiple sensors have been widely used to monitor the degradation status of a unit simultaneously. As those sensor signals are often correlated and measure different characteristics of the same unit, effective fusion of such diverse "gene pool" is important to better understand the degradation process and produce more accurate prediction of the remaining useful life (RUL). This is a challenging task as the true degradation status cannot be directly observed, and the degradation process has to comply with the engineering principles governing the underlying failure mechanism. To address this issue, this article proposes a novel data fusion method that constructs a composite health index (HI) via the combination of multiple sensor signals for better characterizing the degradation process. In particular, we formulate this problem as an indirect supervised learning problem and leverage the quantile regression to derive the optimal fusion coefficient. In this way, the prognostic performance of the proposed method is theoretically guaranteed. To the best of our knowledge, this is the first paper that provides the theoretical analysis of the data fusion method for degradation modeling and prognostics. Simulation studies are conducted to evaluate the proposed method in different scenarios. A case study on the degradation of aircraft engines is also performed, which shows the superior performance of our method over the existing HI-based methods.

4 - Frequentist Consistency of Variational Bayes

Yixin Wang, Columbia University, New York, NY, United States, yixin.wang.sh@gmail.com

A key challenge for modern Bayesian statistics is how to perform scalable inference of posterior distributions. To address this challenge, variational Bayes (VB) methods have emerged as a popular alternative to the classical Markov chain Monte Carlo (MCMC) methods. VB methods tend to be faster while achieving comparable predictive performance. However, there are few theoretical results around!". In this paper, we establish frequentist consistency and asymptotic normality of VB methods. Specifically, we connect VB methods to point estimates based on variational approximations, called frequentist variational approximations, and we use the connection to prove a variational Bernstein-von-Mises theorem. The theorem leverages the theoretical characterizations of frequentist variational approximations to understand asymptotic properties of VB. In summary, we prove that (1) the VB posterior converges to the Kullback-Leibler (%&) minimizer of a normal distribution, centered at the truth and (2) the corresponding variational expectation of the parameter is consistent and asymptotically normal. As applications of the theorem, we derive asymptotic properties of VB posteriors in Bayesian mixture models, Bayesian generalized linear mixed models, and Bayesian stochastic block models. We conduct a simulation study to illustrate these theoretical results.

■ SB65

370F

Decision Analytics Applications

Sponsored: Data Mining

Sponsored Session

Chair: Victoria Chen, vchen@uta.edu

1 - A High Dimensional State Transition Development Framework for Deicing Activities at Dallas Fort Worth International Airport

Ashkan Aliabadi Farahani, University of Texas, Arlington, TX, United States, ashkan.aliabadifarahani@mavs.uta.edu

In complex systems, the system state is often high-dimensional and state transitions are unknown. When system data are available, it may be possible to empirically estimate state transitions to enable simulation and/or optimization of the system. This paper presents a data-driven framework for state transition estimation and development.

2 - TK-MARS: An Efficient Approach for Black-Box Optimization

Hadis Anahideh, University of Texas at Arlington, Arlington, TX, United States, hadis.anahideh@mavs.uta.edu, Jay Rosenberger, Hadis Anahideh

In this study, a modified version of MARS, TK-MARS (Tree Knot MARS), is developed to improve the use of MARS within the surrogate optimization context. TK-MARS is genuinely able to identify peaks and valleys where optimization needs to know. More importantly, due to the limitations of existing optimization test problems, a novel construction of representative surrogate-optimization test problems are presented to overcome the real world noisy black-box function with a set of important variables.

3 - Inverse Probability of Treatment Weighting in Adaptive Pain Management with Correlated Treatments

Nilabh Ohol, University of Texas-Arlington, 900 Greek Row Drive, Apt 201, Arlington, TX, 76013, United States, nilabh.ohol@mavs.uta.edu, Aera Kim LeBoulluec, Victoria C. P. Chen, Li Zeng, Jay Michael Rosenberger, Robert J.Gatchel

Interdisciplinary pain management combines biological and psychosocial factors causing patient's pain and administers best treatments. To improve pain outcomes, our framework employs state transition and outcome models using data from Eugene McDermott Center for Pain at the University of Texas Southwestern Medical Center at Dallas. The sequential treatment structure of the data leads to a form of endogeneity. This research develops a process based on the inverse probability of treatment weighted method to address endogeneity and presents a framework to develop a general approach for correlated treatments.

4 - Machine Learning Approaches to Modeling Category Sales: Implications for Optimal Store-level Pricing and Promotions

Durai Sundaramoorthi, Washington University in Saint Louis, 10352 Conway Road, Saint Louis, MO, 63131, United States, dsundaramoorthi@gmail.com, Seethu Seetharaman

We discuss and propose five machine learning models as candidate models of product category sales as functions of marketing variables (price, display, feature, price promotion), both within and across categories at the same retail store. Using store-level weekly scanner data from 24 product categories in each of 9 stores of a supermarket chain over a period of 5 years, we estimate the five proposed machine learning models and compare their empirical performance to those of three commonly used statistical models. Taking the overall best-performing machine learning, we optimize the profit made by the chain.

■ SB66

371A

Design and Impacts of Parking Systems

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Xin Wang, University of Wisconsin-Madison, 8916 Red Beryl Drive, Middleton, WI, 53562-4278, United States, xin.wang@wisc.edu

Co-Chair: Xin Wang, University of Wisconsin-Madison, Middleton, WI, United States, xin.wang@wisc.edu

1 - Data-driven Modeling and Analysis of Urban Congestion Caused by Demand for Parking

Chase Patrick Dowling, PhD Student, University of Washington, Seattle, WA, 98105, United States, cdowling@uw.edu, Tanner Fiez, Lillian Ratliff, Baosen Zhang

Congestion caused by drivers searching for parking has been limited to theoretical modeling and empirical study; yet, pervasive installation of digital parking meters providing troves of data on parking transactions. These data can be used to estimate occupancy, but are not amenable to canonical theoretical models.We present a new model, amenable to transaction data, using a network of finite capacity queues. We estimate demand for parking across time and location and the subsequent volume of traffic generated. Combined with travel time data, the impact of this congestion can be estimated.

2 - A Data Driven Study on the Relation Between Parking Garage Occupancy and Traffic Speeds in Urban Areas

Rui Ma, University of California, Davis, 2041 Academic Surge, University of California, One Shields Avenue, Davis, CA, 95616, United States, drma@ucdavis.edu, Shenyang Chen, Michael Zhang

Theoretical studies have suggested that parking and traffic conditions in cities are related, yet few empirical studies are conducted to quantify this relationship. We develop a data processing procedure to extract and fuse the time-varying parking garage occupancy and traffic speed data at the street or city blocks levels via APIs, and study their relationship. It is found that during the morning and evening commute periods, the relationship between the average speed and the parking occupancy are distinct and both can be modeled by a reversed logistic function. Such a macroscopic relationship can be exploited to evaluate the effectiveness of downtown access control or congestion charging.

3 - A Spatial-temporal Flexible Parking Reservation System

Xin Wang, University of Wisconsin-Madison, 8916 Red Beryl Drive, Middleton, WI, 53562-4278, United States, xin.wang@wisc.edu, Xiaotian Wang

In a reservation-based parking system, customers departing late cause service failure for subsequent customers. To guarantee the service level, the parking system needs to run at a low utilization, which is a huge waste of parking resources, especially in congested urban area. We propose a flexible reservation system with spatial-temporal flexibility to address the issue. A game-theoretical model is used to capture the customers' utility over the flexibility.

■ SB67

371B

Condition-Based Maintenance and Support Operations

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Chiel Van Oosterom, vanoosterom@ese.eur.nl

1 - Optimally Replacing Multiple Systems in a Shared Environment

David Tarek Abdul-Malak, University of Pittsburgh, 1702 Jancey Street, Pittsburgh, PA, 15206-1146, United States, dta10@pitt.edu, Jeffrey P. Kharoufeh

In this talk we will present a model for replacing multiple stochastically degrading systems using condition-based maintenance. Systems are assumed to degrade in a shared, exogenous, Markov modulated environment. Continuous state variables and a high dimensional state space cause the problem to be computationally intractable. To overcome these complications, structural results are proven and a novel reinforcement learning (RL) approach is employed.

2 - Maintenance Optimization for Partially Observable Multi-component Systems

Ayse Sena Eruguz, Postdoctoral Researcher, Eindhoven University of Technology, P.O. Box 513, Eindhoven, 5600 MB, Netherlands, a.s.eruguz@tue.nl, Rob Basten, Lisa M.Maillart

We consider a multi-component system in which a condition parameter (e.g., vibration or temperature) is monitored. The outcome of monitoring indicates whether the system is functioning properly, is defective, or has failed. However, the condition signal does not reveal which component in the system is defective or has failed. The decision maker needs to infer the exact state of the system from the current condition signal and the past data, in order to decide when to intervene for maintenance. We model this problem as a partially observable Markov decision process.

3 - Joint Planning of Multiaction Maintenance with Complex Effects

Yisha Xiang, Lamar University, 2626 Cherry Engineering Building, Beaumont, TX, United States, yxiang@lamar.edu, Yue Shi, David W. Coit

Existing maintenance literature mainly focus on a single type of preventive maintenance action (e.g., replacement) and often make simple assumptions regarding the effects of maintenance activities. Many important maintenance effects are overlooked in these models, for example, deterioration suppression after maintenance interventions, deterioration rate reduction under maintenance effect, and the random duration of the effective maintenance period. In this research, we consider joint planning for multiple maintenance actions with complex effects, and formulate the problem as Markovian decision process. Structural properties of optimal policies are investigated.

4 - Condition-based Repair Prioritization in Repairable Inventory Supply Chains

Chiel van Oosterom, Eindhoven University of Technology, PO Box 513, Eindhoven, 5600MB, Netherlands, c.d.v.oosterom@tue.nl, Joachim Jacob Arts, Geert-Jan Van Houtum

We propose a model for exploiting information collected via condition monitoring of components operating in the field to dynamically prioritize repairs in a capacitated repair shop. Specifically, we consider a repair shop that supports a serial system with a number of different repairable components, which all deteriorate over time according to continuous-time Markov chains. The system is down whenever a component fails and no ready-for-use spare part is available for that component. The objective in prioritizing repairs is to maximize the long-run availability of the system.

■ SB68

371C

QSR Best Refereed Paper Competition

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Kaibo Wang, Tsinghua University, Beijing, 100084, China, kbwang@tsinghua.edu.cn

Co-Chair: Prahalada Rao, PhD, University of Nebraska-Lincoln, Lincoln, NE, 68588, United States, rao@unl.edu

1 - QSR Competition

Kaibo Wang, Tsinghua University, Department of Industrial Engineering, Beijing, 100084, China, kbwang@tsinghua.edu.cn

The QSR Best Paper Competition intends to promote outstanding research papers on the state-of-the-art methodological development and applications in the area of Quality, Reliability, Statistics, and Data Sciences. Four finalists will be selected to present their work in this session, and a winner will be identify by a panel.

2 - Effective Model Calibration via Sensible Variable Identification and Adjustment, with Application to Composite Fuselage Simulation

Yan Wang, Xiaowei Yue, Rui Tuo, Jeffrey H. Hunt and Jianjun Shi

We introduce a new concept of sensible variables for calibration and propose an effective calibration method to identify and adjust sensible variables with limited physical experimental data. With a skillful integration of engineering design knowledge, this method can overcome the curse of dimensionality in the calibration of composite fuselage computer model.

3 - An Integrated Manifold Learning Approach for Online Process Monitoring of Additive Manufacturing Processes

Chenang Liu, Grado Department of Industrial and Systems Engineering, Virginia Tech, Zhenyu (James) Kong

This paper is to implement a new online process monitoring method for additive manufacturing using online sensing data. To achieve this objective, an integrated manifold learning algorithm termed multi-kernel learning embedded isometric mapping (MKL-ISOMAP) is proposed. In the case studies, this method demonstrates excellent performance in data compression and prediction.

4 - Direct Learning to Rank and Rerank

Cynthia Rudin and Yining Wang

Learning-to-rank is directly relevant for predictive maintenance applications, where equipment needs to be prioritized for inspection or repair. This work exposes a serious problem with the state of learning-to-rank algorithms, which is that they are based on convex proxies that lead to poor approximations. We then discuss the possibility of "exact" reranking algorithms based on mathematical programming. We prove that that a relaxed version of the "exact" problem has the same optimal solution, and provide an empirical analysis.

5 - A Functional Covariate Degradation Model with Application to Degradation Analysis of Dual-phase Steel by Utilizing Its Microstructure Images

Wujun Si, Department of Industrial and Systems Engineering, Wayne State University, Detroit, MI 48202, USA Qingyu Yang, Xin Wu

As the first time, this article conducts degradation analysis utilizing material microstructure image information. A novel functional covariate degradation model is proposed. A penalized least squares estimation method is developed for model parameter estimation. Analytical inferences are developed. Both simulation studies and physical experiments are conducted for validation.

■ SB69

371D

Environmental impacts and the Energy-water-Food Nexus

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Daniel Huppmann, International Institute for Applied Systems Analysis (IIASA), International Institute for Applied Systems Analys, Vienna, n, Austria, huppmann@iiasa.ac.at

1 - Bridging the Resolution Gap to Improve the Assessment of Sustainable Development Pathways

Nils Johnson, Research Scholar, International Institute for Applied Systems Analysis, Laxenburg, Austria, johnsonn@iiasa.ac.at, Edward Byers

The broad scope of global energy-economic models has required a trade-off in terms of spatial and temporal resolution with most models employing 5-10 year temporal intervals and large, often continental-scale, regions. This coarse resolution poses a challenge for exploring how fine resolution phenomena, such as water constraints and climate change, may influence energy transitions. A novel nexus assessment platform is introduced that seeks to bridge this "resolution gap", enable linkages among global change models, and facilitate interdisciplinary research to better understand how land-energy-water interactions influence sustainable development pathways.

2 - Linking Electricity Production Cost Models with Climate and Hydrological Models: Lessons Learned from Multiple Approaches and Scenarios

Jordan Macknick, National Renewable Energy Laboratory, Golden, CO, United States, Jordan.Macknick@nrel.gov, Gregory Brinkman, Matthew O'Connell

Water availability and temperature can affect thermal power plants' heat rate, capacity, and ability to operate, due to physical- and policy-related constraints. The degree to which a generator is affected by water is determined by its fuel, prime mover, and cooling system type. Here we link an electricity production cost model with different climate and hydrologic models to examine how water resource characteristics can affect power system costs and performance characteristics, as well as sensitivities from different scenarios of water availability and temperature. The Eastern Interconnection and Western Interconnection are modeled under alternative infrastructure and climate scenarios.

3 - National and Regional Implications of Water Resource Variability and Climate Change on the Evolution of the United States Power Sector

Stuart Cohen, National Renewable Energy Laboratory, Golden, CO, United States, Stuart.Cohen@nrel.gov

Water resource variability can influence U.S. power sector evolution, including technology selection, siting, and system operation. In addition, temperature rise due to climate change can affect seasonal loads, generator efficiency, and transmission capacity. We use the Regional Energy Deployment System (ReEDS) electric sector capacity expansion model of the United States to explore how myriad climate and policy scenarios could affect the structure and operations of the U.S. power sector, from present day to 2050. We explore electric sector capacity and generation along with environmental and economic impacts.

4 - Energy-water-land Nexus: An Integrated Assessment Modeling Perspective

Mohamad I. Hejazi, PNNL/JGCRI, College Park, MD, United States, mohamad.hejazi@pnnl.gov

Energy, water, and land systems are increasingly interconnected. In this study, we use the Global Change Assessment Model (GCAM), where interactions between population, economic growth, energy, land and water resources interact simultaneously in a dynamically evolving system, to investigate: 1) how water scarcity affects energy and land use decisions; 2) the effects of climate impacts; 3) how these impacts evolve under different policies in the context of the shared socioeconomic pathways; 4) the effects of different adaptation measures and their associate investment costs; and 4) the relative contributions of climate and human systems on water scarcity regionally and globally.

5 - Regional SDG Implications of the Energy-water-land Nexus

Daniel Huppmann, International Institute for Applied Systems Analysis (IIASA), Matthaeusgasse 8, Vienna, Austria, huppmann@iiasa.ac.at

We discuss regional impacts of the energy-water-land nexus on the Sustainable Development Goals using the MESSAGE Integrated Assessment Model.

■ SB70

371E

Big Data

Contributed Session

Chair: Xinbo Geng, Texas A&M University, College Station, TX, United States, gengxbtamu@email.tamu.edu

1 - Internet of Things, Big Data, and New Business Models: A Literature Review

Régis Delafenestre, Professor, SKEMA Business School, Av. Willy Brandt, Lille, 59777, France, regis.delafenestre@skema.edu, Xavier Brusset

With the advent of Big Data and the Internet of Things, e-commerce supply chains require substantial upheavals to remain competitive. New business models will be invented to take advantage of the enormous flow of consumer and Internet of Things data. These business models will remodel supply chains into demand chains which generate the possibility of inventing new ways of creating value for consumers. As a first step, we present the result of a systematic literature review and qualitative content analysis. We leverage the existing knowledge on big data and business models to identify the dimensions of demand-supply alignment and map the drivers, enablers necessary to invent such business models.

2 - An Empirical Study on Workload and Service Lead Times in the Aviation Maintenance Repair Overhaul Industry

Busra Keles, University of Miami, 1251 Memorial Drive, Coral Gables, FL, 33146, United States, bkeles@miami.edu, Murat Erkoc, Nazrul Islam Shaikh

Maintenance-Repair-Overhaul (MRO) service industries are constantly subject to internal and external factors that result in unsteady workload such as, unanticipated and/or irregular complex tasks, unexpected customer requirements, supplier related delays, and resource variations. To predict service time of an upcoming order and negotiate due dates, one should consider the current and future workload that capture complex scheduling, planning, queuing, and costing parameters through processing big data. For this purpose, we develop a model to identify the factors that influence workload and capture their mappings to service performance, capacity requirements, and budget.

3 - Understanding Patients' Purchasing Decisions for Online Healthcare Services an Empirical Study Considering Text Form Interaction Data

Tong Liu, Phd Candidate, Shanghai Jiao Tong University, No 1954 , Hua Shan Road, Xu Hui District, Shanghai, 200030, China, liutong3231@163.com

Now it is of great value to take a look at how patients make purchase decisions for online healthcare services. Some platforms allow patients to interact with physicians in several free chances before they make an order for a paid remote service, so we want to test whether the interaction information contained in those free trails will influence patients' purchasing decision. We use Bayesian updating process to describe the formulation of patients' perceived choice utility when they received the feedbacks from the physicians during interaction, where the prior beliefs come from static information contained on webpages and the updating samples are extracted through text mining methods.

4 - Real-time Segmentation of Consumers for Optimized Targeting

Chandra Devarkonda, Executive Consultant, IBM, Potomac, MD, United States, chandra.devarkonda@us.ibm.com

This paper addresses the issues of providing insightful guidance to retail customer-facing agents be it machine agents (bots) or human agents using data captured in near real time. It considers inherent human decision biases because of brand perceptions, recent buying behavior and influence of networks in buying decisions. Additionally, the solution demonstrates how to capture, ingest, process consumer information almost as it happens and use the outputs to update the understanding of value the consumer brings to the firm. The resulting output demonstrates classification of customers that incorporate both transactional value as well as social value.

5 - A Hybrid Algorithm for Bayesian Network Structure Learning Based on Wrapper Approach

Yi Luo, University of Michigan, 3585 Green Brier Blvd., Apt. 95B, Ann Arbor, MI, 48105, United States, Luo1@email.arizona.edu, Daniel L.McShan, Randall K.Ten Haken, Issam El Naqa

Bayesian Network (BN) allows for understanding hierarchical relationship between variables and predicting outcome, and it also achieves competitive performance compared to other statistical learning methods. But learning the structure of BNs without restrictive assumption is NP-hard. We developed a novel hybrid learning algorithm to seek stable BNs structures from high dimensional dataset based on wrapper method, and it was used to explore biophysical relationship behind radiotherapy outcome. In addition to having a high prediction performance based on the cross validation, our method can be easily extended to build multi-objective dynamic BNs for personalized adaptive decision support.

6 - Learning the LMP-load Coupling from Data: A Support Vector Machine Based Approach

Xinbo Geng, Texas A&M.University, 053E Wisenbaker Building, College Station, TX, 77840, United States, gengxbtamu@email.tamu.edu, Le Xie

We investigate the fundamental coupling between loads and locational marginal prices (LMPs) in security-constrained economic dispatch (SCED). Theoretical analysis based on multi-parametric programming theory points out the unique one-to-one mapping between load and LMP vectors. Such mapping is depicted by the concept of system pattern region (SPR) and identifying SPRs is the key to understanding the LMP-load coupling. The SPR identification problem is modeled as a classification problem and a SVM based data-driven approach is proposed. It is shown that even without the knowledge of system topology and parameters, the SPRs can be estimated by learning from historical load and price data.

■ SB71

371F

Recent Progress in Global Optimization

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Guanglin Xu, University of Iowa, Iowa City, IA, 52242, United States, guanglin-xu@uiowa.edu

1 - A Data-driven Distributionally Robust Bound on the Expected Optimal Value of Uncertain Mixed 0-1 Linear Programming

Guanglin Xu, The University of Iowa, 108 Pappajohn Business Building, Iowa City, IA, 52242, United States, guanglin-xu@uiowa.edu

We study the expected optimal value of a mixed 0-1 linear program with uncertain objective coefficients following a joint distribution. We assume that the true distribution is not known exactly, but a set of independent samples can be observed. Using the Wasserstein metric, we construct an ambiguity set centered at the empirical distribution from the observed samples. The problem of interest is to investigate the bound on the expected optimal value over the Wasserstein ambiguity set. We compare our approach with a moment-based approach from the literature for two applications. Numerical results illustrate the effectiveness of our approach.

2 - Semidefinite Programming for Nash Equilibria in Bimatrix Games

Jeffrey Zhang, Princeton University, 206 Lakeside Road, Princeton, NJ, 08540, United States, jeffz@princeton.edu, Amir Ali Ahmadi

We are interested in exploring the power of SDP relaxations for the problem of finding an additive -approximate Nash equilibrium for bimatrix games. We show that for zero-sum games our SDP is guaranteed to return a rank-1 solution. Furthermore, we prove that if a rank-2 to our SDP solution is found, then a 5/11-NE can be recovered for any game, or a 1/3-NE for a symmetric game. We propose algorithms based on iterative linearization procedure of smooth nonconvex objective functions which empirically often recover solutions of rank at most two and close to zero. We then show how our SDP approach can address two (NP-hard) problems of economic interest. Finally, we relate our SDP to the Lasserre hierarchy.

3 - Globally Solving Non-convex Quadratic Programs via Linear Integer Programming Techniques

Wei Xia, Lehigh University, Bethlehem, PA, 18015, United States, wex213@lehigh.edu, Juan Vera, Luis F.Zuluaga

A quadratic program (QP) is a well-studied fundamental NP-hard optimization problem which optimizes a quadratic objective over a set of linear constraints. We reformulate QP as a mixed-integer linear problem (MILP). This is done via the reformulation of QP as a linear complementary problem, and the use of binary variables together with some fundamental results on the solution of perturbed linear systems, to model the complementary constraints. Reformulating non-convex QPs as MILPs provides an advantageous way to obtain global solutions. To illustrate, we compare the performance of our solution approach with the current benchmark global QP solver quadprogBB on a large variety of QP test instances.

4 - Rank Minimization Problem

Xin Shen, Rensselaer Polytechnic Institute, 2000 6th Avenue, Apt A801, Troy, NY, 12180, United States, shenxinhust@gmail.com, John E.Mitchell

The problem of minimizing the rank of a matrix subject to constraints can be formulated equivalently as a semidefinite programwith complementarity constraints (SDCMPCC). We investigate calmness of locally optimal solutions to the SDCMPCC formulation and hence show that any locally optimal solution is a KKT point, under an assumption on the original set of constraints. We develop a penalty formulation of the problem. We present calmness results for locally optimal solutions to the penalty formulation. We also develop a proximal alternating linearized minimization (PALM) scheme for the penalty formulation, and investigate the incorporation of a momentum term into the algorithm.

■ SB72

372A

Mechanism Design and Network Pricing

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Evdokia Velinova Nikolova, University of Texas at Austin, 400 E Monroe Street, Austin, TX, 78704, United States, nikolova2009@gmail.com

1 - Aversion to Uncertainty and its Implications for Revenue Maximization

Emmanouil Pountourakis, University of Texas at Austin, 16 Bristol Street, Unit 3, Cambridge, MA, 02141, United States, malgor21@gmail.com

Mechanism design often assumes that buyers are risk neutral, or exhibit risk aversion due to a non-linear utility for money. Yet behavioral studies show that real agents exhibit various risk attitudes, which, cannot be captured by any expected utility model. We adopt a model from prospect theory, where an event which occurs with probability x<1 is worth strictly less than x times the value of the event when it occurs with certainty. We characterize optimal mechanisms in the static setting as menus of binary lotteries and we show that under a reasonable assumption, posted pricing obtains a constant approximation. Third, we show that constant approximation is impossible in dynamic settings.

2 - Pricing: How to Induce Optimal Flows under Strategic Link Operators

Thanasis Lianeas, Univeristy of Texas at Austin, Austin, TX, 78704, United States, tlianeas@mail.ntua.gr, Evdokia Velinova Nikolova

Our main result is to observe that a slight regulation on the network owners market solves all three issues above. Specifically, if the authority could set appropriate caps (upper bounds) on the tolls (prices) operators can charge then: the game among the link operators has a unique strong Nash equilibrium and the users' game results in a Wardrop equilibrium that achieves the optimal total delay. We call any price vector with these properties a great set of tolls. We then ask, can we compute great tolls that minimize total users' payments? We show that this optimization problem reduces to a linear program in the case of single-commodity series-parallel networks. Starting from the same linear program, we obtain multiplicative approximation results for arbitrary networks with polynomial latencies of bounded degree, while in the single-commodity case we obtain a surprising bound, which only depends on the topology of the network.

3 - Bifurcation Mechanism Design – From Optimal Flat Taxes to Improved Cancer Treatments

Ger Yang, University of Texas at Austin, Austin, TX, United States, geryang@utexas.edu, Georgios Piliouras, David Basanta

Small changes to the parameters of a system can lead to abrupt qualitative changes of its behavior, a phenomenon known as bifurcation. Such instabilities are typically considered problematic, however, we show that their power can be leveraged to design novel types of mechanisms. Hysteresis mechanisms use transient changes of system parameters to induce a permanent improvement to its performance via optimal equilibrium selection. Optimal control mechanisms induce convergence to states whose performance is better than even the best equilibrium. We apply these mechanisms in two different settings that illustrate the versatility of bifurcation mechanism design. In the first one we explore how introducing flat taxation can improve social welfare, despite decreasing agent "rationality", by destabilizing inefficient equilibria. From there we move on to consider a well known game of tumor metabolism and use our approach to derive novel cancer treatment strategies.

■ SB73

372B

Using Deep Neural Networks for Solving Combinatorial Optimization Problems

Sponsored: Computing

Sponsored Session

Chair: Mohammadreza Nazari, Lehigh University, Bethlehem, PA, 18015, United States, mon314@lehigh.edu

Co-Chair: Afshin OroojlooyJadid, Lehigh University, Bethlehem, PA, 18015, United States, afo214@lehigh.edu

1 - Neural Combinatorial Optimization with Reinforcement Learning

Irwan Bello, Google Brain, Mountain View, CA, United States, ibello@google.com

We present a framework to tackle combinatorial optimization problems using neural networks and reinforcement learning. We focus on the traveling salesman problem (TSP) and train a recurrent neural network that predicts a distribution over city permutations. Using negative tour length as the reward signal, we optimize the parameters of the recurrent neural network using a policy gradient method. With minimal engineering and without heuristic designing, Neural Combinatorial Optimization achieves close to optimal results on 2D Euclidean graphs with up to 100 nodes. Applied to the KnapSack, another NP-hard problem, the same method obtains optimal solutions for instances with up to 200 items.

2 - Learning Combinatorial Optimization Algorithms over Graphs

Le Song, Georgia Institute of Technology, 266 Ferst Drive, Atlanta, GA, 30332, United States, lsong@cc.gatech.edu, Hanjun Dai, Elias B. Khalil, Yuyu Zhang, Bistra Dilkina

Significant expertise is required to design good heuristics for hard graph optimization problems. In many applications, it is typically the case that the same optimization model is solved again and again on a regular basis, maintaining the same problem structure but differing in the data. This provides an opportunity for learning heuristics that exploit the structure of such recurring problems. We propose a unique combination of reinforcement learning and graph embedding to address this challenge, and demonstrate competitive performance for Minimum Vertex Cover, Max Cut, TSP and Set Covering.

3 - Controlling Stochastic VRP Systems by using Deep Reinforcement Learning

Mohammadreza Nazari, Lehigh University, Murray H.Goodman Campus, Bethlehem, PA, 18015, United States, mon314@lehigh.edu, Afshin Oroojlooy Jadid, Lawrence V. Snyder, Martin Takac

We present a deep learning scheme for the VRP problem with stochastic demands. Demands arrive randomly at different locations, and at each time step a vehicle chooses its next destination according to a policy learned by deep reinforcement learning in order to maximize its reward over a time horizon. This problem has applications in distribution networks and real-time taxi allotment and has been widely studied in the stochastic optimization, but most studies assume that the demand distribution is known. A major complexity arises when the demands are non-stationary or from an unknown distribution. In this talk, we address this issue by using deep recurrent Q-networks.

4 - Financial Evaluation of Large Cap Companies on the Stock Market; Artificial Neural Networks Approach to Stock Picking

Alireza Moghimi, New Mexico State University, 1132 E.Mesa Apt.15, Las Cruces, NM, 88001, United States, moghimi@nmsu.edu

The current research proposes an Artificial Neural Network based forecasting model to evaluate the relative financial performance of a group of firms. The model employs company's historical financial data and classifies firms based on their future financial performance. The study attempts to generate portfolios that could outperform the market and shift the distribution of the returns earned by an investor. The model employs the financial statements of the companies on S&P-500 index for 2006 to 2014 period. A portfolio based on the proposed model is compared to several benchmarks by bootstrapping and statistical analysis. The model is significantly outperforming the market.

■ SB74

372C

Computational Advances in VRPs

Sponsored: Computing

Sponsored Session

Chair: Ahmed Ghoniem, University of Massachusetts-Amherst, Amherst, MA, 01003, United States, aghoniem@isenberg.umass.edu

1 - Upper and Lower Bounding Procedures for Snow Plow Optimization

Joris Kinable, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, jkinable@cs.cmu.edu, Willem-Jan Van Hoeve, Stephen F.Smith

Snow plow optimization is a complex process in which routes for a fleet of vehicles have to be determined, while adhering to vehicle operating restrictions, and resource utilization and replenishment constraints. We present upper and lower bounding techniques for a real-world snow plow optimization problem. Feasible routes and schedules are calculated using heuristics and a Constraint Programming approach. To study the quality of our solutions, a bounding procedure is developed based on a Mixed Integer Programming model for Capacitated Arc Routing with Intermediate Replenishment Facilities. Computational experiments are conducted on data from the city of Pittsburgh (USA).

2 - Consistency vs. Flexibility in Multi Objective Vehicle Routing Problems

Mohsen Emadikhiav, University of Connecticut, Storrs, CT, United States, Mohsen.Emadikhiav@business.uconn.edu, David Bergman, David Bergman, Robert Day

In this talk, we discuss a branch-and-price algorithm for a multi-objective consistent VRP with simultaneous pickups and deliveries, and analyze the tradeoffs between several classical VRP objectives. Our experimental results indicate that for short-term planning, enforcing consistency only marginally affects other objectives, but for real-time planning, particularly when there is high variability in order release times, enforcing consistency can significantly impact other objectives.

3 - A Branch-and-price Algorithm for a Vehicle Routing-allocation Problem

Mohammad Reihaneh, University of Massachusetts, 277 Riverglade Dr, Apt 2, Amherst, MA, 01002, United States, mo.reihaneh@gmail.com, Ahmed Ghoniem

We investigate a vehicle routing-allocation problem (VRAP) where the decision-maker jointly optimizes the location of delivery sites, the assignment of customers to (preferably convenient) delivery sites, and the routing of vehicles operated from a central depot to serve customers at their designated sites. We propose an effective dynamic programming-based branch-and-price (B&P) algorithm that is demonstrated to greatly outperform the use of commercial branch-and-bound/cut solvers such as CPLEX. Our computational study demonstrates the efficacy of the proposed approach using a test-bed of 60 challenging problem instances.

4 - Vehicle Routing with Drones

Amro El-Adle, Isenberg School of Management, UMass-Amherst, Amherst, MA, United States, aeladle@umass.edu, Ahmed Ghoniem, Mohamed Haouari

We investigate a vehicle routing problem with drones in which customers may be served either by the vehicle or by a portable drone that is launched from the vehicle. A key consideration in this setting is to synchronize vehicle and drone operations. Models and optimization approaches are presented, along with a computational study.

■ SB75

372D

Distributed and Large-Scale Optimization

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Ermin Wei, Northwestern University, Evanston, IL, 60208, United States, ermin.wei@northwestern.edu

1 - Asynchronous Distributed Newton Method

Ermin Wei, Northwestern University, 2145 Sheridan Rd, Tech L310, Evanston, IL, 60208, United States, ermin.wei@northwestern.edu

The problem of minimizing a sum of local convex objective functions over a networked system captures many important applications and has received much attention in the distributed optimization field. Most of existing work focuses on development of distributed algorithms under the presence of a central clock. The only known algorithms with convergence guarantees in asynchronous setup could achieve linear rate. In this work, we built upon existing literature to develop and analyze an asynchronous Newton method. We show that this algorithm converges almost surely and has superlinear rate in expectation. Numerical studies confirm superior performance against other existing asynchronous methods.

2 - Object-parallel Augmented Lagrangian Solution of Continuous Stochastic Programs

Gyorgy Matyasfalvi, Rutgers University, 100 Rockafeller Road, Piscataway, NJ, 08854, United States, matyasfalvi@gmail.com, Jonathan Eckstein

We describe an "object-parallel' C++ approach to implementing iterative optimization methods, with the goal of coding the algorithms in a readable, MATLAB-like style, but with efficient parallel implementation of underlying low-level linear algebra operations. Recent advances in augmented Lagrangian algorithms and mathematical modeling environments, combined with our "object-parallel' software development techniques suggest efficiently scalable solver implementations for stochastic programming problems, without employing decomposition methods.

3 - Accelerated Distributed Nesterov Gradient Descent

Guannan Qu, Harvard University, Cambridge, MA, 02138, United States, guannan.q@gmail.com, Na Li

This paper considers the distributed optimization problem over a network, where the objective is to optimize a global function formed by a sum of local functions. We develop an Accelerated Distributed Nesterov Gradient Descent (Acc-DNGD) method. When the objective function is convex and smooth, we show that it achieves a $O(\frac{1}{t^{1.4-\epsilon}})$ convergence rate for all $\epsilon\in(0,1.4)$. We also show the convergence rate can be improved to $O(\frac{1}{t^2})$ if the objective function belongs to a special class. When the objective function is μ-strongly convex and L-smooth, we show that it achieves a linear convergence rate of $O([1 - O((\frac{\mu}{L})^{5/7})]^t)$.

4 - Variable Partitioning for Distributed Optimization

Richard Zheng, PhD Student, Georgia Institute of Technology, 6228 Mount Vernon Oaks Dr, Atlanta, GA, United States, richardzyc@gatech.edu

Solving a large-scale optimization problem sequentially can be computational challenging. We focus on one of the most popular distributed approaches, dual decomposition and distributed sub-gradient methods. We explain that a partition of variables can critically affect the speed of convergence and highlight the importance of the number of dualized constraints. Then, we introduce a novel approach to find a partition that reduces the number of dualized constraints by utilizing a community detection algorithm from physics literature. Empirical experiments on a real application show that the proposed method significantly accelerates the convergence of the distributed sub-gradient method.

■ SB76

372E

Advances in Integer Programming

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Akshay Gupte, Clemson University, Clemson University, Clemson, SC, 29634-0975, United States, agupte@clemson.edu

1 - Optimal Group Cuts

Amitabh Basu, Johns Hopkins University, Department of Applied Mathematics and Statist, 100 Whitehead Hall, Baltimore, MD, 21218, United States, basu.amitabh@jhu.edu, Michele Conforti, Marco Di Summa

We investigate natural measures of the quality of cutting planes such as depth of cut, volume cut off, and the so-called "merit index" introduced by Gomory and Johnson. We find the optimal cutting planes according to these measures for the infinite and finite group relaxations introduced by Gomory-Johnson. Interestingly, when the volume cut off is used as the measure, the optimal cuts turn out to be automorphisms of the well-known Gomory mixed-integer cut. The proofs uncover interesting connections with rearrangement inequalities in functional analysis and generalizations of the Brunn-Minkowski theorem to topological groups.

2 - Small and Strong Formulations for Unions of Convex Sets from the Cayley Embedding

Juan Pablo Vielma, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E62-561, Cambridge, MA, 02139, United States, jvielma@mit.edu

There is often a significant trade-off between formulation strength and size in mixed integer programming. When modelling convex disjunctive constraints (e.g. unions of convex sets) this trade-off can be resolved by adding auxiliary continuous variables. However, adding these variables can result in a deterioration of the computational effectiveness of the formulation. We introduce a technique to construct formulations without these detrimental continuous auxiliary variables. We then show it can recover and generalize all known strong formulations without continuous auxiliary variables.

3 - Nonconvex Piecewise Linear Functions: Advanced Formulations and Simple Modeling Tools

Joseph A.Huchette, MIT, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States, huchette@mit.edu

Piecewise linear functions are a central modeling primitive throughout optimization. In this work, we present novel mixed-integer programming (MIP) formulations for (nonconvex) piecewise linear functions. Leveraging recent advances in the systematic construction of MIP formulations for disjunctive sets, we derive new formulations for univariate functions using a geometric approach, and for bivariate functions using a combinatorial approach. All formulations derived are small (logarithmic in the number of piecewise segments of the function domain) and strong, and we present extensive computational experiments in which they offer substantial computational performance gains over existing approaches.

4 - Approximating Integer Programs using the Lexicographic Order

Akshay Gupte, Clemson University, Clemson University, Clemson, SC, United States, agupte@clemson.edu, Michael Eldredge

The convex hull of integer points in a box that are bounded lexicographically above or below a threshold have a useful polyhedral structure. We attempt to solve integer optimization problems over a polytope by enforcing a split in the lexicographical order of the integer points in the polytope. We compare the cuts generated by this disjunction with cuts generated by elementary disjunctions. Here, we present our results.

■ SB77

372F

11:00 - 11:45 GAMS/ 11:45 - 12:30 Optimization Direct, Inc.

Invited: Vendor Tutorial

Invited Session

1 - GAMS - An Introduction

Steven P. Dirkse, GAMS.Development Corporation, DC, WA, United States, sdirkse@gams.com

We'll introduce the key concepts of the GAMS language (e.g. sets, data, variables, equations) as we show how to build an optimization-based decision support application. Along the way, we'll show how GAMS supports an easy growth path to larger and more sophisticated models and provides access to the most powerful large-scale solver packages. We will also look at some of the data management tools included in the GAMS system and show how to analyze and debug large problems using the various tools available within GAMS. Finally, we'll show how our latest release supports integrating GAMS with object-oriented programming languages like C#, Python, and Java.

2 - DSx and CPLEX: Overview of Datascience Experience for Advanced Modeling and Optimization and LatestDevelopments/Results in CPLEX and ODh+CPLEX

Alkis Vazacopoulos, Optimization Direct, Inc., 202 Parkway, Harrington Park, NJ, 07640, United States, alkis@optimizationdirect.com

Organizations are increasingly hiring Data Scientists with Open Source skills. Leverage the capabilities of Data Science Experience DSx to work with Open Source tools like R, Python, Spark, as well as integration with CPLEX and Weather Company data. Come learn how DSx integrates with Open Source tools to enable clients to get the best of both worlds (Open Source programming and the Modeler GUI for those who prefer not to code). Furthermore we will review the latest developments/results in CPLEX Optimization Studio and the new ODh+CPLEX.

■ SB78

381A

Addressing Variability and Uncertainty in Power Systems Operations with Alternative Approaches

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Alberto J. Lamadrid, Lehigh University, Bethlehem, PA, 18015-3120, United States, ajl259@cornell.edu

1 - The Role of Stochastic Optimization in the Electric Power Sector

Kory W. Hedman, Arizona State University, P.O. Box 875706, GWC206 School Of ECEE, Tempe, AZ, 85287-5706, United States, kwh@myuw.net

The electric power sector is seeing an increase in stochastic resources, in the form of non-dispatchable or semi-dispatchable renewable resources as well as distributed energy resources. This talk will begin with a discussion on existing industry practices to manage uncertainty and recently proposed changes within the electric power sector. The presentation will cover how stochastic optimization techniques are already being used to help manage uncertainties and the presentation will cover how recent advanced in two-stage stochastic programming can further assist the electric power sector in the management of stochastic resources.

2 - Evaluating Electric Power Systems

Miguel Ortega-Vazquez, Electric Power Research Institute, 3420 Hillview Avenue, Palo Alto, CA, 94304, United States, mortegavazquez@epri.com, Erik Ela

This presentation will provide an update on research evaluating electric power system operating reserve methods and their comparison with advanced optimization methods for improved reliability and economic efficiency.

3 - Dynamic Electric Vehicle Travel Management in Coupled Power and Transportation Networks

Hao Zhu, University of Illinois Urbana-Champaign, 306 N.Wright Street, 4056 ECE Building, Urbana, IL, 61801, United States, haozhu@illinois.edu

This talk presents a framework to integrate the variable loads due to the changing of electrical vehicles into the operations of power systems.

4 - Multi-stage and Multi-timescale Robust Co-optimization Planning for Reliable and Sustainable Power Systems

Lei Wu, Clarkson University, 8 Clarkson Avenue, P.O. Box 5720, Potsdam, NY, 13676, United States, lwu@clarkson.edu, Bo Zeng

We will develop a decision-support tool Multi-stage and Multi-timescale robust Co-Optimization Planning (MMCOP) that augments existing power utility capabilities to support collaborative planning, analysis, and implementation of emerging variable and distributed power systems and help effectively mitigate risks and uncertainties in both short-term operation and long-term policy/technology changes. This tool will assist power market participants, utilities and regulatory agencies in analyzing economic, reliability, and sustainability issues when considering options for planning new and upgraded transmission facilities to accommodate existing and emerging generation sources.

■ SB78B

380B

Bayesian Approach

Contributed Session

Chair: Thomas G. Yeung, IMT-Atlantique, Nantes, France

1 - Valuing Demand Sample Information Prior to its Collection

Adam Jason Fleischhacker, Associate Professor of Operations Management, University of Delaware, 222 Alfred Lerner Hall, Newark, DE, 19716, United States, ajf@udel.edu, Pak-Wing Fok, Mokshay Madiman

We present both closed-form and computational approaches to valuing sample information prior to its collection. In particular, we look at the value of collecting demand data and its relationship to improving forecasts. Closed form approaches extend the existing literature on preposterior analysis and computational approaches leverage the probabilistic programming language Stan.

2 - Tuning a Bayesian Framework for B2b Pricing

Fang Liang, SAS.Institute, Inc., 100 SAS.Campus Drive, Cary, NC, 27513, United States, fang.liang@sas.com, Maarten Oosten

As in many other B2B markets, rail cargo companies negotiate prices with customers in the form of special agreements that are renewed on a regular basis. We propose a framework for optimizing the agreement prices that includes assessment of existing agreements, estimating the relationship between prices and performance of the agreements, leveraging this relationship to optimize agreement under various scenarios, and utilizing the scenario analysis to support negotiation. This approach needs to respond to changes in the business environment by learning quickly from the latest relevant observations. Bayesian approach is applied to accomplish this and the sensitivity of this approach is tuned.

3 - Evidential Reasoning Rule for Probabilistic Inference & Machine Learning with Ambiguous Data

Dong-Ling Xu, Professor, Manchester University, Manchester Business School, F37 MBS.East, Manchester, M13 9SS, United Kingdom, L.Xu@Manchester.ac.uk, jian-bo yang

The Evidential Reasoning (ER) rule extends Bayes rule for inference with ambiguous data, unknown prior & data with various degrees of reliability. We explain its relationship with Bayes rule & Dempster rule for evidence combination, what assumptions are behind each rule & where the extensions are. We show how to obtain evidence from data (big or small) with ambiguity so that the inference using the ER rule constitutes a maximum likelihood probabilistic inference process, & how to use it in machine learning to build transparent models with maximum likelihood predictions.

4- Representing Markov Process as Dynamic Copula Bayesian Networks

Thomas G.Yeung, Associate Professor, IMT-Atlantique, 4 rue Alfred Kastler BP.20722, La Chantrerie, Nantes, 44307, France, thomas.yeung@imt-atlantique.fr, Alex Kosgodagan-Dalle Torre

In multivariate/high-dimensional statistics, recent attractive approaches include copula-based graphical models such as pair-copula Bayesian networks. Their attractiveness is largely due to the flexibility of copulae to capture dependence. However, very little attention has been given for these models to fit within a full probabilistic framework and for which inference could be performed efficiently. We prove that any k-th order Markov process can be represented as a dynamic pair copula-based Bayesian network. We also show the requirements in order to perform analytical conditioning. We motivate this work through a bridge degradation application and an example focused on Brownian motion.

■ SB79

381B

Recent Advances in AC Optimal Power Flow

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30312, United States, andy.sun@isye.gatech.edu

1 - Optimal Power Flow of Radial Networks and its Variations: A Sequential Convex Optimization Approach

Na Li, Harvard University, 33 Oxford St, Cambridge, MA, 02138, United States, nali@seas.harvard.edu, Wei Wei, Jianhui Wang, Shengwei Mei

A sequential convex optimization method is proposed to solve broader classes of optimal power flow (OPF) problems over radial networks. The non-convex branch power flow equation is decomposed as a second-order cone inequality and a non-convex constraint involving the difference of two convex functions. This approach solves a sequence of convexified penalization problems, where concave terms are approximated by linear functions and updated in each iteration. It could recover a feasible power flow solution, which usually appears to be very close, if not equal, to the global optimal one. Two variations of the OPF problem whose convex relaxation is generally inexact, are elaborated in detail.

2 - Characterizing Non-convexities in the Feasible Spaces of AC OPF Problems

Daniel K.Molzahn, Argonne National Laboratory, 1111 S. Wabash Ave., Apt 1507, Chicago, IL, 60605, United States, dan.molzahn@gmail.com

Optimal power flow (OPF) is one of the key power system optimization problems. OPF problems that use an AC power flow model can have non-convex feasible spaces. As part of an effort to characterize the difficulty associated with solving different AC OPF problems, this presentation discusses approaches for identifying non-convexities in AC OPF feasible spaces. These approaches include a method for computing the entire feasible space for small AC OPF problems and an algorithm for identifying pairs of points which certify the existence of a non-convex region of the feasible space.

3 - Some Techniques for Strengthening the SOCP Relaxations for Solving AC OPF

Andy Sun, Georgia Institute of Technology, 755 Ferst Drive, Atlanta, GA, 30312, United States, andy.sun@isye.gatech.edu

In this talk, we will discuss some techniques to strengthen the SOCP relaxations of ACOPF both single-phase and multi-phase, including minor reformulation of rank one constraints, bound tightening, and some linear transformation techniques.

4 - Convex Relaxation of Optimal Power Flow in Multiphase Radial Networks with Delta Connections

Changhong Zhao, National Renewable Energy Laboratory, 15013 Denver West Pkwy, Golden, CO, 80401, United States, changhong.zhao@nrel.gov, Emiliano Dall'Anese, Steven Low

We proposes a semidefinite relaxation of the AC optimal power flow (OPF) problem in multiphase radial networks with wye and delta connections. Two multiphase power flow models are developed to facilitate the integration of delta-connected loads or generation resources in the OPF problem. The first model is called the extended branch flow model. The second model leverages a linear relationship between phase-to-ground power injections and delta connections under a balanced voltage approximation. Based on these models, pertinent OPF problems are formulated and relaxed to semidefinite programs. Numerical studies on IEEE test feeders show efficiency and exactness of the proposed relaxations.

■ SB80

381C

Designing Energy and Water Supply Chains for Prosperity

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Yao Zhao, Rutgers University, Newark, NJ, 07102-1895, United States, yaozhao@andromeda.rutgers.edu

Co-Chair: Kwon Gi Mun, Fairleigh Dickinson University, 2050, Fort Lee, NJ, 07024, United States, kgmun@fdu.edu

1 - Simulation-based Optimization Models for Electricity Generation Expansion Planning Problems Considering Human Health Externalities

Mark Rodgers, PhD, Rutgers University, Newark, NJ, United States, markrodgersphd@gmail.com

Generation expansion planning models determine capacity investment decisions that minimize market costs. Such models are often dominated with fossil fuel investments. While they are economical sources of electricity, fossil fuels create by-products that have harmful health effects. To mitigate this, we leverage an EPA screening tool along with simulation methods to create a closed-form relationship between expansion decisions and health damages to be included in the objective function of the expansion planning model. This yields minimized societal costs and health damages from emissions in the electricity sector.

2 - Microgrid Formation Approach for Resilient Electricity Networks

Alberto J. Lamadrid, Lehigh University, 621 Taylor Street, R451, Bethlehem, PA, 18015-3120, United States, ajl259@cornell.edu

We propose a program for microgrid formation in the electricity system after a disruption, considering a system with high penetration of renewables and where flows are expected to be undirected. We compare our extended formulation to results presented in the literature. Additionally, we allow for possible mobile and fixed Distributed Generation technologies, Distributed Energy Resources, and demand responsive loads with a minimum satisfiability constraint. The extended mixed-integer linear program (MILP) can be used as an operations and a short term planning tool for DG scenario-based location. The MILP is applied to the IEEE 37-bus, 30-bus and 118-bus systems.

3 - Designing Hydro Supply Chains for Energy Food and Flood

Kwon Gi Mun, Fairleigh Dickinson University, Fort Lee, NJ, United States, kgmun@fdu.edu, Yao Zhao, Razi Ali Rafique

In this research, we apply SCM concepts to water resource development and provide the end-to-end and dynamic perspectives. We found that the development of hydropower has the potential to address all these issues such as water, food, and energy. Our results demonstrate the value of the supply chain perspective on hydro network expansion, and provide insights on the optimal development strategies regarding location, sequence and mix of hydro projects.

■ SB81

382A

Joint Session OPT/Practice: Applications of Stochastic and Robust Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Sebastian Maier, Imperial College London, Imperial College Road, Skempton Building, London, SW7 2AZ, United Kingdom, s.maier13@imperial.ac.uk

1 - Valuing Portfolios of Real Options under Both Exogenous and Endogenous Uncertainties

Sebastian Maier, Imperial College London, Imperial College Road, Skempton Building, London, SW7 2AZ, United Kingdom, s.maier13@imperial.ac.uk, Georg Pflug, David Gann, John Polak

We extend our existing approach for modeling and approximating the value of portfolios of real options to include endogenous, decision- and state-dependent uncertainties. The options are to defer investment, to stage investment, to temporarily halt expansion, to temporarily mothball the operation, and to abandon the project. Two of the underlying uncertainties, decision-dependent cost to completion and state-dependent salvage value, are endogenous, the other two, annual operating revenues and their growth rate, are exogenous. Using a simulation and regression approach we present an efficient valuation algorithm. Its applicability is illustrated by valuing an infrastructure investment.

2 - Integrating Decisions with Advance Supply Information in Assemble-to-order Systems

Jie Chu, McMaster University, 1280 Main St, W. Hamilton, ON, L8S.4M4, Canada, chuj6@mcmaster.ca, Kai Huang

In this paper, we consider a periodic review Assemble-To-Order (ATO) system, where each component follows an independent base stock policy. We first consider the ATO system with lead time and demand uncertainties in which the decision maker has advanced knowledge of uncertain lead times. Then we advance the methodology by considering a situation where the decision maker only has full distributional knowledge of uncertain lead times. The stochastic programming models are proposed and solved by the sample-average-approximation (SAA) algorithm.

3 - On Robust Solutions to Uncertain Hierarchical Transmission Expansion Problems

Shisheng Cui, Pennsylvania State University, University Park, PA, United States, cuishisheng05@gmail.com, Uday Shanbhag

We consider a robust formulation for proactive planning of transmission with imperfect long-run transmission pricing based on a MW-km charging system. The deterministic model is described by a mixed-binary mathematical program with equilibrium constraints (MPEC), a challenging optimization problem. Then, leveraging techniques from robust solutions to uncertain complementary problems, we incorporate robustness into the transmission expansion problem and obtain global solutions via a branching procedure. Preliminary numerics will be provided.

4 - The Value of Flexibility in Robust Location -Transportation Problems

Amir Ardestani-Jaafari, McGill University, Montreal, QC, Canada, amir.ardestanijaafari@mail.mcgill.ca, Erick Delage

We study a robust location-transportation problem in which, while the location and capacity of each facility need to be determined immediately, the determination of final production and distribution of products can be delayed until actual orders are received. It is a computationally challenging task to make wait-and-see decisions adaptable to data while the problem remains practically attractive. To overcome this difficulty, we propose a tractable conservative approximation to the problem that provides a promising trade-off between tractability and wait-and-see decisions flexibility.

■ SB82

382B

New Directions in Stochastic Programming

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Suvrajeet Sen, University of Southern California, University of Southern California, Los Angeles, CA, 90089-0193, United States, s.sen@usc.edu

1 - Algebraic Topics for Stochastic Programming

Ruediger Schultz, University of Duisburg Essen, Department of Mathematics, Thea-Leymann-Str. 9, Essen, D-45127, Germany, ruediger.schultz@uni-due.de

In the talk, selected topics from stochastic programming are discussed, where structural and algorithmic findings benefit from an algebraic point-of-view. In particular, augmentation algorithms for two-stage stochastic integer programs and polynomial optimization models for stationary flows in gas pipelines are forming the departure points for our considerations.

2 - Multistage Stochastic Programming with Parametric Cost Function Approximations

Raymond Perkins, Princeton University, Princeton, NJ, United States, raymondp@princeton.edu, Warren Powell

A widely used heuristic for solving stochastic optimization problems is to use a deterministic rolling horizon procedure which has been modified to handle uncertainty (e.g. buffer stocks, schedule slack). We formalize this approach by proposing these parameterizations as a powerful strategy to hedge against uncertainty, and present a stochastic gradient algorithm for optimizing the parameters in a fully sequential, stochastic base model. This base model, implemented as a simulator, does not require any of the standard assumptions that are widely used in stochastic programming such as two-stage models or intertemporal independence. We derive the gradients and test the algorithm on several parameterizations, demonstrating significant improvements over a vanilla deterministic lookahead.

3 - On the Asymptotical Result of Two-stage Stochastic Quadratic Programming

Junyi Liu, University of Southern California, Los Angeles, CA, United States, junyiliu@usc.edu

We consider a class of two-stage stochastic quadratic programming (STQP) problems with continuous random variables. To accommodate the above structure, Stochastic Decomposition (SD) algorithm constructs affine/quadratic minorants and approaches a statistically acceptable solution. On the convergence side, we present the contraction property of stochastic proximal mapping and show the linear convergence to the neighborhood of the optimum wp1.

4 - An Extension to the Network Flow Optimization Problem

Gerrit Slevogt, Universität Duisburg-Essen, Duisburg, Germany, gerrit.slevogt@uni-due.de

A transient gas network model with the highlight of active elements being modelled multiplicatively at the nodes is extended to stochastic demand and its structure is presented. Going beyond existing literature the modeling of active components is not restricted to compressor stations but includes all common active gas network elements.

■ SB83

382C

Statistical Learning

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Sam Davanloo Tajbakhsh, davanloo-tajbakhsh.1@osu.edu

1 - Symmetry, Saddle Points, and Global Geometry of Non-convex Matrix Factorization

Xingguo Li, University of Minnesota, Minneapolis, MN, 30318, United States, lixx1661@umn.edu

We propose a general theory for the geometry of nonconvex objectives by characterizing stationary points and the null space of the associated Hessian via invariant groups. Moreover, we characterize the global geometry of low-rank matrix factorization and illustrate how the rotational symmetry group raises infinite strict saddle and global minima. We divide the parameter space into the regions: (R1) containing strict saddle with negative curvature; (R2) containing global minima with restricted strong convexity; and (R3) with large gradient. We further extend our result to matrix sensing. This allows us to show global convergence for popular iterative algorithms with random initialization.

2 - Convex Optimization Problems with Misspecified Vector of Parameters: Solution Framework and Rate Analysis

Hesamoddin Ahmadi, Innovative Scheduling DBA Optym, 5333 SW. 75th street Apt L71, Gainesville, FL, 32608, United States, hesamoddin.ahmadi@optym.com
Hesamoddin Ahmadi, Pennsylvania State University, University Park, PA, United States, hesamoddin.ahmadi@optym.com

In this talk, we consider a misspecied optimization problem that requires minimizing a function f over a closed and convex set X with an unknown vector of parameters. The source of misspecification is a deterministic vector that can be obtained by solving another suitably defined optimization problem in parallel, referred to as the learning problem. We develop joint first-order schemes for computation and learning and provide rate statements.

3 - Sample Average Approximation with Sparsity-inducing Penalty for High-dimensional Stochastic Programming

Hongcheng Liu, Stanford University, Stanford, CA, 94085, United States, hql5143@stanford.edu, Xue Wang, Tao Yao, Runze Li, Yinyu Ye

Traditional sample average approximation (SAA) scheme for stochastic programming requires that the number of samples should be polynomial in the number of problem dimensions in order to ensure proper optimization accuracy. We study a modification to SAA in the scenario where the global minimizer is either sparse. By making use of a regularization penalty referred to as the folded concave penalty, we show that the required number of samples can be significantly reduced: the sample size is only required to be poly-logarithmic in the number of dimensions.

4 - On Statistical Learning Problems with Nonconvex L0-Norm Penalty Formulated by Complementarity Constraints

Sam Davanloo Tajbakhsh, The Ohio State University, 210 Baker Systems Building, 1971 Neil Ave, Columbus, OH, 43210, United States, davanloo-tajbakhsh.1@osu.edu

Imposing sparsity in high-dimensional statistical learning could be performed by imposing nonconvex l0 norm penalty. From the statistical perspective, some local solutions to nonconvex problems could be superior to global solutions of convex counterparts. In this talk, we propose our findings to solve the original nonconvex problem formulated by complementarity constraints.

Sunday, 1:30 - 3:00PM

■ SC01

310A

Decision Analysis Practice Award

Sponsored: Decision Analysis

Sponsored Session

Chair: Gregory L. Hamm, Stratelytics, LLC, Alameda, CA, 94501, United States, ghamm@strts.com

1 - A Methodology for Optimized Oil Well Location During Operational Drilling in Presence of Geological Uncertainty

D. Echeverría Ciaurri, IBM.Researcch, Yorktown Heights, NY, United States, decheve@us.ibm.com, V.M. Babin, A.M. Vashevnik, O.S. Ushmaev, A.P. Gruzdev, A.V. Pozdneev, D. Echeverría Ciaurri

We propose a novel methodology for the construction of an oil field development strategy that leverages decision trees and takes into account geological uncertainties of a reservoir. The approach is designed to dynamically decide on the drilling location of the next wells and on the need for appraisal wells. The strategy can be delivered to the drilling operator in the form of a pre-computed manual. The methodology was applied to a new oil field and 15% improvement in expected net present value was obtained with respect to an optimized development strategy with predetermined wells placement.

2 - How to Improve Educational Programs for Underprivileged Children? the Impacts of Value-focused Decision Analysis

Valentina Ferretti, London School of Economics and Political Science, Houghton Streetl London | WC2A 2AE, London, United Kingdom, V.Ferretti@lse.ac.uk, Gabriella Csányi

This project develops a value-focused Decision Analysis intervention designed and deployed to support the Csányi Foundation in selecting underprivileged children to enter the Foundation's Educational program. To minimize dropout rates, the Foundation expressed the need to improve the selection process, by better identifying the selection criteria that will allow the Foundation to meet its objectives and by fostering consensus among the board members. To achieve these targets, we combined a use of Multi Attribute Value Theory and Value Focused Thinking within a facilitated mode of engagement.

3 - Decision Analytics for Reducing Surgical-site Infections: Application to Coronary Artery Bypass Graft Patients

Eva Lee, Georgia Tech, Industrial & Systems Engineering, Ctr for Operations Research in Medicine, Atlanta, GA, 30332-0205, United States, evakylee@isye.gatech.edu

This study focuses on reducing SSI for coronary artery bypass graft(CABG) patients at a large hospital. A system-approach - using decision trees, machine learning, simulation and multi-objective optimization - was employed to account for the interdependency of preoperative, intraoperative and postoperative processes. A number of intervention and process changes were initiated. The site zero percentage within six months and sustained that rate for over 24 months.

■ SC02

310B

Behavioral Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: Matthias Seifert, IE Business School, IE Business School, Madrid, 28006, Spain, matthias.seifert@ie.edu

1 - The Effectiveness of Trimmed Opinion Pools in Time Series Forecasting Involving Structural Breaks

Shijith Kumar Payyadakkath Meethale, PhD Candidate, IE Business School, Madrid, Spain, shijith.pm@Student.ie.edu, Matthias Seifert, Yun Shin Lee

We introduce simple trimming approaches to aggregate judgmental time series forecasts involving structural breaks. While the extant literature explores trimming rules for aggregating forecasts in stable environments, we focus on relatively unstable environments characterized by fundamental regime shifts. In an empirical study, we find that forecasters are relatively under confident and sensitive to regime shifts and fluctuations in time series, making static trimming approaches less applicable. We further propose asymmetric trimming approaches to aggregate opinion pools under such unstable environments.

2 - Risky Choice Following Near Miss Events in Sequential Tasks under Ambiguity

Florian Mathis Federspiel, Assistant Professor, INCAE Business School, Alajuela, Costa Rica, florian.federspiel@incae.edu, Matthias Seifert, Robin Dillon-Merrill

Studies have shown that near miss events can lead to inconsistent risk perceptions. Yet near misses are often clouded in ambiguity, allowing for hubris and misattribution of what caused success or prevented failure. We provide an analytical model of near misses and investigate the experience of such an event on risk taking in a real options task. Over two experiments, we show that increases in risk taking following a near miss occur mainly under ambiguity. We further find that this effect depends on the decision maker's prior expectation. Only those with an expectation of failure fall prey to the near miss bias.

3 - Group Decision Making with Multiple Conflicting Performance Targets

Matthias Seifert, IE Business School, Maria de Molina 12, 5, Madrid, 28006, Spain, matthias.seifert@ie.edu, Enrico Diecidue, Anshdha Ria

In many multi-stakeholder decision contexts, it is of crucial importance to aggregate preferences in a way that rewards the diversity of targets met. Extending Tsetlin & Winkler's (2007) work on multiattribute performance targets, we study the properties of a novel group-weighting rule, which draws on the dis-/similarity of preferences held by individuals and assigns higher values to those alternatives that maximize the diversity of targets achieved. We then benchmark the performance of this rule against classic approaches based on equal weighting (e.g. average winner, majority voting).

4 - Dynamic Pricing under Habit Formation and Satiation

Wen Chen, Providence College, United States, wchen@providence.edu, Ying He

we study the dynamic pricing problem when consumer forms habit and/or satiation from their past consumptions in this paper. Our analysis is based on utility model under habit formation and satiation that are proposed and axiomatized in the decision theory literature recently, which provides a solid behavioral foundation for our model. Based on this utility model, we derive an inter-temporal dependent demand function to model how demand in each period depends on the prices in the current period and previous periods through habit formation and satiation. Our analysis shows that "U-shaped", or "Inverse-U-shaped" policy may become optimal.

■ SC03

310C

Easy Affine Markov Decision Processes: Properties and Applications

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, 6, United States, jopeng@Central.uh.edu

Co-Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, University at Buffalo (SUNY), Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Easy Affine Markov Decision Processes: Properties and Applications

Matthew J.Sobel, Case Western Reserve University - Retired, Department of Operations, 10900 Euclid Avenue, Cleveland, OH, 44106-7235, United States, matthew.sobel@case.edu, Jie Ning

This tutorial introduces a class of decomposable affine Markov decision processes (MDPs) that have continuous multi-dimensional endogenous states and actions, and an exogenous state that follows an exogenous Markov chain. We show that, unlike most MDPs with continuous state and actions, decomposable affine MDPs are free of the curse of dimensionality and can be solved easily and exactly. A decomposable affine MDP has a value function that is affine in the endogenous state, and has an extremal optimal policy. We illustrate the potential applicability of decomposable affine MDPs using examples of fishery management and dynamic capacity portfolio management.

■ SC03A

Grand Ballroom A

APS Student Paper Competition

Sponsored: Applied Probability

Sponsored Session

Chair: Jose Blanchet, Columbia University, 500 West 120th Street, 340 Mudd Building, New York, NY, 10027, United States, jose.blanchet@gmail.com

Co-Chair: John Hasenbein, University of Texas-Austin, 1 University Station Stop C2200, Department of Mechanical Engineering, Austin, TX, 78712-0292, United States, jhas@mail.utexas.edu

1 - Pricing and Optimization in Shared Vehicle Systems: An Approximation Framework

Daniel Freund, Cornell University, 109 Lake St, Ithaca, NY, 14850, United States, df365@cornell.edu, Thodoris Lykouris

Pricing in shared vehicle systems is challenging due to complex network externalities: altering prices in any location affects future supply throughout the system within short timescales. Such externalities are well captured by steady-state Markov chain models, which are widely used in this context. However, optimizing these models is computationally difficult since the resulting problems are high-dimensional and non-convex. We develop a framework for designing pricing policies in such systems, based on a novel convex relaxation which we term elevated flow relaxation, coupled with a new infinite projection and pullback technique for proving approximation bounds. Our approach provides the first efficient algorithms with finite-system guarantees for pricing as well as other demand-supply balancing controls used in shared vehicle systems. In the process, we recover recently discovered asymptotic optimality results via elementary arguments.

2 - On the Euler Discretization Error of Brownian Motion about Random Times

Guido Lagos, University of Chile, Santiago, Chile, guido.lagos.barrios@gmail.com

In this talk we study the simulation of barrier-hitting events and extreme events of Brownian motion, when using a discretization on an equidistant time mesh. Specifically, we study the times and position of the discretized Brownian motion in these events and compare it to the ones for the "real" Brownian motion. We establish new results on weak convergence of the (normalized) errors of time and position in all these cases, and give explicit analytic expressions for the limiting distributions. In doing this we derive new results on diffusion approximations of Gaussian random walks by Brownian motions. More importantly, our results give new insight on the connection between several works in the literature dating back to the 60's where the constant $-\zeta(1/2)/\sqrt{2\pi}$ has appeared, where ζ is the Riemann zeta function.

3 - Multi-Agent Online Learning under Imperfect Information: Algorithms, Theory and Applications

Zhengyuan Zhou, Stanford University, 160 Comstock Circle - Unit 106002, Stanford, CA, 94305, United States, zyzhou@stanford.edu

We consider a model of multi-agent online learning under imperfect information, where the reward structures of agents are given by a general continuous game. After introducing a general equilibrium stability notion for continuous games, called variational stability, we examine the well-known online mirror descent (OMD) learning algorithm and show that the "last iterate" (that is, the actual sequence of actions) of OMD converges to variationally stable Nash equilibria provided that the feedback delays faced by the agents are synchronous and bounded. We then extend the result to almost sure convergence to variationally stable Nash equilibria under both unbiased noise and synchronous and bounded delays. Subsequently, to tackle fully decentralized, asynchronous environments with unbounded feedback delays, we propose a variant of OMD which we call delayed mirror descent (DMD), and which relies on the repeated leveraging of past information. With this modification, the algorithm converges to variationally stable Nash equilibria, with no feedback synchronicity assumptions, and even when the delays grow super-linearly relative to the game's horizon. We then again extend it to the case where there are both delays and noise.

4 - Learning Preferences with Side-Information: Near Optimal Recovery of Tensors

Andrew A. Li, Massachusetts Institute of Technology-ORC, 77 Massachusetts Avenue, Bldg. E40-149, Cambridge, MA, 02139, United States, aali@mit.edu

Many recent problems in e-commerce can be cast as large-scale problems of tensor recovery. Thus motivated, we study the problem of recovering tensors from their noisy observations. We provide an efficient algorithm to recover structurally 'simple' tensors given noisy observations of their entries; our version of simplicity subsumes low rank tensors for various definitions of tensor rank. Our algorithm is practical for massive datasets and provides a significant performance improvement over incumbent approaches to Tensor recovery. Further, we show a near-optimal recovery guarantee. Experiments on music streaming data demonstrate the performance and scalability of our algorithm.

■ SC03C

Grand Ballroom C

M&SOM Student Paper Competition II

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Tunay Tunca, University of Maryland, Silver Springs, MD, 20910, United States, ttunca@rhsmith.umd.edu

1 - Mallows-smoothed Distribution over Rankings Approach for Modeling Choice

Antoine Desir, Columbia IEOR.Department, New York, NY, ad2918@columbia.edu, Vineet Goyal, Srikanth Jagabathula, Danny Segev

Abstract not Available

2 - An Examination of Early Transfers to the ICU Based on a Physiologic Risk Score

Wenqi Hu, Columbia Business School, New York, NY, Contact: wh2274@columbia.edu

Abstract not Available

3 - Robust Dual Sourcing Inventory Management: Optimality of Capped Dual Index Policies

Jiankun Sun, Northwestern University, Evanston, IL, Contact: jiankun-sun@kellogg.northwestern.edu

Abstract not Available

■ SC04

320A

Responsible Supply Chains and Sustainable Products

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Vishal Agrawal, Georgetown University, Washington, DC, 20057, United States, va64@georgetown.edu

1 - Managing Social Responsibility in Multitier Supply Chains

Robert Swinney, Associate Professor, Duke University, 100 Fuqua Dr, Box 90120, Durham, NC, 27708, United States, robert.swinney@duke.edu, Jing-Sheng Jeannette Song

We study the management of social responsibility in a three-tier supply chain in which a Tier 2 supplier sells to a Tier 1 supplier, which in turn sells to a Tier 0 buyer. The Tier 2 supplier potentially violates social and environmental standards, resulting in harm to the Tier 0 and 1 firms. Each member of the supply chain can exert effort to improve the responsibility in Tier 2, and the efforts of Tiers 0 and 1 are substitutable with one another and complementary to the efforts of Tier 2. We determine when it is optimal for the Tier 0 buyer to delegate management of Tier 2 to the intermediate Tier 1 supplier, and when it is optimal for Tier 0 to assume direct control of Tier 2.

2 - Transparency as a Supplier Social and Environmental Responsibility Screening Mechanism

Basak Kalkanci, Georgia Institute of Technology, 3151 Stillhouse Creek Dr SE, Apt 25517, Atlanta, GA, 30339, United States, basak.kalkanci@scheller.gatech.edu, Shi Chen, Erica Plambeck

Some buying firms, facing scrutiny regarding negative social and environmental impacts in their suppliers' operations, have recently made transparency commitments to disclose their audit reports and/or the identities of their suppliers. In this paper, we study the trade-offs faced by a buyer firm in deciding whether or not to make such transparency commitments.

3 - Improving Supplier Social Responsibility under Incomplete Visibility

Leon Matias Valdes, MIT.Sloan School of Management, 77 Massachusetts Avenue, E62 - 459, Cambridge, MA, 02139, United States, lvaldes@mit.edu, Tim Kraft, Yanchong Zheng

We study a manufacturer's decisions when the social responsibility (SR) performance of her supplier cannot be perfectly observed. Only the supplier can directly impact SR; the manufacturer can: (i) invest in the supplier's capabilities to improve SR; and (ii) disclose SR information (true or not) to consumers. In addition, a third party may disclose the true level of SR, which can lead to a penalty for the manufacturer. Our results provide insights into the impact of supply chain visibility on the supplier's and manufacturer's strategies. While greater visibility and third-party scrutiny typically increase SR in the supply chain, we identify situations where this is not the case.

4 - Product Line Design for Greener Products

Iva Petrova Rashkova, Washington University in St Louis, Washington University in St Louis, St Louis, MO, 63130, United States, irashkova@wustl.edu, Lingxiu Dong, Weiqing Zhang

The purpose of this project is to explain why some food manufacturers are adopting local sourcing while others position themselves as organic; while some abandon their traditional products while others expand their product line with the greener versions. We build a model which incorporates two quality valuations - traditional and green - and two market segments - low and high green valuation. We characterize explicitly how the interplay between green-valuation uncertainty, production cost and the size of the green segment affect the manufacturer's optimal product line design.

■ SC05

320B

HIV-Related Applications

Sponsored: Health Applications

Sponsored Session

Chair: Evin U. Jacobson, CDC, Atlanta, GA, 30332, United States, wqm4@cdc.gov

1 - Allocation of HIV Prevention and Treatment Resources in the United States

Evin U. Jacobson, CDC, Atlanta, GA, United States, wqm4@cdc.gov, Katherine A.Hicks, Justin Carrico, Stephanie L.Sansom

To better provide guidance on how HIV prevention resources in the United States could be focused to prevent the most cases of HIV, we explored the optimal allocation of a treatment and prevention budget. The optimal allocation resulted in more than a 40% decrease in new cases over 10 years compared to the estimated current allocation. Coordination of HIV prevention activities could substantially reduce HIV incidence. The optimal allocation is associated with lower overall treatment budget, freeing up additional resources for prevention.

2 - Impact of Enhanced HIV Care and Treatment and Delivering PrEP in the United States

Nidhi Khurana, CDC, Atlanta, GA, United States, Emine Yaylali, Paul Farnham, Katherine Hicks, Benjamin T. Allaire, Evin Jacobson, Stephanie L.Sansom

We used a dynamic, compartmental model of HIV transmission and disease progression to estimate the number of HIV infections prevented in the United States from 2016 to 2020 when pre-exposure prophylaxis (PrEP) was implemented for populations at high risk of acquiring HIV under either the current continuum of care or under an improved continuum that results in the achievement of national HIV prevention goals.

3 - Examining Businesses that Provide Products and Services to Gay and Transgender Individuals Living with HIV

Guruprasad Gadgil, University of North Texas, 1115 Collier Street, #2, Denton, TX, 76201, United States, guruprasad.gadgil@unt.edu, Gayle Prybutok, Victor Prybutok

This mixed method study examines the transference of impression management, the theory of planned behavior, and technology enabled anonymity to develop a model for a HIV-positive population in terms of individuals that run small online businesses that serve the gay and transgender population living with HIV. This work examines why individuals make their data available and why online businesses are motivated to provide practices, products, and services to this community.

■ SC06

320C

Dynamic Decision Making with Application to Major Health Challenges

Sponsored: Health Applications

Sponsored Session

Chair: Shan Liu, University of Washington, Seattle, WA, 98195-2650, United States, liushan@uw.edu

1 - Cost-effectiveness Analysis for Prognostic-based Depression Monitoring

Ying Lin, University of Houston, Houston, TX, United States, ylin58@uh.edu, Shuai Huang, Shan Liu

Inadequate monitoring has been identified as a major challenge in depression treatment follow-up. Prognostic-based monitoring which adaptively allocates monitoring resource to high-risk individuals is promising to improve efficiency and reduce cost. We developed a decision support framework to integrate individual prognostic, monitoring strategy design and cost-effectiveness analysis. We compared several prediction algorithms to monitor high-risk patients for major depression (rule-based, logistic regression, collaborative model, lazy learning, etc.) using a dataset of depression population and identified five cost-effective monitoring strategies.

2 - Dynamic Treatment Selection and Modification for Personalized Blood Pressure Therapy

Margaret L.Brandeau, Stanford University, Management Science and Engineering, 475 Via Ortega, Stanford, CA, 94305-4026, United States, brandeau@stanford.edu

Personalized treatment of disease - identifying which treatments work, for whom, and in what context - can significantly improve patient outcomes compared to treatment based on clinical guidelines. We developed and tested a generalizable computational strategy to help personalize treatment when multiple treatment options, benefits, and risks must be considered, using a Markov Decision Process model informed by high-quality meta-analytic data. We applied the strategy to the selection of blood pressure treatments for a simulated US population, and compared overall benefits and risks to those achieved from application of current blood pressure treatment guidelines.

3 - Adaptive Strategies for Personalized Treatment Selection of Depression in a Heterogeneous Population

Jue Gong, University of Washington, Industrial and Systems Engineering, MEB B14 Box 352650, Seattle, WA, 98115, United States, gongjue@uw.edu, Shan Liu

We established a framework for characterizing personal dynamics in disease progression and making a series of adaptive treatment decisions based on the estimated dynamics. The objective is to select between two treatments of depression to maximize health outcome. Depression progression is assumed to be a POMDP. An extension of the collaborative model and its solution algorithm are developed to estimate the model parameters. The optimal treatment policy is obtained by solving a rolling horizon POMDP. This research has wide applications in chronic disease treatment problems in the era of personalized medicine.

4 - Resource Allocation for Hepatitis C Elimination

Qiushi Chen, Massachusetts General Hospital, 101 Merrimac St., 10th FL, Boston, MA, 02114, United States, qchen@mgh-ita.org, Turgay Ayer, Jagpreet Chhatwal

The burden of hepatitis C virus (HCV) infection continues to rise globally. The advent of highly effective HCV treatment in the last few years enables effective epidemic control and even elimination of the disease. However, high drug cost and unawareness of infection are challenges for achieving this goal. In this study, we develop a hepatitis C transmission model, and identify the optimal allocation for HCV screening and treatment to achieve the disease control target at the minimum cost. We present the allocation policies in different health care settings and target population profiles.

5 - Dynamics of Drug Resistance: Optimal Control of an Infectious Disease

Naveed Chehrazi, McCombs School of Business, Austin, TX, United States, chehrazi@utexas.edu

We study the optimal treatment policy for an SIS-type infectious disease with drug resistance. We prove that the optimal policy is bang-bang with a single switching time and we find that the value function is not Lipshitz continuous. Using numerical analysis, we demonstrate that the optimal policy changes form when the disease transmission rate is a function of disease prevalence (e.g., as a result of social distancing). Our solution approach can be generalized to other control problems.

■ SC07

322A

Modeling and Optimization in Healthcare Decision Applications

Sponsored: Health Applications

Sponsored Session

Chair: Ruichen Sun, University of Pittsburgh, Pittsburgh, PA, 15261, United States, rus19@pitt.edu

1 - Screening for Breast Cancer: the Role of Supplemental Tests and Breast Density Information

Burhaneddin Sandikci, University of Chicago, Booth School of Business, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States, burhan@chicagobooth.edu, Mucahit Cevik

Mammography screening is the gold standard for breast cancer screening in the US, but it is known to be less accurate for women with dense breasts. Supplemental screening methods such as Magnetic Resonance Imaging (MRI) and ultrasound have been recently introduced to improve detection accuracy. We incorporate the breast density information using a partially observable Markov decision process model, and study the impact of supplemental tests in detecting breast cancer.

2 - Optimizing Vaccine Distribution in Low and Middle Income Countries

Yuwen Yang, University of Pittsburgh, Department of Industrial Engineering, Pittsburgh, PA, 15261, United States, yuy49@pitt.edu, Jayant Rajgopal, Hoda Bidkhori

The WHO Expanded Programme on Immunization aims to provide universal access to a recommended suite of vaccines, with a special focus on underserved low and middle income countries. Despite significant economic, geographical and demographic differences, the structure of the vaccine distribution network is almost identical across all these countries, when there is no compelling reason for this to be so. We present a mixed integer programming formulation to optimize the cold chain network, along with the consideration of cold storage and transportation. We study the structure of the model and examine several options to improve its computational performance with data derived from the real world.

3 - Optimal Pooling, Batching and Pasteurizing of Donor Human Milk

Ruichen Sun, University of Pittsburgh, 3700 O'Hara Street, 1048 Benedum Hall, Pittsburgh, PA, 15261, United States, rus19@pitt.edu, Lisa M.Maillart, Andrew J.Schaefer

Donor human milk - collected and dispensed via milk banks - is the standard of care for NICU and outpatient infants whose mother's own milk is not a viable option. It undergoes complex processes at milk banks. We formulate integer programs to optimize the daily milk processing decisions, including the pooling of milk from different donors to meet macronutrient requirements across different product types, and the batching of pooled milk for efficient pasteurization. The numerical study shows an increase of approximately 25% for the overall utility.

4 - Robust Inverse Optimization with Application to Dietary Recommendation

Taewoo Lee, University of Houston, E209 Engineering Bldg 2, 4722 Calhoun Rd, Houston, TX, 77204-4008, United States, tlee20@central.uh.edu, Kimia Ghobadi, Houra Mahmoudzadeh, Daria Terekhov

In this talk, we explore the robustification of inverse optimization. Our work is motivated by problems in which the observation of the solution is partial, noisy, or uncertain. We build an uncertainty set around the observation and derive an inverse model that finds a cost vector that protects against the worst case scenario in the given uncertainty set. Our model generalizes previous work on single-observation inverse models. It can also be seen as more general than inverse optimization with multiple points, since the points can be thought of as a sample from the uncertainty set.

■ SC08

322B

Stochastic and Simulation Modeling in Healthcare Management

Sponsored: Health Applications

Sponsored Session

Chair: Xiang Zhong, Univ. of Florida, 380 Weil Hall, Gainesville, FL, 32611, United States, xiang.zhong@ise.ufl.edu

1 - Modeling of Cost-effective Interventions to Reduce Total Joint Replacement Read Missions

Hyo Kyung Lee, University of Wisconsin-Madison, Madison, WI, United States, hlee555@wisc.edu, Rebecca Jin, Yuan Feng, Philip A. Bain, Jo Goffinet, Jingshan Li

More than a million total joint replacements are performed in the US each year, where hip and knee replacements are the most common ones. Complications can occur in some replacements which lead to unplanned hospital readmissions. To reduce readmissions, prevalent studies focus on finding the risk factors without considering the intervention processes that are carried out post-discharge. Thus, we present a quantitative intervention process model that incorporates patients' identified risk levels to provide patient-centered interventions. By investigating cost-effectiveness of various intervention policies on hospital readmissions, we seek to provide clinical guidelines.

2 - Achieving Optimal Patient-centered Interventions to Reduce Readmission for COPD Patients

Sujee Lee, University of Wisconsin - Madison, Madison, WI, United States, slee776@wisc.edu, Philip Bain, Chris Baker, Jingshan Li

Staring from 2014, the Centers for Medicare and Medicaid Services have penalized hospitals with high risk-adjusted, 30day unplanned readmission rates of the patients admitted for an acute exacerbation chronic obstructive pulmonary disease. In response, hospitals struggle to develop efficient interventions for COPD patient. To support decision making for the hospitals, this study introduces an optimization model to introduce an incentive based postdischarge intervention policy for COPD patients. Based on predicted risk of readmissions, optimal strategies to minimize readmission rate are presented to distribute incentive budget to encourage COPD patients complying with interventions.

3 - Drug Dispensing Data Driven Modeling of Anticholinergic Drug Prescription Behavior

Nan Kong, Purdue University, 206 South Marting Jischke Drive, Biomedical Engineering, West Lafayette, IN, 47906-2032, United States, nkong@purdue.edu

Anticholinergic drug overdose is common among older adults in the U.S. The overdose leads to increased cognitive impairment and contributes to higher care spending. We develop an individually based state-transition simulation to characterize prescription behavior with incorporation of the variations among patients and pharmacists. We test various semi-Markov models to fit the continuous prescription pattern based on drug dispensing data from a metropolitan area. The simulation can help us conduct research on assessing various prescription behavior interventions.

4 - On the Effect of Electronic Patient Portal on Primary Care Delivery

Xiang Zhong, Univ. of Florida, 380 Weil Hall, Gainesville, FL, 32611, United States, xiang.zhong@ise.ufl.edu, Aditya M. Prakash

Electronic visit (e-visit), which allows patients and primary care providers communicating through secure messages, has enabled virtual care delivery as an alternative to traditional office visits. To help identify the conditions that e-visits lead to improved care delivery efficiency and patient access, we modeled the dynamics of appointment backlog using a Markov Modulated Poisson Process (MMPP), and developed numerical methods for computing system performance metrics. The insights obtained from the models provide guidance to care providers who are engaged in facilitating e-visits to apprehend the influence of the novel care delivery channel on their established practices.

5 - A Simulation Optimisation on the Hierarchical Health Care Delivery System Patient Flow Based on Multi-fidelity Models

Yunzhe Qiu, PhD Candidate, Olin Business School, Haidian District, University City, MO, 63130, United States, qiuyunzhe@wustl.edu, Jie Song, Zekun Lu

The imbalanced development among different levels of healthcare facilities in China's urban healthcare system has raised the uneven patient flow distribution. We develop a method integrating the simulation, the multi-objective optimization and the simulation budget allocation together to comprehensively improve the overall system performances by finding the approximate Pareto patient flow distribution in the hierarchical healthcare system. A case study based on the real data shows the recommended Pareto optimal patient flow distribution can improve the overall hierarchical system performances and our methodology is qualified as a quantitative decision tool for decision makers

■ SC09

330A

MSOM Energy and Sustainability

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Yangfang Zhou, Singapore Management University, Singapore, 178899, Singapore, helenzhou@smu.edu.sg

1 - Promoting Solar Panel Investments: Feed-in-tariff Versus Tax-rebate Policies

Safak Yucel, Georgetown University, Georgetown University, 3700 O. St. NW, 523 Hariri Building, Washington, DC, 20057, United States, safak.yucel@georgetown.edu, Volodymyr O. Babich, Ruben Lobel

We compare two policies governments use to promote investment in solar panels by households: feed-in tariff and tax rebate. The feed-in tariff provides a guaranteed stream of payments to the households. The tax-rebate policy reduces the initial investment cost. We investigate the main economic forces that tilt the government's preference towards one of the policies. One such force is the strategic waiting by forward-looking households in the face of uncertainty and irreversible investments. We model uncertainties in prices and investment costs, the percentage of myopic households in the economy, the heterogeneity in generating efficiencies, and the environmental benefits.

2 - Dynamics of Capacity Investment in Renewable Energy Projects

Nur Sunar, UNC, 1604 Village Crossing Drive, Chapel Hill, NC, 27517, United States, nur_sunar@kenan-flagler.unc.edu, John R.Birge

Using a continuous time model, we analyze the dynamics of capacity investment in renewable power. In this context, we explicitly identify the optimal policy. We also present some numerical examples to explain the structure of the optimal strategy.

3 - Optimal Size of a Combined Heat and Power Generator for an Industrial Firm

Wenbin Wang, Shanghai University of Finance and Economics, Shanghai, China, wang.wenbin@mail.shufe.edu.cn, Gilvan Souza, Owen Wu

We consider a manufacturer who uses both steam and electricity in its primary production process makes investment on a Combined Heat and Power (CHP) system. We provide a decision model and find the optimal capacity and operating policy for a CHP system that reduce the total investment and energy costs.

4 - Is Electricity Storage Green? A Study on the Commercial Sector

Yangfang Zhou, Singapore Management University, 50 Stamford Road, Singapore, 178899, Singapore, helenzhou@smu.edu.sg

Electricity storage facilities, such as industrial batteries, are considered the "game changer" in de-carbonizing the electrical grid. They are being widely installed in the commercial sector, e.g., retail stores and corporate offices. We model the problem of managing electricity storage in a commercial building for both the cases with and without a solar photovoltaic system. Our numerical results, based on models calibrated to electricity load data for more than 70 commercial buildings in the U.S., show that for all these buildings, optimal storage operations may increase carbon emissions. We also study the case when commercial buildings are equipped with solar photovoltaic systems.

■ SC10

330B

Value Chain Innovations:Doing Good by Doing Well

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Ravi Anupindi, University of Michigan, Ann Arbor, MI, 48109, United States, anupindi@umich.edu

1 - Giving it Away to Increase Profits: Price Discrimination and the Effect of Free Goods

Jacob Chestnut, University of Michigan, Ann Arbor, MI, United States, jacobpc@umich.edu, Ravi Anupindi, Hyun-Soo Ahn

Conventional wisdom suggests that a service provider must charge a customer in some form to generate profit. However, a handful of providers do not follow this and give away services to some customers for free. Dr. Devi Shetty, called the "Henry Ford of Cardiac Surgery," is the founder of India's Narayana Health, which performs 40% of surgeries for free. India's Aravind Eye Hospital (AEH) is another well-known example. Though nominally non-profit, with a net surplus of 50% while serving 60% of their consumers for free, AEH's performance suggests that offering partially free service may be more than charity; it may actually increase a provider's total profit.

2 - Assessing the Impact of Telemedicine-Equipped Service Channels on Patient Access

Kamalini Ramdas, London Business School, London, United Kingdom, kramdas@london.edu, Sarang Deo, Kraig Delana, Ganesh Babu, Sri Harinath

We use data from the Aravind Eye Care System in India to examine how the introduction of rural vision centers equipped with telemedicine impacts patient visit volumes, patient mix, revenues and outcomes. Using a difference-in-differences model, we find that the introduction of vision centers substantially increases network volumes, largely through new patients. We also find that patients switch to care closer to home when feasible. Our findings suggest that telemedicine can successfully catalyse care seeking behavior and can enable a pull model of care in rural areas.

3 - Optimal Subsidies for Solar Lanterns in Haiti

Chris Tang, UCLA Anderson School, CA, United States, chris.tang@anderson.ucla.edu, ManMohan Sodhi, James Knuckles

Development supply chains focus on the economic sustainability of poor families. To understand these better, we conducted a field study of such supply chains for solar lanterns in Haiti during 2014-2016. Upon interviewing donor organizations such as the World Bank, we found that the answer to which particular echelon in the supply chain should the donor subsidize differed from one donor to the other and even within donor organizations. Using stylized models, we seek to find the best way to subsidize a multi- echelon supply chain when the donor's budget is limited.

■ SC11

332A

Data-driven Decision Making in Healthcare and Service Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States, shi178@purdue.edu

Chair: Nan Liu, Columbia University, Columbia University, New York, NY, 10032, United States, nl2320@columbia.edu

1 - Real-time Outpatient Scheduling Algorithms

Kimia Ghobadi, MIT, 100 Main Street, E62-459, Cambridge, MA, 02142, United States, kimiag@mit.edu, Michael Hu, Retsef Levi, Adam Marshall, Wendi Rieb, Bethany Daily, Inga Lennes, John Stone, Ana Cecilia Zenteno

We developed real-time (online) intra- and inter-day algorithms to schedule outpatient infusion appointments while respecting patient choices. Each appointment is scheduled upon arrival without prior knowledge of future appointments or patient preferences. The goal of the algorithms is to minimize the number of required resources. We analyze the algorithms' performance and provide competitive ratio bounds. The algorithms are tested on two large infusion centers in an academic medical center and the results illustrate up to 34% improvement compared to the centers' historical data.

2 - Improving the use of Operating Rooms using Surgeon Input

Brian Han, Marshall School of Business, University of Southern California, Los Angeles, CA, United States, rongqing.han.2019@marshall.usc.edu, Song-Hee Kim

When allocating operating room times to surgery cases, hospitals need to know how long the surgeries will take. Although the estimation of surgery case duration has been extensively studied, accurately predicting surgery case duration remains a challenge. We examine ways to systematically combine surgeons' forecasts with a model based on observed attributes to improve the accuracy of surgery case duration predictions, and hence the use of operating rooms.

3 - Dynamic Appointment Scheduling of Elective Surgeries under Bed Capacity Constraint

Chengyu Wu, Duke University, 877 Louise Circle, Durham, NC, 27705, United States, chengyu.wu@duke.edu, Li Chen, Jing-Sheng Jeannette Song

We study the problem of scheduling elective surgeries that aims to provide patients with specific surgery dates at the time when they call in, taking into account the ICU capacity and occupancy. In doing so, we develop a heuristic and then validate it using real hospital data.

4 - Managing Appointment-based Services in the Presence of Walk-in Customers

Nan Liu, Columbia University, New York, NY, 10032, United States, nan.liu@columbia.edu, Shan Wang, Guohua Wan

Walk-in customers are accepted in many service industries and especially in healthcare. Motivated by practice in two large community health care networks in NYC, we study how to schedule patients in a clinic session in anticipation for random walk-ins. We use a Poisson regression framework to analyze the temporal pattern of walk-ins based on 3-year data, and propose data-driven optimization models to identify the optimal appointment schedule. We show that the objective function is multimodular, and this elegant structural property allows us to develop efficient solution algorithms. Our models can be applied to general appointment-based services in the presence of random walk-in customers.

■ SC12

332B

Markets, Allocation and Information

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Yash Kanoria, Columbia Business School, New York, NY, 10027, United States, ykanoria@gmail.com

Co-Chair: Irene Yuan Lo, New York, NY, 10025, United States, iyl2104@columbia.edu

1 - Carta: A Course Exploration Platform for Undergraduates

Ramesh Johari, Stanford University, Huang Engineering Center Rm 311, 475 Via Ortega, Stanford, CA, 94305-4121, United States, ramesh.johari@stanford.edu, Tum Chaturapruek, Michael Bernstein, Mitchell Stevens

Students' course choices made early in the college career can largely shape academic options and occupational opportunities later on, but pathways and course selection decision making that leads to these choices are mostly invisible. To address these limitations, we introduce Carta, a web application that provides students with information to inform how they navigate their undergraduate careers. It deploys complete data on enrollments, outcomes, and course evaluations. In this talk we describe the platform, as well as some initial research findings from its deployment.

2 - Non-monetary Dynamic Allocation to Agents with Unit Demand

Peng Shi, USC Marshall School of Business, Los Angeles, CA, United States, pengshi46@gmail.com, Nicholas A.Arnosti

We consider a setting in which agents and items match dynamically over time and monetary transfers are limited. Applications include the allocation of subsidized housing and of discounted tickets. We compare five mechanisms: waitlist with rejection, waitlist without rejection, repeated lottery with infinite entry, single-entry lottery, and ticket-saving lottery. We show that each mechanism is equivalent to one of the two versions of the waitlist. (Equivalence means that for each agent, the distribution of match values are the same in either mechanism.) We compare the utilitarian welfare between these two classes of mechanisms based on the tail of the outside option distribution.

3 - Iterative Local Voting for Collective Decision-making in Continuous Spaces

Vijay Kamble, University of Illinois Chicago, Chicago, IL, United States, vijaykamble.iitkgp@gmail.com

Many societal decision problems lie in high-dimensional continuous spaces not amenable to the voting techniques common for their discrete or single-dimensional counterparts. These problems are typically discretized before running an election or decided upon through negotiation by representatives. We propose a meta-algorithm called Iterative Local Voting for collective decision-making in this setting, in which voters are sequentially sampled and asked to modify a candidate solution within some local neighborhood of its current value. We explore the convergence of such a scheme and test our algorithm for the decision of the U.S. Federal Budget on Mechanical Turk with over 4,000 workers.

4 - Dynamic Matching in School Choice: Efficient Seat Reassignment After Late Cancellations

Irene Yuan Lo, Columbia University, New York, NY, 10025, United States, iyl2104@columbia.edu, Itai Feigenbaum, Yash Kanoria, Jay Sethuraman

We consider the problem in centralized school admissions of reassigning seats after students obtain better outside options. We introduce the Permuted Lottery Deferred Acceptance (PLDA) mechanisms, which assign seats using two rounds of the standard Deferred Acceptance mechanism where the second-round tie-breaking lottery is a permutation of the first-round lottery. We show that a mechanism that reverses the lottery order performs best among all PLDA mechanisms, and characterize PLDA mechanisms as the class of truthful mechanisms satisfying natural efficiency and fairness properties. Empirical investigations based on NYC high school admissions data support our theoretical findings.

■ SC13

332C

Health Care, Strategy and Policy

Contributed Session

Chair: George Miller, Altarum Institute, Ann Arbor, MI, United States, george.miller@altarum.org

1 - The Impact of Provider Consolidation on the Balance of Quality and Process Improvement Efforts in Health Services

Aaron H.Ratcliffe, Assistant Professor, University of North Carolina at Greensboro, 438 Bryan Building, Greensboro, NC, 27402-6165, United States, aaron.ratcliffe@uncg.edu

We develop a competitive queueing model to study how health service providers balance investments in quality which increase patient service valuation against investments in process improvements which increase service efficiency. Our analytical derivations measure the impact of provider consolidation on equilibrium quality effort, service delay and financial performance.

2 - Impact of Structural Quality and Patient Centeredness on Hospitals' Sustainable Operations: An Empirical Evidence from U.S. Hospitals

Yue Zhang, University of Toledo, 2801 W. Bancroft St., Stranahan Hall, Toledo, OH, 43606-3390, United States, yue.zhang@utoledo.edu, Aber Elsaleiby, P.S. Sundararaghavan

The Centers for Medicare & Medicaid Services (CMS) defined sets of quality dimensions as structure, process, outcome, and patient centeredness. This study investigates the role played by these quality measures in impacting hospitals' sustainable operations, which were captured through both reduced unplanned readmission and mortality rates. The analysis was conducted based on data from 571 U.S. acute care hospitals.

3 - Simulations for Evidence Based Interventions

Zhongyuan Yu, Research Assistant Professor, Stevens Institute of Technology, 221 Clinton St, Apt. 4R, Hoboken, NJ, 07030, United States, zyu7@stevens.edu, Michael Pennock

When health providers consider whether or not to implement a new intervention, they are sometimes skeptical of results from randomize clinical trials (RCTs). This is because RCTs are performed under controlled circumstances. Once the intervention is implemented, local factors such as socio-economic status and geographic dispersion of the patient population, as well as organizational culture of the provider can affect realized results. We use an interactive visualization based simulation to rerun the RCT systematically under alterative conditions, which allows decision makers to be better engaged in the discussion, and facilitates adoption of evidence based health care approaches.

4 - CPOE: Is Meaningful Use, Meaningful?

Neset Hikmet, Professor, University of South Carolina, 1301 Gervais St, Suite 1010, Columbia, SC, 29208, United States, nhikmet@sc.edu, Jeffrey S. Puckett, Benjamin Schooley

This study explores the relationship between governmental regulations and the proliferation of Computerized Physician Order Entry (CPOE) between the years 2008-2010 across federally sponsored or administered Health Delivery Organizations within the U.S. We found that a dramatic increase of CPOE installations occurred in tandem with the Medicare Improvements for Patients and Providers Act (MIPPA) of 2008, The American Reinvestment and Recovery Act (ARRA), Health Information Technology for Economic and Clinical Health (HITECH) of 2009 and Stage 1 Meaningful Use objectives (2010-2014).These incentives and mandates appear to have had a strong effect on HDO investments in CPOE technologies.

5 - "Pay for Success" Financing and Home-based Multicomponent Childhood Asthma Interventions: Modeling Results from the Detroit Medicaid Population

George Miller, Institute Fellow, Altarum Institute, 3520 Green Court, Suite 300, Ann Arbor, MI, 48105, United States, george.miller@altarum.org

Pay for Success (PFS) is a mechanism for funding public sector programs with financing from private investors who receive a payout from the public sector only if metrics identified in a performance-based contract are met. To help understand the economics of a PFS intervention in a Medicaid population, we modeled the potential impact of a childhood asthma intervention that targets children enrolled in Medicaid in Detroit. We found that such an intervention has significant potential in a PFS financing scheme if the intervention targets the most severely-affected children.

■ SC14

332D

Emerging Trends in Healthcare Policy

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Hamed Mamani, University of Washington, Seattle, WA, 98195-3226, United States, hmamani@uw.edu

Co-Chair: Shima Nassiri, University of Washington/Foster School of Business, Seattle, WA, 98195, United States, shiman@uw.edu

1 - Contracts for Healthcare Referral Services

Fernanda Bravo, UCLA Anderson School of Management, 110 Westwood Plaza, B4.11, Los Angeles, CA, 90024, United States, fernanda.bravo@anderson.ucla.edu, Elodie Adida

This work focuses on the B2B interaction between a service requester and a service provider in a healthcare environment. The requester is responsible for managing the health of a population of patients, and refers the patient to a provider for advanced care needs. The requester may exert effort to reduce the volume of referrals and the provider may exert effort to reduce the chance of treatment failure. We analyze a variety of payment systems between the two firms and study how to coordinate the effort decisions with either the system optimum or the social optimum.

2 - Longer Quality-adjusted Life Years with Less Cost? – Yes, the Mobile Clinic Operation Can Help

Fang Liu, Nanyang Technological University, S3-B2a-13, 50 Nanyang Avenue, Singapore, 639798, Singapore, liu_fang@ntu.edu.sg, Yulan Wang, Pengfei Guo

In this paper, we consider a discrete-time mobile clinic (MC) delivery model and study the optimal MC implementation from the viewpoint of the government. Specifically, we consider the following three objectives: (1) cost reduction, (2) improving the quality of the adjusted life years (QALYs) of the remote population, and (3) a bi-objective optimization defined as a weighted average of the above two performance measures. We then characterize the corresponding optimal MC delivery policy under each objective, and investigate how disease characteristics affect the MC operation.

3 - Empirical Queues for Health Policy Evaluation

Donald Lee, Yale School of Management, 165 Whitney Ave, Box 208200, New Haven, CT, 06520, United States, donald.lee@yale.edu

A range of health policy questions, from end-of-life care initiation to organ transplant allocation, can be modelled as stochastic networks. The transition dynamics of customers in these networks may depend not only on the network node, but also on the customer's characteristics which may be time-varying. We introduce a new approach for estimating such transition dynamics from data, in order to facilitate the simulation of high resolution counterfactuals. We use the approach to revisit a question concerning the impact of workload on service speed in emergency departments. Based partly on joint works with Ningyuan Chen and with Edieal Pinker.

4 - Reference Pricing for Healthcare Services

Shima Nassiri, University of Michigan - Ross School of Business, Ann Arbor, MI, United States, snassiri@umich.edu, Hamed Mamani, Elodie Adida

The traditional payment system between an insurer and hospitals does not incentivize hospitals to limit their prices and patients to choose less expensive providers, hence contributing to high insurer costs. Reference pricing (RP) has been proposed as a way to better align incentives and control costs. Under RP, the patient may be responsible for part of the cost if they select a high-price hospital. We propose a model to analyze the RP payment scheme that incorporates an insurer, competing hospitals, and patients with the goal of understanding how RP compares with the current payment system.

■ SC15

332E

Retail Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Hao-Wei Chen, University of Toledo, Toledo, OH, 43606, United States, hao-wei.chen@sjsu.edu

1 - Supplier Encroachment with Private Selling Cost Information

Haresh B. Gurnani, Wake Forest University, 319 Farrell Hall, School of Business, 1834 Wake Forest Road, Winston Salem, NC, 27106, United States, gurnanih@wfu.edu, Huiqi Guan, Zhibin (Ben) Yang

We study channel encroachment by a supplier privately informed of its cost of direct selling. The supplier's direct selling capability may positively or negatively affect the supplier's and buyer's profits due to signaling. Both firms and consumers may be worse off from the buyer's acquisition of private cost information.

2 - Managing Opportunistic Consumer Returns in Retail Operations

Mehmet Sekip Altug, George Washington University, 2201 G.Street NW, Funger 415, Washington, DC, 20052, United States, maltug@gwu.edu, Tolga Aydinliyim, Aditya Jain

Although lenient return policies are prominently used in retail, such policies may induce opportunistic return behavior, i.e., short-term purchases with no intention to keep the product, which essentially creates two distinct market segments. In this study, we investigate three state-of-the-art retail strategies: i) Uniform ii) Targeted (enabled by data analytics) iii) Menu of choice return policies. We consider a price-setting newsvendor who also chooses an optimal refund to study the three aforementioned settings and provide insights on when retailers can justify investing in analytics-driven decision making and when they can afford to use traditional approaches to return management.

3 - Improving Supply Quality using Retailer-initiated Returns

Hao-Wei Chen, University of Toledo, Toledo, OH, United States, haowei.chen@utoledo.edu, Wen-Ya Wang

With retailer-initiated returns, customers are encouraged to return purchased items for refunds regardless of their satisfaction level. We investigate how such a strategy affects the supply chain partners' profits and the quality of the product from the supplier through stochastic models. We also discuss the timing for initiating the returns.

■ SC16

332F

Inventory Management

Contributed Session

Chair: Qiang Wang, University of Science and Technology of China, Hefei, China, qiangwan@mail.ustc.edu.cn

1 - Self-reservation Policy to Deal with Fixed and Variable Stockout Costs

Boray Huang, Eindhoven University of Technology, P.O. Box 513, School of Industrial Engineering, Eindhoven, 5600MB, Netherlands, b.huang@tue.nl, Andy Wu

We consider a make-to-stock system to satisfy bulk demand with an exponential inter-arrival time. A key issue in this system is the non-convex shortage cost consisting of fixed and variable expenditures when the demand is not fully satisfied. We propose a type of self-reservation policy by a Markov Decision Process. Our numerical examples indicate the optimal policy may reduce the total average cost by 47% on average.

2 - Simple Modeling Techniques for Base-stock Inventory Systems with State Dependent Demand Rates

Fredrik Olsson, Dr., Lund University, Ole Römers väg 1, Lund, 221 00, Sweden, fredrik.olsson@iml.lth.se

In this paper new modeling techniques of (S-1,S) inventory systems with state dependent demand rates are proposed. Examples of single-location (S-1,S) inventory systems where the demand, experienced by the system, varies due to the state of the system are, e.g., inventory models with partial backorders, lost sales, perishable items, emergency replenishments etc. Instead of, as in the related literature, using partial differential equations we suggest considerably simpler techniques which are based on elementary theory of queueing and renewal processes.

3 - Inventory Models with Service Differentiation Through Response Time Guarantees

Adriana Gabor, Assistant Professor, United Arab Emirates University, Al Ain, United Arab Emirates, adriana.gabor@uaeu.ac.ae, Lars van Vianen, Guangyuan Yang, Sven B.Axsater

Service providers often differentiate their customers through their response time guarantee. Most of the inventory models however, use the fill rate as measure of differentiation. In this paper we incorporate response time guarantees into a (S-1,S,K) model with two customer classes, in which low priority customers are served only if the inventory level is above K. We employ lattice paths combinatorics to derive the exact distribution of the response time for the lower priority class and provide a simple approximation for the response time of the high priority class. We study the impact of response time guarantee on inventory levels as opposed to fill rates.

4 - Effects of Inventory Efficiency, Productivity and Responsiveness on Operational Performance

Gulsah Hancerliogullari, Istanbul Technical University, Macka Campus Faculty of Management, Department of Industrial Engineering, Istanbul, 34367, Turkey, gulsah_2207@hotmail.com, Emra H. Koksalmis

Inventory management has been a well-studied area of research in operations management. The purpose of this study is to examine the relationship between inventory management performance including inventory efficiency, inventory productivity and inventory responsiveness, and firm operational performance. We use financial data for publicly listed various U.S. industries available at Standard & Poor's Compustat database using Wharton Research Data Services (WRDS).

5 - Dual-index Policies for Two-echelon Inventory Systems with Dual Delivery Modes and Batch Orders

Qiang Wang, University of Science and Technology of China, Hefei, China, qiangwan@mail.ustc.edu.cn, Jie Wu, Chaolin Yang, Xiang Ji

In this paper, we consider a periodic-review, infinite horizon two-echelon inventory system with dual delivery modes. These two modes provide different lead times and incur different costs. The downstream stage faces random customer demands. The objective is to find inventory policies that minimize the expected long-run average cost of the system over an infinite planning horizon. Due to the complex system structure, the optimal inventory policy is unknown. In this article, we study a class of simple inventory policies, called dual-index echelon-base-stock policy, which has been proved to be near-optimal for the single-echelon inventory system with dual-sourcing.

■ SC17

340A

Operations Management and Learning in Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Kuang Xu, Stanford University, 655 Knight Way, Stanford, CA, 94305, United States, kuangxu@gmail.com

1 - Dynamic Resource Allocation under Information Loss

Yuan Zhong, University of Chicago / Booth School of Business, 5807 S.Woodlawn Avenue, Chicago, IL, 60637, United States, Yuan.Zhong@chicagobooth.edu, Kuang Xu

We consider the problem of efficient dynamic resource allocation under information loss, in general stochastic processing systems. Information loss is modeled as an information channel. We characterize the capacity region under various channel models, and analyze the role of memory in policy design.

2 - Spectrum Estimation from a Few Entries

Ashish Kumar Khetan, University of Illinois, 104 South Matthews Avenue, Urbana, IL, 61820, United States, khetan2@illinois.edu, Sewoong Oh

Singular values of a data provide insights on the structure of the data. However, in many applications, we only get a partial observation. Under such scenarios, we consider the fundamental problem of recovering spectral properties of the underlying matrix from a sampling of its entries. We are particularly interested in recovering the spectrum, which is the set of singular values, and also in recovering a spectral sum function, which is an aggregate sum of a function applied to each of the singular values. We propose first estimating the Schatten k-norms of a matrix, and then applying Chebyshev approximation to the spectral sum function or applying moment matching to recover the spectrum.

3 - On the Performance of the M/coxian-2/n System with Preemption

Xin Liu, Arizona State University, Tempe, AZ, United States, liuxincell@gmail.com

This presentation discusses the performance of the M/Coxian-2/N system, where the mean service time in the second phase is longer than that in the first phase. The preemption policy assigns the priority to jobs in the first phase. When there are phase-1 jobs in the queue, the policy terminates phase-2 jobs in service and allocates freed servers to phase-1 jobs. The terminated phase-2 jobs are put back to the queue. We use the fluid solution to approximate the number of phase-1 jobs and the number of phase-2 jobs in the system; and use Stein's method to quantify the approximation error. We will discuss the implications of these bounds on the performance of the M/Coxian-2/N system with preemption.

4 - A Lower Bound on the Queueing Delay in Resource Constrained Load Balancing

Martin Zubeldia, MIT, Cambridge, MA, United States, mar.zubeldia@gmail.com, David Famarnik, John Tsitsiklis

We consider a distributed service model where jobs with unit mean, but general distribution, arrive and are immediately dispatched to one of several queues associated with n servers. We assume that the dispatching decisions are made by a central dispatcher endowed with a finite memory, and with the ability to exchange messages with the servers. We develop a novel approach to show that every symmetric dispatching policy with a message rate proportional to n, and with a memory of the order of log(n) bits, results in an expected queueing delay which is bounded away from zero, uniformly in n.

■ SC18

340B

Stochastic Optimization in Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Alessandro Arlotto, Duke University, Durham, NC, 27708, United States, aa249@duke.edu

1 - Process Flexibility for Multiperiod Production Systems

Yuan Zhong, University of Chicago / Booth School of Business, 5807 S.Woodlawn Avenue, Chicago, IL, 60637, United States, yz2561@columbia.edu, Cong Shi, Yehua Wei

We consider process flexibility in a multi-period make-to-order production (MTO) system. First, using a new chaining notion, termed the Generalized Chaining Gap (GCG), we prove that in a general system with high utilization, a sparse flexibility structure with m+n arcs is needed to achieve similar performance as full flexibility, where m and n are the number of plants and of products, respectively. We also provide a simple and efficient algorithm for finding such sparse structures. Moreover, we show that the requirement of m+n arcs is necessary, as for some systems, even the best flexibility structure with m+n-1 arcs cannot achieve the same asymptotic performance as full flexibility.

2 - Robust Data-driven Stochastic Programming from a Bayesian Perspective

Harsha Honnappa, Purdue University, 315 N. Grant Street, West Lafayette, IN, 47906, United States, honnappa@purdue.edu, Prateek Jaiswal, Vinayak Rao

We study the problem of solving a two stage stochastic program with recourse, where the expectation is with respect to a Bayes predictive distribution. We consider two settings: first, a 'classical' Bayesian setting identifying the optimal decision when the likelihood is assumed to be known precisely. Second, an 'expert' posits a likelihood and her uncertainty about this assessment as a Kullback-Liebler ball centered at the likelihood. We then perform a minimax optimization to identify the the set of optimal decisions that are robust against the experts uncertainty. In either case, we provide large sample analysis of the effect of learning the predictive distribution on the value of the program.

3 - Escaping the Local Minima via Simulated Annealing: Optimization of Approximately Convex Functions

Tengyuan Liang, University of Chicago, Chicago, IL, United States, Tengyuan.Liang@chicagobooth.edu, Alexandre Belloni, Alexander Rakhlin, Hariharan Narayanan

We consider the problem of optimizing an approximately convex function over a bounded convex set using only function evaluations. The problem is reduced to sampling from an approximately log-concave distribution using the Hit-and-Run method, which is shown to have the same complexity as sampling from log-concave distributions. In addition to extend the analysis for log-concave distributions to approximate log-concave distributions, the implementation of the 1-dimensional sampler of the Hit-and-Run walk requires new methods and analysis. The algorithm then is based on simulated annealing which does not relies on first order conditions which makes it essentially immune to local minima.

4 - A O(log N)-optimal Policy for the Dynamic and Stochastic Knapsack Problem with Equal Values

Xinchang Xie, Duke University, xinchang.xie@duke.edu, Alessandro Arlotto

We study a dynamic and stochastic knapsack problem in which a decision maker is sequentially presented with n items and needs to select which items to include in a knapsack with fixed capacity. Arriving items have non-negative, independent sizes with common continuous distribution, and every decision is terminal upon arrival. The goal is to maximize the expected number of selections under capacity constraint. An adaptive online policy is proposed and proved to be within O (log n) of the optimal, under mild regularity conditions on the distribution. We also discuss how the distribution of the number of selections under this adaptive policy compares with the number of selections under the optimal policy.

■ SC19

342A

Fintech: The Interface of Technology and Finance

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Jun Li, Ross School of Business, University of Michigan, Ross School of Business, University of Michigan, Ann, MI, 48109, United States, junwli@umich.edu

1 - The Freak Out Factor: Retail Investor Behavior in Response to the Global Financial Crisis

Andrew W. Lo, Massachusetts Institute of Technology, Sloan School of Management, Charles E. & Susan T. Harris Professor, Cambridge, MA, 02142, United States, alo@mit.edu

This paper represents the first look at a novel and comprehensive historical brokerage trading dataset that is unique in its breadth of coverage, with over 700k U.S. accounts, and longevity, containing monthly snapshots spanning January 2005 to December 2015. By synthesizing this data with daily asset price series, we are able to observe the dynamics of retail households' investment portfolios at daily frequency before, during, and after the 2008 Global Financial Crisis. We identify canonical empirical behaviors such as the propensity to sell securities and/or portfolios when experiencing extreme positive or negative returns in the recent past, known in the psychology literature as the "disposition" and "loss aversion" effects. We use modern machine learning methods to develop performant predictive models of trading and liquidation, and assess the sensitivity of these models to their key factors including past returns, past trading, balances, allocations, and demographic characteristics. We also document liquidation behavior during the crisis, defined as the reallocation of holdings in risky assets to cash for prolonged periods of time, both for investors facing different drawdowns in their portfolios and those from different demographic segments. We find that investors with the worst historical experiences during the crisis were more likely to liquidate, maintained less aggressive allocations in risky assets for longer periods of time, and experienced worse risk-adjusted returns during the post-crisis recovery period.

1 - Text Based Positioning of Firms Along the Supply Chain

Dimitry Slavin, Ross School of Business, University of Michigan, Ann Arbor, MI, United States, dslavin@umich.edu

An objective method of identifying a firm's economic position based on the content of its annual financial disclosures is proposed. The method's key components include (i) the creation of a consumption-risk related lexicon, (ii) several natural language processing techniques (keyword-extraction, part-of-speech tagging, named-entity recognition, etc.), and (iii) an iterative clustering procedure. The proposed method reveals previously-unknown interdependencies between firms, and is expected to serve as a new, unbiased measure of a firm's supply-chain-related risk.

2 - R&D Spending: Dynamic or Persistent?

Christophe Pennetier, INSEAD, 6 Marina Boulevard, # 27-15, Singapore, 018985, Singapore, christophe.pennetier@insead.edu, Karan Girotra, Jurgen Mihm

We study how a given amount of R&D spending is best allocated over time to optimize R&D performance. Using a sample of US public companies, we estimate the interaction between R&D investment and types of innovation strategy.

■ SC20

342B

Sourcing Innovation Using Contests

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Lakshminarayana Nittala, Rady School of Management, lakshmi.nittala@rady.ucsd.edu

1 - Innovation Tournaments with Multiple Contributors

Ersin Korpeoglu, University College London, Flat 27 Kingfisher Heights Waterside Way, London, N17 9GL, United Kingdom, e.korpeoglu@ucl.ac.uk, Laurence Ales, Soo-Haeng Cho

In an innovation tournament, an organizer seeks innovative solutions from multiple agents. Agents exert efforts to improve solutions, whose performance is uncertain. We analyze a general model of uncertainty and consider a case in which the organizer seeks multiple solutions. We show that contrary to existing theories, increased competition in a tournament can increase agents' efforts when agents expect good outcomes with high likelihood, and a free-entry open tournament should be encouraged only when agent uncertainty is high or the organizer seeks many diverse solutions.

2 - Motivating Participation and Effort in Innovation Contests

Konstantinos Stouras, Postdoctoral Research Fellow, The Darden School, University of Virginia, 100 Darden Boulevard, Charlottesville, VA, 22903, United States, kostas@virginia.edu, Jeremy Hutchison-Krupat, Raul Chao

An innovation contest is a business process through which a firm crowdsources innovation to a large pool of solvers. Solvers are ex ante heterogeneous and decide whether to participate and how much effort to exert to enhance their performance. We characterize how firm's choice of reward allocation affect solver voluntary participation and effort behavior in equilibrium. We show that multiple awards are beneficial to balance the tension between how many solvers to attract and of what type, and how much effort they would exert towards maximizing the top performance of the participating solvers.

3 - Simultaneous vs. Sequential Crowd Sourcing Contests

Lu Wang, University of Toronto, Rotman School of Management, 105 St George Street, Toronto, ON, M5S.3E6, Canada, lu.wang12@rotman.utoronto.ca, Ming Hu

In a crowdsourcing contest, innovation is outsourced to an open crowd. We consider two alternative mechanisms for an innovative project involving multiple attributes. One is a simultaneous contest, where the best solution is chosen from the aggregate solutions simultaneously submitted by all contestants. The other is multiple sequential sub-contests, with each dedicated to one attribute and the contestants asked to build upon the best work in progress from previous sub-contests. While both mechanisms have their own advantages, either could win over depending on situations.

4 - Designing Internal Innovation Contests

Lakshminarayana Nittala, University of California-San Diego, Rady School of Management, 9500 Gilman Drive, La Jolla, CA, 92093, United States, lnittala@ucsd.edu, Sanjiv Erat, Viswanathan Krishnan

Firms can use contests to engage employees in finding solutions to its problems related to innovation and product development. We present an analytical model inspired by field work to highlight the unique aspects associated with such internal contests and discuss design recommendations.

■ SC21

342C

Data Analytics Models for Healthcare

Invited: InvitedHealthcare Systems and Informatics

Invited Session

Chair: Kai Yang, Wayne State University, Detroit, MI, 48201, United States, kai.yang@wayne.edu

1 - Integration of Multiple Health Information Systems for Quality Improvement of Radiologic Care:

Jing Li, Ph.D, Arizona State University, AZ, United States, jing.li.8@asu.edu

In radiology, several electronic Health Information Systems (HISs) are used: EHR, RIS, and PACS. Each HIS records partial and complementary information about the radiologic care process. We developed a novel technology called Department Data Depot (DDD) that integrates multiple HISs in radiology. We propose nine Quality of Care (QoC) metrics defined upon the data from DDD that measure various dimensions of care quality such as timeliness, efficiency, patient satisfaction, and workload distribution. To demonstrate the clinical utility of DDD, we developed and deployed a web application system, the Radiology Quality Dashboard (RQD), at Mayo Clinic in Arizona (MCA). Use cases will be presented.

2 - Mining Major Patterns of Disease Progression in Patients with Multiple Chronic Conditions

Adel Alaeddini, Assistant Professor, University of Texas at San Antonio (UTSA), San Antonio, TX, United States, Adel.Alaeddini@utsa.edu

Approximately one in four Americans and 75% of citizens aged 65+ years are burdened with MCC. Treatment for people living with MCC currently accounts for an estimated 66% of the Nation's health care costs; a number that is only expected to grow. However, it is still not known precisely how MCC emerged among individuals or in the general population. Using a dataset of more than half million patients being monitored over 10 years, this study investigates major patterns of MCC progression in a diverse population of patients and identifies the risk factors affecting the patterns.

3 - The Vector Representation of Medical Codes using Latent Semantic Mapping

Liwen Cui, Tsinghua University, Shunde Building, Room 615, Beijing, 100084, China, cuiliwen0512@126.com, Xiaolei Xie, Zuo-Jun Max Shen, Zuo-Jun Max Shen, Haibo Wang, Rui Lu

Nowadays, modern machine learning techniques are widely applied in healthcare fields, a tremendous challenge faced by previous research is how to deal with the huge amount of different medical codes that represent diagnosis or surgical operations. We propose a framework that transforms medical codes to vector representations using latent semantic mapping in natural language processing. Our method significantly outperforms various traditional dimensionality reduction methods in healthcare resources prediction, which demonstrate its application potentiality in healthcare predictive analytics.

4 - Hospital Time-to-Readmission Risk Modeling with Latent Heterogeneity

Suiyao Chen, University of South Florida, 5017 Patricia Court, Apt 237, Tampa, FL, 33617, United States, suiyaochen@mail.usf.edu, Nan Kong, Xuxue Sun, Hongdao Meng, Mingyang Li

Hospital readmission risk modeling is of great interest to reduce preventable readmissions and advance care quality. A readmission risk model is preferable if it exhibits superior prediction performance, identifies risk factors and constructs composite metrics to evaluate multiple hospitals. To simultaneously address these features, this paper proposes the models with incorporation of level-specific latent heterogeneity, leveraging the larger scale and less fragmented administrative claims data. To demonstrate the prediction performances of the proposed models, a real case study is considered on a state-wide heart failure patient cohort.

■ SC22

342D

Revenue Management with Choice Models

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Zizhuo Wang, University of Minnesota, Minneapolis, MN, 55414, United States, zwang@umn.edu

1 - Assortment Optimization under a Single Transition Model

Zizhuo Wang, University of Minnesota, 1009 5th Street SE, Minneapolis, MN, 55414, United States, zwang@umn.edu, Kameng Nip, Zhenbo Wang

We consider a Markov chain choice model with single transition. In this model, customers arrive at each product with a certain probability. If the arrived product is unavailable, the seller can recommend a subset of products and the customer will purchase one of the recommended products or choose not to purchase with certain transition probabilities. We study the assortment optimization problem under this model. We show that this problem is NP-Hard while proposing polynomial time algorithms for several special cases and a compact mixed integer program formulation that can solve this problem of large size. We also provide a tight performance bound for revenue-ordered assortments.

2 - Assortment Optimization under Paired Combinatorial Logit Model

Heng Zhang, University of Southern California, Los Angeles, CA, 90007, United States, hengz@usc.edu, Paat Rusmevichientong, Huseyin Topaloglu

We study uncapacitated and capacitated assortment optimization under the paired combinatorial logit model, where the goal is to find a set of products to maximize the expected revenue. We show that even the unconstrained problem is strongly NP-hard. We cast both problems as one of finding the fixed point of a function, whose evaluation requires solving a non-linear integer program. Relaxing this integer program provides a framework for approximation algorithms. We use LP and SDP relaxations with randomized rounding to give 0.6 and 0.79 performance guarantees for the un-capacitated problem, and use LP relaxation with iterated rounding to give a 0.25 performance ratio for the capacitated problem.

3 - Multi-stage Assortment Problems under the Multinomial Logit Model

Yuhang Ma, Cornell University, Ithaca, NY, United States, ym367@cornell.edu, Huseyin Topaloglu

We consider an assortment problem where we offer sets of products in multiple stages and the choice process at each stage is driven by the multinomial logit model. In particular, we have K stages. At each stage, we offer a distinct set of products. If the customer makes a purchase at a certain stage, then her choice process terminates. If the customer does not make a purchase at a certain stage, then she observes the set of products offered at the next stage. The goal is to find a set of products to offer at each stage to maximize the expected revenue obtained from a customer. We show that the problem is NP-hard and develop an FPTAS.

4 - Data Driven Assortment Optimization

Velibor Misic, UCLA Anderson School of Management, Los Angeles, CA, 90095, United States, velibor.misic@anderson.ucla.edu, Dimitris Bertsimas

We present a procedure for transforming data into assortment decisions through a nonparametric, ranking-based choice model. Our procedure consists of an estimation step, which involves solving a large-scale linear optimization problem using column generation to obtain a ranking-based model, and an optimization step, which involves solving a mixed-integer optimization model to obtain the assortment. We provide theoretical results on the tractability of our formulations. We evaluate the effectiveness of our method numerically with real and synthetic data and show that it outperforms alternative parametric and nonparametric proposals.

■ SC23

342E

Pricing and Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Yanqi Xu, Princess Cruises, Valencia, CA, 91355, United States, yanqi6@yahoo.com

1 - Quantile Regression - Another Option to Calculate Elasticity for Market Response Models

Justin Ji, Consultant, Operations Research, Revenue Analytics, Atlanta, GA, United States, jj@revenueanalytics.com, Pratik Mital

Quantile regression was first introduced by Roger Koenker and Gilbert Bassett in 1978. It offers more complete statistical model than traditional least squares regression. Quantile regression targets at estimating the conditional median or quantiles of the response variable via investigating the relative level of influences for predictor variables. In addition, quantile regression method is more robust against outliers. In this study, the authors will use traditional least square regression model and quantile regression model to calculate elasticity for market response model.

2 - Emerging Topics in Revenue Management for the Cruise Industry

Greg Vogel, Holland America, Seattle, WA, United States, gvogel@hollandamerica.com

Much research has been done in traditional travel and hospitality industries such as Airlines, Hotels, Resorts, Casinos etc. Very little has been done in regards to the specific problem that are cruise lines. In this talk we discuss similarities and differences between traditional OR research into these industries and the cruise industry and then delve into the problems that the industry is most interested in solving along with an overview of problems that are currently being investigated.

3 - Dynamic and Static Airline Overbooking for Network

Wei Wang, Ph.D, PROS, Houston, TX, United States, weiwang@pros.com

Overbooking and cancellation are important aspects of revenue management, and much research including dynamic programming-based solutions is available in the literature. However, in practice airlines today are still applying static approaches. As an extension to our previous work for single leg, we present a simulation-based comparison of different models under both dynamic and static policies on the network, in particular we allow both no-show refund and cancellations refund to be class dependent.

4 - Maximizing Impact of Customer Reviews & Ratings Sentiment Analysis for Hoteliers

Vinodh Balaraman, ZS Associates, NJ, United States, vinodh.balaraman@zs.com

Maximizing Impact of Customer Reviews & Ratings Sentiment Analysis for Hoteliers Customers' choices seemingly are limitless and so too are their outlets for sharing experiences & opinions. This leaves hotels struggling to influence the customer decision journey, protect their brand and win business. As the volume of social media content explodes, how can hotels leverage data from customers' online activity to deliver a truly unique experience and capture greater market share? In this session, actionable steps will be offered to: 1. Select and process the right customer data from the vast amounts available. 2. Build a strategic roadmap to drive incremental ROI.3. Create greater customer loyalty.

■ SC24

342F

Sharing Economy and Peer-to-Peer Marketplaces

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Jose A Guajardo, University of California-Berkeley, Berkeley, CA, 94720-1900, United States, jguajardo@berkeley.edu

Co-Chair: Zhe Zhang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, zhezhang@cmu.edu

Co-Chair: Vibhanshu Abhishek, Carnegie Mellon University, Pittsburgh, PA, 19104, United States, vibs@cmu.edu

1 - Dynamic Two-Side Platform Pricing in C2C Online Sharing Ecosystems

Peter Angerer, University of Innsbruck, Innsbruck, Austria, peter.angerer@uibk.ac.at, Daniel Provin, Steffen Zimmermann, Barrie R.Nault

Sharing platforms facilitate the sharing of goods between lenders and borrowers. Using an analytical model, we found that sharing platforms have to dynamically adjust platform fees to both consumer groups (dynamic two-sided platform pricing) in order to be profit maximizing. However, the impact of dynamic two-sided platform pricing on consumer's perception of fairness remains unclear. Using a laboratory experiment, we find that fee changes over time have only a moderate effect on perception of fairness while fee differences between lenders and borrowers have a strong negative effect on perception of fairness and intention to share. Thus, sharing platforms need to be aware of those effects on perception of fairness when applying dynamic two-sided platform pricing.

2 - Hitting too Close to Home?: Impact of Airbnb on Hotel Entry

Uttara Madurai Ananthakrishnan, Carnegie Mellon University, 3 Bayard Road, Apt B3, Pittsburgh, PA, 15213, United States, umadurai@andrew.cmu.edu

Participation in sharing economy has been increasing in the past few years. In this paper, we study how entry of sharing economy firms impacts the entry of incumbent hotels in the context of Airbnb. To understand the impact on entry, we exploit the temporal and geographical variability in Airbnb's entry into a market and employ a difference-in-differences specification. Further, we build an entry-model to estimate the business stealing effect of Airbnb. Our results indicate that 10% increase in Airbnb properties leads to a decrease in hotel entries of about 0.4%. Based on this, we perform simulations and provide policy recommendations to city governments to plan for an increasing number of Airbnb entrants.

3 - The Tragedy of your Upstairs Neighbors: When is the Home-Sharing Externality Internalized?

Apostolos Filippas, New York University-Stern, New York University-Stern, New York, NY, 10012, United States, apostolosfilippas@gmail.com, John Joseph Horton

A common critique of home-sharing platforms is that they enable hosts to impose costs on their neighbors. We consider four potential public policy responses that differ in whether the decision right to host is allocated to: (1) individual tenants, (2) building owners, (3) cities, and (4) a social planner. We find that (2) and (4) are equivalent, with (3) leading to too little hosting, and (1) to too much hosting. The efficiency of (2) depends on building owners being indifferent between allowing and banning home-sharing in their buildings. To assess this "no policy arbitrage" prediction, we constructed a dataset of NYC rental apartments listings. Although we do not observe building home-sharing policies, there are several "policy" attributes captured in the data, such as whether buildings allow subletting. Consistent with our prediction, we find that policy choices have no detectable effect on rental prices. Despite the attractiveness of the equilibrium of policy (2), tenants must "sort" across buildings, potentially at substantial cost. We explore this sorting with an agent-based model, and show how individual preferences and moving costs affect the equilibrium.

4 - The Welfare Effects of Peer Entry in the Accommodations Market: the Case of Airbnb

Andrey Fradkin, Massachusetts Institute of Technology, 179 Prospect Street, Cambridge, MA, 02139, United States, Afradkin@gmail.com

I will present one of two projects on the effects of peer-to-peer marketplaces on the economy. Either a project about the accommodations industry or a project about the local services industry. These will include analysis of data from digital platforms.

■ SC25

350A

Managing Information and License in Technology Industries

Invited: New Product Development

Invited Session

Chair: Hyoduk Shin, UC-San Diego, La Jolla, CA, 92093, United States, hdshin@ucsd.edu

Co-Chair: Jingqi Wang, jingqi@hku.hk

1 - Perils of Bargaining Power in Biotechnology R&D Licensing

Niyazi Taneri, National University of Singapore, Singapore, niyazi@nus.edu.sg, Arnoud De Meyer

Both the fate of a product and future payments to the innovator (licensor) in R&D license agreements depend on go/no go decisions. This presents a tradeoff between enhanced outcomes due to partner expertise and terminations purely due to a partner's economic concerns even when clinical prospects are good. We find support for the argument that a larger deal value creates a higher hurdle to clear, thereby increasing the likelihood of a termination. Further investigation reveals that this is due to endogeneity: Underlying drivers of deal value determine whether its effect is positive or negative.

2 - Managing Technology and Licensing in Supply Chains

Jingqi Wang, The University of Hong Kong, Room 806, K.K. Leung Building, The University of Hong Kong, Hong Kong, jingqi@hku.hk

We study how a supplier should manage the technology and license in a supply chain with competing manufacturers. Should the supplier implement cross-licensing policy? Our research shows that it depends. We also investigate the impacts of such cross-licensing policies on manufacturers, and consumers.

3 - Information Exchange in Parallel Search

Ni Fang, University of Cologne, Cologne, Germany, fang@wiso.uni-koeln.de, Fabian J. Sting

How should organizations share and use information in parallel innovation, from an internal and external competitive perspective? Using a framework of co-evolutionary search on a technology landscape, we demonstrate how firms can strike a balance for the fundamental trade-off: the efficiency of channeled search vs. the breadth of autonomous search.

■ SC27

350C

Economics of IS and Operations-Marketing?? Interface

Invited: Social Media Analytics

Invited Session

Chair: Soohyun Cho, Rutgers University, Newark, NJ, 07102, United States, scho@business.rutgers.edu

1 - Designing Electronic Markets for Transportation

Arim Park, Rutgers University, Newark, NJ, United States, arim.park@rutgers.edu, Yao Zhao

There are many trucker strikes since 2002 in Korea which brought significant losses on the nation's economy. We would like to design a fair and efficient mechanism for an electronic market of transportation services in Korea. To this end, we would first identify preferences for both customers and carriers, then develop a two-sided matching model for transportation services to facilitate transaction between customers and carriers. Our objective is to design efficient and fair market mechanism which can serve as the engine of the electronic market.

2 - Beauty Contest and Fintech Revolution

Anurag Garg, Graduate Assistant, University of Florida, Warrington College of Business, Bryan Hall 100. PO Box 117150, Gainesville, FL, 32603, United States, anurag.garg@warrington.ufl.edu, Liangfei Qiu, Subhajyoti Bandyopadhyay

Following the insight of Keynes (1936) on beauty contest, we develop a model that formalizes higher order beliefs and speculative trading in financial markets. We look into the effects of higher order beliefs (and precision of private and public information) on price drift, trading volume - price volatility relationship and on social welfare.

4 - Corporate Prediction Market with Over-Optimistic Participants
Jingchuan Pu, University of Florida, 2300 SW 43rd Str, R1, Gainesville, FL, 32607, United States, jingchuan@ufl.edu, Liangfei Qiu

Recently, corporate prediction market has been growingly popular for the decision making. Even though it has an important role to integrate participates' information, the corporate prediction market is inevitably affected by the participates' irrational thinking. Over-optimism is one of well-known irrationality in the corporation. In this study, we investigate the effect of the information precision and social interactions on the prediction market performance, when there is systematical over-optimism among the market participants.

5 - Quantifying the Effect of Social Media On Crowdfunding Campaigns
Mahdi Moqri, University of Florida, 725 NW. 13th St. 3410, Gainesville, FL, 32601, United States, mahdi.moqri@warrington.ufl.edu

Using a unique dataset from 590 crowdfunding campaigns observed over 4 months, we examine to what extent, and how quickly online WOM affect the rate of contributions. In addition, we explore the effect of different phases of fundraising and of the coverage of the campaigns in online news websites.

■ SC28

350D

Auction Applications

Invited: Auctions

Invited Session

Chair: Robert Day, University of Connecticut, Storrs, CT, 06269-1041, United States, Bob.Day@business.uconn.edu

1 - The Role of Optimization in the Incentive Auction
Karla L. Hoffman, George Mason University, System Eng and Operations Research Dept, 4400 University Drive Mailstop 4a6, Fairfax, VA, 22030, United States, khoffman@gmu.edu, Brian Smith, James Andrew Costa, Rudy K.Sultana, Anthony Coudert

The FCC completed the Broadcast Incentive Auction on March 29, 2017. This auction reassigned television stations onto fewer channels in the United States and Canada and repurposed a significant amount of spectrum for wireless use. Optimization played a vital role in the success of the auction. This talk will reflect on the OR activities that took place before, during and after the auction. We will highlight some of the results from the auction and some of the lessons learned.

2 - Watershed Market Design: the Case of the Central Platte Groundwater Exchange
David McAdams, Duke University, 100 Fuqua Drive, Durham, NC, 27708, United States, david.mcadams@duke.edu

Groundwater and surface water are connected hydrologically, but limited options are available for groundwater and surface water users to contract on water use. I propose a relatively simple watershed-market design that generates location-specific water prices and respects regulatory constraints on water flows and water use. This market design was adopted by farmers in the Central Platte Natural Resources District in Nebraska in 2016.

3 - Bidding and Learning in Repeated Auctions
Karti Puranam, LaSalle University, Philadelphia, PA, 19141, United States, kartys.here@gmail.com, Michael Katehakis

We consider the problem of a firm that procures substitutable items in a sequence of auctions by bidding against the "market." The firm and the "market" learn from each winning bid. We study bidding strategies for the firm when the objective of the firm is to maximize long run discounted profit.

4 - Supplier Versus Supply Base Development
Karca Duru Aral, Syracuse University, 721 University Avenue, Syracuse, NY, 13244, United States, kdaralwa@syr.edu

A buyer may choose to sign a long-term contract with an incumbent to encourage cost reduction (which consequently strengthens the incumbent's monopoly). The buyer can instead choose to invest in developing entrants to challenge the incumbent in a competitive-bid procurement auction - both of which are risky options. We analyze when the buyer should break the incumbent's monopoly and characterize how this decision changes with the buyer's business environment.

■ SC29

350E

Analyzing Social Networks and Social Media for Healthcare

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Xi Wang, University of Iowa, Iowa City, IA, 52246, United States, xi-wang-1@uiowa.edu

1 - Mining User-generated Data in OHC for Drug Related Information
Zhao Mengnan, PhD Candidate, Drexel University, Philadelphia, PA, United States, mz438@drexel.edu

A variety of data resources has been used to identify healthcare-related information, mainly including biomedical database, medical literature, electronic health record (EHR), and clinical note. While these data sources are informative, they are mainly contributed by healthcare professionals. None of them capture the information offered by health consumers. Meanwhile, the popularity of Web 2.0 not only breeds the various online social media sites like Facebook and Twitter, but also fosters online health communities (OHCs). OHCs have been widely used for exchanging health information between health consumers. We focus on detecting drug-related information from OHC data.

2 - Impact of Social Media on Copycat Suicides
Jie Mein Goh, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6, Canada, jmgoh@sfu.ca, Srabana Dasgupta, Nilesh Saraf, Dianne Cyr

Prior studies have suggested that widely publicized celebrity suicides often lead to an increase in copy-cat suicides. This is also known as the Werther effect. Given the prevalent use of social media, social-media based conversations after the suicide of a celebrity create significant buzz and generate publicity. However, whether the Werther effect can be caused by social-media conversations on celebrity suicides remains an empirical question. In this study, we test this effect by examining whether and how social media impacts copy-cat suicides using a data set collected from Twitter.

3 - The Impact of Social Capital on Users' Future Contributions in an Online Health Community
Xi Wang, University of Iowa, 810 W. Benton St B213, Iowa City, IA, 52246, United States, xi-wang-1@uiowa.edu
Xi Wang, Central University of Finance and Economics, Beijing, China, xi-wang-1@uiowa.edu, Yuanyang Liu, Kang Zhao, Gautam Pant

Online health communities are increasingly popular sources of information and support for people with health concerns. Encouraging users to make contributions on these platforms, however, is a challenge. Using an online health community for cancer survivors, this study examined if a user's social capital could impact the user's level of future contributions. The outcome reveals that different types of social capital may trigger a user's future contributions in one or more ways.

■ SC30

350F

Social Media and Analytics – A Spectrum of Ideas from Diverse Industries

Invited: Social Media Analytics

Invited Session

Chair: Fay Cobb Payton, North Carolina State University, Raleigh, NC, 27695, United States, fay_payton@ncsu.edu

1 - The Value of Social Media Data in Color Trends Forecasting and Inventory Decisions
Youran Fu, University of Pennsylvania, 3730 Walnut Street, Room 532, Philadelphia, PA, 19104, United States, youranfu@wharton.upenn.edu, Marshall L.Fisher

We partnered with 3 leading apparel retailers to investigate how to use social media data to improve fashion color trend forecasting. We find that using fine-grained Twitter data and the Google search volume index to predict product-color sales three months out can significantly reduce forecast error compared to conventional methods.

2 - Social Sharing and Emerging Infectious Disease Contexts
Bridget Kelley, RTI International, Research Triangle Park, NC, United States, Sarah Ray, Brian Southwell, Linda Squiers, Molly Lynch

Social media may amplify information sharing, but their role during infectious disease outbreaks is unclear empirically. Our content analysis of Twitter posts (n=400) during the 2014 Ebola outbreak suggests most (61%) shared news articles whereas almost none shared government or public health websites, which holds implications for communication efforts.

3 - Brainwave Data Analytics
Kyla McMullen, University of Florida, Gainesville, FL, United States, dr.kyla.mcmullen@gmail.com

Brain-computer interface (BCI) involves the collaboration between a brain and a hardware device, which enables signals from the brain to direct some external activity. BCI data contains the recordings of brain activity through a number of channels over time. Using an Electroencephalography (EEG) device to record brainwave data, a channel can be defined as the electrical potential between a recording electrode and a reference electrode, on the scalp. To control a BCI, the user must produce different brain activity patterns that are identified by a system and translated into commands. The present work uses pattern recognition to create an adaptive brainwave classification system for contexts in which portions of the brainwave signals are missing or otherwise deteriorated.

4 - Does Government Surveillance Give Twitter the Chills?
Uttara Ananthakrishnan, Carnegie Mellon University, 1 Bayard Road, # 28, Pittsburgh, PA, 15213, United States, uttara@cmu.edu

Since Edward Snowden's revelations regarding mass surveillance programs implemented by the NSA, the research community has attempted to estimate what many refer to as "chilling effects" of surveillance, or the tendency to self-censor in order to cope with mass monitoring systems. We propose a new method in order to test for chilling effects in online social media platforms. We use a unique, large dataset of Tweets and propose the use of new statistical machine learning techniques in order to detect anomalous trends in user behavior (use of predetermined, sensitive sets of keywords) after Snowden's revelations made users aware of existing surveillance programs.

■ SC31

351A

Industry Job Search Panel

Invited: INFORMS Career Center

Invited Session

Chair: Warren Hearnes, Cardlytics, Atlanta, GA, whearnes@hotmail.com

This panel discusses the industry interview process and do's and don'ts associated with the job search. In addition to comment from current and former recruiters, time will be provided for questions and answers.

■ SC32

351B

Drone Delivery Systems – III

Invited: InvitedDrone Delivery Systems (tentative title)

Invited Session

Chair: Jaeyoung Cho, Lamar University, Beaumont, TX, 77710, United States, jcho@lamar.edu

1 - Optimizing a Drone Network to Deliver Automated External Defibrillators
Justin James Boutilier, University of Toronto, 532 Palmerston Boulevard, Apartment 6, Toronto, ON, M6G 2P5, Canada, j.boutilier@mail.utoronto.ca, Timothy Chan

Public access defibrillation programs can improve survival after out-of-hospital cardiac arrest (OHCA), but automated external defibrillators (AEDs) are rarely available for bystander use at the scene. In this paper, we develop a framework that combines both location and queueing models to optimize the deployment of drone resources. In particular, we use a CVaR-based response time model that accounts for the historical 911 response time distribution and models the efficiency-equity trade-off between urban and rural areas. We applied our framework to 50,000 historical OHCAs in a large area composed of rural and urban regions surrounding Toronto, Canada.

2 - A Real-time Drone Reroute Planning under Uncertain Flight Duration
Seonjin Kim, University of Houston, 529 Barker Clodine, 17101, Houston, TX, 77094, United States, sonjin64@gmail.com, Gino J.Lim

A real-time drone reroute planning method is proposed to handle the issue of uncertain flight duration. Such undesired situations can arise due to unexpected external events such as strong winds and moving obstacles on the flight path. A rerouting algorithm is designed to utilize alternative routes in real-time. A solution approach is also developed to improve the computational performance of the proposed optimization model. In a numerical example, feasibility and effectiveness of the proposed method are illustrated using a case study.

3 - Strategic Network Design for Parcel Delivery with Drones
Fatma Gzara, University of Waterloo, 200 University Avenue W, Waterloo, ON, N2L.3G1, Canada, fgzara@uwaterloo.ca

We study the effects of drone delivery on network design for e-retailers. We develop a nonlinear optimization model that locates warehouses and decides on services offered where one of the services is delivery by drones within a short time window. Customer demand is modeled using interaction model. We develop a novel Logic based Benders decomposition algorithm to solve the nonlinear formulation and perform numerical testing on the NYC case.

4 - Utilization of Unmanned Aerial Vehicles in Port Operations
Jaeyoung Cho, Lamar University, P.O. Box 10024, Beaumont, TX, 77710, United States, jcho@lamar.edu, Maryam Hamidi, Berna Tokgoz

The purpose of this study is to lay the foundation for the development of future port system using unmanned aerial system. We propose a new mathematical optimization model of chemical tankers routing which are performing their respective loading / unloading operations by the support of unmanned aerial vehicles (UAVs). This problem is modeled as a two-echelon vehicle routing problem as the route of the vessels and the path of UAVs must be optimized at the same time.

■ SC33

351C

AAS Best Student Presentation Competition II

Sponsored: Aviation Applications

Sponsored Session

Chair: Virginie Lurkin, Ecole Polytechnique Fédérale de Lausanne, Route Cantonale, Lausanne, 1015, Switzerland, vlurkin@ulg.ac.be

Co-Chair: Peng Wei, Iowa State University, Iowa State University, Ames, IA, 50011, United States, pwei@iastate.edu

1 - A Static Model in Single Leg Flight Airline Revenue Management
Behrooz Pourghannad, University of Minnesota, 1007 29th Avenue SE, Apt B, Minneapolis, MN, 55414, United States, behrooz@umn.edu

Static models on single leg airline revenue management generally consider booking limits or protection limits as the main decision variables to control reservation requests. In the current paper, we provide an alternative framework in which the decision variables are the closing times of fare classes. In a continuous time model with nonhomogeneous Poisson arrivals, cancellations, and noshows, we study the problem of finding optimal closing times to maximize the expected net revenue from a given flight. We analyze the value function, point out some easy cases, and bring an easily implementable dynamic programming based solution method. We also illustrate this method on some numerical examples.

2 - An Optimization Approach for Airport Slot Allocation under the IATA Guidelines
Nuno Ribeiro, cmu, Portugal, Coimbra, Portugal, nribeiro@andrew.cmu.edu

We present a novel modeling and computational approach to optimize slot allocation decisions at schedule-coordinated airports. The model minimizes the displacement from airlines' slot requests, while complying with the "primary criteria" of the IATA guidelines and airport declared capacities. We introduce a strong formulation that provides exact solutions in short computation times at medium-size airports for a full season of operations. Results from Madeira (FNC) and Porto (OPO) airports suggest that the model can improve the slot allocation outcomes, as compared to historical decisions.

3 - The Airline Schedule Recovery Problem

Navid Rashedi, Dartmouth College, Dartmouth, NH, United States, Navid.Rashedi.TH@Dartmouth.edu

The Airline Schedule Recovery problem attempts to repair a schedule of flights to handle disruption events. However, obtaining an online and near-optimal solution for this problem is often challenging. In this research, a Machine Learning based method is developed to achieve a near-optimal solution within a short runtime. Using binary classification techniques, a set of aircraft routings that are more likely to be in the solution will be generated. Then, based on a randomized greedy procedure, the best possible set of feasible aircraft routings is constructed.

■ SC34

351D

Operations Research and Security

Sponsored: Military Applications

Sponsored Session

Chair: Andrew Oscar Hall, PhD, United States Military Academy, 86 B Patridge Pl, West Point, NY, 10996, United States, andrew.hall@usma.edu

1 - Simulation Based Multi-mission Cutter Scheduling for the Coast Guard

Sercan Demir, PhD Candidate, University of Miami, 1251 Memorial Drive #268, Department of Industrial Engineering, Coral Gables, FL, 33146, United States, s.demir@umiami.edu, Gregory E.Higgins, Nurcin Celik

The United States Coast Guard (USCG) plans the world-wide operations of its ships, referred to as cutters. Scheduling is executed manually and focused on large-scale strategic priorities. Yet, this is problematic as stochastic events are increasingly costly and priorities have and will continue to shift. In 2013, USCG cutters lost four times the amount of operational days lost due to unplanned events. We propose a comprehensive multi-mission schedule evaluation mechanism which utilizes historical data to forecast productivity output at the tactical level, given limited resources across a spectrum of current and future scenarios.

2 - Coordinated Defender Strategies for Border Patrols

Víctor Bucarey, PhD Student, Universidad de Chile, Beauchef 851 of 506, Santiago, Chile, vbucarey@ing.uchile.cl

Security is a worldwide concern that in many situations requires the coordinated use of diverse types of resources. In particular the task of patrolling a border requires the coordinated use of may resources to monitor of vast stretches of land 24/7. We formulate a Security Stackelberg game as an integer programming problem that globally combines police precincts and location to be proctected in a border patrol context. We present tight formulations based on the matching polytope and present two sampling methods to provide implementable patrolling strategies.

3 - Valuation of Jumboization for Military Transportation Ships a Real Options Approach

Fikri Kucuksayacigil, Iowa State University, 610 Squaw Creek Drive, Unit 18, Ames, IA, 50010, United States, fksayaci@iastate.edu, K.Jo Min

When transportation requirements increase in the navy, some of the practical solutions involve jumboization. Jumboization is defined as increasing the capacity of an existing ship by extending its length at a future date. The choice of the ship design has future ramifications: With fixed design (the ship is not designed initially envisioning future jumboization investment), jumboization later will be costly. With flexible design, jumboization later will be less costly, however the initial cost may be more because of initially strengthened hull of the ship. We analyze both cases, and determine conditions under which one design is superior to another by using stochastic optimal control approach.

■ SC35

351E

Supply Chain Management

Contributed Session

Chair: Wenting Pan, Saint Mary's College of California, Moraga, CA, United States, wp3@stmarys-ca.edu

1 - Decision-maker's Preferences Modeling within Ambidextrous Supply Chain

Belaid Aouni, Associate Dean, Qatar University, College of Business and Economics, Al Jamiaa Street, Doha, 2713, Qatar, belaid.aouni@qu.edu.qa

The aim of this paper is to utilize the concept of satisfaction function and Goal Programming model to explicitly incorporate the Decision-Maker's preferences for selecting the best supply chain that aggregates simultaneously exploitation and exploration capabilities.

2 - Information Leakage and Sharing in a Two-period Decentralized Supply Chain

Weixin Shang, Associate Professor, Lingnan University, Hong Kong, Hong Kong, shangwx@ln.edu.hk

We consider a supply chain with one manufacturer selling to one retailer who processes private demand information over two selling periods. We examine the retailer's information sharing decisions with and without side payment, and firms' subsequent pricing decisions. Without information sharing, in period 2 the manufacturer will infer the retailer's private information via period-1 order quantity. We find that the retailer does not share the information voluntarily due to harmful double marginalization. However, the retailer shares the information to the manufacturer with side payments when demand uncertainty is high.

3 - Investment Decisions for Improving Quality Along Supply Chains

Yi Man, Shanghai Jiaotong University, Antai College of Economics and Management, 1954 Huashan Rd, Shanghai, 200030, China, iamdiyer@sjtu.edu.cn

In this paper, we consider a supply chain with one supplier and one retailer who jointly make their efforts to improve product quality along supply chains. Investment decisions of the retailer and the supplier as well as order quantity of the retailer are made consequently in order to maximize each party's own profit. From analytical results, we find that the retailer only places the order if the joint investment exceeds certain threshold. The region in which the supplier and retailer make joint efforts in the investment is provided when the demand is exponentially distributed. Numerical studies are given to reveal the effect of the parameters.

4 - The Influence of Supply Network on the Innovation Capability of Firms

Shubhobrata Palit, Student, Georgia Institute of Technology, Atlanta, GA, 30308, United States, shubhobrata.palit@scheller.gatech.edu

We explore the role of a firm's supply network in driving innovation in firms. Using secondary data, we examine how the diversity and the intensity of the knowledge and expertise of suppliers enable firms to drive their own innovation. We also examine the moderating effects of the structural position of the firm in its supply network and the ability of the firm to assimilate external knowledge, in driving its innovation. We find significant associations of innovation characteristics of supply network with the innovation output of the firm. The results have valuable managerial implications to help firms better manage their supply network.

5 - Location and Capacity Optimization for Electron Beam Facilities for Phytosanitary Treatment of Mexican Import Commodities

Yiwei Huang, Pennsylvania State University - Shenango, Sharon, PA, United States, yuh201@psu.edu

We develop a generalizable decision support system for determining the optimum number of eBeam facilities to treat fruits and vegetables imported from Mexico to the U.S., their capacities, and their locations. This system also selects the optimal assignment for each truckload of fresh fruit from Mexican growing regions to the eBeam facilities, and then to the U.S. hubs for distribution. In addition to the standard components of a cost function (transportation, operations, capacity, and building), our nonlinear mathematical model takes into account the time spent waiting at the border crossing and the time lost because of congestion at the eBeam facilities by using queuing approximations.

6 - Impact Supplier's Lead Time has on Assembler's Strategic Decisions

Wenting Pan, Associate Professor, Saint Mary's College of California, 1928 Saint Mary's Road, Moraga, CA, 94556, United States, wp3@stmarys-ca.edu, Yuhong He

This paper examines the impact the supplier's lead time has on the assembler's strategic choice of partnership. Specifically, we study when the assembler would buy components from the suppliers and when the assembler would have a vendor-managed consignment contract with the suppliers. Furthermore, we also explore the conditions under which a supplier would be selected by the assembler as a sub-assembler to manage other suppliers.

■ SC36

351F

Service Science in the IT Industry

Sponsored: Service Science

Sponsored Session

Chair: Aly Megahed, IBM Research - Almaden, San Jose, CA, 95123, United States, aly@gatech.edu

1 - Data Analytics for Pricing Highly-Valued IT Service Contracts

Aly Megahed, IBM.Research - Almaden, 150 Palm Valley Blvd APT.2066, San Jose, CA, 95123, United States, aly@gatech.edu, Taiga Nakamura, Kugamoorthy Gajananan, Mark Smith, Gregory R.Heim

Service providers in B2B (e.g., consulting, outsourcing, healthcare, logistics) often must prepare bids to win service outsourcing contracts. The contracting process can be expensive and highly uncertain as to whether a provider that bids will win a contract. This study presents a data analytics approach for pricing and winning service contracts in the IT industry. We propose a base model and model enhancements, using historical and market data. We show how our tools enhance insights and provide better visibility for contract managers of a real IT outsourcing service provider.

2 - Analytics Driven Business Travel Management Solution

Pawan Chowdhary, IBM.Research, 650 Harry Road, E3-238, San Jose, CA, 95120, United States, chowdhar@us.ibm.com

Business travel is essential to meet customers and for the company to grow. Mid to large enterprise has business travel as one of the largest spend items but still not managed efficiently. IBM Travel Manager is a solution that is catered for the Travel Program Manager to effectively manage travel spend and leverage analytics to get spend insights and savings opportunities. In the presentation we will go few such analytics and touch over cognitive aspect that will drive the travel manager to act upon opportunities pro-actively.

3 - Cognitive & Optimal Solution Composition for it Service Contracts

Ahmed Nazeem, IBM.Research - Almaden, San Jose, CA, 95120, United States, ahmed.nazeem@ibm.com, Aly Megahed, Hamid Motahari, Taiga Nakamura, Hung N.(Nam) Ho-Nguyen

For Information Technology (IT) service providers, composing a customized solution for a given request for proposal (RFP) is a tedious and time-consuming task. It requires a lot of expertise in reading and compiling the client's requirements. Furthermore, composing a solution from existing services to meet the client's requirement has a significant influence on the pricing of the deal, and hence, on the likelihood to win the deal.

Given the complexity of the IT services, their range of attributes, and their inter-dependencies, their a need to develop an automated framework that provides an end-to-end efficient solution for technical solution managers. The project has two 2 main components: (i) a natural language processing components for parsing and compiling the RFP document, and (ii) an optimization component for composing the existing IT services in a way that increases the likelihood of winning the deal. To enable online solution composition, we develop efficient heuristic approaches using business insights and the domain knowledge.

■ SC37

352B

Best IBM Service Science Student Paper Award Competition 3

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Penn State (The Pennsylvania State University), Penn State (The Pennsylvania State University), Malvern, PA, 19355, United States, robinqiu@psu.edu

1 - Proactive Inpatient Bed Reservations from ED to Reduce Patient Boarding

Seung Yup Lee, Wayne State University, 673 Prentis Street, Detroit, MI, 48201, United States, seung.lee@wayne.edu, Ratna Chinnamm, Evrim Dalkiran, Seth Krupp, Michael Nauss

We explore the benefits of early task initiation for the service network spanning the ED and inpatient units within a hospital. In particular, we investigate the value of proactive bed reservation signals based on future state information of ED patients to reduce ED patient boarding using a fork-join queueing system. Model accounts for the performance of the predictive analytics model for disposition decision. Our results show that proactive bed reservations can lead to significant reductions in ED patient boarding. The insights gained from our models should encourage hospital managers to embrace proactive coordination and adaptive work flow technologies enabled by modern health IT systems.

2 - Outcomes-based Reimbursement Policies for Chronic Care Pathways

Sasa Zorc, INSEAD, 1 Ayer Rajah Avenue, PhD Office, Singapore, 138676, Singapore, sasa.zorc@insead.edu, Stephen Chick, Sameer Hasija

We develop an outcomes-based model of contracting in care of chronic patients, using data from United Kingdom's NHS. The government contracts with healthcare providers in effort to maximise population health minus the cost. We consider the decision of whether to contract with individual healthcare providers or groups of such providers, as well as which contract type to use. Individual contracts fail to provide the desired incentives if providers under such contracts cooperate (collusion), however so do group contracts if group members fail to coordinate (free-riding). We demonstrate that individual outcomes-adjusted capitation contracts are the most resistant to these adverse effects.

3 - Directed Disease Networks based Multiple-Disease Risk Prediction Modeling

Tingyan Wang, Tsinghua University, RM.519, Shunde Building, Beijing, 100084, China, wangty14@mails.tsinghua.edu.cn, Ming Yu, Runtong Zhang

In this study, we propose a novel framework that combines directed disease network and collaborative filtering techniques to enhance multiple disease risk predictive modeling. Firstly, a directed disease network considering temporal information will be developed. Then based on this directed disease network, we investigate different disease risk score computing approaches. We validate the proposed methods with real-world datasets. The results demonstrate the potential value of the proposed modeling framework, e.g., a reference for medical experts to offer effective healthcare guidance for patients, or a tool that helps individuals create and maintain a better healthcare plan over time.

■ SC38

352C

Applications and Methodological Issues on MCDA/M

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Adiel De Almeida-Filho, Brazil, ataf@cdsid.org.br

Co-Chair: Roman Slowinski, Poznan University of Technology, Pl. Marii Sklodowskiej-Curie 5, NIP: 777-00-03-699, Poznan, 60-965, Poland, roman.slowinski@cs.put.poznan.pl

1 - Dominance Analysis of Conflict Amongst Bodies of Evidence for DST using DRSA

Lucimario Gois de Oliveira Silva, Universidade Federal de Pernambuco, 1350 Av Cons Agiar, Boa Viagem 404 Flores, Recife-PE, 51011030, Brazil, lucio_gois@hotmail.com, Adiel Teixeira De Almeida Filho, Roman Slowinski, Salvatore Greco

One of the main problems encountered in Evidence Theory concerns with the identification when two bodies of evidence are high degree of conflict. Thus, different approaches have been developed in the literature without success. To circumvent such problems, this article develops the notion of consistency in conflict where it is possible formally to define when a metric or reduce set of metrics is consistent to classify the conflict. In addition, to obtain this set, the technique known as DRSA is used. In relation to conflict identification, it is possible to use DRSA to generate decision rules on classifying conflict which avoids using subjective thresholds that can be difficult to elicit.

2 - A TOPSIS with Intuitionistic Fuzzy Sets and DEA Approach to Evaluate Retail Industry Performance Ability

Babek Erdebilli, Atılım University, Ankara, 06854, Turkey, babekd@atilim.edu.tr

This research paper discusses a decision-making algorithm with hierarchical structure to find performance efficiencies in order to develop the performance evaluation process in RI in Turkey. The offer presents an Intuitionistic Fuzzy TOPSIS and DEA to utilize both qualitative and quantitative criteria. Firstly, IFTOPSIS can be used to handle more complex problems. At this stage, all qualitative values are weighted by IFTOPSIS; then, the alternatives are formulated by DEAs. It is shown that using the IFTOPSIS value as the only output into DEA classification is more accurate than just using the entire quantitative variables.

3 - Interactive Evolutionary Multiobjective Optimization Driven by Decision Rules

Roman Slowinski, Professor, Poznan University of Technology, Pl. Marii Sklodowskiej-Curie 5, NIP: 777-00-03-699, Pozna , 60-965, Poland, roman.slowinski@cs.put.poznan.pl, Salvatore Corrente, Salvatore Greco, Salvatore Greco, Benedetto Matarazzo

Evolutionary multiobjective optimization can lead more quickly to a small subset of most preferred non-dominated solutions if the search of the solution space is driven by a preference model constructed simultaneously with the search. Here we propose a preference model in terms of "if , then " decision rules induced from rough approximations of preference information given by the user every k generations in terms of classification of a small sample of solutions into "promising" and "to-be-avoided". We present results of very encouraging experiments with this method performed on some well-known benchmark problems.

4 - A Multicriteria Approach to Support the Performance Evaluation Process for Tariff Revisions in Brazil

Adiel Teixeira De Almeida Filho, Universidade Federal de Pernambuco, Caixa Postal 7471, Cx Postal 7471, Av. General San Martin,1083, Recife-PE, 50.630-971, Brazil, atalmeidafilho@yahoo.com.br, Danielle Morais, Luanna T. da Silva Lira, José R.Figueira, Ana Paula C. Costa

Electrical power tariffs in Brazil may be revised according to recent changes introduced by a law approved in 2013. The agency that regulates the Brazilian electric system considers a decision model that includes a benchmark evaluation based on a DEA model to estimate operating costs, followed by public hearings to decide upon a tariff revision for each electricity company. Such decision process is relevant once it affects the profitability of electricity companies as well as final customers' electricity bill. This work presents the ongoing research about this subject and how a multicriteria decision-making technique may contribute to this decision process, which is currently based only on DEA.

■ SC39

352D

Emerging Concepts

Sponsored: Analytics

Sponsored Session

Chair: Harrison Schramm, CANA Advisors, Pacific Grove, CA, 93950, United States, harrison.schramm@gmail.com

1 - Microservice Architecture for Delivering Analytic Models

Jon A.Higbie, Revenue Analytics, 3100 Cumberland Blvd., Suite 1000, Atlanta, GA, 30339, United States, jhigbie@revenueanalytics.com

Since 2011 Micro Service Architecture (MSA) has been gaining favor as an architecture and method for developing software, particularly in the cloud. MSA breaks an application down to small components that perform a single function. These microservices then communicate with each other via web services. If done correctly, the resulting application has high reliability and the microservices are easily reusable. Learn how this approach is changing the way complex analytic solutions are delivered.

2 - Hetergenous Quantum Computing

Gideon Bass, Booz Allen Hamilton, Washington, DC, United States, tb

Quantum computing offers the possibility of producing significant speed-up and improved solution quality when compared to traditional computing. There are now commercially available quantum annealing (QA) devices that are designed to solve difficult optimization problems. We present a heterogeneous computing stack that combines QA with traditional hardware and allows usage of QA on problems larger than existing quantum hardware could solve in isolation, and, as a representative problem, we discuss a sample satellite constellation assignment problem, and the exciting results of this research.

■ SC40

352E

Doing Good with Good OR

Invited: Doing Good with Good OR

Invited Session

Chair: Turgay Ayer, Georgia Institute of Technology, School of Industrial and Systems Engineering, Groseclose 417, Atlanta, GA, 30332, United States, ayer@isye.gatech.edu

Co-Chair: Jonathan Helm, Indiana University, Kelley School of Business, 1309 East Tenth Streeet, Bloomington, IN, 47405, United States, helmj@indiana.edu

1 - Doing Good with Good OR - Student Paper Competition

Turgay Ayer, Georgia Institute of Technology, School of Industrial and Systems Engineering, Groseclose 417, Atlanta, GA, 30332, United States, ayer@isye.gatech.edu

Doing Good with Good OR - Student Paper Competition is held each year to identify and honor outstanding projects in the field of operations research and the management sciences conducted by a student or student group that have a significant societal impact.

2 - Optimal Design ofEfficient Rooftop Photovoltaic Arrays

Madeleine Udell, Cornell University, 301 Ithaca Road, New York, Ithaca, NY, 14850, United States, madeleine.udell@gmail.com

Abstract not available.

3 - Mobile Money Agent Inventory Management

Karthik Balasubramanian, Harvard Business School, 25 Harvard Way, Morgan T81, Boston, MA, 02163, United States, kartbala@gmail.com

Mobile money agents exchange cash for electronic value and vice versa, forming the backbone of an emerging electronic currency ecosystem in the developing world. We model the agent's inventory problem, develop policy recommendations, and evaluate these policies with East African data.

4 - Truthful Mechanisms for Medical Surplus Product Allocation

Can Zhang, Georgia Institute of Technology, 499 Northside Circle NW, Apt 315, Atlanta, GA, 30309, United States, czhang2012@gatech.edu, Atalay Atasu, Turgay Ayer, Beril L. Toktay

We analyze resource allocation problems faced by medical surplus recovery organizations (MSROs) that recover reusable medical products to fulfill the healthcare needs of under-served regions/countries. We present strategies to improve MSROs' value provision when recipient needs are private information, and validate our results using historical data from a partner MSRO.

■ SC41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Shanshan Wang, Beijing Institute of Technology, Beijing, China, shshwang_bit@163.com

1 - Risk-averse Inpatient Discharge Planning

Maryam Khatami, Texas A&M.University, 4050 ETB, College Station, TX, 77840, United States, maryam.khatami@tamu.edu, Lewis Ntaimo, Mark Alan Lawley

We study the inpatient discharge planning (IDP) problem on a daily basis. Discharge delay deteriorates patient satisfaction, incurs extra costs to the hospital and additional stress to the staff, and causes admission delay for patients in upstream units. We formulate the IDP problem as a risk-averse two-stage stochastic program. Our model captures two sources of uncertainty: inpatient discharge processing time and bed request time. To the best of our knowledge, we are the first to apply the stochastic decomposition algorithm to solve a risk-averse stochastic model. We solve our model for several instances of the IDP problem generated using data from a Texas hospital.

2 - Modelling Delay Dissatisfactions in Appointment Scheduling Problems

Shuming Wang, Associate Professor, University of Chinese Academy of Sciences, No. 80 Zhong-Guan-Cun East Rd, Beijing, 100190, China, wangshuming@ucas.ac.cn, Marcus Teck Meng Ang, Tsan Sheng NG

We consider a problem of appointment sequencing with uncertain service times and no-shows. A Tolerance Aware Delay (TAD) index is proposed to quantify the user's dissatisfaction by incorporating their delay tolerance level. We develop two appointment optimization models using the TAD index, one based on sample average approximation, and the other based on the limited distributional information of the service times. The corresponding optimization models are shown to be in the formats of a mixed-integer LP and mixed-integer SOCP, respectively, which can be evaluated efficiently using off-the-shelf solvers. Numerical experiments demonstrate the performance and insights of using our TAD models.

3 - Real Time Scheduling of Regular and Emergency Patients with Waiting Time Targets

Jing Wen, Shanghai Jiao Tong University, Shanghai, China, janewen@sjtu.edu.cn, Na Geng, Xiaolan Xie

To reduce the waiting time of appointed patients without affecting the treatment quality of emergency patients, this paper studies the real-time scheduling between regular and emergency patients with waiting time targets. A Markov Decision Process model is proposed to minimize the total waiting cost and structural properties of the optimal control policies are established. Several heuristic policies are proposed to solve the large size problem. Numerical experiments are performed to show the influence of parameters and compare the performances of heuristic policies. Key words: emergency patients; waiting time target; regular patients; Markov decision process; heuristic policies

4 - Two-stage Stochastic Surgery Downstream Capacity Planning with Chance Constraint and Equity Metric

Shanshan Wang, PhD Candidate, Beijing Institute of Technology, 5 Southstreet Zhongguancun, Haidian District, Beijing, 100081, China, shshwang_bit@163.com, Jinlin Li

This paper investigates surgery planning on a given planning period, taking downstream resources (e.g. beds in surgical intensive care unit) into consideration. Surgery durations and length of stay are uncertain. The equity of access which can be thought of as a match between patients and providers is defined as constraint of the same access levels among different types of patients. Overtime for ORs captured by chance constraint to guarantee the probability of overtime is no more than a given risk parameter. We propose a two-stage stochastic model with recourse decision, and design an enhanced decomposition scheme. Finally, a practical case study is performed by real data to test our model.

■ SC42

360A

Manufacturing Informatics

Invited: Advanced Manufacturing

Invited Session

Chair: Li Zeng, Texas A&M University, College Station, TX, 77843, United States, lizeng@tamu.edu

Co-Chair: Qiang Zhou, The University of Arizona, Tucson, AZ, 85721, United States, q.zhou@arizona.edu

1 - Modeling of Hydrogel Swelling in 3D Printing of Artificial Meniscus

Qian Wu, Texas A&M.University, 1501 Harvey Road, Apt 839, College Station, TX, 77840, United States, hi_qianwu@tamu.edu

Hydrogel is a class of biomaterials that has great potential as materials in 3D printing of artificial meniscus (3DPAM). Swelling of hydrogel is critical to geometric fidelity and long-term stability of 3D printed meniscus. On the other hand, hydrogel designed for the 3DPAM application has complex structure and its swelling property is unknown. This study proposes a data-driven modeling framework for hydrogel swelling based on an integration of varying-coefficients models and engineering knowledge. In the case study, the proposed method is applied to data from a novel 3DPAM process and insight that helps understand the underlying swelling mechanism is obtained.

2 - In-situ Monitoring and Modeling of Melt Pools for Porosity Prediction of Laser Based Additive Manufacturing Processes

Mojtaba Khanzadehdaghalian, Mississippi State University, Mississippi State, MS, United States, mk1349@msstate.edu

LBAM is still not widely accepted and is often considered inconsistent and unreliable for many industrial applications. The objective of this research is to characterize and use the underlying thermo-physical dynamics of LBAM captured by melt pool signals to predict porosity during the build. Herein, we propose a novel porosity prediction method on morphological features and the temperature distribution of the top surface of the melt pool as the LBAM part is being built. Self-organizing maps are then used to further analyze the 2D melt pool dataset to identify similar and dissimilar melt pools. To experimentally locate porosity within the Ti-6Al-4V thin wall specimen X-Ray tomography is used.

3 - High Dimensional Functional Regression for a Manufacturing Process

Mostafa Reisi Gahrooei, Georgia Institute of Technology, Atlanta, GA, United States, mrg9@gatech.edu

Many of manufacturing processes involve a set of process variables measured over time or space that directly affect the geometric shape of the output. Understanding the effects of the input variables on the output shape requires a model that combines the functional inputs to predict a surface. The main goal of this paper is to develop a high dimensional regression model that efficiently estimates a high dimensional output based on a set of functional inputs. To enable the proposed method for fast implementation, we exploit regularized high-dimensional regression, to decompose the output surface. With several simulation and case studies, we evaluate the performance of the proposed method.

4 - A Vision-based Approach for Real-time Quality Monitoring for Cyber-manufacturing Processes

Zimo Wang, Texas A&M.University, College Station, TX, 77843, United States, zimowang@tamu.edu, Ashif S.Iquebal, Satish Bukkapatnam

Laser kirigami processes that use sheet precursors offer considerable advantages over traditional powder based additive manufacturing for fast realization of functional complex shapes for custom manufacturing. An in-process monitoring tool that captures shape transformation and process thermomechanics in real time is necessary to assure cost and quality parity with mass production. We present a spatial regression model to combine information from multiple low resolution cameras for real-time monitoring of core kirigami processes. Experimental investigations on our test bed suggest that the present approach can provide fast (fps~5) and accurate (2% error) geometric feature estimates.

■ SC43

360B

Community-based Operations Research

Sponsored: Public Sector OR

Sponsored Session

Chair: Michael Johnson, University of Massachusetts-Boston, University of Massachusetts-Boston, Boston, MA, United States, michael.johnson@umb.edu

1 - Improving Decision-making Skills of Nonprofit Professionals

Michael P.Johnson, University of Massachusetts-Boston, Department of Public Policy & Public Aff, 100 Morrissey Boulevard, Boston, MA, 02125-3393, United States, michael.johnson@umb.edu, Jason Wright

Nonprofits face gaps in organizational capacity, including program design and evaluation, but previous research suggests that capacity building exercises have a positive effect. We describe a data analytics training workshop with staff from Boston-area nonprofits reflecting a wide range of sectors. Through analysis of participant work on case studies provided by the instructor, we examine how participants made sense of training materials, the various strategies employed by participants to solve three case study problems, and participant feedback about the session. Our findings provide a basis for novel interventions in community-based operations research.

2 - Refugee Resettlement via Integer Programming

Andrew C.Trapp, Worcester Polytechnic Institute, Foisie Business School, 100 Institute Rd., Worcester, MA, 01609, United States, atrapp@wpi.edu, Alex Teytelboym

Hundreds of thousands of refugees are resettled yearly from refugee camps to host countries. Local areas that host refugees are reluctant to open capacity, and most impose tight restrictions on the refugee family types they accept. We model this matching challenge as a 0-1 knapsack variant and explore various objectives in the search toward an optimal allocation. We tackle several new theoretical and computational obstacles, and using actual historical resettlement data to simulate realistic scenarios, we address fairness and welfare criteria that play an important role in the current process.

3 - Considering Practical Ethics in Community Based Operations Research (CBOR)

David T. Hunt, Oliver Wyman, One University Square, Princeton, NJ, 08540, United States, david.hunt@oliverwyman.com

We like to think that CBOR involves the application of analytical methods to "do good" locally; and, most will agree these efforts are "doing good." However, what is meant by "doing good" and how do we know when our models are not "doing good" and may in fact be causing harm? Some philosophers consider happiness as the only good, and utilitarianism is based on maximizing happiness. But maximizing happiness can create winners and losers, and are we really "doing good" as long as the pluses outweigh the minuses? This presentation will explore these topics using examples drawn from CBOR.

4 - A Multi-methodology Approach for Community-based Operations Research in a New World Heritage Site

Valentina Ferretti, London School of Economics and Political Science, Houghton Streetl London I WC2A 2AE, London, United Kingdom, V.Ferretti@lse.ac.uk

This study develops a participatory multi-methodology intervention designed and deployed to support planning in a new World Heritage site, i.e. the vineyard landscape of Langhe, Roero and Monferrato in Northern Italy. The proposed framework uses Spatial SWOT Analysis and Multicriteria Decision Aiding (MCDA) in Phase 1 (problem identification - knowledge phase), Stakeholders' Analysis and Spatial MCDA in Phase 2 (problem formulation - planning phase), and Choice Experiments during Phase 3 (problem solving - design). This talk focuses on the results and impacts associated with each phase of the process, by discussing the respective levels of community engagement and methodological innovation.

■ SC44

360C

Healthcare Analytics Applications

Sponsored: Public Sector OR

Sponsored Session

Chair: Andres Garcia-Arce, Geisinger Health Systems, Danville, PA, 17822, United States, garciampu@gmail.com

1 - Stacking Machine Learning Models for the Prediction of No-shows in Outpatient Neurological Appointments

Andres Garcia-Arce, Geisinger Health Systems, 100 North Academy Avenue, MC 30-65, Danville, PA, 17822, United States, garciampu@gmail.com

Patients not showing for their appointments hurt the access and quality of care for other patients. This study aims to improve predictive models for no-shows using machine learning algorithms, including ensembles of models. A novel aspect is that we consider cancelation within 7 days as a no-show. We use data from neurological outpatient appointments made in clinics from Geisinger Health Systems. This contribution will help improve the existing efforts in the reduction of no-shows, increase the access to care, and therefore, improve quality of care and patient satisfaction.

2 - Scenario-based Ambulance Deployment with Two Types of Servers

Soovin Yoon, University of Wisconsin–Madison, 1415 Engineering Drive, Room 3261, Madison, WI, 53706, United States, yoon57@wisc.edu

Ambulance deployment problem with multiple server types is challenging to solve due to inherent uncertainties in emergency calls as well as dependencies between servers. We propose a scenario-based ambulance deployment model with two types of servers, where the objective involves not only the response times but also the match between the server type and patient priority. The problem is formulated as a stochastic integer program with data-driven scenarios. Decomposition algorithms are applied to solve large size instances.

3 - Discovering Patterns in Self-reported Care Experience Data and Clinical Outcome Data to Improve Patient Experience

Qianyu Hu, Penn State University, 126 E.Nittany Avenue, Apt 12, State College, PA, 16801, United States, qianyuhu312@gmail.com

Over past 25 years, patient satisfaction has gained increasing attention. Research has shown that patient experience is critical to improving clinical outcomes and should be measured in addition to standard quality and safety metrics. Therefore, providing a better patient experience, measuring and reporting is regulatory. However, literature is divided on this. We study and analyze the relationship between patient satisfaction and clinical outcomes using statistical and graphical techniques. We use HCAHPS survey data to examine the relationship between patient perspective and clinical outcomes, to provide quality care.

4 - A Predictive Model to Estimate Post Acute Care Needs: A Cohort Study of Patients with Coronary Artery Bypass Graft or Valve Replacement

Ineen Sultana, Graduate Research Assistan, Texas A&M.University, College Station, TX, 77843, United States, ineensultana@tamu.edu

Predicting Discharge Location (DL) for patients is essential for better care coordination with post-acute care (PAC) facilities; it not only aid in efficient discharge planning but also help the PAC facilities project the evolving demands. In this study, a retrospective cohort analysis of patients with coronary artery bypass graft or valve replacement is conducted, and a predictive model is developed using multinomial logistic regression to estimate the potential DL for a patient. Our analysis identified the hospital location, characteristics, and stay in hospitals as well as the characteristics and comorbidity of patients to be the most significant influential factors for the DL estimation.

5 - Real-Time Asset Distribution System: Deploying Machine-learning Solutions in the Emergency Department

Diego Martinez, Johns Hopkins University, Baltimore, MD, United States, dmart101@jhmi.edu, Jeffrey Appelbaum

Hospitals are challenged to provide timely patient care while maintaining high resource utilization. Real-time asset management is one of such initiative whereby clinical staff convenes each morning to forecast low- to high-demand hospital units and ensure that the necessary equipment, such as IV pumps, are available for providing patient care. We designed and deployed a real-time asset distribution system that leverages on machine learning, electronic medical records, and real-time location system to guide clinical staff in recovering under-utilized equipment and relocate them where they are (or will be) needed.

■ SC45

360D

JFIG Panel Discussion: Best Practices in Reviewing Papers

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: Jose Luis Walteros, University at Buffalo, SUNY, 413 Bell Hall, Buffalo, NY, 14260, United States, josewalt@buffalo.edu

1 - JFIG Panel Discussion: Best Practices in Reviewing Papers

Canan Gunes Corlu, Boston University, 808 Commonwealth Avenue, Boston, MA, 02215, United States, canan@bu.edu

The panelists consist of senior professors with vast experience in reviewing papers for different journals, including Management Science, Operations Research, INFORMS Journal on Computing and Decision Analysis. The panel will share guidelines and best practices for paper reviewing. They will also answer questions pertaining to writing and publication.

2 - Panelist

Jennifer Ryan, University of Nebraska-Lincoln, Lincoln, NE, United States, jennifer.ryan@unl.edu

3 - Panelist

Jay Simon, American University, 4400 Massachusetts Avenue, NW, Washington, DC, 20016, United States, jaysimon@american.edu

4 - Panelist

Laurens G.Debo, Dartmouth College, 100 Tuck Hall, Hanover, NH, 03755, United States, laurens.g.debo@tuck.dartmouth.edu

5 - Panelist

James R.Wilson, North Carolina State University, Charlotte, NC, United States, jwilson@ncsu.edu

■ SC46

360E

Operations Analytics and Optimization for Manufacturing, Logistics and Energy Systems

Invited: Project Management and Scheduling

Invited Session

Chair: Lixin Tang, Northeastern University, Northeastern University, Shenyang, 110004, China, lixintang@mail.neu.edu.cn

1 - Enterprise Wide Optimization for Refinery Planning with Coordination of Energy Consumption and Product Quality

Lijie Su, Institute of Industrial & Systems Engineering, Northeastern University, Shenyang, China, sulijie@ise.neu.edu.cn, Lixin Tang, Ignacio E.Grossmann

This paper focuses on the Enterprise-wide Optimization(EWO) of planning for refinery plant. The process models of refinery units are integrated in the production planning. The properties of material flow are controlled in order to satisfy the international standard for product oils and environmental demand. The energy consumption with the refining process is taken into account, and coordinated with the properties of final oil products. We present a new mathematical formulation for the EWO of planning to maximize the net profit of refinery. We also analyze the net profit of refinery under different variation conditions, like properties of crude oil, energy consumption and standard of product oil.

2 - A Learning-based Differential Evolution Algorithm for Open-order Coil Allocation Problem in the Steel Industry

Fei Zou, Institute of Industrial & Systems Engineering, Northeastern University, Shenyang, China, zfhelen6@163.com, Lixin Tang

Open-order coil allocation problem is to allocate open-order coils to unfulfilled customer orders for reducing surplus inventory and improving the material utilization. Since the problem is NP-hard, an improved differential evolution algorithm called DEANS is proposed to achieve the near optimal solutions. In the algorithm, construction heuristics are designed to obtain initial solutions and some greedy strategies are proposed to repair infeasible solutions. Mod mutation operators and learning-based mechanisms are adopted to describe and generate the population. Computational experiments on different scale instances verify the effectiveness of the proposed model and algorithm.

3 - Data Analytics-based for Temperature Prediction in Blast Furnace Top System

Xiangman Song, Institute of Industrial & Systems Engineering, Northeastern University, NO. 3-11, Wenhua Road, Heping District, Shenyang, 110004, China, sxmars.cloud@gmail.com, Lixin Tang

Iron-making process is the biggest environmental loader with the largest energy consumption. From the perspective of data analytics, the relationship between the temperature distribution of furnace burden in the top of blast furnace and the corresponding charge level shape is studied and the linear regression model is proposed. In addition, a space-time Kalman method is proposed to predict the temperature distribution. Utilizing the relationship model and the predicted temperature, the burden charging operations can be obtained to reduce the energy consumption. Furthermore, the real iron-making data are used to test the performance. Experimental results show that the method is effective.

4 - A Multi-stage Modeling Method for Converter Steel Making Process

Chang Liu, Institute of Industrial & Systems Engineering, Northeastern University, Shenyang, China, lc1987328@126.com, Lixin Tang

This study concerns with dynamic basic oxygen furnace (BOF) steelmaking process and proposes a data-analytics prediction method. According to the analysis of actual field data, a multi-stage modeling method is proposed for BOF steelmaking process. The key idea of the proposed method is to solve the dynamic prediction in the whole BOF steelmaking process. In order to predict temperature and carbon content more accurately in BOF steelmaking process, IPSO-LSSVM is utilized to establish multi-stage prediction models. In addition, the real industrial data are used for testing. Experimental results show that the data analytics prediction method has a better prediction performance.

5 - Integrated Scheduling of Rolling Section in Steel Production with Demand-side Management

Shengnan Zhao, Institute of Industrial & Systems Engineering, Northeastern University, Shenyang, China, shengna1@andrew.cmu.edu, Ignacio E.Grossmann, Lixin Tang

Electric grid is now using time-of-use pricing strategy on industry customer, which has great impact on the profit of demand side. Involving energy-intensive process, the steel companies can take advantage of processing flexibility to make better use of electric power, and thus reduce energy cost. In this work, we address a new integrated scheduling problem derived from rolling section of steel production, with consideration of batching decision and demand-side management. The problem is formulated as a mixed integer nonlinear optimization model and then reformulated to a MILP model. Numerical experiments are conducted and results show the model is efficient.

■ SC47

360F

Cyber-Security and Sharing Economy

Sponsored: EBusiness

Sponsored Session

Chair: Gal Oestreicher-Singer, Tel Aviv University, galos@tau.ac.il

Co-Chair: Zhepeng Li, York University, zli@schulich.yorku.ca

1 - Incentivize Ride Matching via Repeated Games

Shumin Ma, Chinese University of Hong Kong, Shatin, NT, Hong Kong, smma@se.cuhk.edu.hk, Qi Wu

Subsidizing drivers generates a supply multiplier effect at the cost of a firm. It contrasts with surge pricing policies, where excessive demand is accommodated at the cost of riders through price hikes, threatening a firm's market share. Supply-side incentives thus provide an alternative for a firm to respond to demand surges when increasing fare price is not an option. We take a game approach and model the spatial matching problem as a repeated Stackelberg game. We show that through driver-targeted loyalty programs, the optimal throughput in equilibrium is attained at the optimal amount of incentives. Incentivize excessively, however, would be disruptive as matching ratios will decline.

2 - Comparing Two Solution Seeking Mechanisms in the Online Labor Market

Jiahui Mo, Nanyang Technological University, 19251 Preston Road, Apt 2520, Dallas, TX, 75252, United States, jhmo@ntu.edu.sg

In the online labor market, firms can seek project solutions via two auction mechanisms: procurement auction and tournament. It is unclear for firms which mechanism to use when they look for better solutions with the same budget. This research compares these two mechanisms and provides some empirical evidences on the effectiveness of these mechanisms. Our findings can provide insights for firms to choose the proper mechanism in the online labor market.

3 - Hotel Strategies to Influence Sales: Incumbents Reaction to Competition from Airbnb

Cheng Nie, University of Texas-Dallas, Richardson, TX, United States, cxn123430@utdallas.edu, Eric Zheng, Sumit Sarkar

The emergence of Airbnb provides an untapped wealth of supplies to the accommodation market, posing a threat to the incumbent hotels. What should hotels do to improve market performance in face of Airbnb? We consider four strategies that hotels could use to improve their sales: manipulate review, improve quality, reduce price, respond to review. We empirically investigate the effectiveness of these strategies by combining data from Airbnb, Expedia, TripAdvisor, the Texas Comptroller office, and Smith Travel Research.

■ SC48

361A

Operations Systems with Worker Discretion

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Hummy Song, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19104, United States, hummy@wharton.upenn.edu

1 - Shared Medical Appointments: An Innovative Approach to Healthcare Delivery

Nazl I. Sonmez, PhD Student, London Business School, London, NW1 4SA, United Kingdom, nsonmez@london.edu, Ryan Buell, Kamalini Ramdas

In this paper, we examine shared medical appointments (SMAs) as a substitute for one-on-one appointments. Under this innovative approach, a group of patients with similar chronic conditions meet with a doctor simultaneously. We conduct a randomized controlled trial at the Aravind Eye Hospital's Glaucoma Clinic to assess the effectiveness of shared medical appointments. Preliminary results obtained with the data we have so far suggest that the knowledge and satisfaction level of patients who attend shared medical appointments is significantly higher than that of patients who attend one-on-one appointments.

2 - Seeking to Belong: How Beneficiaries Influence Performance
Bradley R.Staats, University of North Carolina at Chapel Hill, Campus Box 3490, McColl 4721, Chapel Hill, NC, 27599-3490, United States, bstaats@unc.edu, Paul Green, Francesca Gino

We examine how connecting to beneficiaries of one's work increases performance. In a field experiment of harvesters, we find that beneficiary contact with the end customer did not improve productivity, contact with an internal beneficiary yielded a persistent increase in productivity. We validate this effect in the laboratory.

3 - Speed-quality Trade offs in Home Health: the Effects of Time Spent with Patients on Hospital Readmission
Hummy Song, The Wharton School, University of Pennsylvania, 560 Jon M. Huntsman Hall, 3730 Walnut Street, Philadelphia, PA, 19104, United States, hummy@wharton.upenn.edu, Elena Andreyeva, Guy David

Using a novel dataset on home health care episodes, this study quantifies the effects of reduced time spent with patients during a post-acute nursing visit on hospital readmissions. Since both visit length and readmission are likely to be correlated with unobserved illness severity, we use the daily sequence of nurse visits as an instrument for visit length. As the day progresses, visit length significantly shortens. Omitted variable bias leads to a positive correlation between visit length and readmissions. Using our instrument and controlling for patient, visit, and nurse characteristics, we examine how an increase in visit length affects the likelihood of hospital readmission.

4 - An Econometric Analysis of How Facility Layout Impacts Care Provision in the Emergency Department
Lesley Meng, The Wharton School, University of Pennsylvania, 3730 Walnut Street, Suite 500 JMHH, Philadelphia, PA, 19104, United States, lmeng@wharton.upenn.edu, Robert Batt, Christian Terwiesch

We study how the facility layout of ED patient rooms impacts nurse workflow decisions. Specifically, linking our infrared nurse location tracking data to room occupancy patient data, we are able to investigate potential facility layout variables, such as distance from the nurses' station, that impacts the patient's length of stay in the ED.

■ SC49

361B

Behavioral Modelling for Critical Infrastructure and Security Issues

Invited: InvitedBehavioral Aspects of OR

Invited Session

Chair: Ignacio J Martinez-Moyano, PhD, Argonne National Laboratory, Argonne National Laboratory, Argonne, IL, 60439, United States, imartinez@anl.gov

Co-Chair: Todd E. Combs, Ph.D., Idaho National Laboratory, Idaho National Laboratory, 1955 N. Fremont Ave., Idaho Falls, ID, 83415, United States, todd.combs@inl.gov

1 - Optimizing Counter-propaganda Strategies to Prevent the Spread of Extreme Ideologies Online
Chaitanya Kaligotla, PhD, Argonne National Laboratory, Chicago, IL, 60439, United States, ckaligotla@anl.gov

This talk presents a mathematical model of opinion dynamics at an individual and group level, to characterize the spread of extreme ideologies on internet discussion platforms. Assuming the existence of some prevalent 'red' agents spreading extreme ideologies to other agents, an optimization problem is formulated to develop strategy for the delivery of counter-propaganda messages, by a group of 'blue' agents, to counter the spread of such extreme ideologies in a time and cost effective manner, a problem of increasing relevance to national security. This talk also extends existing research on opinion dynamics and behavioral modeling of internet users.

2 - Behavioral Considerations in Detection Dynamics: Interlacing Human Judgment, Outcome Decomposition, and Threshold Setting
Ignacio J.Martinez-Moyano, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL, 60439, United States, imartinez@anl.gov

Detection-selection mechanisms are at the core of security processes in complex systems. Security procedures are designed to protect systems from ill-intentioned individuals and other risks. Detection processes precede defensive action as the identification of threats is needed to determine adequate protective action. In order to identify threats in complex dynamic systems, the coupling of human judgment (many times aided by technology) and outcome understanding is essential to setting adequate thresholds for protective action. Understanding the interaction of human judgment, outcome decomposition, and threshold setting is a promising approach to improving security systems.

■ SC50

361C

Modeling and Analysis of Emerging Mobility Services I

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Yu Nie, Northwestern University, Evanston, IL, 60208, United States, y-nie@northwestern.edu

1 - Optimization-based Strategies for Autonomous Vehicle Fleet Operations
Michael Hyland, Northwestern University, 600 Foster St, Evanston, IL, 60208, United States, mhyland@u.northwestern.edu, Hani S.Mahmassani

We consider the problem of operating a fully autonomous vehicle fleet in real-time to serve passenger demand. The problem's twin objectives include minimizing operational costs and maximizing quality of service. Given the highly dynamic and stochastic nature of the problem, we employ a rolling-horizon, optimization-based solution approach. We develop a simulation framework to model the dynamic, stochastic problem, and to test operational strategies. Lastly, we seek to generalize the computational results via empirical relationships between problem parameters (e.g. service area, average trip distance, etc.) and their impact on the problem's objectives.

2 - Analyzing Regional Mobility Impact of Zero Occupancy Vehicles (ZOVs) in Presence of Connected and Automated Vehicles (CAVs)
Omer Verbas, PhD, Argonne National Laboratory, Lemont, IL, 60439, United States, omer@northwestern.edu

The deployment of CAVs in significant numbers is imminent. However, due to novelty of the technology, predicting their impact is challenging. In this study, we investigate the effect on regional mobility of ZOV travel enabled by CAVs. An optimization algorithm has been developed, to minimize the number of cars and travel cost of households, while optimizing individual daily activity-travel schedule, considering their simulated flexibility. The algorithm has been implemented in an advanced integrated activity-based travel demand simulator and scenarios were evaluated for the Chicago region.

3 - An Advanced Parking Navigation System for Downtown Parking
Zhibin Chen, University of Michigan, Ann Arbor, MI, United States, chipin@umich.edu

This paper develops a novel parking navigation system for downtown parking that aims to mitigate parking competition by guiding drivers to appropriate vacant parking spaces. Given drivers' real-time locations and their parking preferences, a two-sided matching algorithm is adopted to achieve a stable driver-optimal matching, under which drivers will be guided to their most appropriate parking spaces (if any), and have no incentive to misreport their private information. Simulation experiments are conducted to demonstrate the ability of the proposed navigation system on reducing driving time and the times of changed assignment compared with other navigation systems.

4 - Fair Versus Optimum On-demand Ride-sharing Plan
Jane Lin, University of Illinois-Chicago, 842 W. Taylor Street (M/C 246), Chicago, IL, 60607, United States, janelin@uic.edu, Luca Foti, Ouri Wolfson

Ride sourcing companies such as Uber and Lyft are offering ride sharing service. When matching passengers, these services attempt to optimize savings at a global level. But it may result in a passenger A matched to passenger B, while if matched to passenger C both A and C would have saved more money. This introduces the concept of "fairness" in ride sharing, which consists of finding the Nash equilibrium in a ridesharing plan. We compare the optimum and the fair plan in different contexts. We show that the gap between the two is not significant when fares are computed on distance traveled and, as a result, the fair plan can be issued without significant losses.

5 - Taxi Market Competition under Spatial Equilibrium
Zhoutong Jiang, Master Student, University of Illinois at Urbana-Champaign, Champaign, IL, Champaign, United States, zjiang30@illinois.edu

The taxi market is complex to model when competition between different companies is considered. A Stackelberg game model based on continuum approximation is proposed to help taxi companies select best driver dispatching and pricing strategies under competition. Properties of market competition are demonstrated using numerical examples.

■ SC51

361D

Digital Marketplaces and Platforms

Sponsored: Information Systems

Sponsored Session

Chair: Jing Gong, Temple University, Philadelphia, PA, 19103, United States, gong@temple.edu

1 - Large Scale Cross Category Analysis of Consumer Review Content on Sales Conversion Leveraging Deep Learning

Xiao Liu, New York University, Stern School of Business, 44 W. 4th Street, New York, NY, 10013, United States, xliu@stern.nyu.edu

Using a dataset that tracks individual-level review reading and purchase behaviors, we quantify the causal impact of content information in the "read" reviews on sales. To extract content information, we apply deep learning natural language processing models and identify six dimensions of content. The comparative advantage of deep learning model is that it sifts category-specific content features across a wide range of product categories without human intervention or domain knowledge. We find that aesthetics and price content significantly affect conversions. Counterfactual simulation suggests that re-ordering reviews can have the same effect as a 1.6% price cut for boosting conversion.

2 - From Automobile to Autonomous: Does Self-driving Improve Traffic Conditions?

Yingjie Zhang, 401 Shady Ave, Apt C-704, Pittsburgh, PA, 15206, United States, yingjie2@andrew.cmu.edu, Jinyang Zheng, Yong Tan

Recently, Uber launched its autonomous car service. While debate has surrounded its impact, limited empirical work has been devoted to investigating the effects of this adoption on the society. This paper makes the first step to exploit this entry effect, using a DID approach applied on a unique accident dataset. We find a significant decrease in traffic accident volumes after the entry of Uber autonomous car service. A mechanism analysis suggests that this effect is mainly driven by the change in public reaction to the adoption. This pilot study contributes to the understanding of values in the adoption of autonomous car technology, as well as its social effects from the transportation perspective.

3 - Uber Might Buy Me a Mercedes Benz: An Empirical Investigation of the Sharing Economy and Durable Goods Purchase

Jing Gong, Assistant Professor, Temple University, 1810 North 13th Street, 201C Speakman Hall, Philadelphia, PA, 19122, United States, gong@temple.edu, Brad N.Greenwood, Yiping Song

In this work, we examine how the introduction of sharing platforms affects durable goods purchase. In particular, we use a unique dataset of new vehicle registrations in China and exploit a natural experiment, the variation in timing of Uber entry across different locations, to estimate the effect on vehicle purchase. Findings suggest that Uber entry is associated with a considerable increase (8%) in new vehicle ownership, suggesting that consumers are actively changing their stock of held resources in order to capture excess rents offered by these platforms. Further, results indicate that the effect of Uber entry varies considerably across gender, age, and vehicle types.

4 - Revenue Management in Crowdfunding

Jiding Zhang, University of Pennsylvania, Philadelphia, PA, United States, jiding@wharton.upenn.edu, Senthil Veeraraghavan, Sergei Savin

Crowdfunding, a mechanism in which funds are raised online using small donations from a large number of individual donors, has recently emerged as a popular approach to funding new ideas. In our paper, we model a setting where a creator of a crowdfunding project selects the amount of contribution it requests from donors and the duration of crowdfunding campaign with the goal of maximizing the raised amount. Our analysis provides project creators with detailed, practical, and intuitive guidelines on how to successfully manage the revenue generation process in a crowdfunding campaign.

■ SC52

361E

Warehousing and Distribution

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Debjit Roy, Indian Institute of Management Ahmedabad, Ahmedabad, 560078, India, debzitt@gmail.com

1 - Hyperconnected Urban Deployment and Delivery of Large-items

Nayeon Kim, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, nkim97@gatech.edu, Benoit Montreuil

In this paper, we contrast a Physical Internet based hyperconnected deployment and last-mile delivery of large-items over an openly shared logistics network with a current dedicated logistics scheme in an urban environment. We use an agent-based simulation to compare distinct scenarios distinguished by network structure, connectivity, inventory positioning strategy and delivery routing. The potential economic, environmental, and social impact of such hyperconnected logistics on last-mile operations is described.

2 - Synthetic Demand Data to Drive Warehouse Design

Leon McGinnis, Georgia Institute of Technology, Isye Dept, 755 Ferst Drive, Atlanta, GA, 30332-0205, United States, leon.mcginnis@isye.gatech.edu, Di Liu

Suppose you are designing a new automated order fulfillment center to serve many local stores with daily deliveries. How do you model the "demand" from these stores? This talk describes a bootstrap approach to creating synthetic demand data streams. The method enables structural modifications to the demand stream to reflect a wide range of possible changes in the demand pattern, allowing proposed system designs to be "stress tested" prior to installation.

3 - On-demand Warehousing Models

Jennifer A.Pazour, Rensselaer Polytechnic Institute, 110 8th street, CI I.5217, Troy, NY, 12180, United States, pazouj@rpi.edu, Kaan Unnu

On-demand warehousing matches independent operators who have extra space to ones who need warehouse space on-demand. We develop optimization models to determine which warehousing options (construction, long-term lease, or on-demand) is best to fulfill distributed demand requests over multiple periods. The models capture varying commitment and capacity granularity of the different options and are used to quantify the benefits of on-demand options in different customer environments.

4 - Modeling Parallel Process Flows in Intra-logistics Systems

Debjit Roy, Indian Institute of Management, House Number 308, IIM.Ahmedabad, Vastrapur, Ahmedabad, 560078, India, debjit@iima.ac.in, Govind Kumawat

We present an exact two-phase server based stochastic modeling approach for analyzing performance of parallel process flows found in several intra-logistics systems. In comparison to the existing sequential modeling approach, the proposed modeling approach gives substantially better throughput estimates for automated warehousing systems.

5 - Dynamic Slotting using Predictive Analytics

Parvaneh Jahani, University of Louisville, 781 Theodore Burnett Court, Apt 2, Louisville, KY, 40217, United States, parvaneh.jahani@louisville.edu, Kevin Gue

Dynamic slotting continuously adjusts the current state of the forward area with real-time decisions in conjunction with demand predictive analytics. Therefore, the layout of the fast picking area is updated over time with replenishment of the appropriate SKUs, as opposed to traditional methods that periodically reslot the forward area to reach a predefined target map. We explored the methods for demand pattern detection and demand forecasting as well as proposed MIP mathematical model for the dynamic forward-reserve problem for the first time. This model relaxes the major implicit assumptions of the static model and quantifies the effects of the static strategy versus the dynamic strategy.

■ SC53

361F

Emerging Data Sources and Travel Demand Modeling I

Invited: TSL, Intelligent Transportation Systems (ITS)

Invited Session

Chair: Alireza Khani, University of Minnesota, 136 Civil Engineering Building, 500 Pillsbury Drive S.E., MInneapolis, MN, 55455, United States, akhani@umn.edu

1 - Time-Dependent Origin Destination Matrix Calibration for Transit Network Modeling

Jacqueline Nowak, University of Minnesota, Twin Cities, MN, 56267, United States, nowak123@umn.edu, Alireza Khani

Outdated transit demand data presents a challenge for transit network modeling. This work aims to use Automated Passenger Count (APC) data to update an existing origin destination matrix to a time-dependent OD matrix for application in dynamic transit assignment. Results from the Twin Cities transit network are presented.

2 - Special Event Transit Demand Estimation using AFC Data
Pramesh Kumar, University of Minnesota, Minneapolis, MN, 55414, United States, kumar372@umn.edu, Alireza Khani

An improved trip chaining algorithm is proposed for transit origin-destination matrix estimation using Automatic Fare Collection (AFC) data. An optimization model is proposed to decompose the OD matrix ta regular and irregular demand, to capture the effect of special events on transit demand. Results from the Twin Cities transit network are presented.

3 - Observability Quantification of Dynamic Transit Systems with Multi-source Sensor Data
Jiangtao Liu, Arizona State University, 2026 S.Hammond Drive, Apt 205, Tempe, AZ, 85252, United States, jliu215@asu.edu, Xuesong Zhou

A transit network with low observability creates barriers for effective and reliable transit service supply. By incorporating the passenger-based trip time from smart card and flow count data from surveillance system, we propose an agent-based arc-based mixed integer programming (MIP) to estimate the whole transit system state in a time-discretized space-time network. Further, an agent-based path-based binary integer programming (IP) model is offered to quantify the flow range of targeted paths to evaluate the system observability under the estimated transit state before.

■ SC54

362A

Operations Research in Agriculture

Invited: Agricultural Analytics

Invited Session

Chair: Shrikant Jarugumilli, Monsanto, 12447 Bennett Springs Ct, St. Louis, MO, 63146, United States, shrikant.jarugumilli@monsanto.com

1 - Field Production Planning Based on Operational
Rogerio Lenza, Monsanto Company, Rua Joaquim Nabuco, 163 ap 1501, Maringa, Brazil, rogerio.p.lenza@monsanto.com

This project has made use of analytics through operational research built with a novel technology in order to deliver a Crop Placement solution for the corn business in Brazil. This solution allows the generation of multiple what-if scenarios focused on minimizing production cost considering the entire supply chain. Additionally, it has transformed the overall crop planning process, improved the quality of the production plan and increased the productivity of the planning team for all corn plants.

2 - Integrated Supply Chain Optimization at Monsanto Utilizing Advanced Analytics
Barry Surber, Monsanto, Creve Coeru, MT, United States, barry.l.surber@monsanto.com

The flow of material through the production and distribution processes within a Supply Chain is far too often managed through a series of individual decisions that are analyzed independently of the processes that proceed or follow them. In order to efficiently manage these processes in an optimal manner a series of user interfaces, processes, algorithms and an optimization engine was developed to integrate the decision making processes into one system that considers the costs and constraints from these individual decisions in one integrated solution. This solution was developed in-house and has met with outstanding acceptance due to its ease of use and logical process flow for creating scenarios.

3 - Machine Learning Based Simulation and Optimization of Soybean Variety Selection
Durai Sundaramoorthi, Washington University in Saint Louis, 10352 Conway Road, Saint Louis, MO, 63131, United States, dsundaramoorthi@gmail.com, Lingxiu Dong, Yu Li, Xiao Tan, Piruthiviraj Sivaraj

Humanity is facing the greatest challenge of feeding itself. The World Food Programme estimates that about 795 million people do not have adequate food to have a healthy life. About 3.1 million children die every year because of poor nutrition. As a small part of addressing this great humanitarian challenge, this research proposes an analytics framework for growing the optimal soybean varieties. Selecting soybean varieties for planting is an important decision that has significant implications for the yield of the farm. We formulated and solved a simulation-based optimization problem to determine the optimal soybean-mix to minimize the risk associated with the yield.

4 - Application of Vehicle Routing with Time Windows and Split Deliveries in Agriculture
Hadi Panahi, Monsanto, St, Louis, MO, United States, hadi.panahi@monsanto.com, Naveen Singla

Every year Monsanto's testing pipeline tests new seeds for their yield and traits. Seeds are planted in the fields, and harvested for data collection. Advancement decisions can be made once data is collected throughout the harvest season. However, the timing of harvest has a direct effect on the quality of the data. To collect the highest data quality to enable making reliable advancement decisions, first the optimal harvest time is determined via predictive modeling and next harvesters (combines) are deployed from hubs to fields within the recommended harvest time window. In the literature, this problem is studied as Vehicle Routing Problem with time windows and split deliveries (VRPTWSD) as multiple combines can visit the same field. A mixed-integer programming model (MIP) along with a heuristic providing feasible solutions to the MIP as warm start are developed for this problem. Agricultural business rules and objectives are also captured by the MIP model and the heuristic algorithm. This model has been used to provide operational routes during harvest season and to determine the fleet size.

■ SC55

362B

Stochastic Systems in Finance

Sponsored: Financial Services

Sponsored Session

Chair: Alexandra Chronopoulou, achronop@illinois.edu

1 - Indifference Pricing of XVA in Stochastic Volatility Models
Stephan Sturm, WPI, Department of Mathematical Sciences, 100 Institute Road, Worcester, MA, 01609, United States, ssturm@wpi.edu

We consider the pricing of XVA in markets with stochastic volatility. Assuming that the hedger's risk preferences are given by a convex dynamic risk measure, we study the hedger's indifference price for entering the underlying contract with value adjustments due to credit risk, collateralization and differential rates.

2 - Trading Illiquid Goods: Market Making as a Sequence of Sealed-Bid Auctions
Andrew Papanicolaou, NYU, Tandon, Brooklyn, NY, United States, ap1345@nyu.edu

We provide analytic results for the optimal control problem faced by a market maker who can only obtain and dispose of inventory via a sequence of sealed-bid auctions. Under the assumption that the best competing response is exponentially distributed around a commonly discerned fair market price we examine properties of the market maker's optimal behavior. We show that simple adjustments to skew and width accommodate customer arrival imbalance. We derive a straightforward relationship between the market marker's fill probability and direct holding costs.

3 - A Financial Market of a Stochastic Delay Equation
Kiseop Lee, Purdue University, kiseop@purdue.edu

We propose a stochastic delay financial model which describes influences driven by uncertain historical events. The underlying is modeled by stochastic delay differential equation (SDDE).

4 - Designing Clearinghouse Default Funds: the Role of Risk-taking Incentives
Agostino Capponi, Columbia University, 500 W. 120th Street, New York, NY, 10027, United States, ac3827@columbia.edu, Jessie Wang, Hongzhong Zhang

Central counterparties (CCPs) are mandated to reduce counterparty risk in the over-the-counter derivatives markets. We study the optimal design of the default fund contributions, serving the purpose of mutualizing losses of defaulted clearing members. While the default funds allow members to effectively share counterparty risk ex post, we highlight a novel mechanism related to loss mutualization and inducing members to take excess risk ex ante due to an inherent externality among them. We show that the CCPs can mitigate such an inefficiency by optimally choosing a default fund level, balancing the ex post risk-sharing and ex ante risk-taking.

■ SC56

362C

Continuous Facility Location

Sponsored: Location Analysis

Sponsored Session

Chair: Atsuo Suzuki, PhD, Nanzan University, 18 Yamazato-cho, Nagoya, 466-8673, Japan, atsuo@nanzan-u.ac.jp

1 - Multi-range Sensor Location Problem

Daisuke Watanabe, Tokyo University of Marine Science and Technology, 2-1-6 Etchujima, Koto-ku, Tokyo, 135-8533, Japan, daisuke@kaiyodai.ac.jp, Richard Church

In this study, we formulate the optimal location model for surveillance platform with multi-range sensor based on the Maximum covering location model. The objective is to maximize the probability of detecting a historical set of piracy attacks. Using this model, we solve the optimal location of the Counter-Piracy Surveillance System in Somalia.

2 - The Big Triangle Small Triangle Method for the Weber Problem with Line Barriers

Atsuo Suzuki, Nanzan University, Dept of Systems and Mathematical Sciences, 18 Yamazato-cho, Nagoya, 466-8673, Japan, atsuo@nanzan-u.ac.jp, Zvi Drezner, Tammy Drezner

We apply the Big Triangle Small Triangle (BTST) method to the Weber problem with line barrier on the plane. We assume that there are demand points on the plane, and a line barrier with several passing points separates the demand points into two groups. It is a simple model of the situation where a river with bridges prohibits the direct access for the users to the facility on the other side of the river. The objective function of the problem is not convex because it is represented as the minimum of the convex functions. While a naive descent method fails to obtain the exact solution, the BTST algorithm obtains the exact solution.

■ SC57

362D

Aviation Applications in Simulation

Sponsored: Simulation

Sponsored Session

Chair: John Shortle, George Mason University, George Mason University, Fairfax, VA, 22030-4444, United States, jshortle@gmu.edu

1 - A Distance-based Network Simulation for Airport Runway and Priority Scheduling

Haluk Damgacioglu, PhD Candidate, University of Miami, 1251 Memorial Drive McArthur Engr Bldg Room 280, Coral Gables, FL, 33146, United States, haluk.damgacioglu@miami.edu, Alyssa Guller, Nurcin Celik

Runways are the main bottlenecks in airport ground networks leading to extended flight delays and hindering with its throughput. Here, we develop a distance-based network simulation for runway and flight scheduling to minimize the total delay time of all flights and maximize overall runway throughput. The proposed model incorporates both the technical and regulatory constraints for safety, and system uncertainties. The capabilities of the model are demonstrated in San Diego and Ft. Lauderdale airport runways under various scenarios of different priority logics for queueing, and runway layouts.

2 - Measuring Fuel and Travel Time Benefits for Oceanic Flights through Computer Simulation

Arman Izadi, Virginia Institute of Technology, Blacksburg, VA, 24061, United States, armaniz@vt.edu, Antonio Trani

Advanced technologies such as Automatic Dependent Surveillance-Broadcast (ADS-B) have significantly improved situational awareness and communication between pilots and controllers in remote oceanic areas. Reducing oceanic separation minima and proposing novel concepts for the Organized Track System could improve oceanic operations. This talk presents a discrete-time model that simulates all phases of flight from takeoff to landing in order to evaluate these concepts in terms of fuel consumption, travel time, controller workload and safety.

3 - OTP Maximizer: Robust Scheduling with Optimal Block and Ground Times

Zeynep Sargut, Optym, 7600 NW. 5th Place, Sakarya Caddesi No:156, Gainesville, FL, 32607, United States, zeynepsargut@gmail.com, Pranav Gupta, Revindra K. Ahuja, Nomesh Bolia

An airline company usually solves its schedule planning problem considering a little or no stochasticity to maximize its profitability. Highly optimized schedules show an opposite trend in terms of operational metrics such as On Time Performance (OTP). We develop a simulation-based approach to measure the operability of a given schedule under various uncertainties. We aim to optimize the schedules by allocating the available time among the turn and block times so that OTP is maximized at minimal cost using a mixed integer programming formulation.

4 - Simulationof Collision Risk for Alternate Airspace Architectures

John Shortle, George Mason University, Dept of Systems Engineering & OR, 4400 University Drive MS.4A6, Fairfax, VA, 22030-4444, United States, jshortle@gmu.edu

Future airspace architectures will need to handle a wide diversity of aircraft operating in a semi-autonomous fashion. This talks presents a simulation of an airspace architecture in which the core requirement is maintaining a target level of collision risk in all regions of the airspace. Aircraft with better collision avoidance capabilities are thus able to fly in denser airspace. The talk presents a simulation of the concept and discusses implications to capacity, delay and collision risk.

■ SC58

362E

Data Collection and Mining on Traffic Networks

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Seyedbehzad Aghdashi, North Carolina State University, 112 Gwinnett Pl, Cary, NC, 27518, United States, saghdas@ncsu.edu

1 - Travel Time Estimation in the Age of Big Data

Arthur J. Delarue, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, MA, 02139, United States, adelarue@mit.edu, Dimitris Bertsimas, Patrick Jaillet, Sebastien Martin

In this talk, we show that we can leverage network optimization insights to tractably extract accurate travel time estimations from taxi travel time data, with the additional ability to take advantage of many other sources of traffic information. Using synthetic data, we establish the robustness of our algorithm to uncertainty, and display its ability to significantly reduce input variance. We show on real data that our algorithm can leverage any avail- able amount of data, even in a high-variance environment, to provide accurate insights about urban traffic patterns on different scales.

2 - Understanding City Dynamics from Taxis Trajectory Data

Shirin Najafabadi, PhD Student and Research Assistant, The City University of New York (CCNY), 160 Convent Ave, Steinman Hall - Room T-117, New York, NY, 10031, United States, snajafabadi@ccny.cuny.edu, Mahdieh Allahviranloo

This study focuses on trajectories obtained from GPS-enabled taxis and their applications for mining urban commuting patterns. A case study with a taxi trajectory data-set in New York, USA is presented to demonstrate and evaluate spatial distribution of taxi ridership and reveal facts about city dynamics. Using grid cell decomposition method, taxi data dis-aggregated into uniform size units and a radiation model was applied to model spatial correlations of factors associated with urban density to taxi ridership. Also, this paper presents a novel approach using temporal attractiveness of POIs (Point of Interests) to identify activity-locations as well as duration from raw GPS trajectory.

3 - An Optimization Approach to Install License Plate Recognition Sensors in a Traffic Network for Full Road Flow Monitoring Considering the Measurement Errors

Mostafa Salari, Research Assistant, University of Calgary, 312 3420 50th St., NW, Calgary, AB, T3A 2E1, Canada, Mostafa.salari2@ucalgary.ca, Lina Kattan

This work addresses the network sensor location problem (NSLP) to install the minimum number of license plate recognition (LPR) sensors on roads in a traffic network to meet full road flow monitoring. The objective function of the model also aims at minimizing the total measurement errors of sensors while meeting the budget constraint. The Monte Carlo simulation is then applied to consider the randomness of the measurement errors in finding the optimum location set of sensors. Eventually, the concept of backup sensors is developed to maintain the full road flow monitoring regarding the possibility of sensors failures in monitoring the flows.

4 - Reliable Sensor Deployment under Probabilistic Disruptions
Siyang Xie, U. of Illinois at Urbana-Champaign, 205 N.Mathews Avenue, B156 Newmark Lab, Urbana, IL, 61801, United States, sxie13@illinois.edu, Zhoutong Jiang, Yanfeng Ouyang

Many location-aware systems use multiple sensors for geographical positioning and surveillance. The accuracies depend on how the sensors are deployed and used, and may suffer from sensor disruptions when sensors are subject to failures. To optimize the sensor locations and maximize the positioning/surveillance accuracy under disruption risks, we first study the optimal layout of sensor locations on an infinite homogeneous plane. Then we develop a continuum approximation model to formulate the reliable sensor location problem under homogeneous/heterogeneous settings. Numerical examples are presented to illustrate how the proposed model can be applied for sensor deployment optimization.

5 - Predictive Models for Driver Aggressiveness on Arterial Streets using Unsupervised Learning
Nabaruna Karmakar, Graduate Research Assistant, NC State University, Raleigh, NC, United States, nkarmak@ncsu.edu, Seyedbehzad Aghdashi, Masoureh Jeihani, Celeste Chavis, Zohreh Rashidi Moghaddam

Predictive models have been developed to determine drivers' aggressiveness in response to change in arterial road Level of Service (LOS) through data mining of large amount of trajectory and probe vehicle data. K-means clustering has been used to recognize patterns in trajectory data. A Neural Network model is proposed to generate predictive models. Models developed in this research will help decision makers to determine safety impacts of arterial streets treatments.

■ SC59

362F

Joint session RAS/Practice: RAS Student Paper Awards and Presentations

Sponsored: Railway Applications

Sponsored Session

Chair: Steven Harrod, PhD, Technical University of Denmark, Bygning 424, Kgs. Lyngby, 2800, Denmark, stehar@dtu.dk

1 - Awards and Three Speakers to be Announced at Conference
Steven Harrod, Technical University of Denmark, Room 132, Building 424, Kgs. Lyngby, 2800, Denmark, stehar@dtu.dk

Awards for the 2017 Railway Applications Section Student Paper Competitions will be presented, along with presentations by the finalists. Winners are announced at the conference, or a few weeks before at the earliest.

■ SC60

370A

Analytics Curricula in OR/IE Programs

Sponsored: INFORMEd

Sponsored Session

Chair: Joel Sokol, Georgia Institute of Technology, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, jsokol@isye.gatech.edu

1 - MS in Data Science and MS in Business Analytics at ColumbiaUniversity
Adam Elmachtoub, Columbia University, Columbia University, New York, NY, 10027, United States, adam@ieor.columbia.edu, Garud N.Iyengar

The MS in Data Science is offered by the Data Science Institute at Columbia University. Our networked world is generating a extremely large amounts of data that has the potential to transform business, government, engineering and the applied sciences. A new discipline of data science is focused on the tools required to generate information from this data. This MS program is focused on developing new methodologies and applying them to innovative applications.

2 - Master of Science in Analytics at Northwestern: The Importance of Agility
Barry L. Nelson, Northwestern University, Dept of Industrial Eng and Mgmt Sciences, 2145 Sheridan Road, Room C216, Evanston, IL, 60208-3119, United States, nelsonb@northwestern.edu, Diego Klabjan

Analytics is a quickly evolving field and thus education programs must be adaptable and agile. We will discuss how the Master of Science in Analytics program at Northwestern University copes with these challenges.

3 - The Cornell M.Eng. Program – Data Analytics and Beyond
David B. Shmoys, Cornell University, 231 Rhodes Hall, 136 Hoy Road, Ithaca, NY, 14853-3801, United States, david.shmoys@cornell.edu

The Cornell M.Eng. Operations Research program provides a number of concentrations, & the fastest growing is in Data Analytics, blending coursework in OR, data science, & computing, with a client-based project where a team of students work with a faculty member to address a real-world problem. This is complemented by a new program at Cornell Tech in NYC, which combines traditional academic rigor with the energy & opportunity that come with studying in the heart of NYC's tech startup community, & includes an immersive Studio experience, that develops team-building and leadership skills as well as new product ideas in response to the strategic needs of a real organization, & create your own startup.

4 - Georgia Tech's Interdisciplinary MS inAnalytics: On-campus, Online, and International
Joel Sokol, Director, Master of Science in Analytics, Georgia Institute of Technology, School of ISYE, 765 Ferst Drive, Atlanta, GA, 30332-0205, United States, jsokol@isye.gatech.edu

Georgia Tech's Master of Science in Analytics degree is co-owned and co-administered by the College of Engineering, College of Computing, and Scheller College of Business. With an interdisciplinary core, three tracks, 60+ elective choices, and an applied practicum requirement, the degree allows students to specialize and personalize their learning to fit their individual interests and career goals. We offer a premium on-campus option with a variety of perqs, a high-quality MOOC-style online delivery, and a combined MS/MBA option. In this talk, we'll show how it all works.

■ SC61

370B

Stochastic Models for Emergency Response Logistics

Sponsored: Minority Issues

Sponsored Session

Chair: Emmett J Lodree, University of Alabama, Tuscaloosa, AL, 35487-0226, United States, ejlodree@cba.ua.edu

1 - Managing Volunteer Convergence at Disaster Relief Centers
Hussain Abualkhair, North Carolina A&T.State University, Greensboro, NC, United States, hfabualk@aggies.ncat.edu, Lauren Davis

Disaster Relief center managers face uncertainty in both the timing and quantity of donations, as well as the number of spontaneous volunteers. Volunteer convergence is one of the biggest challenges for relief center managers. To better understand this phenomenon and find effective management strategies, we develop an agent-based simulation model consisting of donors providing relief items, beneficiaries in need of relief items and random arrivals and departures of volunteers. We investigate volunteer assignment policies that reduce donor beneficiary waiting time under given changes in volunteer capacity, available inventory, and beneficiary's arrival rates.

2 - The Optimal Assignment of Spontaneous Volunteers to Parallel Queues with Stochastic Demand
Kyle Paret, North Carolina State University, Raleigh, NC, United States, keparet@ncsu.edu, Maria Esther Mayorga

Immediately following a disaster people converge to assist the affected community. Spontaneous volunteers (SVs) are in a unique position to provide valuable aid at a crucial point in the disaster cycle. Oftentimes these volunteers are ineffectively used or refused all together. Improved methods to integrate spontaneous volunteers are required. In this paper, a multi-server queuing model is formulated to represent the dynamics of assigning SVs to tasks in a post-disaster setting. An optimal assignment policy is generated using a Markov Decision Process. Finally, we use simulation to compare the optimal policy against several heuristic policies and discuss real world implications.

3 - Ambulance Service Region Design under Uncertainty
Shakiba Enayati, State University of New York, Plattsburgh, NY, United States, senayat@ncsu.edu, Osman Ozaltin, Maria Esther Mayorga

Limiting response area for each ambulance may lead to shorter response times to emergency scenes and more evenly distributed workload for ambulances. We propose a two-stage stochastic mixed-integer programming model to address the service region design problem under uncertainty. The output of this model is to locate ambulances at the potential stations in the service area and to assign a set of demand zones to each station at different backup levels. The objective function of our model is to maximize the expected number of covered calls while the assigned workload to each ambulance is restricted. The proposed model can be optimized offline similar to the idea of "patrol-beats" used in policing models.

4 - Approximate Dynamic Programming-based Policies for Donation Collection and Distribution

Robert Alexander Cook, University of Alabama, Tuscaloosa, AL, 35487, United States, Racook1@crimson.ua.edu

This study introduces Approximate Dynamic Programming (ADP) techniques for solving a Markov Decision Problem (MDP) in which we distribute stochastically-arriving donations to disaster survivors. Donations accumulate over time at collection sites and are periodically transported to relief centers where they are distributed to beneficiaries. The MDP model minimizes expected unsatisfied demand during a finite horizon.

■ SC62

370C

Capacity and Inventory Logistics

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Satya Sarvani Malladi, Georgia Institute of Technology, Atlanta, GA, 30329, United States, mss@gatech.edu

1 - SKU Rationalization with Substitutable Demands in a Packaged Gas Supply Chain

Ethan Malinowski, University at Buffalo (SUNY), 2014 Delaware Avenue, Apt 5, Buffalo, NY, 14216, United States, ejmalino@buffalo.edu, Mark Henry Karwan, Lei Sun, Jose M. Pinto

Effective SKU rationalization is advantageous when applied to businesses with high variance and a variety of potentially substitutable product offerings. Advantages include lower production costs, reduced inventory, and system-wide reductions in transportation costs. We develop two MILP formulations for an industrial gas business with over ten thousand SKU's. One model considers maintaining current customers' product choices and the other introduces notions of swapping and equivalence among SKU's. Both models minimize production and transportation costs while simultaneously reducing SKU variance throughout the system. Computational results and policy implications are presented.

2 - Looking Upstream: Optimal Policies for a Class of Capacitated Multi-stage Inventory Systems

Alexandar Angelus, The University of Texas at Dallas, Jindal School of Management, 800 West Campbell Road SM.30, Richardson, TX, 75080, United States, alexandar.angelus@gmail.com, Wanshan Zhu

We consider a multi-stage, multi-period inventory system with stochastic demand and capacity constraints at each stage. For a class of such systems characterized by having the smallest capacity at the most downstream stage and system utilization above a certain threshold utilization, we identify the structure of the optimal policy. We find the explicit functional form of the order-up-to levels, and show that they depend (only) on upstream echelon inventories. We establish that, above the threshold utilization, this form of the optimal policy achieves the decomposition of the multidimensional objective cost function for the system into single-dimensional convex optimization subproblems.

3 - Exploration of Flexibility Schemes for Time Window Management in E-fulfillment

Charlotte Köhler, Viadrina University Frankfurt (Oder), Frankfurt (Oder), Germany, koehler@europa-uni.de, Jan Fabian Ehmke, Ann Melissa Campbell

When accepting customer requests, online retailers can build tentative delivery routes and check if each customer can be accommodated feasibly with the remaining delivery capacity. Extending customer acceptance mechanisms from the literature, we consider the remaining logistics capacity, the time of the request relative to the booking horizon, and the customer location in the decision of how many different time windows and what time window widths to offer to the customer. We investigate the impact of these ideas on the number of served customers given the demand structure of order data from an e-grocer in Berlin, Germany.

4 - Dynamic Mobile Capacity Logistics and Multi-location Inventory Control

Satya Sarvani Malladi, Georgia Institute of Technology, 2209 Briarcliff Rd NE, Apt 17, Atlanta, GA, 30329, United States, mss@gatech.edu, Alan Erera, Chelsea C. White

We investigate the logistics of distributed production-inventory systems that allow mobile production capacity to be shared dynamically. We establish the value addition over fixed systems and present well-performing heuristics to solve the problem efficiently.

■ SC63

370D

Energy and Climate 3

Invited: Energy and Climate

Invited Session

Chair: Yongyang Cai, Ohio State University, Ohio State University, cai.619@osu.edu

1 - Adding Quantity Certainty to a Carbon Tax: the Role of a Tax Adjustment Mechanism for Policy Pre-Commitment

Hafstead Marc, Hafstead@rff.org

2 - External Impacts of Local Energy Policy: the Case of Renewable Portfolio Standards

Alex Hollingsworth, Indiana University, Bloomington, IN, United States, hollinal@indiana.edu, Ivan Rudik

Renewable portfolio standards are state policies that require in state electricity providers to procure a minimum percentage of electricity sales from renewable sources. We show how RPSs induce out of state emissions reductions through state trade of the credits used for RPS compliance. When one state passes an RPS, it increases demand for credits sold by firms in other states. We find evidence that increasing a state's RPS decreases coal and increases wind generation in outside states. We perform a welfare simulation to evaluate benefits of reductions in local coal fired pollutants, a 1 percentage point increase a state's RPS results in up to $100 million in benefits towards the United States.

3 - Build Today, Regret Tomorrow? Infrastructure and Climate Policy

Yongyang Cai, Ohio State University, Columbus, OH, United States, cai.619@osu.edu, Elizabeth Baldwin, Elizabeth Baldwin, Karlygash Kuralbayeva

The timing of optimal policy to combat climate change is controversial. We consider this question in the light of irreversible "dirty" and "clean" investments. This leads to a "Reverse Green Paradox": the knowledge of an increasing carbon tax will reduce investments in assets that pollute, and so reduce emissions in the short term. This contrasts with the well-known effects of such policy on the suppliers of fossil fuels. So stranded assets play opposing roles, depending on whether these assets supply or demand fossil fuels. Additionally, we show that it is optimal to begin deployment of clean technologies early, if their cost decreases with their cumulative deployment.

4 - Optimal Clean Energy R&D Investments under Uncertainty

Giacomo Marangoni, FEEM, Corso Magenta 63, Milano, 20123, Italy, giacomo.marangoni@feem.it, Gauthier de Maere d'Aertrycke, Valentina Bosetti

The improvement of clean energy technologies asks for risky efforts in research and development (R&D). When evaluating optimal R&D portfolios, accounting for uncertainty while maintaining the rich set of information produced by complex climate-economy models can lead to intractable problems. We avoid succumbing to computation complexity thanks to Approximate Dynamic Programming. We exemplify the methodology by computing the optimal allocation of near-term innovation investments in four key clean energy technologies. We employ an integrated assessment model (WITCH) with a fairly rich description of the energy-economy nexus, and experts' beliefs on future costs to quantify uncertainty.

5 - Promoting Clean Technologies Through Consumption and Production Subsidies

Soheil Shayegh, Fondazione Eni Enrico Mattei (FEEM), 149 Madison Avenue, Midland Park, NJ, 07432, United States, soheilsh@gmail.com

New clean energy technologies typically cost more than established technologies. In order to help clean technologies compete in energy markets, governments can provide two classes of deployment subsidies to different recipients: production subsidies, which lower production costs, or consumption subsidies, which reduce the final price to consumers. Here, we use demand curves to quantify the impacts of these classes of subsidies on technology deployment, social welfare, and market structure. We identify a critical market share in which social welfare is equal under both subsidy schemes. At market shares smaller than the critical value, the benefits of competition favor production subsidies.

■ SC64

370E

Data Analytics & Modeling in Medical Imaging Analysis & Decision Making

Sponsored: Data Mining

Sponsored Session

Chair: Shouyi Wang, University of Texas at Arlington, Arlington, TX, 76013, United States, shouyiw@uta.edu

1 - Supervised Discriminative EEG Brain Source Imaging with GraphRegularization

Feng Liu, University of Texas at Arlington, 1020 W. Abram Street, Apt 172, Arlington, TX, 76013, United States, feng.liu@mavs.uta.edu

The advances in computing and advanced data analytics techniques have led to powerful and promising data-driven tools to solve complex healthcare and medical decision making problems based on increasingly large amounts of data. This session provides a collection of talks in the field to present several most recent research studies that develop data-driven approaches and machine learning techniques for comprehensive decision modeling in medical imaging analysis and decision making.

2 - Discriminative Spectral Pattern Analysis for Prostate Cancer Detection using Light Reflectance Spectroscopy

Rahil Hosseini, University of Texas-Arlington, Arlington, TX, United States, rahilsadat.hosseini@mavs.uta.edu

This talk presents an effective classification procedure that detects the positive margin in prostate cancer by application of data mining techniques. We developed a data-driven method to process and extract features from the Light Reflectance Spectroscopy (LRS) spectrum data, and developed support vector machine and ensemble trees approach for binary and multi-class classification for prostate cancer detection.

3 - A Supervised Learning Model for Predicting Tibia Soft Tissue Insertions using Multi-response Support Vector Regression

Kin Ming Puk, University of Texas at Arlington, 711 Linda Vista Ave, Apt 112A, Arlington, TX, 76013, United States, pukkinming@gmail.com

It has been an ongoing research to precisely identify the location of knee injury without affecting adjacent tissues during the surgical operation, subject to difficulties in locating ligament and related soft tissues and high inter-person morphological variability between patients. This work presents a new prediction framework which is capable of achieving personalized identification of cruciate ligament and optimal position of soft tissue insertions. It is made possible because tibia outline can be accurately and reliably measured from computed tomography imaging and features can thus be extracted for model building with L2,1-regularized multi-response support vector regression.

4 - A Network Modeling and Prediction Framework for Better Epilepsy Surgical Decisions

Shouyi Wang, University of Texas-Arlington, 2029 Randy Snow Road, # 1310, Arlington, TX, 76011, United States, shouyiw@uta.edu

Resective surgery is currently the most effective overall treatment for patients with epilepsy. However, there is still considerable risk of surgical failures for lacking of priori knowledge of seizure spread network. This talk will present a novel network modeling framework using cortico-cortical evoked potentials (CCEP) to understand network mechanisms of epileptogenesis and render clinicians better epilepsy surgical decisions in the future.

■ SC65

370F

1:30 - 2:15 Arundo/ 2:15 - 3:00 Tableau

Invited: Vendor Tutorial

Invited Session

1 - IIOT and Data-Driven Modeling in Asset Heavy Industry

Tailai Wen, Arundo, Houston, TX, United States, tailai.wen@arundo.com, Roy Keyes

The traditional industries start moving towards big data in recent years. While most acknowledge it may bring efficiency improvement and cost reduction to those asset-heavy sectors, to deploy data modeling infrastructure in an enterprise to industrial scale still faces challenges that were not seen in align and less complex modern industries before. In this talk, we will introduce the opportunities and obstacles in this field using real examples that Arundo works on, and demonstrate our solutions to these challenges.

2 - Experience Visual Analytics with Tableau

Ali Kherani, Tableau Software, Seattle, WA, United States, kherani@tableausoftware.com

Get ready to learn how to inform and inspire others when presenting data with Tableau's business intelligence platform. Join us for this tutorial to discover how to turn data into actionable insights and find out why Forbes recently ranked Tableau as the technical skill with the third biggest rise in demand. We'll provide an overview of Tableau and demo the key features and functionality of our visual analytics platform. This overview will excite you to explore your data in a different way!

■ SC66

371A

Autonomous Vehicles

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Yiwen Xu, North Dakota State University, P.O. Box 6050, Industrial & Manufacturing Engineering, Fargo, ND, 58108-6050, United States, yiwen.xu6@gmail.com

1 - Recasting Interseciton Automation as a CAV Scheduling Problem within the Mixed Traffic Environment

Pengfei (Taylor) Li, Assistant Professor, Mississippi State University, P.O. Box 9546, 501 Hardy Road, 235 Walker Hall, Mississippi State, MS, 39762, United States, pengfei.li@cee.msstate.edu, Xuesong Zhou

Within the mixed traffic environment, connected-automated vehicles (CAV) are both part of traffic flow and green light request senders. We propose a new vehicle-centered traffic representation and a phase-time-traffic (PTR) hypernetwork model to optimize intersection automation policy (IAP). The new vehicle-centered traffic representation can reflect new features of CAVs in traffic flows. The PTR hypernetwork is to model the integration of mixed traffic with traffic signal operations. We also develop exact algorithms to reduce search space and search the exact optimal solution based on branch-and-bound framework. Algorithms are further enhanced with parallel computing technique.

2 - UAV Delivery Planning Considering Mission Failure Probability

Yiwen Xu, Assistant Professor, North Dakota State University, PO Box 6050, Industrial & Manufacturing Engineering, Fargo, ND, 58108-6050, United States, yiwen.xu@ndsu.edu

Commercialization of Unmanned aerial vehicles (UAVs) is more and more popular. As an emerging application, UAV delivery has attracted considerable attentions. Most previous research on the UAV delivery planning, however, did not consider the mission failure probability and the corresponding hazards. In this talk, we consider such factors and formulate the models to mixed integer programming (MIP) problems. The objective function is set to minimize the expected cost (including expected hazard costs) under given total mission time for all deliveries. We consider both deterministic demands and distributed demands. The models are solved by MIP solvers and numerical examples are included.

■ SC67

371B

Machine Learning for Manufacturing Informatics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Hao Yan, yanhao@gatech.edu

Co-Chair: Jianjun Shi, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, jianjun.shi@isye.gatech.edu

1 - Machine Learning via Nonconvex Model Based Optimization

Tuo Zhao, Georgia Tech, 755 Ferst Dr. NW, Atlanta, GA, 30332, United States, tourzhao@gatech.edu, Han Liu, Tong Zhang

Nonconvex optimization arises in many machine learning problems. Although classical optimization theory has shown that nonconvex optimization is computationally intractable, practitioners have proposed numerous heuristic algorithms, which achieve outstanding performance in real-world applications. To bridge this gap between practice and theory, we propose a new generation of model-based optimization algorithms and theory, which incorporate the statistical thinking into modern optimization. We exploit hidden geometric structures behind nonconvex optimization problems, and obtain global optima with desired statistics properties in polynomial time with high probability.

2 - Machine Learning for in SITU Quality Monitoring of Manufacturing Processes

Bianca Maria Colosimo, Politecnico di Milano, Via La Masa, 1, Milan, I-20156, Italy, biancamaria.colosimo@polimi.it, Marco Grasso

In-situ monitoring of advanced manufacturing processes requires monitoring signal and image data with time. The contribution describes how machine learning approaches can be usefully included in the SPC procedure to detect unnatural process conditions.

3 - Modeling the Distribution of Nonlinear Profile with Application for Process Monitoring and Denoising

Hao Yan, 3525 Highgrove Way NE, Atlanta, GA, 30319, United States, yanhao@gatech.edu

Unsupervised learning of nonlinear profiles has attracted increasing attention among researchers as well as practitioners because of its applications in process monitoring and diagnostics. However, existing unsupervised learning techniques for profile monitoring are typically based on linear models such as Principal Component Analysis, which fails to model the distribution of nonlinear profiles. We present a unified framework for nonlinear profile modeling framework based on variational inference, which a testing statistics can be naturally derived. We then demonstrate how this framework can be used for denoising and profile monitoring with various simulations and case studies.

■ SC68

371C

QSR Student Interaction Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Chiwoo Park, Florida State University, Tallahassee, FL, 32310-6046, United States, cpark5@fsu.edu

Co-Chair: Linkan Bian, Mississippi State University, MS, 39762, United States, bian@ise.msstate.edu

1 - QSR Student Interaction

Linkan Bian, Mississippi State University, MS, 39762, United States, bian@ise.msstate.edu

The Student Introduction and Interaction Session is designed for QSR student members to get acquainted with each other, promote themselves in front of our community, and learn from invited guests. In this session, each student will be given two minutes to deliver an elevator speech about his/her research interests and accomplishments; senior QSR members and guests will be invited to interaction with all attendees. A parallel Best Student Poster Competition will be hold at the same room. Students are encouraged to prepare poster presentations to have better exposure. All posters will enter the competition automatically. A winner will be selected by a panel of judges, announced at the QSR business meeting, and awarded a certificate.

■ SC69

371D

Food-Energy-Water and Sustainability

Sponsored: Energy, Natural Res & The Environment Environment & Sustainability

Sponsored Session

Chair: Urmila Diwekar, Vishwanathan Research Institute, urmila@vri-custom.org

1 - Stochastic mixed-integer Programming (MIP) to the Competition of Biofuel and Food Production

Esra Buyuktahtakin, New Jersey Institute of Technology, Newark, NJ, United States, esratoy@njit.edu, Halil Cobuloglu

We present a two-stage stochastic MIP model that maximizes the economic and environmental benefits of food and biofuel production under yield and price uncertainty. The first-stage variables define binary decisions for allocating various land types to food and energy crops, while the second-stage variables are operational decisions related to harvesting, budget allocation, and amounts of different yield types. Results indicate the significant benefit of using the stochastic yield-level information in an optimization model that is solved by a Benders' decomposition algorithm.

2 - Optimizing Spatiotemporal Sensors Placement for Nutrient Monitoring: An Algorithmic Framework

Urmila Diwekar, Vishwamitra Research Institute, 2714 Crystal Way, Crystal Lake, IL, 60012-2224, United States, urmila@vri-custom.org, Rajib Mukherjee

Nutrient monitoring is very important for the area of food-energy-water nexus. In this work, we have proposed a methodology to optimize a dynamic sensor network which can address the spatiotemporal aspect of nutrient movement in a water shed. This is a first paper in the series where an algorithmic and methodological framework for spatiotemporal sensor placement problem is proposed. This framework is based on a novel stochastic optimization algorithm called Better Optimization of Uncertain Systems (BONUS) and is very efficient. A small case study of the dynamic sensor placement problem is presented to illustrate the approach.

3 - Limits to Growth and Global Sustainability of Food-energy-water Nexus

Urmila Diwekar, Vishwamitra Research Institute, Crystal lake, IL, United States, urmila@vri-custom.org, Heriberto Cabezas

A mathematical representation of World dynamics has been constructed inspired by the Limits to Growth. It includes an ecosystem, human population, industry, energy generation, water and the food-energy-water nexus, macro-economy, and rudiments of a legal system with private property, taxation, and regulation. The model provides the conceptual machinery for "steering" the system towards sustainability using socio-economic policies. Optimal control theory is used to forecast policies for three versions of the model. Analysis of sustainability with various scenarios is discussed, and controllability and socio-economic policies to bring the system towards sustainability are described.

■ SC70

371E

Big Data

Contributed Session

Chair: Anurag Agarwal, University of South Florida, Sarasota, FL, United States, agarwala@usf.edu

1 - Real Time Detection of Acute Hypotensive Episode in Intensive Care Unit to Reduce Mortality Rate

Rupesh Agrawal, Research Assistant, Oklahoma State University, 700 N. Greenwood Ave., Tulsa, OK, 74106, United States, rupesh.agrawal@okstate.edu, Surya B. Ayyalasomayajula, Dursun Delen, Ramesh Sharda, Bruce Benjamin

Acute Hypotensive Events (AHE) requires timely attention for intensive care unit (ICU) patients to keep mortality rate low. Timely detection and trend of AHE from "normal" state to "not-normal" state can help ICU medical staff for timely intervention. This study uses rule-based "Complex Event Process" (CEP) detection method to calculate real-time state (normal/not-normal) of "Arterial Blood Pressure" (ABP) signal in real-time. ABP signal streaming at the rate of 125 Hz is used for this study to calculate AHE per second vs per minute, allowing medical professionals between 10-30 mins to provide timely intervention.

2 - Microarray Data Analysis in the Prognosis of Cancer

Sharmin Nahar Mithy, Doctoral Candidate, University of South Florida, 2208 Fitness Club Way, Apt 204, Apt: 204, Tampa, FL, 33612, United States, sharminmithy@mail.usf.edu, Grisselle Centeno

More than one million people get affected by colorectal cancer yearly. The best estimation of prognosis in colorectal cancer is related to the anatomic extent of disease determined on pathologic examination of the resection specimen. Development of statistical models to help the clinicians who will estimate the probability of developing cancer is of great interest in today's research. In this research a neuro-fuzzy approach will be considered in the areas of classification of microarray data analysis. By combining the advantages of both Neural Network and Fuzzy Inference System, Nuero-Fuzzy approaches will be able to achieve a higher accuracy within a relatively shorter training time.

3 - Insights into the Data Mining Cost Model

David Perkins, Associate Professor of Business, Grand Canyon University, 717 East Country Plaza North, Gilbert, AZ, 85234, United States, david.perkins@cox.net

The Data Mining Cost Model (DoCoMo) attempts to provide a robust parametric approach for estimating the cost of a data mining project. This presentation will provide a review of important literature associated with the DoCoMo, will suggest how the DoCoMo can be applied in today's analytics organizations, and will recommend further areas of application and research.

4 - Real-time Data-driven Decision-support Toolkit for the Incentivization and Guidance of Shared Electrified and Automated Vehicles

Chenfeng Xiong, Assistant Research Professor, University of Maryland, 1173 Glenn Martin Hall, College Park, MD, 20770, United States, cxiong@umd.edu, Lei Zhang, Ya Ji

We develop an integrated, personalized, real-time traveler information and incentive technology to incentivize energy-efficient travel, such as the adoption of Shared, Electrified, and Automated Vehicles. Based on machine learning and artificial intelligence, a behaviorally sound and computationally efficient agent-based model is developed to simulate the transportation systems in real-time. The online training of the AI models is based on real-time big-data streams leveraging the biggest transportation data warehouse in the U.S., the Regional Integrated Transportation Information System, which enables accurate system monitoring and effective control/operations.

5 - Augmenting Text Mining to Numerical Analysis to Improve Lift

Anurag Agarwal, Professor, University of South Florida, Information Systems and Decision Sciences, College of Business, Sarasota, FL, 34243, United States, agarwala@usf.edu

We show how lift and classification accuracy can be improved by augmenting numerical data analysis with text mining, if text data is available in addition to numeric data for a classification problem.

■ SC71

371F

Non-convex and Convex Optimization

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Daniel Bienstock, Columbia University, New York, NY, 10027, United States, dano@columbia.edu

1 - On the Construction of Converging Hierarchies for Polynomial Optimization Based on Certificates of Global Positivity

Amir Ali Ahmadi, Princeton University, Dept. of Operations Research&Financial Eng., Sherrerd Hall (Room 329), Charlton Street, Princeton, NJ, 08544, United States, a_a_a@princeton.edu, Georgina Hall

In recent years, techniques based on convex optimization that produce converging hierarchies of lower bounds for polynomial optimization problems (POPs) have gained much popularity. At their heart, these hierarchies rely crucially on Positivstellensatze from the late 20th century (e.g., due to Putinar and Schmudgen) that certify positivity of a polynomial on an arbitrary basic semialgebraic set. In this paper, we show that such hierarchies could in fact be designed from much more limited Positivstellensatze dating back to the early 20th century that only certify positivity of a polynomial globally.

2 - Rank-one Generated Spectral Cones Defined by Homogeneous Linear Matrix Inequalities

Charles J. Argue, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, cjargue@gmail.com, Fatma Kilinc-Karzan

A cone K which is a subset of positive semidefinite cone, is called rank-one generated (ROG) if all of its all of its extreme rays are rank one matrices. Semidefinite relaxations of non-convex quadratic optimization problems are exact for every linear objective function if and only if they lead to conic programs over ROG cones. We study the necessary and sufficient conditions under which the intersection of the positive semidefinite cone with two homogeneous linear matrix inequalities is an ROG cone. Our results also yield a method for giving efficient certificates for whether such a cone is ROG or not.

3 - Volume Computation for Sparse Boolean Quadric Relaxations

Jon Lee, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109-2117, United States, jonxlee@umich.edu, Daphne Skipper

Motivated by understanding the quality of tractable convex relaxations of intractable polytopes, Ko et al. gave a closed-form expression for the volume of a standard relaxation Q(G) of the BQP P(G) of the complete graph. We extend to structured sparse graphs, giving: (i) an efficient algorithm for calculating vol(Q) when G has bounded tree width, (ii) closed-form expressions (and asymptotic behaviors) for vol(Q) for all stars, paths, and cycles, and (iii) a closed-form expression for vol(P) for all cycles. We show that when G is a cycle, the light Q is a very close model for the heavy P.

4 - Computational Experiments and Methodology for QCQPs

Daniel Bienstock, Columbia University, Dept of IEOR, 342 Mudd, New York, NY, 10027, United States, dano@columbia.edu

We describe current computational work using linear relaxations and binary approximations to continuous variables in the context of polynomial optimization problems.

■ SC72

372A

Network Optimization I

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Colin P Gillen, University of Pittsburgh, 1025 Benedum Hall, Pittsburgh, PA, 15261, United States, cpg12@pitt.edu

1 - An Efficient Algorithm of Constructing Highly Fault Tolerantvirtual Backbone to Reduce the Transmission Cost with Damage Loss Uncertainty in Wireless Network

Mengnan Chen, University of Central Florida, 12800 Pegasus Drive, P.O. Box 162993, Orlando, FL, 32816-2993, United States, cmn891127@knights.ucf.edu

We study the problem of constructing virtual backbones in wireless network to reduce the transmission cost and maintain the network when the backbone nodes are damaged, called the virtual backbones for cost reduction and network maintenance (VBRM) problem. The backbone node is the foundation of this routing scheme. This is two level problem modeled by the stochastic programming. Our model can find the optimal solution between guaranteed rates of data delivery within different situation.We also consider to improve energy-efficient of data communications by reducing the transmission cost.

2 - Exact Algorithms for the Minimum Cost Vertex Blocker Clique Problem

Farzaneh Nasirian, University of Massachusetts Boston, 100 William T. Morrissey Blvd, Boston, MA, 02125, United States, Farzaneh.Nasirian001@umb.edu, Foad Mahdavi Pajouh, Josephine Namayanja

This talk addresses the minimum cost vertex blocker clique problem which is to find a minimum cost subset of vertices whose removal bounds the maximum weight of a clique in a network. We propose a new characterization of the set of feasible solutions that results in new linear 0-1 programming formulations solved by lazy-fashioned branch-and-cut algorithms. We also develop the first combinatorial branch-and-bound algorithm for this problem. The computational performance of these exact algorithms is studied on a test-bed of randomly-generated and real-life instances.

3 - Maximum Induced Path in a Graph

Dmytro Matsypura, The University of Sydney, Sydney, 2006, Australia, dmytro.matsypura@sydney.edu.au, Alexander Veremyev, Oleg A.Prokopyev, Eduardo Pasiliao

We consider the problem of finding the maximum induced path in a graph. We develop three conceptually different MIP formulations and study their properties. We develop a number of valid inequalities and various enhancements to the proposed MIPs. We also propose exact iterative algorithms to solve the problems. Finally, we conduct an extensive computational study to evaluate the performance of the proposed algorithms and to reveal the properties of the proposed formulations.

4 - Robust Node Hardening Against Influence Propagation

Colin P. Gillen, University of Pittsburgh, 405 Franklin Avenue, #1, Pittsburgh, PA, 15221, United States, cpg12@pitt.edu

We consider a variation of the classical Linear Threshold model in which the node thresholds are known, but the arc weights (influence) is uncertain. The decision maker wishes to harden a set of nodes, within a limited budget, in order to minimize the spread of influence given a set of seed nodes. NP-hardness of the problem is proved, some polyhedral results are discussed, and solution approaches are presented. Some computational results demonstrating the effectiveness of our algorithms and their enhancements are shown.

■ SC73

372B

Blockchain for Supply Chain and Logistics

Invited: Operations Research and the Future of Computing

Invited Session

Chair: Robin Lougee, IBM Research, Yorktown Heights, NY, 10598, United States, rlougee@us.ibm.com

Co-Chair: Chandra Narayanaswami, IBM Research, NY, United States, chandras@us.ibm.com

1 - The Systemic Adoption of Blockchain with in the Aviation Ecosystem

Robert J. Rencher, The Boeing Company, Seattle, WA, 98008, United States, robert.j.rencher@boeing.com

This presentation is intended to provide to the participants a background on aviation industry supply chain as it exists today, challenges it is facing - in speed, trust, repetitive work, complexity, provenance, disputes, etc. We will discuss the following: 1) Why Blockchain is of interest to the aviation industry. 2) A primer on the state of managing information in the aviation ecosystem. 3) Challenges for Blockchain adoption by the aviation industry and 4) Value propositions blockchain brings to the aviation industry.

2 - Blockchain Technology for Ocean Container Shipping

Jeffrey L. Howard, INTTRA, Parsippany, NJ, 07504, United States, jeff.howard@inttra.com

Jeff Howard, SVP and Chief Product Officer of ocean shipping e-commerce leader INTTRA, will discuss his observations of the use and potential benefits of Blockchain technologies in the ocean shipping industry and logistics. Howard will also share his observations of challenges facing the ocean container shipping industry including complex, multi-party transactions, the need for digitization, issues with trust across transactions and parties, transaction velocity and workflow, as well as the desire to balance transaction confidentiality and security with increased visibility to required workflow milestones.

3 - Introduction to Blockchain Technology and Supply Chain Use Cases

Chandra Narayanaswami, Principal Research Staff Member, IBM.Research, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States, chandras@us.ibm.com

A Permissioned Blockchain provides an immutable, shared ledger that is kept consistent using distributed and resilient consensus protocols, along with inherent provisions for data separation, privacy and security among the participants. Executable smart contracts orchestrate automation and efficiency. Additional analytics offer insights on aspects such as compliance and quality.

Together it provides what is needed for an efficient next generation supply chain, with provable provenance, for ordering, tracking, and maintaining assets and services need to operate in distributed cross-organizational settings where partial lack of trust among organization is common.

■ SC74

372C

Computational Methods in Healthcare

Sponsored: Computing

Sponsored Session

Chair: Amin Khademi, Clemson University, Central, SC, 29630, United States, khademi@clemson.edu

1 - Infectious Disease Modeling in a Meta-Population

Ceyda Yaba, Clemson University, 833 Old Greenville Highway, Apt 614, Clemson, SC, 29630, United States, cyaba@g.clemson.edu, Burak Eksioglu, Amin Khademi

We studied an infectious disease without cure in a meta-population over a geographical region that is divided into subpopulations. Each individual is either susceptible or infected; and the rate of infection is independent for every subpopulation. We model this scenario as a Markov Decision Process, where the actions are defined as the number of people to quarantine in every subpopulation under a capacity constraint for the entire population. We solve this model by Approximate Dynamic Programming approach in which a column generation algorithm is used. The results from the column generation are then compared to a simulation model to offer bounds for the value functions of the Markov Decision Process.

2 - Mitigating Ambiguity in Markov Decision Processes using Multiple Models of Parameters

Lauren N.Steimle, University of Michigan, 3261 Bolgos Circle, Ann Arbor, MI, 48105, United States, steimle@umich.edu, David L. Kaufman, Brian T. Denton

Markov decision processes (MDPs) are a powerful tool for optimizing sequential decision-making under uncertainty. However, the usefulness the resulting policy is often at the mercy of the data used to parameterize the MDP. Often times, the transition probabilities must be estimated from external sources, and it can be unclear which source is most appropriate to use. In this talk, we describe a new method for mitigating the effects of parameter ambiguity by allowing for multiple models of the MDP parameters. We discuss properties of optimal policies, the complexity, and solution methods. We highlight the merits of this approach using a case study in the context of cardiovascular disease management.

3 - Establishing an Optimal IRT Threshold for Cystic Fibrosis

S. Saloumeh Sadeghzadeh, PhD Candidate, Virginia Tech, 428 Harding Ave, Blacksburg, VA, 24060, United States, saloumeh@vt.edu, Ebru Korular Bish, Douglas R. Bish

Cystic Fibrosis (CF) is one of the most prevalent genetic diseases in the United States. Newborn screening for CF allows for early diagnosis, and can substantially improve outcomes. Most first-tier screening for CF in the United States is performed via the IRT test, which measures the level of a CF-related biomarker. However, newborn testing practices for CF that involve the IRT test vary significantly among the states. We determine optimal testing schemes for newborn CF screening. Our case study demonstrates the value of the proposed testing schemes in newborn screening.

4 - Optimal Set of Interventions for Childhood Obesity: Benefit and Cost

Parisa Zahiri, M.Sc., Tehran Azad University, Tehran, Iran, Islamic Republic of, zahiriparisa86@gmail.com

Childhood obesity is a public health crisis in many other countries. The cause of childhood obesity is complex, involving biological, behavioral, psychosocial, demographic, economic, community, and environmental factors. The goal of this project is to create a model to estimate the effect of each intervention on childhood obesity over time considering a broad range of risk factors widely accepted in the literature and adherence. The most cost-effective set of interventions is then investigated.

■ SC75

372D

Global Optimization

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Boris Houska, borish@shanghaitech.edu.cn

Co-Chair: Mario Eduardo Villanueva, PhD, Texas A&M University, College Station, TX, United States, me.villanueva@tamu.edu

1 - Global Optimization based on Edge-Concave Underestimators

M.M. Faruque Hasan, PhD, Texas A&M.University, College Station, TX, United States, hasan@tamu.edu

A new relaxation technique is developed for the deterministic global optimization of twice-differentiable continuous problems. Instead of using a convex underestimator, the relaxation is based on an underestimator which is edge-concave. The underestimator is constructed by subtracting a positive quadratic expression. We use the linear facets of the vertex polyhedral convex envelope of the edge-concave underestimator to obtain a linear programming (LP)-based relaxation of general nonconvex functions. The method will be presented with theoretical results and will be compared with convexification/ underestimation techniques such as BB and its variants through test examples.

2 - Global Optimization of Differential Games

Mario Eduardo Villanueva, Texas A&M.University, Research Parkway, College Station, TX, 77845, United States, me.villanueva@tamu.edu, Xuhui Feng, Boris Houska

This talk presents novel strategies of formulating 2-stage dynamic games in the form of a generalized optimal control problem (OCP) for systems with two control inputs. The first control input is chosen by Player 1. Player 2 plays after Player 1 by choosing the second control input. Both players have to satisfy state- and control constraints or loose the game. In addition, one of the players tries to minimize an objective that is maximized by the other player. First, we discuss differences and similarities to standard robust OCPs. Then, we outline numerical strategies for analyzing and solving dynamic games by using algorithms from the field of set-valued propagation and dynamic global optimization.

3 - Linear Convex Underestimators for Dynamic Systems
Kamil Khan, PhD, McMaster University, Hamilton, ON, Canada, kamilkhan@mcmaster.ca

A new efficient adjoint-based method is presented for computing useful affine underestimators for solutions of parametric ordinary differential equations, to provide bounds to methods for deterministic dynamic global optimization. This method harnesses several recent advances, including a general framework for convex relaxation generation by Tsoukalas and Mitsos, an instance of this framework that yields continuously differentiable relaxations, and a technique by Scott and Barton for describing convex relaxations for ODE systems as solutions of hybrid discrete/continuous systems.

■ SC76

372E

Advances in Learning and Optimization

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Sebastian Pokutta, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, sebastian.pokutta@isye.gatech.edu

Chair: Alfredo Torrico, Georgia Institute of Technology, Atlanta, GA, United States, atorrico3@gatech.edu

1 - Learning Combinatorial Structures
Swati Gupta, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, swatig@mit.edu, Michel X. Goemans, Patrick Jaillet

We study the minimization of separable strictly convex functions over polyhedra. This problem is motivated by online convex optimization methods whose bottleneck relies on the minimization of a (often) separable, convex metric, known as the Bregman divergence. We provide a conceptually simple algorithm, Inc-Fix, in the case of submodular base polyhedra. For cardinality-based submodular polytopes, we show that Inc-Fix can be speeded up to be the state-of-the-art method for minimizing uniform divergences. We show that the running time of Inc-Fix is independent of the convexity parameters of the objective function.

2 - Posterior Sampling for Reinforcement Learning: Worst-case Regret Bounds
Randy Jia, PhD Candidate, Columbia University, New York, NY, United States, rqj2000@columbia.edu, Shipra Agrawal

We present a posterior sampling aka Thompson sampling based algorithm for the reinforcement learning problem. Our main result is a \tilde{O}(D\sqrt{SAT}) bound on the worst-case (minimax) regret of our approach when the underlying unknown Markov Decision Process (MDP) is communicating with a finite diameter D, finite number of states S and actions A. Here, regret compares the total reward achieved by the reinforcement learning algorithm to the total expected reward of an optimal infinite-horizon undiscounted average reward policy, over a finite time horizon T.

3 - Dynamic Data-driven Estimation of Non-parametric Choice Models
Nam Ho-Nguyen, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, hnh@andrew.cmu.edu, Fatma Kilinc-Karzan

We study non-parametric models for consumer choice behaviour. These models were introduced to alleviate unreasonable assumptions and issues of suboptimal model fit/selection present in traditional parametric approaches. We present a simple convex optimization-based framework to efficiently learn a non-parametric choice model from data. Our method enjoys provable convergence guarantees and extends naturally to the dynamic observation model. Each iteration of our method, as well as existing approaches from the literature, requires solving a combinatorial subproblem. We examine this in detail and identify conditions under which it can be efficiently solved.

3 - Dynamic Stochastic Approximation for Multistage Stochastic Optimization
Zhiqiang Zhou, Georgia Institute of Technology, Atlanta, GA, Contact: zzhoubrian@gatech.edu, Guanghui Lan

This paper considers optimizing a multi-stage programing problem with stochastic conic constraints in every stage. We first present a new algorithm, namely Dynamic stochastic approximation (DSA), to handle this optimization problem. We show this algorithm can achieve an optimal rate O(1/\epsilon^4) of convergence in terms of number of random samples when applied to a 3-stage stochastic optimization problem under the assumption that objective function is general convex, and we also show this rate can be improved to O(1/\epsilon^2) when the objective function is strongly convex. Moreover, we present a variant of DSA when applied to an extended multi-stage programming problem..

■ SC77

372F

Novel Approaches in Distributed/Large-scale Optimization

Sponsored: Optimization, Computational Optimization and Software

Sponsored Session

Chair: Ilbin Lee, Georgia Tech, 755 Ferst Dr. NW, Atlanta, GA, 30332, United States, ilee79@gatech.edu

1 - Fast Algorithms for Robust PCA via Gradient Descent
Constantine Caramanis, University of Texas, Mail Code C0806, Austin, TX, 78712-0240, United States, constantine@utexas.edu

Abstract not available.

2 - Computational Sensitivity Analysis for High-Dimensional Linear Programs
Stewart Curry, Georgia Tech, scurry9@gatech.edu

Sensitivity analysis is an integral part of decision-making using optimization modeling. Such analysis is particularly important in situations where the input parameters are uncertain. Global sensitivity analysis estimates the variance of the optimal objective value attributable to each input parameter. However, it relies on solving a given optimization problem for randomly generated data points, and methods for doing so efficiently are not studied. In this talk, we will discuss recent efforts to make global sensitivity analysis more computationally efficient and, in doing so, provide insights into the geometry of parametric linear programs.

3 - Communication-Efficient Decentralized Stochastic Optimization
Soomin Lee, Georgia Tech, 144 Ponce de Leon Avenue NE, Apt 1608, Atlanta, GA, 30308, United States, soomin.lee@isye.gatech.edu, Guanghui Lan, Yi Zhou

Optimization problems arising in decentralized multi-agent systems have gained significant attention combined with privacy preservation and distributed data mining/processing issues. The distributed nature of the problems is inherent due to partial knowledge of the problem data, which necessitates costly communications among neighboring agents. In this talk, we present a new class of decentralized first-order methods for nonsmooth and stochastic optimization problems which can significantly reduce the number of inter-node communications and efficiently solve subproblems through linearizations of their local objective functions.

■ SC78

381A

Data-driven Distributed Optimization and Learning for Modern Power Systems

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30312, United States, andy.sun@isye.gatech.edu

1 - Deep Learning in Power Markets
Joel Macaluso, Texas A&M University, jmacaluso@tamu.edu

In this work, we are interested in exploring deep learning techniques and their application to power markets. Power markets are known for extreme price volatilityand sensitivity to random variables such as weather. Electricity dispatch requires planning ahead while taking into account reliability concerns. In this work we apply deep learning to the task.

2 - A Multi-sensor Feedback Estimator for Forecasting Variability in Local Area Photo-voltaic Power Generation
Jeff Manning, University of Texas at Austin, Austin, TX, United States, jeff.manning@rastrac.com

We propose and investigate the tractability of prediction of surface-driven convective cumulus clouds in a local area by use of a feedback estimator. The estimator senses the spatio-temporal cloud shadow field and uses a Navier-Stokes fluid solution to estimate the surface heating field and ultimately the evolution of the future cloud field which results therefrom. Such clouds have lifetimes ranging from five to thirty minutes, so a predictor must account for cloud evolution in addition to mere horizontal advection. The design is challenged by loss of information due to convective turbulence in the ABL, so we investigate conditions under which the problem may or may not be practically solvable.

3 - Optimal Price Threshold Control for Battery Operation with Aging Phenomenon

Yuhai Hu, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, 18015, United States, yuh212@lehigh.edu, Boris Defourny

This talk is concerned with grid-level battery storage operations, taking battery aging into consideration. Battery operations under price uncertainty are modeled as a Markov Decision Process with expected cumulated discounted rewards. An algorithm that takes advantage of the problem structure and works directly on the continuous state space is developed to maximize the objective over the life of the battery. Computational results are presented to compare the proposed approach to a standard dynamic programming method, and to evaluate the impact of refinements in the battery model. Error bounds for the proposed algorithm are established to demonstrate its accuracy.

4 - Load Scheduling for Residential Demand Response on Smart Grids

Luce Brotcorne, INRIA, Lille, 59000, France, luce.brotcorne@inria.fr, Miguel Anjos, Martine Labbé, Maria Restrepo

We present a mixed integer linear program for a load scheduling problem in the context of residential demand response. The model schedules the operation time and power consumption level of each load and controls the use of energy storage devices to minimize the total energy cost and manage peak in power consumptions. Numerical results show that electricity cost savings and reductions in power peak consumptions can be achieved by shifting demands and using efficiently the battery.

■ SC78B

380B

Data Envelopment Analysis

Contributed Session

Chair: Erhan Berk, National Defence University, Hava Harp Okulu Komutanligi Yesilyurt, Istsnbul, 34149, Turkey, eberk@hho.edu.tr

1 - University Selection for Masters Degree with Data Envelopment Analysis and Analytical Hierarchy Process

Xiaojun (Gene) Shan, University of Houston-Clear Lake, Houston, TX, United States, shan@uhcl.edu, Mukesh Dachapally

Efficiency of 20 similar U.S. universities were evaluated using data envelopment analysis (DEA) and analytical hierarchy process (AHP). The inputs for DEA are tuition fees, Student to faculty ratio and number of research-only faculty while the outputs are graduation rate, freshman retention rate and number of publications. Then, AHP was applied to identify the best university for master's degree. 64 participants participated in a survey to identify criteria. The five criteria are tuition fee, University global ranking, weather, scholarship and Career opportunities. This study found Binghamton University as the most efficient university.

2 - A Research on Energy Efficiency under Dual Mechanisms of Inter-provincial Trade and R&D Investment in China

Rui Wang, Tongji University, Shanghai, China, 2822930768@qq.com, Dajian Zhu

Market segmentation is the backward areas' trade protection behavior of not participating in cooperation and work division in order to obtain technical progress in high technology industry, but it causes the efficiency loss of resources allocation. Based on the panel data of Chinese 30 provinces from 2003 and 2014, this paper uses the SFA model contracted with joint estimation of technical inefficiency and influencing factors to investigate the influence of Chinese provincial trade and its work with different levels of R&D activities on energy efficiency, we find that these R&D activities play heterogeneous roles in different forms of inter-provincial trade's improvement of energy efficiency.

3 - A Predictive Model for Estimating the Generation of Solar PVS and Wind Turbines with Various Predictors within the United States

Narjes Nouri, PhD Student, University of Wisconsin-Milwaukee, Milwaukee, WI, 53211, United States, nourin@uwm.edu, Mohammad Hasan Balali

Development in PV panels and wind turbines technologies and growing number of operable solar and wind farms made these two renewable sources best potentials for traditional sources in the last decades.There are various types of parameters which affect the installed capacity of these sources. There are many articles which studied the impact of environmental parameters such as wind speed and air temperature on the renewable energy generation. On the other hand, there are social parameters which have indirect effects that might not be as evident as environmental parameters. In this study, a regression model has been presented between renewable energy generation and some selected social parameters.

4 - A Two Stage Data Envelopment Analysis Model for the Efficiency Assessments of 39 State's Wind Power in the United States

Umit Saglam, Assistant Professor, East Tennessee State University, Department of Management and Marketing, P.O. Box 70625, Johnson City, TN, 37614, United States, saglam@etsu.edu

Wind power is the second largest renewable energy source to generate electricity in the United States. Therefore, in this study, a two-stage Data Envelopment Analysis (DEA) is developed to quantitatively evaluate the relative efficiencies of the 39 state's wind power performances for the electricity generation. Both input- and output-oriented CCR and BCC models are applied to pre-determined four input and six output variables. The sensitivity analysis is conducted to test the robustness of the DEA models. Tobit regression models are conducted by using the DEA results for the second stage analysis. The DEA results indicate that more than half of the states operate wind power efficiently.

5 - Using Data Envelopment Analysis Approach to Analyze the Impacts of Technical Efficiency in Turkey

Erhan Berk, National Defence University, Hava Harp Okulu Komutanligi Yesilyurt, Istanbul, 34149, Turkey, eberk@hho.edu.tr

This study aimed to measure the technical efficiency of healthcare centers in Turkey by size and to identify the possible factors affecting their technical inefficiency. In the first stage, an input oriented data envelopment analysis was adopted to compute the technical efficiency scores for three types of healthcare centers by two DEA models. In the second stage, in order to classify the healthcare centers for which the assessment values equal to 1, the super efficiency model was used for further sorting to determine the factors that affect technical inefficiency of the healthcare centers. The study revealed that the average technical efficiency score of healthcare centers was 64%.

■ SC79

381B

Stability-constrained Optimal Operation of Electric Power Systems

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30312, United States, andy.sun@isye.gatech.edu

1 - Design, Stability and Control of Ad-hoc Microgrids

Konstantin Turitsyn, Massachusetts Institute of Technology, Cambridge, MA, United States, turitsyn@mit.edu, Kathleen Cavanagh, Petr Vorobev

Low voltage microgrids is a promising technology for bringing power to about 1 billion of people living in non-electrified regions. Modern planning and operation practices cannot be easily downscaled to these microgrids. This talk will introduce a concept of ad hoc microgrid that remain stable for arbitrary interconnection topologies. After discussing the main destabilization mechanisms related to large gain droops, constant power loads and inductive delays in lines, we will develop a systematic theory for derivation of design constraints that guarantee stability for arbitrary topologies. The nature of worst case scenarios and conservativeness of the constraints will be discussed in the end.

2 - A New Voltage Stability-constrained Optimal Power Flow Model: Sufficient Condition, SOCP Representation, and Relaxation

Bai Cui, Georgia Tech, Atlanta, GA, United States, bcui7@gatech.edu

Simple characterization of the solvability of power flow equations is of great importance in the monitoring, control, and protection of power systems. In this presentation, we introduce a sufficient condition for power flow Jacobian nonsingularity. We show that this condition is second-order conic representable when load powers are fixed. Through the incorporation of the condition, we propose a voltage stability-constrained optimal power flow formulation as a second-order cone program. An approximate model is introduced to improve the scalability of the formulation to larger systems. Extensive computation results on standard instances confirm the effectiveness of the formulation.

3 - Necessary and Sufficient Conditions for Voltage Stability in Homogeneous Balanced Radial Networks

Enrique Mallada, Johns Hopkins University, Baltimore, MD, United States, Mallada@jhu.edu, Krishnamurthy Dvijotham, John Simpson-Porco

Voltage stability is a critical constraint for the safe operation of power systems. However, enforcing voltage stability in power flow optimization problems is quite challenging due to the implicit nature of the stability constraint. We derive necessary and sufficient conditions on the power injections for the existence of a voltage stable power flow solution in radial distribution networks with homogeneous lines. We further show that the solution satisfies several desirable properties (unique high-voltage solution and voltage-regularity). We use this formulation to show that robust ACOPF in power distribution networks can be solved exactly via a convex relaxation under natural assumptions.

■ SC80

381C

Energy System Optimization

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Kai Pan, University of Florida, Gainesville, FL, 32611, United States, kpan@ufl.edu

1 - Design and Dispatch Optimization of a Solid-oxide Fuel Cell Assembly for Unconventional Oil and Gas Production

Alexandra M. Newman, Colorado School of Mines, 1500 Illinois St, Golden, CO, 80401, United States, anewman@mines.edu, Gladys Anyenya, Neal Sullivan, Robert Braun

We present a multi-objective design and dispatch optimization model of a solid-oxide fuel cell (SOFC) assembly for unconventional oil and gas production. Heat produced by SOFCs during electricity generation is used to pyrolyze kerogen into a mixture of oil, hydrocarbon gas and carbon-rich shale coke. The Geothermic Fuel Cell (GFC) system costs, heating and electrical efficiencies are optimized, subject to geology heating demands, auxiliary component electric power demands and the GFC system performance characteristics. The resulting optimal cost of oil and gas produced using the GFC technology is about $39/bbl which is comparable to that from other unconventional oil extraction techniques.

2 - The Community Microgrid Distribution System of the Future

Lei Wu, Clarkson University, 8 Clarkson Avenue, P.O. Box 5720, Potsdam, NY, 13676, United States, lwu@clarkson.edu

Community microgrids (CMG) connect critical loads and distributed energy resources of multiple owners for providing reliable and resilient electricity services through distribution lines owned by a local power utility company. Thus, different from current single-owner microgrids, CMGs present significant new design goals, operating constraints, and business models. This presentation discusses key characteristics, identifies operation challenges, and proposes potential solution methodologies for the operation and control of the future CMGs. A practical community resilience microgrid that is underway for serving Potsdam, NY will also be discussed.

3 - Pricing Electricity Considering Non-convexity and Uncertainty in the Day-ahead Pool Market

Jianhui Wang, Southern Methodist University, Dallas, TX, United States, jianhui@smu.edu

Jianhui Wang, Argonne National Laboratory, Argonne, IL, United States, jianhui@smu.edu

A new market clearing mechanism for the day-ahead market is proposed in this paper, which considers both the non-convexity caused by the unit commitment decisions, and the uncertainty of real-time operation. By applying this method, sufficient flexibility can be reserved through proper commitment decisions. Meanwhile, every dispatched unit is guaranteed for adequate revenue to recover costs without additional side payments. A primal-dual approach associated with specific revenue adequacy rules is applied to formulate the problem.

4 - Optimization of Food and Biofuel Production with Economic and Environmental Impacts

Halil Cobuloglu, Senior Analytics Fellow, McKinsey & Company, 404 wyman st Suite 300, Boston, MA, 02451, United States, halil.cobuloglu@gmail.com, Esra Buyuktahtakin

Biofuel production from food crops leads to debates about the security of the food supply while biofuels offer positive environmental impacts. To solve this trade-off, we propose a multi-objective mixed-integer optimization model to investigate the economic and environmental impacts of biofuel and food production using switchgrass and corn. This model provides optimal decisions regarding land allocations to food and energy crops, seeding time, harvesting time and amount, and budget allocations to farm operations. Finally, we present a two-stage MIP model that maximizes the economic and environmental benefits of food and biofuel production.

■ SC81

382A

Approximate Dynamic Programming for Stochastic Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Selvaprabu Nadarajah, College of Business, University of Illinois at Chicago, College of Business, University of Illinois at Chi, Chicago, IL, 60607, United States, selvan@uic.edu

1 - Dynamic Matching of Workers to Jobs with Learning Curves

Daniel Adelman, University of Chicago, Booth School of Business, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States, dan.adelman@chicagobooth.edu, Adam J. Mersereau

We consider the dynamic assignment of multiple workers to multiple classes of jobs. Workers are heterogeneous and become more effective at a job class with experience, and therefore the scheduler faces a tradeoff between matching workers with familiar jobs to minimize short-term cost versus matching workers with unfamiliar jobs to build expertise. A deterministic version of the problem has distinct structure that we leverage to derive price-directed approximations to stochastic versions featuring randomly arriving workers and jobs.

2 - Learning Symmetries for Faster Reinforcement Learning

Theja Tulabandhula, UIC, Chicago, IL, 60607, United States, tt@theja.org, Anuj Mahajan

We explore methods to exploit symmetries for achieving sample efficiency in reinforcement learning. This problem is motivated by recent advances in the use of deep networks for complex tasks that end up requiring large amounts of training data. We propose a method for detecting symmetries using reward trails observed during episodic experiences and provide a framework for incorporating these discovered symmetries in functional approximation based architectures. Finally we show that the use of potential based reward shaping is especially effective for our symmetry exploitation mechanism. Experiments show that our methods improve performance significantly when symmetry is exploited.

3 - Approximations to Stochastic Dynamic Programs via Information Relaxation Duality

David Brown, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708, United States, dbbrown@duke.edu, Santiago Balseiro

A common technique in the analysis of stochastic systems is the use of "hindsight bounds," in which decisions are made after all uncertainties are revealed. In some applications, however, hindsight bounds may lead to very weak performance guarantees. We show how to obtain stronger guarantees by incorporating penalties that punish the use of additional information, and demonstrate the technique on several applications, including stochastic knapsack problems.

4 - Revisiting Approximate Linear Programming using Root Finding and First Order Methods

Selvaprabu Nadarajah, College of Business, University of Illinois at Chicago, 601 South Morgan Street,, U. H.2406, Chicago, IL, 60607, United States, selvan@uic.edu, Qihang Lin, Negar Soheili Azad

Approximate linear programs (ALPs) are well-known models for approximating high dimensional Markov decision processes (MDPs). Solving ALPs exactly remains challenging, for instance, in applications where (i) the MDP includes nonlinear reward and transition dynamics and/or (ii) rich basis functions are required to obtain a good VFA. We address this tension between ALP theory and solvability by proposing a novel ALP reformulation and solution approach that combines root finding and first order methods. We present convergence guarantees for our approach and test it on inventory control and energy storage applications.

■ SC82

382B

New Paradigms in Optimization Under Uncertainty

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Grani Adiwena Hanasusanto, The University of Texas at Austin, ETC 5.120, Austin, TX, 78712, United States, grani.hanasusanto@utexas.edu

1 - "Dice"-sion Making under Uncertainty: When can a Random Decision Reduce Risk?

Erick Delage, HEC Montreal, 3000 Ch de la Cote-Sainte-Catherine, Montreal, QC, H3T.2A7, Canada, erick.delage@hec.ca, Daniel Kuhn, Wolfram Wieseman

Consider an Ellsberg experiment in which one can win by calling the color (red or blue) of the ball that will be drawn from an urn in which the balls are of unknown proportions. It is well known (yet rarely advertised) that selecting the color based on a fair sided coin completely eradicates the ambiguity about the odds of winning. In this talk, we explore what are conditions under which a decision maker that employs a risk measure should have his action depend on the outcome of an independent random device. Surprisingly, we show that for any ambiguity averse risk measure there always exists a decision problem in which a randomized decision strictly dominates all deterministic decisions.

2 - Value of Randomization in Distributionally Robust Facility Location Problems

Ahmed Saif, University of Waterloo, 1095 Whetherfield St., Unit 39, London, ON, N6H0B6, Canada, ansaif1976@yahoo.com, Delage Erick

We study two classical facility location problems with distributional ambiguity and provide data-driven tractable reformulations that use a finite number of sample points: An UFLP with a Wasserstein-metric-based ambiguity set and a nonlinear location-inventory problem with a moment-based ambiguity set. We also study the potential benefit of randomization in MIP problems, prove that for a minimax problem, the solution of the corresponding maximin problem provides an upper bound on the value of randomization and identify the conditions under which this bound is tight. Finally, we devise and implement an efficient column-generation algorithm for facility location problems with randomization.

3 - Robust Optimization under Endogenous Uncertainty

Nikolaos Lappas, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, nlappas@andrew.cmu.edu, Anirudh Subramanyam, Chrysanthos E. Gounaris

When applying Robust Optimization (RO) in settings that feature uncertainty of endogenous nature, one needs to capture functional changes in parameter correlations induced by the decision-maker's policies as well as eradicate conservatism e ects from parameters that become irrelevant in view of the optimal decisions. To that end, we introduce generic decision-dependent polyhedral uncertainty sets, and we derive the corresponding RO counterpart models as well as discuss a number of relevant algorithmic considerations. We demonstrate the versatility of our proposed sets via a number of case studies stemming from a wide range of applications.

4 - Robust Quadratically Constrained Quadratic Programming

Can Gokalp, University of Texas, Austin, TX, United States, cangokalp@utexas.edu, Grani Adiwena Hanasusanto

We study robust convex QCQPs where the uncertain problem parameters can contain both continuous and integer components. Under the natural boundedness assumption on the uncertainty set, we show that the generic problems are amenable to exact copositive programming reformulations. The emerging convex optimization problems are NP-hard but admit a conservative SDP approximation that can be solved efficiently. We prove that this approximation is stronger than the state-of-the-art approximate S-lemma scheme and demonstrate its effectiveness on a wide spectrum of computational experiments.

■ SC83

382C

Statistics- and Information-based Approaches to Stochastic Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Saumya Sinha, University of Washington, University of Washington, Seattle, WA, 98105, United States, saumya@uw.edu

1 - A Bayesian Risk Approach to Data-Driven Stochastic Optimization

Di Wu, Georgia Institute of Technology, 1995 Defoor Ave NW, Apt C, Atlanta, GA, 30318, United States, woody10074026@gmail.com, Enlu Zhou, Helin Zhu

A large class of stochastic programs involve optimizing an expectation taken with respect to some underlying distribution that is unknown in practice. When data is available, a popular way to deal with such uncertainty is via distributionally robust optimization, which usually aims to hedge against the worst case over an ambiguity set. To explore the middle ground between completely ignoring the distributional uncertainty and optimizing over the worst case, we propose a Bayesian risk approach for parametric underlying distributions, which is to optimize a risk measure taken with respect to the posterior distribution of the unknown distribution parameter.

2 - Monte Carlo Tree Search with Sampled Information Relaxation Dual Bounds

Daniel Jiang, University of Pittsburgh, 1002 Benedum Hall, 3700 O'Hara Street, Pittsburgh, PA, 15261, United States, drjiang@pitt.edu, Lina Al-Kanj, Warren B.Powell

MCTS is a well-known strategy for solving sequential decision problems, particularly in the area of game-play AI. We propose a new technique called Primal-Dual MCTS that utilizes sampled information relaxation (Brown et. al., 2010) bounds on potential actions in order to make tree expansion decisions. The approach shows promise when used to optimize the behavior of a driver navigating a graph while operating on a ride-sharing platform.

3 - Robust Countable-state Markov Decision Processes

Saumya Sinha, University of Washington, 5204 15th Avenue NE, Apt 101, Seattle, WA, 98105, United States, saumya@uw.edu, Archis Ghate

Robust optimization is a technique used to account for parameter uncertainty in stochastic optimization and has been applied extensively to the study of Markov decision processes (MDPs). For the countable-state case, however, the existing theoretical and algorithmic results are limited. In this talk, we will discuss theory as well as convergent solution-methods for countable-state robust MDPs.

4 - Probably Approximately Correct (PAC) Selection in Simulation/Best-Arm Problems

David J.Eckman, Cornell University, 118 Compton Rd, Ithaca, NY, 14850, United States, dje88@cornell.edu, Shane Henderson

For the problem of selecting the best from a set of simulated alternatives, the multi-armed bandit and simulation communities concentrate on two contrasting fixed-confidence guarantees. Best-arm identification procedures often guarantee selecting a near-optimal arm, i.e., probably approximately correct (PAC) selection, while ranking-and-selection procedures commonly guarantee the probability of correct selection (PCS) under the indifference-zone formulation. We discuss why PAC selection guarantees are superior and present conditions under which procedures with PCS guarantees under the indifference-zone formulation simultaneously deliver PAC selection guarantees.

Sunday, 3:10 - 4:00PM

■ Sunday Plenary

GBCC- General Assembly B, Level 3

Sports Scheduling Meets Business Analytics

Plenary

Invited Session

1 - Sports Scheduling Meets Business Analytics

Mike Trick, Carnegie Mellon University in Qatar

Over the last 20 years, the ability of operations research techniques to create practical sports schedules has increased tremendously. Some of this increased ability is due to faster computers and better underlying optimization software. Increased understanding of the unique aspects of sports scheduling optimization has also played a role. This is allowing the integration of predictive and prescriptive analytics resulting in schedules that are not just playable but are also profitable.

Sunday, 4:30 - 6:00PM

■ SD01

310A

Developments in Utility Theory

Sponsored: Decision Analysis

Sponsored Session

Chair: Ying He, University of Southern Denmark, Odense, M, 5230, Denmark, yinghe@sam.sdu.dk

1 - Multiattribute Utility with Bounded Tradeoffs

Ilia Tsetlin, INSEAD, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, ilia.tsetlin@insead.edu, Alfred Müller, Marco Scarsini, Robert L. Winkler

Suppose that, in a multiattribute setting, more of an attribute is preferred to less and states that some of the tradeoffs are bounded - e.g., both high sales and high profit are good, and one is willing to trade a particular number of units of sales for one unit of profit. We establish the form of a multiattribute utility function satisfying pre-specified bounds on the tradeoffs. Then we relate the tradeoff bounds to other preference conditions, such as the one-switch property, preferences for combining good with bad and stochastic dominance. One relevant context is the one of time preferences, where "more is better and "earlier is better" and there is also some bound on period-to-period discount rate.

2 - Foundations of Discounted Satiation
Manel Baucells, PhD, Darden School of Business, University of Virginia, 100 Darden Blvd, Charlottesville, VA, United States, BaucellsM@darden.virginia.edu

We provide axiomatic foundations for a representation of preferences that relaxes the time separability axiom of discounted utility. Our goal is to account for diminishing marginal utility in a dynamic setting where recent past consumption decreases the marginal utility of current consumption. We clarify the relationships between satiation, durability and time-separable preference, and offer an analytical characterization of the optimal consumption profile that maximizes satiation preferences.

3 - Range Dependent Utility for Risk and Time
Manuel Baucells, Darden School of Business, University of Virginian, Charlottesville, VA, United States, BaucellsM@darden.virginia.edu

We propose Frame Dependent Utility, a behavioral model to evaluate risky prospects, possibly with temporal delay. Frame dependent utility is able to explain the most robust anomalies (four-fold pattern, common ratio and common consequence, hyperbolic discounting, and the magnitude effect), as well as the preference reversal phenomenon which has eluded many descriptive theories of decision making. The model is simpler to use than cumulative prospect theory because it does not require sorting outcomes from highest to lowest.

4 - Revisiting Ellsberg and Machina's Paradoxes: A Two-Stage Evaluation Model under Ambiguity
Ying He, University of Southern Denmark, Campusvej 55, Odense, M, 5230, Denmark, yinghe@sam.sdu.dk

We revisit the Ellsberg paradox by showing that the preferences satisfy the independence axiom. Such an observation motivates us to develop a two-stage evaluation model under ambiguity. Events in state space are classified into ambiguous and risky events. We define a special type of risky event as hedge. In our model, a conditional subjective expected utility (SEU) on each hedge is nested into an SEU to represent preferences over acts. We show that our two-stage model can not only accommodate preferences in different Ellsberg's paradoxes but also the preferences in paradoxes in Machina (2009) and Machina (2014) that challenge the validity of many existing models for decision making under ambiguity.

■ SD02

310B

Data-Driven Bayesian Modeling

Sponsored: Decision Analysis

Sponsored Session

Chair: Debarun Bhattacharjya, IBM, T J Watson Research, Yorktown Heights, NY, 12, United States, debarun@us.ibm.com

Co-Chair: Hiba Baroud, Vanderbilt University, Nashville, TN, 37240, United States, hiba.baroud@vanderbilt.edu

1 - Design Optimization for Resilience for Risk-averse Firms
Ramin Giahi, Iowa State University, Ames, IA, United States, rgiahi@iastate.edu, Cameron MacKenzie

Engineered systems can face various adverse conditions during their lifetime. Designers should try to design systems that are resilient to these conditions. This research quantifies the resilience of an engineered system under time-dependent adverse conditions by simulating the degradation and recovery of the system's components. The firm incorporates the future conditions under which the system operates into a risk-averse utility function or via a value-at-risk measure. Since the optimization model requires a complex simulation to evaluate the objective function, we use Bayesian Optimization, in conjunction with the ranking and selection method, to optimize the design of the system.

2 - Bayesian Decision-making of Smart Systems under Uncertainty
Saideep Nannapaneni, Vanderbilt University, Nashville, TN, United States, saideep.nannapaneni@vanderbilt.edu, Abhishek Dubey, Sankaran Mahadevan

This talk discusses a model-based framework for the quantification of multiple uncertainty sources affecting the performance of a smart system. With strong feedback coupling between the subsystems of a smart system (plant, cyber, actuation, sensors), the uncertainty in the system output amplifies over time. The coupling occurs at two levels: (1) coupling between individual subsystems, and (2) coupling between computational nodes. The coupled smart system is decoupled and considered as a feed-forward system over time and modeled using a two-level Dynamic Bayesian Network; one at each level of coupling. The proposed methodology is demonstrated for the design of a smart infrastructure system.

3 - Hierarchical Bayesian Modeling of Infrastructure Network Recovery
Mackenzie G. Whitman, Graduate Research Assistant, Vanderbilt University, Nashville, TN, 37203, United States, mackenzie.g.whitman@vanderbilt.edu, Hiba Baroud

Risk managers are interested in measuring and improving the ability of critical infrastructure systems to withstand and recover from disruptions which constitutes to the system's resilience. This work utilizes hierarchical Bayesian methods to assess the recovery rate of network components using multiple data sources to estimate recovery parameters, offering probabilistic instead of deterministic outcomes to better account for uncertainty. We apply this method to three interdependent infrastructure systems that represent the water, electric, and gas distribution networks for Shelby County, Tennessee.

4 - Event Sequence Models for Scenario Recommendations
Debarun Bhattacharjya, IBM.TJ.Watson Research Center, 501 East 78th Street, Apt. 2A, New York, NY, 10075, United States, debarunb@us.ibm.com, Nicholas Mattei

Predicting the future is a ubiquitous human endeavor, practiced from antiquity to modern professions including business, finance and intelligence analysis. Our intent is to build systems that can support long-term predictions using knowledge generalized from the past and learned from a variety of sources including historical event datasets. In this talk, I will present some ongoing work on models for predicting future event sequences. The emphasis will primarily be on probabilistic models for prediction, but I will also discuss other approaches such as prediction by analogy.

■ SD03

310C

Metabolic Networks and Modern Research Problems in Operations Research

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, 77204, United States, jopeng@Central.uh.edu

Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Metabolic Networks and Modern Research Problems in Operations Research
J. Paul Brooks, Virginia Commonwealth University, Dept of Stat. Science and OR, P.O. Box 843083, Richmond, VA, 23284, United States, jpbrooks@vcu.edu, Allen Holder

Biochemical reactions that sustain life are modeled as a system of differential equations, forming a metabolic network. These nonlinear systems curtail into linear, algebraic systems under asymptotic assumptions, which thus define the feasible flux states of a cell in equilibrium. An optimization problem is then imposed to further identify metabolic conditions in an optimal growth situation. The result is a linear programming (LP) technique called Flux Balance Analysis (FBA), and the primary goal of this tutorial is to illustrate several modern research questions about FBA that are compliant with operations research. We pose several open avenues for research that touch LP, mixed-integer programming (MIP), nonlinear programming, combinatorial optimization, optimization under uncertainty, and robust optimization.

■ SD03A

Grand Ballroom A

Stochastic Dynamics on Networks and Graphs

Sponsored: Applied Probability

Sponsored Session

Chair: Kavita Ramanan, Brown University, Providence, RI, 02912, United States, kavita_ramanan@brown.edu

1 - High Frequency Trading and Limit Order Book Dynamics: from Point Processes to Stochastic Pdes
Rama Cont, Imperial College London, London, SW7 2AZ, United Kingdom, Rama.Cont@imperial.ac.uk

The advent of high frequency electronic trading has lead to a heterogeneous market landscape where algorithms at different trading frequencies interact through the limit order book, whose evolution summarizes the dynamics of supply, demand and price. We show that the dynamics of the limit order book may be described by a stochastic partial differential equation (SPDE), obtained as scaling limit of a queueing model with high and low frequency traders. The dynamics of bid/ask prices is endogenous and derived from the dynamics of order flow. We exhibit an analytically tractable class of solution and show that they reproduce empirical features of limit order book profiles and price dynamics.

2 - Weakly Interacting Particle Systems on Inhomogeneous Random Graphs
Ruoyu Wu, Brown University, 182 George Street, Providence, RI, 02912, United States, ruoyu_wu@brown.edu, Shankar Bhamidi, Amarjit Budhiraja

We consider weakly interacting diffusions on time varying random graphs. The system consists of a large number of nodes in which the state of each node is governed by a diffusion process that is influenced by the neighboring nodes. The collection of neighbors of a given node changes dynamically over time and is determined through a time evolving inhomogeneous random graph process. A law of large numbers and a propagation of chaos result is established for a multi-type population setting, in which the edge probability is allowed to decay to 0 as the size of the system grows. A central limit theorem is established for the single-type population case under stronger conditions on the edge probability function.

3 - Ranking on Inhomogeneous Directed Random Graphs
Mariana Olvera-Cravioto, Visiting Associate Professor, University of California, Berkeley, 4125 Etcheverry Hall, Berkeley, CA, 94720, United States, molvera@berkeley.edu

We present results for a broad family of inhomogeneous directed random graphs which includes as special cases directed versions of the Erdos-Renyi, Chung-Lu, and Norros-Reittu models, among others. We discuss how they can be used to model scale-free directed complex networks, e.g., the web graph, Twitter, ResearchGate, and establish their basic connectivity structure. We then show how recent results for Google's PageRank algorithm extend to this new family of random graphs, and how this provides a more natural way to model the relationship between highly ranked nodes and their attributes. We also discuss new insights on the influence of in-degree/out-degree correlations on ranking results.

4 - Metastability of Queuing Networks with Mobile Servers
Francois Baccelli, University of Texas, Austin, TX, United States, Baccelli@math,utexas.edu

We study symmetric queuing networks with moving servers and FIFO service discipline. The mean-field limit dynamics demonstrates unexpected behavior which we attribute to the meta-stability phenomenon. Large enough finite symmetric networks on regular graphs are proved to be transient for arbitrarily small inflow rates. However, the limiting non-linear Markov process possesses at least two stationary solutions. The proof of transience is based on martingale techniques.

■ SD03B

Grand Ballroom B

Emerging Topics in Pricing and Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Pnina Feldman, University of California-Berkeley, Berkeley, CA, 94720, United States, feldman@haas.berkeley.edu

1 - Social Learning and the Design of New Experience Goods
Ella Segev, Ben-Gurion University of the Negev, Beer Sheva, 84105, Israel, ellasgv@bgu.ac.il, Pnina Feldman

Consumers often consult the reviews of their peers before deciding whether to purchase a new experience good; however, their initial quality expectations are typically set by the product's observable attributes. In this talk we discuss the implications of social learning for a monopolist firm's choice of product design.

2 - Loyalty Program Liabilities and Point Values
Nikolaos Trichakis, MIT, 100 Main Street, E62-576, Cambridge, MA, 02143, United States, ntrichakis@mit.edu, So Yeon Chun, Dan Andrei Iancu

A loyalty program (LP) introduces a new currency, the points, through which customers transact with a firm. Such points constitute a promise for future service, and therefore count as liabilities on the firm's balance sheet. Since the value of points is controlled by the firm, this introduces subtle channels through which decisions affect profitability. We study the problem of setting the monetary value of loyalty points in view of these liabilities. We show that the value of points can be thought of as inventory, and optimal policies set this value, and the associated liability, to reach "base-stock" targets.

3 - Dynamic Pricing under Debt: Spiraling Distortions and Efficiency Losses
Dan Andrei Iancu, Stanford University, 655 Knight Way, Stanford, CA, 94107, United States, daniancu@stanford.edu, Omar Besbes, Nikolaos Trichakis

Firms often finance their inventories through debt. The pricing of products is consequently driven by both inventory and debt servicing considerations. We show that limited liability under debt induces sellers to charge higher prices and to discount products at a lower pace. We find that these distortions result in revenue losses that compound over time, leading to some form of performance spiral down. We quantify the extent to which these inefficiencies can be mitigated by practical debt contract terms that emerge as natural remedies from our analysis, and find debt amortization or financial covenants to be the most effective, followed by debt relief and early repayment options.

4 - The Revenue Impact of Dynamic Pricing Policies on Major League Baseball Ticket Sales
Joseph Xu, Carnegie Mellon University, Pittsburgh, PA, United States, jiaqixu@andrew.cmu.edu, Peter Fadet, Senthil Veeraraghavan

We study the implementation of multiproduct dynamic pricing by a Major League Baseball franchise for single game tickets. We develop a customer choice model to help design dynamic pricing policies for the franchise. Our model encompasses relevant aspects of customer demand generation process, including ticket quantity and seat section choice. Furthermore, our demand model incorporates external factors that drive the overall sport ticket price sensitivity such as the home team's on-field performance, as well as the correlation between customers' arrival timing and product choice. Our counterfactual results show potential revenue improvement of up to 17.2% through dynamic pricing.

■ SD03C

Grand Ballroom C

Aligning Operational and Marketing/Financial Incentives

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Panos Kouvelis, Washington University in St. Louis, Saint Louis, MO, 63130-4899, United States, kouvelis@wustl.edu

Co-Chair: Duo Shi, Olin Business School, Washington University-St Louis, Olin Business School, St. Louis, MO, 63130, United States, dshi@wustl.edu

1 - Co-opetition in Service Clusters with Waiting-area Entertainment
Tinglong Dai, Johns Hopkins University, 100 International Dr, Baltimore, MD, 21202, United States, dai@jhu.edu, Gongtao Lucy Chen, Srinagesh Gavirneni, Xuchuan Yuan

Unoccupied waiting feels longer than it actually is. Service providers operationalize this psychological principle by offering entertainment options in waiting areas. In a service cluster with a shared waiting space, firms have an opportunity to cooperate in the investment for providing entertainment options. In this paper, we model co-opetition in a service cluster with shared entertainment options for waiting customers. We show that as much as co-opetition facilitates resource sharing in a service cluster, it also heightens price competition. Furthermore, as the intensity of price competition increases, service providers may opt to charge higher service fees.

2 - Who Compensates the Sales Agent?
Duo Shi, Olin Business School, Washington University-St Louis, K.H.401, Olin Business School, 1 Brookings Drive, St. Louis, MO, 63130, United States, dshi@wustl.edu, Panos Kouvelis

We analytically study a value chain consisting of three segments: a manufacturer, a retailer, and a sales agent. Five distinct value-chain structures are considered: an integrated value chain, an integrated distribution channel (the manufacturer and the retailer) compensating the sales agent, non-integrated channels with the manufacturer compensating the sales agent, with the retailer compensating the sales agent, and with joint compensation. We compare the strategic implications across all these value-chain structures.

3 - The Effects of International Tax Policy on Firms Production Outsourcing Strategies
Yixuan Liu, The University of Texas at Austin, yixuan.liu@utexas.edu, Guoming Lai, Wenqiang Xiao

We study the effects of international tax policy on firms' production outsourcing strategies. We find that the U.S. tax deferral system may result in subtle changes of a firm's strategy with international tax disparity. Our analysis shows that besides the general concern of income shifting, tax considerations can further lead to operational distortions. We then discuss the implications of a frequently raised tax reform proposal that suggests prohibiting tax deferral but lowering the home country tax rate. We find that there can exist a win-win tax rate region from a specific firm's and the stakeholders' perspectives.

■ SD04

320A

Emerging Topics in Responsible Operations

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Jayashankar M. Swaminathan, University of North Carolina, University of North Carolina, Chapel Hill, NC, 27599-3490, United States, msj@unc.edu

1 - Improving Supplier Compliance through Joint and Shared Audits with Collective Penalty

Prashant Chintapalli, University of California, Los Angeles, Anderson School of Management, 11000 Weyburn Drive, Apt# 419, Los Angeles, CA, 90024, United States, prashant.chintapalli.1@anderson.ucla.edu, Felipe Caro, Kumar Rajaram, Chris Tang

When suppliers fail to comply with safety regulations, buyers improve supplier compliance by auditing and imposing penalties. We analyze three audit mechanisms namely, independent, joint, and shared mechanisms. While in independent audit the buyers audit the supplier individually, in joint audit they audit jointly and share the audit cost. In shared audit they audit individually but share the information. We compare the three mechanisms in terms of audit levels, compliance levels, and the profits of the buyers, the supplier and the supply chain. We identify the cases when joint audit can improve supply chain profit so that both the buyers and the supplier can benefit from joint audits.

2 - Cover-up of Safety Hazards in Product Recalls

Woonam Hwang, HEC Paris, Jouy-en-Josas, 78350, France, hwang@hec.fr, Soo-Haeng Cho, Victor DeMiguel

Product safety regulators often have to rely on manufacturers' voluntary disclosure of information when investigating product defects. However, manufacturers may not always truthfully report all safety hazard information. In this paper, we investigate how regulators can induce manufacturers to truthfully report any safety issues in a timely manner. Specifically, we examine the different regulatory policies employed in the automotive industry in the U.S. and the U.K., and compare their effects in inducing truthful reports from manufactures and the resulting social welfare.

3 - Optimal Seeding Policy under Rainfall Uncertainty

Ying Zhang, University of North Carolina, Chapel Hill, NC, 27599, United States, ying_zhang@kenan-flagler.unc.edu, Jayashankar M. Swaminathan

In this paper, we develop a model to determine the optimal seeding policy under rainfall uncertainty using a finite-horizon stochastic dynamic program. In our model, a farmer needs to decide the amount of seeds to plant in each period given the soil moisture. We show that the optimal planting policy is a time dependent threshold-type policy. Utilizing field weather data from Southern Africa, we investigate the impact of climate conditions on the relative yield advantage of the optimal planting schedule over commonly used heuristics in practice. For a real size planting problem, our computational study demonstrates significant relative yield advantage of the optimal planting schedule.

4 - Sustainable Sourcing Practices: Global Coverage, Characteristics and Drivers

Joann De Zegher, jfdezegher@stanford.edu, Tannis Thorlakson, Eric Lambin

Companies use a variety of Sustainable Sourcing Practices (SSPs) to address social and environmental challenges in their supply chains. Our current understanding of such SSPs is largely based on theoretical models, literature reviews and case studies. We use a random sample of 450 public companies to study the range of SSPs that companies pursue, addressing the following questions. What SSPs do companies adopt? How many tiers in the supply chain do SSPs cover and to what extent are these SSPs audited? What factors explain the type of SSP a company adopts and are these factors in line with theoretical predictions? This research helps direct the research agenda in sustainable supply chain management.

■ SD05

320B

Advances in Healthcare Logistics

Sponsored: Health Applications

Sponsored Session

Chair: Eva Lee, Georgia Tech, Atlanta, GA, 30332-0205, United States, evakylee@isye.gatech.edu

1 - Medical Imaging Log Files: Big Data Analysis & Findings

Larissa P.G. Petroianu, University of Washington, 3801 Brooklyn Avenue NE, Stevens Court - K302, Seattle, WA, 98105, United States, lpetroia@uw.edu, Rebecca J.Mieloszyk, Christina Mastrangelo

MRIs are important for the detection and monitoring of specific conditions; however, the exam is expensive. Wasted scanner time caused by poor scheduling, failed/low value sequences, or idleness is to be avoided. This Philips Healthcare project analyzes data from scanner logs containing over 230,000 observations. We use machine learning to work with big data and focus on reducing "wasted" time to ascertain the root causes of unintended utilization patterns. Prior work utilized human observation which is subject to error, while this work develops analyses based on machine information. We will discuss the challenges of working with log files, present results and discuss the impact of these findings.

2 - Inventory Management and Scheduling for Blood Products: An Effect of Transfer among Regional Block Blood Centers

Mari Ito, Tokyo University of Science, 2641 Yamazaki, Noda-shi, Chiba, 278-8510, Japan, mariito@rs.tus.ac.jp, Ryuta Takashima, Kazuhiro Kobayashi

We investigate a management for regional block blood centers, which are established by Japanese Red Cross, by means of an inventory control and scheduling model for blood products. We propose a mathematical programming model which minimizes the number of discarded blood products and maintains a minimum blood supply. This model determines the number of blood products transferred from one regional block blood center to another one at one day and collected in one regional block blood center at one day. We show an effect of regional block blood centers on the number of collected, transferred and discarded blood products.

3 - Vaccine Prioritization for Optimal Population Health Protection

Eva Lee, Georgia Tech, Industrial & Systems Engineering, Ctr for Operations Research in Medicine, Atlanta, GA, 30332-0205, United States, evakylee@isye.gatech.edu, Yifan Liu

This study is joint with CDC. When the vaccine supply is limited during infectious disease outbreaks, prioritized vaccination is broadly considered as an effective strategy. In this study, we present a general-purpose framework to model the effect of mass vaccination during pandemics. This model integrates compartmental model for disease propagation and stochastic queueing for vaccination operations. Results for a smallpox outbreak will be discussed.

■ SD06

320C

Emergency Services Analytics

Sponsored: Health Applications

Sponsored Session

Chair: David L Kaufman, University of Michigan - Dearborn, Dearborn, MI, 48126, United States, davidlk@umich.edu

1 - Emergency Department Capacity Planning in Presence of Competition

Elham Torabi, Assistant Professor, James Madison University, 421 Bluestone Dr., MSC 0202, Harrisonburg, VA, 22807, United States, torabiex@jmu.edu, Baback Vaziri

Emergency departments (EDs) use historical patient arrival data to forecast future demand. The foretasted demand is then used for capacity planning purposes. However, this task becomes challenging if there is new competition in the region. We analyze the case of two EDs over a five-year period - one is a new ED entering the market and the other is an established ED facing new competition. We derive useful operational and managerial insights for EDs trying to cope with challenges in capacity planning in presence of competition.

2 - ED Physician Staffing via a Multiclass Multistage Network: Opening the Blackbox

Caglar Caglayan, Georgia Institute of Technology, 765 Ferst Drive , Room 321 ISyE Main Building, Atlanta, GA, 30332, United States, ccaglayan6@gatech.edu, Yunan Liu, Mustafa Y. Sir, Turgay Ayer, David Nestler, Kalyan Pasupathy

We propose an "intuitive", "realistic" and "tractable" emergency department (ED) staffing model. More specifically, we analyze a multi-class multi-stage (MCMS) queuing network with time-varying arrivals where the objective is to determine the optimal number of ED physicians, stabilizing tail probability of delay for each patient class and treatment stage. We apply our proposed method to real data from Mayo Clinic for numerical analysis and test its performance by a realistic simulation model under different routing rules. We further analyze the staffing of "efficiency-driven queue without abandonments" since this structure represents most of the queue stations appearing in the MCMS network.

3 - Improving Patient Transport Services through Crew Flexibility

Craig Froehle, University of Cincinnati, 2925 Campus Green Drive, Cincinnati, OH, 45221-0130, United States, craig.froehle@uc.edu, David James Rea, Elizabeth Powell

Patient transport services, where stable patients are moved between facilities using a variety of crew and vehicle types, are a largely unexplored part of healthcare operations. We build a discrete-event simulation model based on a dataset of ~30,000 patient transports to identify preferential policies regarding crew flexibility and vehicle location. In addition to system-level operational performance, a financial analysis also permits assessment of the policies' overall cost-effectiveness.

4 - Introducing Swing Shifts to Dynamically Respond to Emergency Department Workload Uncertainty

David L.Kaufman, University of Michigan - Dearborn, 19000 Hubbard Drive, Fairlane Center South, Dearborn, MI, 48126, United States, davidlk@umich.edu, Kalyan Pasupathy, Daniel Cabrera, Mustafa Y. Sir

A fundamental problem of emergency care is matching resources to uncertain patient demands. Staffing allocation decisions require good matching with workloads but also consider the needs of emergency providers at very high risk of burnout. Mayo Clinic Emergency Department recently introduced a "swing shift," which allows physicians to leave early depending on a workload threshold. While popular, swing shifts introduce several challenges: How to design a threshold mechanism? What is the optimal length of the furlough? When should these shifts start and what is their impact? We introduce an effective and tractable data-driven optimization model for a complex stochastic problem.

■ SD07

322A

Modeling and Optimization for Cancer Screening and Treatment

Sponsored: Health Applications

Sponsored Session

Chair: Jennifer Mason Lobo, University of Virginia, Charlottesville, VA, 22902, United States, jem4yb@virginia.edu

1 - A Dynamic Model for Understanding Long-term Trends in Prostate Cancer Screening

Ozge Karanfil, Harvard T.H. Chan School of Public Health, 651 Huntington Avenue, FXB Building, 643E, Boston, MA, 02115, United States, karanfil@hsph.harvard.edu, Hazhir Rahmandad, Jack Homer, John D. Sterman

Whereas guidelines for routine screening should be based on medical evidence, evidence often has relatively little impact on practice, which has led to ongoing controversy and conflict over guidelines. There are significant variations in clinical practice, including evidence of both over and underscreening. To explain the patterns of overscreening, fluctuations, and low adherence to guidelines, we develop an explicit broad boundary feedback theory tested in a formal model. The model presents an extended case study specific to PSA screening, including realistic presentations for test specifics, natural progression of the disease, and respective changes in population size and composition.

2 - Personalized Modeling for Assessing HPV Vaccination Strategies for Females

Shengfan Zhang, University of Arkansas, 4207 Bell Engineering Center, Department of Industrial Engineering, Fayetteville, AR, 72701, United States, shengfan@uark.edu, Fan Wang

Human papillomavirus (HPV) is the most common sexually transmitted infection in the United States. Currently, catch-up vaccines are recommended for males and females through age 21 and age 26, respectively, if they did not get vaccinated previously. In this research, we hypothesize that the cut off age of catch-up vaccine should be determined based on every single woman's risk characteristics, rather than a one-size-fit-all age 26. We develop a discrete-event simulation model, incorporating patient-specific HPV risk estimation, to evaluate multiple clinical consequences after a woman get vaccinated based on a number of personal attributes.

3 - A Cost-effectiveness Analysis of Adjuvant Paclitaxel and Trastuzumab Regimen in Early Node-negative, Her2-positive Breast Cancer

Ali Hijjar, University of Wisconsin-Madison, 1513 University Avenue, 3233 Mechanical Engineering Building, Madison, WI, 53706, United States, hjaar@wisc.edu, Mehmet Ergun, Murtuza Rampurwala, Oguzhan Alagoz

Patients with early node-negative, HER2-positive breast cancer do not receive standard treatment since most were excluded from adjuvant trastuzumab trials. In this study, we investigated the cost-effectiveness of a novel one-year adjuvant paclitaxel and trastuzumab therapy that shows a decrease in the relapse rate and toxicity adverse events using a Markov model. We performed sensitivity and probabilistic analyses to evaluate the impact of uncertainty on model results.

4 - Optimal Liver Cancer Surveillance in Hepatitis C-infected Population

Qiushi Chen, Massachusetts General Hospital, 101 Merrimac St., 10th FL, Apt D3, Boston, MA, 02114, United States, qchen@mgh-ita.org, Turgay Ayer, Jagpreet Chhatwal

Liver cancer incidence rates have increased sharply in the United States. Although surveillance for liver cancer has shown survival benefit, the optimal surveillance policy remains unknown. To identify the most cost-effective surveillance policy, we develop a mixed-integer programming-based framework which allows to formulate practical policy structures. Our numerical results find that (1) the optimal surveillance interval should depend on patient's stage of hepatitis C and age, and (2) expanding surveillance to earlier stage of hepatitis C improves the cost-effectiveness of HCC surveillance.

■ SD08

322B

Stochastic Models in Health Systems Engineering

Sponsored: Health Applications

Sponsored Session

Chair: Anil Aswani, UC Berkeley, San Francisco, CA, 94103, United States, aaswani@berkeley.edu

Co-Chair: Philip Kaminsky, University of California-Berkeley, Berkeley, CA, 94720-1777, United States, kaminsky@berkeley.edu

1 - Data-driven Appointment Scheduling

Tugce Gurek, University of California, Berkeley, 6141 Etcheverry Hall, Berkeley, CA, 94720, United States, tugce.gurek@berkeley.edu, Philip Kaminsky

We focus on appointment scheduling of stochastic tasks on a highly utilized server where the task processing durations are challenging to estimate. Appointment scheduling involves both sequencing tasks, and setting estimated start times of those tasks. Tasks types are known prior to the appointment date, but task duration data is initially limited so duration estimates are continuously updated. Our goal is to develop a data-driven approach to sequencing and scheduling these tasks that also integrates expert knowledge into the scheduling decision.

2 - Improving Predictions of Pediatric Surgical Durations with Supervised Learning

Zhengyuan Zhou, 160 Comstock Circle - Unit 106002, Stanford, CA, 94305, United States, zyzhou@stanford.edu

We consider a model of multi-agent online learning under imperfect information, where the reward structures are given by a general continuous game. After introducing a general equilibrium stability notion, called variational stability, we examine the well-known online mirror descent learning algorithm and show that the iterates converge to variationally stable Nash equilibria under a variety of imperfect feedback. We then present two applications: non-convex stochastic optimization and power management in random wireless networks. We conclude with a discussion on further extensions.

3 - Data-driven Incentive Design in the Medicare Shared Savings Program

Auyon Siddiq, 1749 Oxford St, Unit 22, Unit 22, Berkeley, CA, 94709, United States, auyon@berkeley.edu, Anil Aswani, Zuo-Jun Max Shen

The Medicare Shared Savings Program (MSSP) was created to control escalating Medicare spending by incentivizing providers to deliver healthcare more efficiently. We formulate the MSSP as a principal-agent model and propose a new type of contract that includes a performance-based subsidy for the provider's investment. We show that the proposed contract dominates the existing MSSP contract by producing a strictly higher expected payoff for both Medicare and the provider. We then present a maximum likelihood approach for estimating the parameters of the principal-agent model as well as the potential increase in savings under the proposed contract.

4 - Mixed-Integer Linear Programming Applications in Public Policy
Matt Olfat, PhD Student, UC Berkeley IEOR, Berkeley, CA, 94702, United States, molfat@berkeley.edu

We present two applications of integer programming in policy. The first showcases the power of integer programming in capturing the nuances of individual behavior, allowing policymakers more accurate insights in the potential responses of constituent populations to their policies. In the second, we target fairness constraints in classification algorithms. In particular, we seek to handle FTC regulations on equitable lending. We propose a new discrete SVM framework to maintain this additional restriction. Further, we provide a duality argument to ensure that non-predictability is maintained at any level of thresholding.

■ SD09

330A

Frontiers in Supply Chain Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Sang Kim, Yale University, 165 Whitney Ave, New Haven, CT, 06520, United States, sang.kim@yale.edu

1 - Supply Chain Design for Substitutable Digital and Physical Information Goods
Zhenhuan Lei, PhD Student, Duke University, 100 Fuqua Drive, Mailbox #300, Durham, NC, 27708, United States, zhenhuan.lei@duke.edu, Robert Swinney

We consider a firm selling two partially substitutable goods, one digital and one physical, e.g., a downloadable and DVD version of the same movie. The physical good is characterized by non-zero marginal production cost, positive production leadtime, and, potentially, a mismatch between supply and demand. The digital good is characterized by zero marginal cost and no inventory constraints. We consider how market and product characteristics drive the firm to price each product, determine inventory, choose a selling strategy involving one or both goods, and design its supply chain.

2 - Grocery Access and Food Waste
Elena Belavina, University of Chicago Booth School of Business, 5807 S.Woodlawn Ave, Chicago, IL, 60637, United States, elena.belavina@chicagobooth.edu

This paper studies how access to grocery stores influences food waste. Our investigation reveals that store density in most American cities is well-below optimal level, and modest increases in store density substantially reduce waste; e.g. in Chicago, just 3-4 more stores (per 10 sq-km) can lead to a 6-9% waste reduction, and a 1-4% decrease in grocery expenses. These results arise from the principal role of consumer waste, suggesting that activists and policy makers' focus on retail waste may be misguided. Store operators, urban planners and decision makers should aim to increase store densities to make grocery shopping more affordable and sustainable.

3 - Social Learning and the Design of New Experience Goods
Yiangos Papanastasiou, University of California, Berkeley, Berkeley, CA, United States, yiangos@berkeley.edu, Pnina Feldman, Ella Segev

This work focuses on the implications of social learning from product reviews for a monopolist firm's choice of product design. Our main finding is that, in the presence of social learning, the firm's design choice results in a product whose expected quality is lower either in the absolute sense, or relative to the product's price.

4 - Competing to Discover Compliance Violations: Self-inspections and Enforcement Policies
Sang-Hyun Kim, Yale University, 165 Whitney Ave, PO Box 208200, New Haven, CT, 06520, United States, sang.kim@yale.edu, Saed Alizamir

In this study we consider dynamic interactions between a regulator and a firm who perform competitive inspections of a production facility that undergoes random compliance violations. Upon detecting noncompliance, the regulator orders the firm to restore compliance via either temporary fix or permanent fix. On the other hand, if the firm detects noncompliance, he restores compliance privately via temporary fix, preempting the regulator's detection. The incentive conflict that arises from these interactions gives rise to equilibrium outcomes that shed light on strengths and weaknesses of different enforcement policies that the regulator can employ.

5 - Analysis of Critical Success Factors for Sustainable Supply Chain Management in the Indian Steel Sector: An Application of Structural Equation Modelling
Kunal Gaurav, Indian Institute of Technology Kharagpur, Kharagpur, India, kg.kunalgaurav@gmail.com, Rudra P. Pradhan

Organizational sustainability performance is highly dependent on organization's culture and work practices including sustainable supply chain management. External pressures influence organizational practices and this also reflects on the sustainability performance indicators. This study presents an analysis of their inter-relationships in the context of Indian steel sector. The twenty one measures representing dimensions of external pressure, organizational internal practices and sustainability performance were developed based on literature survey and inputs from industry experts. A conceptual model has been proposed which has been empirically tested by survey data collected from 145 industry practitioners through online and offline survey. Using structural equation modelling technique, the study establishes that organizational practices positively impact the sustainability performance in the context of Indian steel sector.

■ SD10

330B

Responsible Research in Business and Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Serguei Netessine, University of Pennsylvania, Wharton School, Philadelphia, PA, 138676, United States, netessin@wharton.upenn.edu

Co-Chair: Christopher S. Tang, University of California-Los Angeles, Los Angeles, CA, 90095-1481, United States, chris.tang@anderson.ucla.edu

1 - Socially and Environmentally Responsible Value Chain Innovations: New Operations Management Research Opportunities
Christopher S.Tang, University of California-Los Angeles, UCLA Anderson School of Management, Operations and Technology Management, Los Angeles, CA, 90095-1481, United States, chris.tang@anderson.ucla.edu

I will discuss opportunities in Responsible Research that emerge from the subject of socially and environmentally responsible value chains. I will talk about topics that are likely to become important going forward.

2 - Responsible Research in Business and Management
Serguei Netessine, University of Pennsylvanuia, Philadelphia, PA, United States, netessin@wharton.upenn.edu

I will report on the new initiative led by 24 faculties across disciplines on Responsible Research in Business and Management (RRBM), which culminated in a white paper "A Vision of Responsible Research in Business and Management: Striving for credible and useful knowledge".

3 - What do we Mean by Responsible Research in Operations Management?
Luk Van Wassenhove, INSEAD, Fontainebleau, France, luk.van-wassenhove@insead.edu

Operations management is a problem-driven applied discipline rooted in the realities of business. Within that context, Responsible can mean many things. First, who decides and are all stakeholders taken into account? Second, what about being Responsible for the correctness of our recommendations? Third, should we strongly involve decision makers in problem description, and validating results? Very few studies support their findings with high-quality empirical evidence. Fourth, Responsible could mean we should study large societal problems to justify the cost of our research to society. I propose a few thoughts from my personal experience.

■ SD11

332A

Economics of Queueing Systems: Learning, Pricing, Priorities, and Reneging

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Philipp Afeche, University of Toronto, Toronto, ON, M5S 3E6, Canada, afeche@rotman.utoronto.ca

Co-Chair: Shiliang Cui, Georgetown University, McDonough School of Business, Washington, DC, 20057, United States, shiliang.cui@gmail.com

1 - Learning and Earning for Congestion-prone Service Systems
N. Bora Keskin, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Philipp Afeche

Consider a firm selling a service in a congestion-prone system to price- and delay-sensitive customers. The firm faces Bayesian uncertainty about the consumer demand for its service and can dynamically make noisy observations on the demand. We characterize the structure and performance of the myopic Bayesian policy and well-performing variants.

2 - Coverage, Coarseness and Classification: Determinants of Social Efficiency in Priority Queues
Martin Lariviere, Northwestern University, 2001 Sheridan Road, Evanston, IL, 60208, United States, m-lariviere@kellogg.northwestern.edu, Itai Gurvich, Can Ozkan

In a service system with a continuum of customers, a decision maker must determine how much of the market to cover, how coarse a priority scheme to offer, and how to classify admitted customers to priority levels. We show that differences between revenue maximization and social optimality are largely questions of classification.

3 - Invite Your Friend and You'll Move Up in Line
Luyi Yang, Johns Hopkins University, Baltimore, MD, United States, luyi.yang@jhu.edu, Laurens G.Debo

The referral priority program, an emerging business practice adopted by a growing number of technology companies that manage a waitlist of customers, enables existing customers on the waitlist to gain priority access if they successfully refer new customers to the waitlist. We study the effectiveness of such a scheme as a marketing tool for customer acquisition and an operational approach for waitlist management.

4 - In-Queue Observation and Abandonment
Shiliang Cui, Georgetown University, Washington, DC, 20057, United States, Shiliang.Cui@georgetown.edu, Senthil Veeraraghavan, Jinting Wang, Yu Zhang, Yu Zhang

Waiting in a line for service is not pleasant. Reneging happens when the initial estimated delay was tolerable so a customer joined the queue upon arrival. However, after spending some time waiting, the customer realizes that the actual service speed is slower than what he anticipated and the revised prediction of waiting time has exceeded his tolerance threshold. We investigate in this paper whether and when a revenue-maximizing server is in its best interest to reveal service speed information to customers upfront in the presence of such reneging behavior.

■ SD12

332B

Incentives in Queueing and Sharing Platforms I

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Amy R. Ward, University of Southern California, Los Angeles, CA, 90089-0809, United States, amyward@marshall.usc.edu

Co-Chair: Rouba Ibrahim, University College London, London, WC1E 6BT, United Kingdom, rouba.ibrahim@ucl.ac.uk

1 - Pricing and Optimization in Shared Vehicle Systems: An Approximation Framework
Daniel Freund, Cornell University, Ithaca, NY, 14850, United States, df365@cornell.edu, Siddhartha Banerjee, Thodoris Lykouris

Optimizing shared vehicle systems is more challenging compared to traditional resource allocation due to complex network externalities. In particular, pricing/rebalancing in any location affects future supply throughout the system within short timescales. Such externalities are captured by steady-state Markovian models. However, using such models to design control policies is computationally difficult since the resulting optimization problems are high-dimensional and non-convex. To this end, we develop a general approximation framework that provides the first efficient algorithms with rigorous approximation guarantees for a wide range of objective functions and controls.

2 - Pooling Queues with Discretionary Service Capacity
Hummy Song, The Wharton School, University of Pennsylvania, 560 Jon M. Huntsman Hall, 3730 Walnut Street, Philadelphia, PA, 19104, United States, hummy@wharton.upenn.edu, Mor Armony, Guillaume Roels

Contrary to traditional queuing theory, recent case studies in health care and call centers indicate that pooling queues may not necessarily result in less expected work-in-process. We develop a game-theoretic model that proposes that this may arise when servers have some discretion over their choice of service capacity and are work averse, i.e., bear a cost associated with either their expected workload or their degree of busyness. Our work suggests that system designers may need to consider the servers' type and extent of work aversion as well as their degree of capacity choice discretion before pooling their workload.

3 - Matching while Learning
Ramesh Johari, Stanford University, Huang Engineering Center Rm 311, 475 Via Ortega, Stanford, CA, 94305-4121, United States, ramesh.johari@stanford.edu

We consider the problem faced by a service platform that needs to match supply with demand, but also to learn attributes of new arrivals in order to match them better in the future. We introduce a benchmark model with heterogeneous workers and jobs that arrive over time. Job types are known to the platform, but worker types are unknown and must be learned by observing match outcomes. Workers depart after performing a certain number of jobs. The payoff from a match depends on the pair of types and the goal is to maximize the steady-state rate of accumulation of payoff. Our main contribution is a complete characterization of the structure of the optimal policy in the limit that each worker performs many jobs.

4 - Pricing and Matching with Forward Looking Buyers and Sellers
Yiwei Chen, Singapore University of Technology and Design, Singapore, Singapore, yiwei_chen@sutd.edu.sg, Ming Hu

We study a dynamic market for a single product or service in which buyers with heterogeneous private valuations and sellers with heterogeneous private supply costs dynamically arrive. A single market-making intermediary decides dynamically on the ask and bid price that will be posted to buyers and sellers, respectively, and on the matching decisions after buyers and sellers agree to buy and sell. Buyers and sellers can wait strategically for better prices after they arrive. We use the mechanism design methodology to analyze the problem. We propose a simple matching and pricing policy that is asymptotically optimal. Under this policy, buyer and sellers behave myopically.

■ SD13

332C

Health Care, Therapy and Treatment

Contributed Session

Chair: Ning Liu, Pennsylvania State University, University Park, PA, United States, nul147@psu.edu

1 - Barriers to use Clinic Decision Support and Computerized Provider Entry Among Physician Practices
Yunfeng Shi, Assistant Professor, The Pennsylvania State University, 504E Ford Building, University Park, PA, 16802, United States, yus16@psu.edu

In this study, using a unique dataset from Minnesota, we longitudinally analyzed the major challenges faced by physician practices in adopting and using two main HIT functionalities - Clinical Decision Support (CDS) and Computerized Provider Order Entry (CPOE). We found that although the adoption rate increased between 2014 and 2016, the proportion of physician practices facing challenges in using these two functionalities also increased. We identified several major challenges reported in the data, and examined the physician practice characteristics associated with these challenges.

2 - Predicting Hospital Participation in Accountable Care Organizations
Onyi Nwafor, University of Houston, 5710 Ballina Canyon Ln, Houston, TX, 77041, United States, onyid.nwafor@gmail.com, Norm Johnson

Hospitals are increasingly joining Accountable Care Organizations (ACOs). Evidence suggests that this trend is primarily due to the financial rewards ACOs offer these hospitals when they are able to save costs without diminishing quality of care. Though such rewards may explain why hospitals join ACOs, the profile of hospitals that join tend to differ. Not knowing what this profile is for members and non-members of ACO implies that the net value of participation in ACOs is not clear. To address this problem, we conduct a study that uses a data-driven technique and a large data set to uncover the profile of these two groups. Our analysis reveals a new standard for entities seeking to join ACOs.

3 - Mining and Interpreting Patient Satisfaction Survey Data
Ning Liu, Pennsylvania State University, University Park, PA, United States, nul147@psu.edu, Soundar Kumara

Patient satisfaction is one of the most important metrics for measuring the quality of health care services. This research aims to focus on identify the key drivers of patient satisfaction and improving the quality of care from the patients' perspective. In this paper, we establish a framework to evaluate the patterns of patients' care experience by learning and interpreting the self-reporting survey data. We develop methods based on regularized locally weighted regression to individually explain model result so as to discover the reasons behind patients' experiences and overall satisfaction. We focus on the negative patient experience to find the drivers of quality healthcare.

■ SD14

332D

Advances in Healthcare Policy

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Soroush Saghafian, Harvard Univeristy, Cambridge, MA, 02138, United States, soroush_saghafian@hks.harvard.edu

1 - Analyzing Approaches to the Backlog of Untested Sexual Assault Kits in the U.S.
Lawrence M.Wein, Stanford University, Graduate School of Business, 655 Knight Way, Stanford, CA, 94305-5015, United States, lwein@stanford.edu, Can Wang

Motivated by the debate over how to deal with the huge backlog of untested sexual assault kits in the U.S., we use data from Detroit to build and analyze a mathematical model that predicts the number of hits (i.e., DNA matches to the database) as a function of both the proportion of the backlog that is tested and whether the victim-offender relationship is used to prioritize which kits are tested. Our analysis suggests that the entire backlog should be tested.

2 - Redesigning Primary Care Delivery: Customized Office Revisit Intervals and E-visits
Hessam Bavafa, Wisconsin School of Business, 4284C Grainger Hall, 975 University Avenue, Madison, WI, 53706, United States, hbavafa@bus.wisc.edu, Sergei Savin, Christian Terwiesch

The demand for physician services in primary care is shaped by the number of patients associated with each physician and the frequency of scheduled office visits. While a physician can typically set the size of her patient panel without regard for individual patient preferences, office revisit intervals are determined jointly by the physician and her patients. We analyze these decisions by modeling patient demand for office visits as a function of office revisit intervals.

3 - Impact of the United States Health Care Delivery System Reform on Care Patterns: Evidence from Cancer Care
Lina Song, Harvard University, 11 Peabody Terrace, #509, Cambridge, MA, 02138, United States, dahye.lina.song@gmail.com, Soroush Saghafian

The recent U.S. health care delivery reform could alter the care patterns by changing the provider-side resources. We take advantage of the exogenous changes in area-level provider structures such as hospital closures or horizontal mergers to gain insights into how provider-side resource variables (e.g., patient-provider distance, provider density, and hospital capacity) affect care patterns. We draw evidence from cancer diagnosis and treatment delay times, and use Medicare data to examine multiple types of cancer patients. We find that the shift of patients from low- to high-volume hospitals does not affect the patient-provider distance and reduces the diagnostic and treatment delays.

4 - Hospital-patient Alignment in Healthcare Systems
Soroush Saghafian, Harvard Univeristy, Kennedy School of Government, 79 John F. Kennedy Street, Cambridge, MA, 02138, United States, soroush_saghafian@hks.harvard.edu, Wallace J.Hopp

Choice of hospital is a key determinant of healthcare quality. But lack of transparent information and other factors introduce distortion into the alignment between patient choices and hospital capabilities. We study ways that patients, payers, and hospitals can improve patient outcomes by achieving better alignment.

■ SD15

332E

Game Theory in Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States, dai@jhu.edu

1 - Omni-channel Retailing with Consistent Products and Pricing
Xiaomeng Guo, Assistant Professor, Hong Kong Polytechnic University, Kowloon, Hong Kong, xiaomeng.guo@polyu.edu.hk, Panos Kouvelis, Danko Turcic

This paper develops a game-theoretical model to compare the traditional multi-channel strategy and omni-channel strategy in a supply chain setting. We examine whether and when implementing omni-channel strategy by offering consistent products and prices across multiple channels can benefit firms.

2 - Signaling Supplier Risk through Buy-back Contract
Shouqiang Wang, The University of Texas at Dallas, Naveen Jindal School of Management, 800 W. Campbell Rd, Richardson, TX, 75080, United States, Shouqiang.Wang@utdallas.edu, Haresh B.Gurnani, Upender Subramanian

Buyback Contracts are a widely used contractual arrangement in supply chains across a variety of industries. However, legal disputes involving alleged breach of contracts caused by the suppliers' failure to honor the return clauses abound. Can the buyback contract terms carry information about such supplier's risk? How does it differ from the situation where the supplier tries to signal its demand information.

3 - Efficient Dynamic Auction Mechanisms for Resource Allocation with Information Asymmetry
Yimin Yu, City University of Hong Kong, Department of Management Sciences, 83 Tat Chee Ave., Kowloon, Hong Kong, yiminyu@cityu.edu.hk

We study the impact of multilateral information asymmetry on the efficiency of markets when there is insufficient capacity for a resource. We consider a "distribution system", in which one upstream principal allocates a resource across multiple downstream agents. Based on the market mechanism, we propose a new dynamic auction mechanism under the multilateral information asymmetry. Surprisingly, our dynamic auction mechanism is a first best iterated dominant-strategy incentive compatible mechanism given that every party is aware of insufficient capacity. Moreover, our dynamic auction mechanism is practical as it is simple and privacy preserving.

4 - Crowdfunding in Green Energy Investment
Ying Xu, Singapore University of Technology and Design, 8 Somapah Road, Engineering System & Design, Singapore, 487372, Singapore, xu_ying@sutd.edu.sg, Ronghuo Zheng, Katia P. Sycara

This paper studies a new green energy investment model —- green crowdfunding, in which a green energy project is financed by many small individual investors. In this paper, we develop a sequential game model to study the factors that can affect the total green energy investment volume in such green crowdfunding. Surprisingly, we find that the total volume might decrease as crowdfunders are more aware of the environmental benefit of green energy investment, especially when the installation cost of green energy project is low. Moreover, the impact of the crowdfunders' awareness is affected by the business structure of crowdfunding.

■ SD16

332F

Inventory Management

Contributed Session

Chair: Daniel Taylor, The Ohio State University, Fisher College of Business, Columbus, OH, United States, taylor.465@osu.edu

1 - Order Policy of Short Life-cycle Products Based on Dynamic Demand Forecasting
Xianhao Xu, Huazhong University of Science & Technology, 1037 Luoyu Road, Wuchang, Wuhan, 430074, China, xxhao@hust.edu.cn

Based on the characteristics of short life-cycle products, a twice procurement strategy model of short life cycle products based on the dynamic demand forecast is discussed. The results show that the procurement strategy of short life-cycle products based on dynamic demand forecasting in line with the real business has a better performance than the procurement strategy based on static demand forecasting.

2 - Value of IoT in Spare Parts Logistics Networks
Erhan Kutanoglu, University of Texas-Austin, OR/IE Graduate Program, Dept. of Mechanical Engineering, Austin, TX, 78712, United States, erhank@mail.utexas.edu, Ilyas Iyoob, Krishna T.Rekapalli

We introduce a framework to evaluate the impact of continuous data feed on the maintenance condition of in-use equipment shared via the Internet of Things technology on a multi-echelon spare parts logistics network. We develop a simulation model and conduct extensive experiments to study the system-wide effects of different factors like shipment times, inspection intervals, replacement policies, etc. The simulation results help us analyze different policies as wells as the impact of IoT on several measures such as cost, inventory levels, and system efficiency under different settings. We introduce a metric that reflects the cost to benefit ratio for IoT investment.

3 - Collaborative Robots for Material Handling in Dynamic Environments
Henry I. Ibekwe, GreenBerry Logistics, 10777 Westheimer, Suite 1100, Houston, TX, 77042, United States, hibekwe@startmail.com

Modern state-of-the-art material handling systems are highly dynamic and complex requiring sophisticated automated facilities, advanced inventory management systems, and material moving equipment. There is constantly a need to optimize the process to reduce cost and increase output. This has led to interest in the application of adaptive, learning collaborative robots to perform repetitive and mundane tasks in contrast to the traditional fixed robot manipulator systems. We explore various models of collaborative robots that perform tasks alongside human personnel as a means to improve the operational efficiency and reduce the complexity of material handling in diverse environments.

4 - Channel Competition for Inventory with in an Omnichannel Ship-from-store Network: Examining Channel Sales Cannibalization
Daniel Taylor, PhD Candidate, The Ohio State University, Fisher College of Business, Columbus, OH, 43210, United States, taylor.465@osu.edu, Keely Croxton, A. Michael Knemeyer

Implementing buy-online-ship-from-store (BOSS) tends to increase online sales. Without inventory adjustment, the policy can also result in a decline of in-store sales. Shifting inventory from an online distribution center to store-based fulfillment centers tends to increase in-store sales at those centers, but may place some online sales in jeopardy. This paper uses simulation and stochastic optimization to demonstrate these phenomena and to illustrate the effect of some BOSS inventory policies on channel service levels.

■ SD17

340A

Optimal Control of Stochastic Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Mark S Squillante, IBM Thomas J. Watson Research Center, Yorktown Heights, NY, 10598, United States, mss@us.ibm.com

1 - Electrical Vehicle Charging: A Queueing Approach
Bert Zwart, Buddy Boldenlaan 44, Eindhoven, 5629RD, Netherlands, Bert.Zwart@cwi.nl

We propose and analyse stochastic systems that model the performance of large-scale electrical vehicle charging systems.

2 - Revenue Management for Finite-buffered Tandem Queues
Tonghoon Suk, IBM.Thomas J. Watson Research Center, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States, tonghoon.suk@gmail.com, Xinchang Wang

We study pricing policies for a tandem queueing system finite buffers. The problem is formulated as an infinite-horizon Markov decision process model maximizing the long-run average revenue. We propose a simple static policy and show that the policy is asymptotically optimal over all possible policies as the buffer size before the first station becomes sufficiently large. A variety of numerical studies are offered to test the performance of the simple static policy, and quite interestingly, we learn from the numerical results that the revenue obtained under the simple policy is quite close to the maximum obtainable revenue even for moderate-sized buffer for the first station.

3 - On the Optimality of Reflection Control, with Production-Inventory Applications
Hengqing Ye, Assistant Professor, Hong Kong Polytechnic University, Kowloon, Hong Kong, lgtyehq@polyu.edu.hk, Jiankui Yang, David Yao

We study the control of a Brownian motion (BM) with a negative drift, so as to minimize a long-run average cost objective. We show the optimality of a class of reflection controls that prevent the BM from dropping below some negative level r, by cancelling out from time to time part of the negative drift; and this optimality is established for any holding cost function h(x) that is increasing in |x|. Furthermore, we show the optimal reflection level can be derived as the fixed point that equates the long-run average cost to the holding cost. We also show the asymptotic optimality of this reflection control when it is applied to production-inventory systems driven by discrete counting processes.

4 - On the Control of Density-dependent Stochastic Population Processes with Time-varying Behavior
Mark S. Squillante, IBM.Thomas J. Watson Research Center, Thomas J. Watson Research Center, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States, mss@us.ibm.com, Yingdong Lu, Chai W. Wu

We study a class of density-dependent stochastic population processes in which the rates that impact the density-dependent population structures and behaviors are time varying. Under a mean-field scaling, we extend classical results to show that such density-dependent stochastic population processes converge to a corresponding dynamical system and that the optimal control of such density-dependent stochastic population processes converges to the optimal control of the limiting dynamical system. We further investigate local (micro) and global (macro) behaviors within these processes and extend our results to support nearly completely decomposable stochastic process structures.

■ SD18

340B

Stochastic OR Methods in Machine Learning

Sponsored: Applied Probability

Sponsored Session

Chair: Jose Blanchet, Columbia University, New York, NY, 10027, United States, jose.blanchet@gmail.com

1 - Unbiased Monte Carlo Computations for Optimization and its Applications
Yanan Pei, Columbia University, 506 W. 122nd St Apt 22, New York, NY, 10027, United States, yp2342@columbia.edu, Jose Blanchet, Peter W. Glynn

We present general principles for the design and analysis of unbiased Monte Carlo estimators for optimal solutions of general stochastic optimization. Our estimators possess finite work-normalized variance under mild regularity conditions, such as uniqueness of optimizer and Lipschitz continuity of objective functions. With such unbiased estimators, it is convenient to implement estimations in parallel computations in practice. We apply our estimators to various settings of interest, such as regularized logistic regression and LASSO. Numerical experiments are also given to illustrate our result on real industry data.

2 - Robust Wasserstein Profile Inference: A Novel Approach Towards Choosing Regularization Parameters in Machine Learning
Karthyek Murthy, Columbia University, New York, NY, United States, karthyek@gmail.com, Jose Blanchet, Yang Kang

The objective of this talk is to introduce a novel, distributionally robust optimization based inference procedure called Robust Wasserstein Profile Inference (RWPI). The proposed procedure exploits connections between Empirical Likelihood, Distributionally Robust Optimization (DRO) and the theory of Optimal Transport. A key element of RWPI is the so-called Robust Wasserstein Profile function, a suitably scaled version of which, as we shall see, allows us to optimally choose tuning parameters for popular machine learning estimators such as generalized Lasso, regularized logistic regression, etc., without having to use the brute-force tuning approach of cross-validation.

3 - Doubly Robust Data-driven Distributionally Robust Optimization
Fei He, Columbia University, IEOR.Department, Mudd 345, New York, NY, 10027, United States, fh2293@columbia.edu

We formulate a double robust framework for optimal transport based distributionally robust optimization (DRO), and explore its applications in statistical learning. We apply robust optimization (RO) method to metric learning to learn a robust data-driven cost function and apply the cost function into DRO formulation, where we call it double robust DRO. DRO deals with finite sample uncertainty in model fitting; while RO metric learning takes care of the noisy estimation in constraints set. The double robust DRO provides a robust data-driven regularization for model fitting. Numerical experiments on real data sets shows that our method is superior comparing to its single robust counterpart.

4 - Data Driven Optimal Transport Cost Selection for Distributionally Robust Optimization
Fan Zhang, Stanford University, Stanford, CA, United States, fzh@stanford.edu, Jose Blanchet, Yang Kang, Karthyek Murthy

Recently, Blanchet, Kang and Murthy (2016) have shown that many machine learning algorithms, such as generalized Lasso, Support Vector Machines, and regularized logistic regressions, among many others, can be exactly represented as distributionally robust optimization (DRO) problems. The distributional uncertainty is defined as a neighborhood centered at the empirical distribution. We propose a methodology which learns such neighborhood in a natural data-driven way, thereby improving both theoretically and empirically (as we demonstrate) upon the classical algorithms.

■ SD19

342A

Operations Issues in Agriculture

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Onur Boyabatli, Singapore Management University, Singapore, 178899, Singapore, oboyabatli@smu.edu.sg

1 - Reining in Onion Prices by Introducing a Vertically Differentiated Substitute: Models, Analysis, and Insights

Omkar Palsule-Desai, Indian Institute of Management Indore, Indore, India, omkardpd@iima.ac.in, Muge Yayla Kullu, Srinagesh Gavirneni

We examine the pricing ordeal in India's onion markets caused by the fresh produce traders. As a remedy, policy makers have been proposing to establish processed produce competition in the market by either cooperatives or private firms. We formulate and analyze this situation in a mathematical model that captures (i) competition between non-profit and for-profit organizations, (ii) consumers' valuation discount for the processed produce, and (iii) perishability of the fresh produce. We identify and discuss the conditions under which (i) it is optimal to introduce the processed produce; and (ii) the processed onion should be managed by cooperatives instead of private firms.

2 - Pricing of Wine Futures and Recently Bottled Wines under Weather Uncertainty

Burak Kazaz, Syracuse University, Whitman School of Management, 721 University Avenue, Syracuse, NY, 13244, vUnited States, bkazaz@syr.edu, M.Hakan Hekimoglu

Using a comprehensive set of data gathered from Liv-ex and the world's largest wine distributor, this study examines the pricing of wine futures (i.e., wine sold in advance before it is bottled) and recently bottled wines. Our study helps wine distributors build a more sophisticated understanding of how young wine prices evolve based on various weather and market indicators.

3 - Understanding Farmers Crop Allocation Decisions and the Role of Intermediaries

Sripad K. Devalkar, Indian School of Business, Ac3 L1 Room 3114, Hyderabad, 500032, India, sripad_devalkar@isb.edu, Sridhar Seshadri, Bharat Ramaswami

Exclusive cultivation of high yield varieties of rice and wheat crops has led to depletion of groundwater tables and soil fertility in many states of India. In this research, we identify major factors including access to labour, markets, and information that affect the farmers' decisions not to diversify to alternate crops that are beneficial to the farmer and the environment. We consider the role of supply chain intermediaries in enabling farmers to diversify and test the model using data on farmers' crop allocation decisions in the state of Punjab.

4 - Optimal Supply Planning for Commercial Seeds

Utku Serhatli, INSEAD, Constance de le Boulevard, Fontainebleau, 77590, France, utku.serhatli@insead.edu, Andre Du Pin Calmon, Enver Yucesan

We analyze the optimal production and inventory assortment decisions of a seed manufacturer. We first derive the structure of the optimal decisions for the general case and characterize solutions for the single-period case. Second, we demonstrate the impact of operational flexibility: Salvaging opportunity motivates higher production through the mitigation of yield risk and postponement strategy impacts the optimal production quantity via overage cost reduction and demand pooling effects. Third, our numerical results show that while the salvaging strategy provides protection against yield uncertainty, the postponement strategy is an effective defense against demand uncertainty.

■ SD20

342B

Design Choices in Innovation Management

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Pascale Crama, Singapore Management University, Singapore, 178899, Singapore, pcrama@smu.edu.sg

1 - Delegated Testing of Design Alternatives

Jochen Schlapp, University of Mannheim, Wilhelm-Leuschner-Str. 241, Griesheim, 64347, Germany, jschlapp@bwl.uni-mannheim.de

The testing of different design alternatives is a vital element of any R&D process. Yet, in reality, the benefits of testing are not easy to harvest because these activities are usually delegated to experts who may pursue their own agenda. We examine how to optimally incentivize these experts and how to design the testing process.

2 - The Valuator's Curse is Entrepreneur's Boon: Decision Analysis of Post-launch Surprise

Onesun Steve Yoo, University College London, School of Management, Gower Street, London, WC1E 6BT, United Kingdom, onesun.yoo@ucl.ac.uk, Kevin F.McCardle

Evidence from IPOs show that entrepreneurial ventures tend to be initially over-valued. A common explanation is irrationality, e.g. overconfidence. We provide a rational explanation which we term the valuator's curse. It is similar in nature to the winner's curse in auctions and the optimizer's curse in decision analysis, but the source is neither from the competitive nor optimization effects. The effect is generated in the evaluation itself, even though the inputs to the evaluation are unbiased. We formalize it in a Bayesian setting, and suggest several approaches to mitigate the effect.

3 - Effect of Flexibility on Consumption of Services

Sreekumar R. Bhaskaran, Southern Methodist University, Cox School of Business, P.O. Box 750333, Dallas, TX, 75275, United States, sbhaskar@mail.cox.smu.edu, Rajiv Mukherjee, Sanjiv Erat

In this paper, we experimentally investigate how flexibility in consumption interacts with the actual usage of a service by consumers. Subsequently, we study a firm's pricing and capacity planning decision under the presence of these effects. The results have interesting implications in industries where managing congestion is an important consideration.

4 - Sourcing Innovative Goods: System or Component

Zhi Chen, INSEAD, 1 Ayer Rajah Avenue, Singapore, Singapore, zhi.chen@insead.edu, Jurgen Mihm, Jochen Schlapp

Many purchasing projects involve buying complex systems, which require the suppliers to perform some custom product or technology development regardless of whether they win the project or not. Viewing such a procurement setting through the lense of contest, we study under which circumstances a buying firm should source an integrated system or individual components.

■ SD21

342C

Data-driven Decision Making in Healthcare

Invited: InvitedHealthcare Systems and Informatics

Invited Session

Chair: Taewoo Lee, University of Houston, Houston, TX, 77204-4008, United States, tlee20@central.uh.edu

1 - Patient Specific Radiotherapy Treatment Policy: A Data-driven POMPD Framework

Nasrin Nouri, University of Houston, Houston, TX, United States, nnouri2@uh.edu, Gino Lim

In radiotherapy treatment planning the goal is to deliver the prescribed dose to the tumor structure while sparing organs at risk and normal tissues. Currently an equal dose is delivered in all treatment sessions, however tumor biological response to radiation is not constant during the whole treatment horizon. Depending on tumor density and shape, the growth rate of tumor cells and their sensitivity to radiation will change. Therefore, a dynamic customized treatment plan is required for each patient and each tumor site. In this study, we develop an indefinite horizon, constrained POMDP framework to provide optimal treatment policy where the state of tumor before each treatment session is uncertain.

2 - Personalizing Health Treatments using Bayesian Inverse Optimization

Anil Aswani, UC Berkeley, 8 10th St, Apt 1704, San Francisco, CA, 94103, United States, aaswani@berkeley.edu, Philip Kaminsky, Yonatan Mintz, Elena Flowers, Yoshimi Fukuoka

Treatments for managing chronic disease are sensitive to patient adherence, as well as to the treatment efficacy on each patient. Better quantification of such parameters can improve the efficiency of health care delivery (by more accurate allocation of costly treatment resources) and improve health outcomes (by prompting earlier escalation of care when needed). This talk describes a Bayesian approach to inverse optimization that can quantify such parameters. We provide mathematical programming formulations for and theoretical results about our approach, and conclude with simulations that show the effectiveness of our approach in personalizing a weight loss and physical activity treatment.

3 - Solution Methods for Generalized Inverse Optimization

Rafid Mahmood, University of Toronto, 3831 Janice Drive, Mississauga, ON, L5M.7Y6, Canada, rafid.mahmood@mail.utoronto.ca, Timothy Chan, Taewoo Lee, Daria Terekhov

Practitioners of inverse optimization often create specialized methods to solve a specific problem. A previous work introduced a generalized inverse optimization (GIO) formulation for linear programs, that could easily specialize to the different custom methods. In this work, we extend the previous formulation to the case of multiple observed decisions. Although the prior work introduced solution methods for the classically non-convex problem, we extend these results to show how the problem and it's specializations can be solved efficiently in nearly all scenarios. Finally, we provide a set of guiding rules for practitioners in implementing inverse problems.

4 - Data-driven Objective Selection in Multi-objective Optimization

Temitayo Ajayi, Rice University, Houston, TX, United States, temitayo.ajayi@rice.edu, Taewoo Lee, Andrew J.Schaefer

A challenge in radiation therapy treatment planning is selecting which clinical objectives to use in the optimization. We propose the inverse optimization method with a cardinality constraint to infer the most important objectives from historical treatment plans. We use a greedy algorithm to select objectives and provide theory, a generalization of a result by Nemhauser (1978), to support our results. We compare the proposed method to the cardinality-constrained inverse problem, and show that our method efficiently finds a small number of objectives that generates clinical quality treatment plans.

■ SD22

342D

Revenue Management with Intertemporal Consumer Behavior

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ilan Lobel, New York University, New York, NY, 10012, United States, ilobel@stern.nyu.edu

1 - Dynamic Pricing Model for a Subscription Contract Offered to Strategic Customers with Fixed Term Lengths in a Growing Market

Roozbeh Yousefi, Queen's University, 310 Bath Rd., Unit 1112, Kingston, ON, K7M9H1, Canada, r.yousefi@queensu.ca, Jue Wang, Yuri Levin, Mikhail Nediak

Subscriptions are agreements between a company which commits to deliver a service or provide access to a service and its customers. We present a continuous time dynamic pricing model for a monopolist offering a fixed term subscription contract without per-use charges and limit of access, to strategic customers whose utility is affected by the number of subscribers. We formulate the monopolist's problem in terms of optimal control, derive its optimality conditions, and study the structure of the stationary optimal solution. We demonstrate the optimal pricing results in numerical experiments.

2 - Joint Pricing and Inventory Management with Strategic Customers

Yiwei Chen, Singapore University of Technology and Design, Singapore, Singapore, Yiwei_chen@sutd.edu.sg, Cong Shi

We study a joint pricing and inventory management problem with strategic customers. Demand is allowed to be backlogged. The seller incurs fixed ordering cost and inventory holding cost. Our model allows customers to be heterogeneous in arriving times and valuations. We use mechanism design approach to characterize the seller's optimal pricing and inventory policy and customer equilibrium behaviors.

3 - Intertemporal Price Discrimination with Time-varying Valuations

Victor Araman, American University of Beirut, Beirut, Lebanon, va03@aub.edu.lb

Customers approach the firm and can either purchase the product on arrival, or remain in the system for a period of time. During this time, each customer's valuation changes following a discrete and homogenous Markov chain. We show that, in this context, cyclic strategies are optimal, or nearly optimal. When the pace of pricing is constrained we characterize the cycle length and obtain an efficient algorithm that yields the optimal solutions. We cast part of our results in a general framework of optimizing the long-run average revenues for a class of payoffs that we call weakly coupled.

4 - Dynamic Pricing with Heterogeneous Patience Levels

Ilan Lobel, New York University, 44 West 4th St, Kmc 8-71, New York, NY, 10012, United States, ilobel@stern.nyu.edu

We consider the problem of dynamic pricing in the presence of patient consumers. We call a consumer patient if she is willing to wait a certain number of periods for a lower price and will purchase as soon as the price is equal to or below her valuation. We allow for arbitrary joint distributions of patience levels and valuations. We propose an efficient algorithm for finding optimal pricing policies. The dynamic program requires a larger state space than its counterpart for a strategic consumers model. We find numerically that optimal policies can take the form of incomplete cyclic policies, combining features of both nested sales policies and decreasing cyclic policies.

■ SD23

342E

Pricing and Revenue Management in Retail Operations

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Mehmet Sekip Altug, maltug@gwu.edu

1 - Curing the Addiction to Growth

Marshall L. Fisher, University of Pennsylvania, Wharton School Oper & Info Mgmt. Dept, Jon M. Huntsman Hall, Room 542, Philadelphia, PA, 19104, United States, fisher@wharton.upenn.edu, Vishal Gaur, Herbert Kleinberger

Successful retailers grow quickly in their early years simply by opening new stores, but what happens when growth inevitably slows? To answer this question, we examined the financials of 37 publically traded retailers continuously active during 1993-2014 whose average top line growth slowed from 14.1% initially to 4.6% in the last 5 years. Despite slower top line growth, 17 of these retailers outperformed the S&P during 2011-15 by following a strategy of curtailing new store opening and instead increasing sales in their existing stores through a variety of initiatives.

2 - Assortment Planning with N-pack Purchasing Customers

Ying Cao, University of Texas at Dallas, 19251 Preston Rd, Apt 1324, Dallas, TX, 75252, United States, Ying.Cao@utdallas.edu, Dorothee Honhon

For many product categories, customers often buy multiple differentiated products on a given store visit for staggered consumption until the next store visit. Such customers are referred to as n-pack purchasing customers in Fox et al (2016). We consider a retailer who makes product assortment decisions in a given product category facing n-pack purchasing customers. We study the structural properties of the optimal assortment under three different customer choice rules. And we explore how the retailer's assortment decision and total profits are impacted when the retailer ignores the "choice premium" which captures the utility that consumers derive from variety in their shopping basket.

3 - Trusting the Computer: Adherence to the Recommendations of a Pricing Decision Support System

Anna Saez de Tejada Cuenca, UCLA Anderson School of Management, Los Angeles, CA, United States, anna.sdtc.1@anderson.ucla.edu, Felipe Caro

We analyze empirically the drivers of adherence to the prices recommended by a decision support system during the sales season of a fast fashion retailer. We study the effect on two interventions (nudges) aimed to encourage adherence to the DSS's recommendations on the overall season adherence, as well as the effect of inventory levels and impatience on the evolution of adherence over each sales season.

4 - Optimal Dynamic Allocation of Sales and Rental Inventory at a Retailer

Mehmet Sekip Altug, George Washington University, 2201 G. Street NW, Funger 415, Washington, DC, 20052, United States, maltug@gwu.edu, Oben Ceryan

We consider a retailer that simultaneously sells and rents its product over a given horizon. In every period, the retailer faces uncertain demand that splits between renters and buyers based on their utility. We characterize the optimal dynamic rental allocation policy and study its properties. We propose various implementable heuristics. We then extend our results to the duopoly case and characterize the equilibrium. We derive the conditions that lead to "pure sales", "pure rental" or "mixed" strategy equilibrium and discuss their implications.

■ SD24

342F

Innovative Topics in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: So Yeon Chun, McDonough School of Business, Georgetown Universit, Wyashington, DC, 20057, United States, sc1286@georgetown.edu

1 - Advance Selling to Strategic Consumers: the Advance Selling Target and the Preorder Contingent Production Strategy

Mingcheng Wei, University at Buffalo, 326C Jacobs Management Center, Buffalo, NY, 14260, United States, mcwei@buffalo.edu, Fuqiang Zhang

Motivated by emerging industry practices, this paper studies the effectiveness of a new advance selling strategy in counteracting strategic consumer behavior: the preorder contingent production (PCQ) strategy, where the seller's production decision is contingent on preorder quantities. We find that compared to the traditional advance selling strategy, the PCQ strategy is effective in mitigating strategic waiting behavior and thus can significantly improve the seller's profit performance.

2 - Selective Selling in Social Networks

Ruslan Momot, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, ruslan.momot@insead.edu, Elena Belavina, Karan Girotra, Karan Girotra

We consider the use and value of social network information in selectively selling goods and services whose value derives from exclusive ownership among network connections. Our model accommodates customers who are heterogeneous in their number of friends (degree) and proclivity for social comparisons (conspicuity). We show how the firm with information on either (or both) of these traits can use it to increase profits making a product selectively available to the firm's best targets - high-conspicuity customers within intermediate-degree segments. We find that information about degree is more valuable than information about conspicuity and that the two are substitutes.

3 - The Effects of Menu Costs on Supply Chain Efficiency: Evidence from Adoption of the Electronic Shelf Label Technology

Ioannis (Yannis) Stamatopoulos, University of Texas at Austin, McCombs School of Business, 2110 Speedway, B6000 Austin, TX 7870, Office 6484, Austin, TX, United States, yannis.stamos@mccombs.utexas.edu, Antonio Moreno-Garcia, Achal Bassamboo

We use the differential timing of adoption of electronic shelf labels (ESLs) in stores of a major international grocery retailer in the UK to identify the effects of reducing physical menu costs on supply chain efficiency. ESLs effectively eliminate the physical costs associated with price adjustment (e.g., costs of printing and distributing price tags). We find that the elimination of physical menu costs benefits all supply chain stakeholders.

4 - Loyalty Program Design and Consumer Decisions to Redeem Points or Spending Money

So Yeon Chun, McDonough School of Business, Georgetown University, 37th & O.Streets, Hariri Building, office #542, Washington, DC, 20057, United States, sc1286@georgetown.edu, Rebecca Hamilton

In many loyalty programs, customers earn points for their purchases, which they can later exchange for additional products and services. In a sense, points function as a currency that consumers can spend on products instead of spending money. However, we uncover systematic differences in the way consumers spend loyalty points compared with money. To highlight different mechanisms by which loyalty program design characteristics may influence redemption, we first propose a model of the consumer's choice to redeem points or use money for a specific purchase, and then we conduct a series of studies to investigate the impact of these characteristics on consumers' choices.

■ SD25

350A

Outsourcing Innovation and Product Development

Invited: New Product Development

Invited Session

Chair: Ersin Korpeoglu, University College London, London, N17 9GL, United Kingdom, e.korpeoglu@ucl.ac.uk

Co-Chair: C Gizem Korpeoglu, University College London, London, WC1E 6BT, United Kingdom, c.korpeoglu@ucl.ac.uk

1 - Technology Choice in Dynamic Competition

Feng Tian, University of Michigan, 1760 Broadway St, Apt 303, Ann Arbor, MI, 48105, United States, ftor@umich.edu, Izak Duenyas, Mohamed Mostagir

Two firms innovate over time and the firm that produces the better innovation by the end of the horizon wins. Firms have access to different technologies and have to decide which technology to use in each time period given the past choices and outcomes. Technologies are heterogeneous along several dimensions: they may have different variances, costs, and ability to learn from previous attempts. We characterize the equilibria of this dynamic competition and compare their welfare properties as a function of the different parameters of the problem.

2 - The Role of Feedback in Dynamic Crowdsourcing Contests: A Structural Empirical Analysis

Zhaohui Jiang, PhD Student, University of Michigan, Ann Arbor, MI, 48109, United States, jiangzh@umich.edu, Yan Huang, Damian Beil

This paper examines the impact of performance feedback on the outcome of crowdsourcing contests. We develop a dynamic structural model to capture the economic processes that drive contest participants' behavior, and estimate the model using a data set collected from a major online crowdsourcing platform. The model captures key features of the crowdsourcing context, including a large participant pool, entries by new participants throughout the contest, and exploitation and exploration behaviors by contest incumbents. Using counterfactual simulations, we show that providing feedback throughout the contest may not be optimal; the late feedback policy leads to a better overall contest outcome.

3 - Optimal Stochastic Feedback in Asymmetric Dynamic Contests

Jurgen Mihm, Insead, Boulevard De Constrance, Boulevard de Constance, 77305, France, jurgen.mihm@insead.edu, Jochen Schlapp

A contest is an incentive mechanism in which a number of contestants compete against each other at their own expense of effort to provide the best performance and to win a limited number of prizes. Feedback can be a mechanism for contest holders to increase the effort levels of the contestants and hence contest outcomes. In this talk, we characterize a contest holder's optimal choice of (stochastic) public feedback for asymmetric dynamic contests.

4 - Contest Among Contest Organizers

C. Gizem Korpeoglu, University College London, Gower Street, London, WC1E 6BT, United Kingdom, c.korpeoglu@ucl.ac.uk, Ersin Korpeoglu, Isa Hafalir

We study multiple contests where contest organizers elicit solutions to innovation-related problems from a set of agents. Each agent may participate in multiple contests and exert effort to improve her solution, but the quality of her solution also depends on an output uncertainty. We show, somewhat surprisingly, that organizers benefit from agents' participation in multiple contests when agents' output uncertainty is sufficiently large. We then show that the organizer profit is unimodal in the number of contests, and more interestingly, the optimal number of contests increases with agents' output uncertainty. This finding may explain why many organizations run multiple contests in practice.

■ SD26

350B

DEA Applications

Invited: Data Envelopment Analysis

Invited Session

Chair: Kankana Mukherjee, Babson College, Wellesley, MA, 02481, United States, kmukherjee@babson.edu

1 - Efficiency and Productivity Dynamics of Indian Bank Branches
Kankana Mukherjee, Babson College, Babson Park, MA, United States, kmukherjee@babson.edu, Subhash C.Ray, Abhiman Das

This paper examines the trajectory of efficiency and productivity dynamics of a network of branches of a large Indian bank during the post Great Recession period. We use Data Envelopment Analysis to study branch level data for the years 2009-10 through 2016-17. By isolating the contributions of technical change, efficiency change, and scale change to overall productivity change of each branch, we are able to identify the sources of superior versus inferior branch level performance, which helps to provide guidelines for improving the performance of the bank at the institutional level.

2 - Environmental Productivity Growth in Consumer Durables
Xun Zhou, Doctoral Candidate, Aalto University School of Business, Runeberginkatu 22-24, Helsinki, 00100, Finland, xun.zhou@aalto.fi

Only one previous study considers environmental performance of consumer durables. This is somewhat surprising because during their use phase consumer durables are actually production units that consume energy to provide services for consumers and thus contributors to pollutions. This study aims to develop an index of environmental productivity change specific to consumer durables. We first specify how to model the production activity during the use of consumer durables. Then we present an overview of conventional measurements of environmental productivity and describe how they can be applied in this study. Finally we use a Finnish dataset to illustrate interpretations of the proposed index.

3 - Building Models for Efficiency and Effectiveness in the Financial Industry
Abbas Attarwala, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L.3G1, Canada, abbas.attarwala@gmail.com, Stanko Dimitrov

We review recent work on evaluating models of efficiency and effectiveness for the financial industry. Using the reviewed evaluation procedure and publicly available data we computationally efficiently and systematically search the space of efficiency and effectiveness data envelopment analysis models to present models of efficiency and effectiveness valid for multiple datasets. We conclude with some key managerial takeaways from our findings.

■ SD27

350C

Ideas And Discussing Relating to the Future of Social Media Analytics Research

Invited: Social Media Analytics

Invited Session

Chair: Christopher M Smith, Air Force Institute of Technology, Air Force Institute of Technology, Xenia, OH, 45385, United States, cms3am@virginia.edu

1 - Ideas and Discussion Relating to the Future of Social Media Analytics Research
Chris Smith, Air Force Institute of Technology, 2950 Hobson Way, 2950 Hobson Way, Wright-Patterson AFB, OH, 45433, United States, cms3am@virginia.edu

A brief general overview of our cluster is provided. Trends in the literature are reviewed as well as in topics within past INFORMS clusters. A set of discussion topics are proposed for all the participants and, ideally, for the audience.

2 - Review of Decision Problems in Social Media Analytics
Theodore T. Allen, Ohio State University, Columbus, OH, 43210-1271, United States, allen.515@osu.edu

This presentation focuses on reviewing recent decision problems explored in social media analytics. An example is so-called "Timely Decision Analysis" enabled by social media analytics. Yet, many other examples ranging from financial investments to optimal target identification

3 - Role Identification and Modeling of Online Health Communities"
Jiaqi Zhou, C ity University of Hong Kong, 12-200 Lau Ming Wai, Hong Kong, jiaqi.zhou@my.cityu.edu.hk, Qingpeng Zhang, Mingyang Li

Online health communities present a platform for users to exchange information and get social support from other users, particularly those suffering from similar diseases. In this study, we focus on the impact of OHCs on people with depression. We combined text mining, social network analysis, and econometric analysis and characterized their roles with topological measures. Finally, we discovered the changing patterns of users' roles dynamically and found that patients' emotion could be significantly enhanced by responses of other OHC users."

4 - Review of Business Strategy Problems in Social Media Analytics
Michel Ballings, University of Tennessee, University of Tennessee, Knoxville, TN, 37996, United States, michel.ballings@utk.edu

A review of business strategy research is given with an emphasis on building networks and their roles in marketing and sales.

■ SD28

350D

Combinatorial Mechanisms

Invited: Auctions

Invited Session

Chair: Benjamin Lubin, Boston University, Boston, MA, 02215, United States, blubin@bu.edu

1 - Probably Approximately Efficient Combinatorial Auctions via Machine Learning
Benjamin Lubin, Boston University, School of Management, 595 Commonwealth Avenue, Boston, MA, 02215, United States, blubin@bu.edu, Gianluca Brero, Sven Seuken

A well-known problem in combinatorial auctions is the exponential growth of the value space in goods, burdening both bidders and the auctioneer. We introduce a new design paradigm for CAs based on machine learning. Bidders report bids to a proxy agent via a small number of value queries. The proxy then uses an ML algorithm to generalize from those bids to the whole value space, and the efficient allocation is computed over these generalizations. We introduce the concept of probably approximate efficiency (PAE) to measure the efficiency of the new ML-based auctions, and formally show how the generelizability of an ML algorithm relates to the efficiency loss incurred by the corresponding ML-based auction.

2 - Efficient Dynamic Auctions for Private Valuations
Oleg V. Baranov, University of Colorado-Boulder, 256 UCB, Boulder, CO, 80309, United States, oleg.baranov@colorado.edu

The literature on dynamic implementation of the VCG mechanism routinely uses price-demand queries for preference elicitation. As a result, all known dynamic auction procedures that implement the Vickrey outcome for the general private valuation domain are impractical. The paper makes two contributions. First, we show that the general problem of designing a dynamic VCG mechanism is reduced to a problem of specifying an appropriate elicitation process that satisfies certain properties. Second, we characterize an ascending auction that implements the Vickrey outcome for general private valuation domain while using a single linear and anonymous price trajectory for preference elicitation.

3 - Competitive Equilibrium Pricing in Auctions and Exchanges
Robert Day, University of Connecticut, 2100 Hillside Road U-1041, Storrs, CT, 06269-1041, United States, Bob.Day@business.uconn.edu

Cutting plane methods allow us to generate competitive equilibrium prices for an arbitrary combinatorial auction. We explore the computational aspects of these methods and their extension to the arbitrary case of combinatorial exchanges.

■ SD29

350E

Healthcare Informatics

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Haijing Hao, University of Massachusetts-Boston, 12 Inman Street Apt 31, Cambridge, MA, 02139, United States, haohaijing@gmail.com

1 - Social Media and Health Insurance Choice in China

Haijing Hao, University of Massachusetts-Boston, 12 Inman Street Apt 31, Cambridge, MA, 02139, United States, haohaijing@gmail.com, Yunfeng Shi, Anqichen Shi

China has been undertaking health insurance reforms in the past couple of decades, transforming from narrow coverage of government paid insurance to limited government staff to wider population from all walks of people. Chinese people have more and flexible choices of health insurance. This study examines the daily social media usage and health insurance choices in China based on a national survey study.

2 - Dynamics and Misinformation in Health Social Networks

Wencui Han, University of Illinois at Urbana Champaign, 1206 S. Sixth Street, 350 Wohlers Hall, Champaign, IL, 61820, United States, wenhan@illinois.edu

Health social networks provide patients opportunities to connect with each other. However, misinformation on these platforms poses threats to patient safety. This paper uses physician-evaluated posts collected from a popular health social network site to explore factors can be used to predict and monitor misinformation. We focus on the impacts of two main concepts that embedded in the dynamics of the interaction on social networks: similarity between responder and question poster, and dynamic clique variables.

3 - Digital Divide in Online Health Community

Haijing Hao, University of Massachusetts-Boston, 12 Inman Street Apt 31, Cambridge, MA, 02139, United States, haohaijing@gmail.com

The present study intends to explore what factors may have an impact on online health utilization in China by examining various economic-related variables. We use Tableau mapping features to illustrate the geographical visualization and also run quantitative fixed effect regression models. Our preliminary results show that percentage population that can access the Internet of a province in China has a statistical significant impact on the online health utilization of that province.

4 - Efficiently Identifying Trends in Healthcare using Text Mining, and Topic Detection and Tracking

Yu-Hung Chiang, National Cheng Kung University, Tainan City, Taiwan, momois87@hotmail.com

Most published healthcare research literature is recorded online databases such as PubMed. As the number of online articles increases rapidly, it becomes challenging for researchers to accurately and efficiently identify current research trends in specific topics of healthcare. In this study, we construct a trend analysis method to obtain research topics from PubMed. Using text mining methods and topic Detection and Tracking (TDT), we aim to improve the efficiency in identifying and tracking topics from large databases.

■ SD30

350F

Social Media Use and New Product Development Performance

Invited: Social Media Analytics

Invited Session

Chair: Debasish N Mallick, University of St. Thomas, Minneapolis, MN, 55403, United States, dnmallick@stthomas.edu

Chair: Julie Zhang, University of Massachusetts Lowell, Lowell, MA, 01854, United States, juheng_zhang@uml.edu

1 - Social Media Use & New Product Development Performance

Debasish N. Mallick, University of St. Thomas, Opus College of Business, 1000 La Salle Avenue # TM.H.443, Minneapolis, MN, 55403, United States, dnmallick@stthomas.edu

Use of social media is becoming increasingly popular in NPD. Yet, the performance impact of social media use in NPD remains inconclusive. Using a cross industry survey of new product development projects, we explore the factors affecting the relationship between social media use and NPD performance

2 - Using Microblogging to Predict IPO Success

Dirk Van den Poel, Professor of Data Analytics/Big Data, Ghent University, Faculty of Economics and Business Administration, Tweekerkenstraat 2, Gent, B.9000, Belgium, Dirk.VandenPoel@UGent.be, Michel Ballings

This research investigates the influence of microblogging - in particular Twitter social media messages - on Initial Public Offering (IPO) success. We analyze the (potential) impact of the number of tweets and their sentiment on (1) the difference between the IPO price and the closing price of the stock at the day of becoming public, and (2) the difference between the closing price on the first day of trading and the closing price after three months of trading.

■ SD31

351A

George B. Dantzig Dissertation

Invited: The George B. Dantzig Dissertation Prize

Invited Session

Chair: Wedad Elmaghraby, University of Maryland, R H Smith, College Park, MD, 2, United States, welmaghr@rhsmith.umd.edu

1 - Robust Optimization for Renewable Energy Integration in Power System Operations

Álvaro Lorca, Pontificia Universidad Católica de Chile, Departamento de Ingeniería Eléctrica, Av Vicuna Mackenna 4860, Santiago, 7820436, Chile, alvarolorca@uc.cl

Motivated by the increasing adoption of variable renewable energy sources such as wind and solar power, this talk will present robust optimization models and algorithms that determine innovative methods to operate modern power systems. In particular, we will present a multistage adaptive robust optimization model for the unit commitment problem, i.e. for the problem of scheduling power generation over one whole day, including on/off and dispatch decisions. The most innovative aspect of this model is that the causality of the dispatch process is respected, that is, dispatch decisions at any given time can only depend on the revealed uncertainty up to that time. We will also discuss solution methods based on cutting planes, the concept of dynamic uncertainty sets to account for spatial and temporal correlations in renewable power uncertainty, and the potential impact in the electric power industry.

2 - Deep Exploration via Randomized Value Functions

Ian Osband, Stanford University, Stanford, CA, United States, ian.osband@gmail.com

In this dissertation we present an alternative approach to deep exploration through the use of randomized value functions. Our work is inspired by the Thompson sampling heuristic for multi-armed bandits which suggests, at a high level, to "randomly select a policy according to the probability that it is optimal". We provide insight into why this algorithm can be simultaneously more statistically efficient and more computationally efficient than existing approaches. We leverage these insights to establish several state of the art theoretical results and performance guarantees. Importantly, and unlike previous approaches to deep exploration, this approach also scales gracefully to complex domains with generalization. We complement our analysis with extensive empirical experiments; these include several didactic examples as well as a recommendation system, Tetris, and Atari 2600 games.

3 - Robust Solutions for Geographic Resource Allocation Problems

Mehdi Behroozi, Northeastern University, Allston, MA, 02134, United States, m.behroozi@neu.edu

The concept of geography is a fundamental one in many domains such as transportation, facility location, logistics, surveillance, reconnaissance, and territory division, among many others. This dissertation is devoted to the study of geographic resource allocation (GRA) problems. In such a problem, our goal is to minimize or maximize an objective function that is defined over a geographic region. The distinguishing attribute of such problems is that spatial properties such as distance, shape, perimeter, area, connectedness, fatness, or convexity will appear in these problems either in the objective function or as a constraint. This dissertation considers these problems under uncertainty and aims to achieve some sort of robustness against that uncertainty. In order to take advantage of the above spatial properties and geometric principles to overcome the drawbacks of current approaches to solving such problems, we adopt an interdisciplinary approach that combines concepts, theories, and methods from computational geometry, geometric probability theory, calculus of variations, infinite-dimensional optimization, and topology. We first show the inability of the existing operations research tools to obtain reasonable solutions for some special but common and practical cases, like clustered data, and then we show that our approach makes these problems easy to solve. The results of this research have been used by Oracle Labs in a routing package for their forthcoming spatial database products and by a major mapping company in a worldwide LIDAR surveying project to scan neighborhoods and collect street level data in five continents

4 - Real-Time Optimization of Personalized Assortments
Negin Golrezaei, University of Southern California, 812 S.Marengo Avenue, Unit 6, Pasadena, CA, 91106, United States, golrezae@usc.edu

Motivated by the availability of real-time data on customer characteristics, we consider the problem of personalizing the assortment of products for each arriving customer. Using actual sales data from an online retailer, we demonstrate that personalization based on each customer's location can lead to over 10% improvements in revenue compared to a policy that treats all customers the same. We propose a family of index-based policies that effectively coordinate the real-time assortment decisions with the backend supply chain constraints. We allow the demand process to be arbitrary and prove that our algorithms achieve an optimal competitive ratio. In addition, we show that our algorithms perform even better if the demand is known to be stationary. Our approach is also flexible and can be combined with existing methods in the literature, resulting in a hybrid algorithm that brings out the advantages of other methods while maintaining the worst-case performance guarantees.

5 - Velocity-based Storage and Stowage Decisions in a Semi-automated Fulfillment System
Rong Yuan, Massachusetts Institute of Technology, 2014, 235 Albany St., Cambridge, MA, 02139, United States, rongyuan@mit.edu

Our research focuses on a new semi-automated operating architecture of an order fulfillment system where the inventory is stored on mobile pods, moved by robotic drives, and picked manually by stationary operators. Our work is one of the first research efforts to optimize the design and operational processes of a real world large-scale semi-automated storage system. We proposed novel and effective operational policies for the storage (where to return a pod upon the completion of a pick or stow operation) and stowage (in which zone and on which pod to store the receiving inventory) decisions. We further use simulations to verify our findings with real world data provided by our industrial partner.

■ SD32

351B

Drone Delivery Systems - IV

Invited: InvitedDrone Delivery Systems (tentative title)

Invited Session

Chair: Andrea Arias, Texas Tech University, andrea.arias@ttu.edu

1 - A Dynamic Programming Approach for the Traveling Salesman Problem with Drone
Niels Agatz, Rotterdam School of Management, Erasmus University, Burg. Oudlaan 50, Rotterdam, Netherlands, nagatz@rsm.nl, Paul Bouman, Marie Schmidt

A promising new operating model is the use of a delivery truck that collaborates with a drone to make deliveries. This model gives rise to a new planning problem that we call the Traveling Salesman Problem with Drone (TSP-D). In this contribution, we propose an exact solution approach based on dynamic programming and present experimental results of different dynamic programming based heuristics.

2 - Optimal Path Construction and Routing of Drones for Inspecting Disaster-affected Regions
Sudipta Chowdhury, Mississippi State University, 260 McCain Engineering Building, ISE Department, Starkville, MS, 39762, United States, sc2603@msstate.edu, Sandip Kumar, Mohammad Marufuzzaman, Linkan Bian

Aerial drones are one of the most promising and powerful new technologies to improve disaster response and relief operations. This study introduces a heterogeneous fleet routing problem for drones, by considering multiple charging stations and respecting operational requirements. First, paths are constructed for the drones by obeying the restrictions set by the Federal Aviation Agency (FAA), technological, geographical, and environmental factors into account. We then propose a hybrid metaheuristic to solve the heterogeneous fleet routing problem. A case study, using three disaster-prone coastal counties in Mississippi, is developed to visualize and validate the algorithmic results.

3 - GPU Enhanced Shortest Path Finding for an Unmanned Aerial Vehicle
Roksana Hossain, University of Calgary, Calgary, AB, Canada, rhossain@ucalgary.ca, Sebastian Magierowski, Geoffery G. Messier

Situated robots like unmanned aerial vehicles (UAVs) need to decide the sequence of multiple destinations. The traveling salesman problem (TSP) is used for identifying an efficient sequence of goals. For real-time mission-critical operations, such decisions need to be made quickly with sufficient accuracy. In this report, to enhance the computational execution rate without incurring excessive system cost, a graphics processing unit (GPU) is used. A genetic algorithm and clustering algorithms is used to solve the TSP in an aerial network delivery context. The implemented GPU code works 4.8 times faster than serially implemented code and the algorithm can solve large problems with 4000 waypoints.

4 - Decomposition Heuristics for the Last-mile Delivery Problem
Andrea Arias, Pontificia Universidad Catolica de Valparaiso, Valparaiso, Chile, Andrea.arias@ttu.edu
Andrea Arias, Texas Tech University, Lubbock, TX, United States, Andrea.arias@ttu.edu, Ricardo Gatica, Jimena Pascual, Timothy I. Matis

We consider an extension of the Vehicle Routing Problem in which a single Unmanned Aerial Vehicle (UAV) is used to support a delivery truck in the last-mile delivery process. In this problem, the objective is to determine a coordinated tour for both the truck and the UAV, such that all the packages are delivered at a minimum cost. It is assumed that once the UAV is launched from the truck to deliver a package, the truck continues visiting other clients and meets the UAV in a later position of the tour. We propose alternative decomposition-based heuristics for the problem and show results on preliminary computational tests.

■ SD33

351C

MAS Tutorial: Thomas R. Willemain

Sponsored: Military Applications

Sponsored Session

Chair: Greg H. Parlier, North Carolina State University, 255 Avian Lane, Madison, AL, 35758, United States, gparlier@knology.net

1 - Three Unexploited Ideas in Simulation Analysis
Thomas R. Willemain, Smart Software, Inc, 2520 Peters Lane, Niskayuna, NY, 12309-2413, United States, trw@smartcorp.com

Some promising ideas have not yet been added to the simulation canon. I review three such under-appreciated ideas. Idea 1: Using bootstrap methods to generate realistic inputs from a single sample of actual system operation. Idea 2: Creating malicious simulation inputs to test design resilience. Idea 3: Using transient behavior to compute rapid estimates of steady state behavior.

■ SD34

351D

Studies and Scheduling

Sponsored: Military Applications

Sponsored Session

Chair: Andrew Oscar Hall, United States Military Academy, 86 B Patridge Pl, West Point, NY, 10996, United States, andrew.hall@usma.edu

1 - Nato Systems Analysis Studies Panel
Richard F. Deckro, Professor of Operations Research, Air Force Institute of Technology, Afit/ENS; Bldg 641, 2950 Hobson Way, Wright Patterson AFB, OH, 45433-7765, United States, richard.deckro@afit.edu, Timothy Povich

The NATO Science and Technology Organization's System Analysis and Studies (SAS) Panel fosters co-operative research, exchange of information, and the advancement of science and technology among the NATO Nations in the field of operations for defense and security. This presentation provides an overview of the SAS Panel's mission, goals and operations. Selected examples of previous studies will be provided.

2 - Kalman Filtering for Artillery Fire Shift
Michael Bendersky, Holon Institute of Technology, 52 Golomb St Holon, Holon, 58102, Israel, michael.bendersky@gmail.com, Israel David

Firing Shift or transfer of Fire is the shifting of artillery fire from one target to another with the application of corrections determined from the adjustment on the first target to the initial firing data for the second. In introducing a linear model for artillery fire accuracies - the parameters of which are easily obtainable from extant Firing Tables - we propose a new algorithm for making the shift, based on a static Extended Kalman Filter. It assumes concurrent fire adjustments on multiple auxiliary targets. Numerical examples are included, which attest to the potential of the approach.

3 - A New Optimization Approach for Unmanned Aerial Vehicle Assignment and Scheduling

Haitao Li, University of Missouri-St Louis, College of Business Administration, 229 Express Script Hall, St Louis, MO, 63121-4400, United States, lihait@umsl.edu

Managing unmanned aerial vehicles (UAVs) operations to accomplish military missions is often a formidable task, as it requires both assignment and scheduling decisions to be made simultaneously to optimize performance metrics, while satisfying various technical requirements. We develop a new modeling framework based on assignment-type resource-constrained project scheduling (RCPSP), and devise a decomposition algorithm to obtain optimal or near-optimal solutions for large-scale instances in reasonable computational time. A real world use case is presented to demonstrate the effectiveness and efficiency of our solutions.

■ SD35

351E

Supply Chain Management

Contributed Session

Chair: Zahra Azadi, Clemson University, 110 Heritage Riverwood Drive, Apt M, Central, SC, 29630, United States, zazadi@clemson.edu

1 - Value of RFID in a Non-profit Supply Chain Subjected to Inventory Inaccuracy

Arun Kumar Biswal, Research Scholar, IIT Kharagpur, ISE Department, IIT Kharagpur, West Medinipur, Kharagpur, 721302, India, akb@iem.iitkgp.ernet.in, Arun Kumar Biswal, Mamata Jenamani, Sri Krishna Kumar

This research investigates the impact of RFID in a Non-profit supply chain to study the effect of shrinkage,misplacement and shrinkage recovery rate on overall costs.We model the situation as a Newsvendor problem to minimize the total expected cost and compare two scenarios with and without RFID. We incorporate deprivation cost in the model to account for the human suffering due to delay in delivery of critical items.We apply the model to Indian Public Distribution System and the results show that ,incentive to deploy RFID depends on the severity of error, the shrinkage recovery rate and the deprivation cost.

2 - Simulation and Optimization for Reevaluating Order Fulfillment Decisions in an Online Retail Environment"

Matthew Petering, University of Wisconsin-Milwaukee, Industrial and Manufacturing Engineering Dept, Ems E367, Milwaukee, WI, 53201, United States, mattpete@uwm.edu, Amir Kalantari

We devise a discrete event simulation (DES) and optimization framework to compare options for assigning the orders placed with an online retailer to the retailer's fulfillment centers. We show that large online retailers can meaningfully reduce total shipping costs by intelligently reevaluating their order fulfillment plans. Importantly, the optimization routines in our framework are fully embedded within a DES model so that both the decisions made, and the computation time used, by the optimization routines affect the future evolution of the DES model from time 0 to time infinity.

3 - Stochastic Optimization Models for Vaccine Supply Chain Network Design

Zahra Azadi, clemson university, 110 Heritage Riverwood Drive, Apt M, Central, SC, 29630, United States, zazadi@clemson.edu, Sandra D.Eksioglu

The main objective of this research is to increase vaccine coverage in low-middle income countries by improving the performance of the corresponding supply chain. We develop a stochastic optimization model which identifies optimal supply chain designs and management strategies. The model considers the limited shelf life of vaccines, variation in manufacturing lead time, facility and transportation costs, as well as variations in patient arrivals at health clinics. The proposed model is an extension of the supply chain network design model. We use a two-stage stochastic Benders decomposition algorithm within a rolling horizon framework to solve the problem.

■ SD36

351F

Service Supply Chain Management

Sponsored: Service Science

Sponsored Session

Chair: Chiehyeon Lim, UC Merced; POSTECH, 790-784, Engineering Building #4-316, San 31, Hyoja-Dong Nam-Gu, Gyungbuk, Na, Korea, Republic of, chlim@unist.ac.kr

1 - Physical Internet Inspired Network Design for Daily Cyclic Routes

Zhengyang Hu, Research Assistant, Iowa State University, 3014 Black Engineering, Ames, IA, 50014, United States, zhengya@iastate.edu, Guiping Hu

Conventional dispatching logistics network requires a single trucker picks up at source and delivers to sink. Relay networks have been proposed for improving trucker life as well as solving other drawbacks of conventional networks like high deadhead cost. More recently, Physical Internet has renewed interest by introducing different modeling strategy. In this paper a two-stage mixed integer programming model is proposed for hub and routing design. The model determines the locations and capacities of hubs to meet uncertain demand. The model minimizes overall cost including fixed cost, deadhead cost, transportation cost. A real case study based on the highway grid for Western United State is considered to demonstrate operational practice of the model.

2 - Mechanisms of Smart Service Systems

Chiehyeon Lim, Assistant Professor, UNIST.(Ulsan National Institute of Science and Technology), Ulsan, Korea, Republic of, chlim@unist.ac.kr, Paul Maglio

Smart service systems are everywhere - in homes and in transportation, energy, and healthcare sectors. In this talk, we discuss mechanisms of smart service systems based on text mining of the broad literature of smart service systems and R&D projects concerning the design of smart transportation, health, energy, and home systems. A model based on such empirical studies is proposed for smart service system design.

3 - Shop Floor Lot-sizing and Scheduling under Uncertain Demand and Workforce Efficiency

Yihua Li, Iowa State University, 3014 Black Engineering, Ames, IA, 50014, United States, yihuali@iastate.edu, Guiping Hu

A two-stage stochastic programming model is proposed to solve the shop floor lot-sizing and scheduling problem under two sources of uncertainties - products demand from the market, and workforce effectiveness caused by different operational issues (e.g. proficiency of workers, parts availability). The model aims to determine optimal lot sizes and the sequence of lots that minimize total system costs over the production planning horizon, including setup, inventory and fixed costs. A case study is preformed to a supply chain producing brake equipment in the automotive industry.

■ SD37

352B

Best IBM Service Science Student Paper Award Competition IV

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Pennsylvania State University, Malvern, PA, 19355, United States, robinqiu@psu.edu

1 - Strategically Giving Service: the Effect of Real-Time Information on Service Efficiency

Nil Karacaoglu, Northwestern University, 531 Grove Street, Evanston, IL, 60201, United States, n-karacaoglu@kellogg.northwestern.edu, Antonio Moreno, Can Ozkan

Real-time information in on-demand services provides agents with access to an unprecedented amount of information about their competitors. We study the impact of the increased availability of real-time information on the behavior of strategic agents and the implications of this phenomenon for service efficiency using data from an e-hailing taxi platform in South America. We find that agents scatter when they receive real-time information indicating the entry of new competitors into the area. The response is heterogeneous. Agents with a high scattering propensity achieve higher utilization. We investigate the consequences of this behavior for the efficiency of service systems.

2 - Dynamic Availability and Pricing of Upgrades

Xiao Zhang, The University of Texas at Dallas, 800 West Campbell Rd, Richardson, TX, 75080, United States, xiao.zhang@utdallas.edu, Metin Çakanyıldırım, Özalp Özer

Upgrading, a travel industry practice to mitigate supply-demand mismatches, is often implemented either at the booking time or at the check-in time. We consider dynamically-offered upgrades between the booking and the check-in times by a firm that sells two types of products (premium and regular). The firm decides on the number of regular product purchasers to receive an upgrade notification that includes a link to an upgrade website. A regular product purchaser may accept or reject the upgrade after clicking the link and observing an upgrade fee dynamically determined by the firm. The optimal number of notifications and the optimal upgrade fee are monotone with respect to the leftover capacities.

3 - Selling Off-Grid Light to Liquidity Constrained Consumers
Bhavani Shanker Uppari, INSEAD, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, BhavaniShanker.Uppari@insead.edu, Ioana Popescu, Serguei Netessine

A large proportion of the world's population has no access to electricity and so relies on noxious kerosene for their lighting needs. As an alternative, there are business models relying on rechargeable light bulbs that are sold at a subsidized price (which renders them affordable) and require regular micropayments for recharges (which eases liquidity constraints). These bulbs provide a cheaper and healthier light source than kerosene, yet their adoption is lower than expected and some consumers continue to use kerosene. This paper explores the potential drivers of such preferences and proposes strategies to alter them.

■ SD38

352C

Bilevel Optimization and Applications

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Kalyanmoy Deb, Michigan State University, East Lansing, MI, 48824, United States, kdeb@egr.msu.edu

1 - Comparison of Multiobjective Optimization Approaches for Spatially Targeting Agri-environmental Policy
Bradley Barnhart, United States EPA, 200 SW. 35th Street, Corvallis, OR, 97333, United States, bradleybarnhart@gmail.com, Gerald Whittaker, Moriah Bostian, Zhichao Wu, Ankur Sinha, Kalyanmoy Deb

Spatially targeting agri-environmental policy has been widely studied and requires optimization of multiple objectives from multiple stakeholders, including policy makers and policy followers. This study tests the Platypus package in Python for multiobjective optimization and compares the results of multiple algorithms available within the framework (e.g., NSGAII, NSGAIII, MOEA/D) for spatially targeting a fertilizer tax that aims to reduce nonpoint source pollution and increase water quality throughout a heterogeneous, mixed-use watershed. The resulting policy trade-offs are compared to the DEAP package in Python and the MATLAB implementation of BLEAQ.

2 - Optimal Management of Naturally Regenerating Uneven-aged Forests
Pekka Malo, Aalto University School of Business, Runeberginkatu 22-24, Helsinki, 00100, Finland, pekka.malo@aalto.fi, Ankur Sinha, Janne Rämö, Olli Tahvonen, Markku Kallio

A shift from even-aged forest management to uneven-aged management practices leads to a problem rather different from the existing straightforward practice that follows a rotation cycle of artificial re-generation, thinning of inferior trees and a clearcut. A lack of realistic models and methods suggesting how to manage uneven-aged stands in a way that is economically viable and ecologically sustainable creates difficulties in adopting this new management practice. To tackle this problem, we propose an algorithm that is able to handle a realistic uneven-aged stand management model that is otherwise computationally tedious and intractable.

3 - Hub Interdiction and Protection Problem: Models and Solution Approaches
Ankur Sinha, PhD, IIM Ahmedabad, India, IIM Ahmedabad, India, Ahmedabad, India, asinha@iimahd.ernet.in

Many of the important sectors in the economy such as transportation, communication and energy deploy a hub-and-spoke network. Hub-and-spoke networks are attractive because of its cost advantages, but is also prone to severe network disruption in the event of one or more hubs failing. We present different formulations and solution methods for the hub interdiction and protection problem. We model the interdiction problem as a bilevel mixed integer linear program and then utilize the problem properties to reduce the number of optimization levels to one. We also study the three level protection problem, where we utilize the ideas developed for interediction to solve the trilevel optimization task.

■ SD39

352D

Making Decisions Considering Uncertainty – Decision Trees and Simulation

Sponsored: Analytics

Sponsored Session

Chair: Brian H. Putt, Self Employed, Fremont, CA, 94536, United States, brianputt@theputts.com

1 - Optimal Pipeline Maintenance Policy with Sipmath in Native Excel
Brian H.Putt, Self Employed, 4372 Nagle Way, Fremont, CA, 94536, United States, brianputt@theputts.com, Sam L.Savage

The US has thousands of miles of pipelines that have been in the ground for many years. Pipeline failures near residential and commercial locations are costly and deserve a higher maintenance priority because of their potential cost. But the maintenance budget is constrained and we want to stay within the budget. Which pipes should we replace based on Likelihood of Failure (LoF), uncertain Cost of Failure (CoF) and uncertain cost to maintain? In the San Francisco Bay Area we also have the potential for earthquakes. Maintenance of the pipelines reduces the LoF when an earthquake occurs. We will show how all these uncertainties are modeled using SIPmath and Excel, and then optimized using Excel's Solver.

2 - Selecting a Technology Application in Upstream using Sipmath
Ahren Lacy, Chevron, 1400 Smith St, 38188, Houston, TX, 77002, United States, ahrenlacy@gmail.com

Selecting technologies for selecting in upstream projects involves assessing, quantifying, and evaluating uncertainties in cashflows. The author will present an example of using SIPmath to quickly incorporate uncertainty into common cashflow worksheets.

■ SD40

352E

Behavioral Considerations in Pricing and Revenue Management Models

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Javad Nasiry, Hong Kong University of Science and Technology-HKUST, Lee Shau Kee Business Building, Room 4079, Hong Kong, nasiry@ust.hk

Co-Chair: Ningyuan Chen, HKUST, Hong Kong, nychen@ust.hk

1 - Information Provision and Revenue Management in the Presence of Consumer Search Costs
Zizhuo Wang, University of Minnesota, 1009 5th Street SE, Minneapolis, MN, 55414, United States, zwang@umn.edu, Yan Liu, William L.Cooper

Should a seller make product information readily accessible, so that customers do not have to incur substantive cost to learn about those products? We consider a stylized model with two products to answer this question. We find that if product uncertainties are small but highly correlated, then withholding both products' information is best for the seller. If the uncertainties are small in both magnitude and correlation, then providing one product's information but not the other is the best. If the uncertainties are large in both magnitude and correlation, then providing both products' information is the best. Also, when correlation is low, withholding both products' information cannot be optimal.

2 - Consumer Choice Models with Reference Prices
Ruxian Wang, The Johns Hopkins Carey Business School, 100 International Dr, Baltimore, MD, 21202, United States, ruxian.wang@jhu.edu

We incorporate reference price into consumer choice models and investigate the problems on revenue management and pricing.

3 - Are Markets with Loss-averse Consumers More Sensitive to Losses?
Zhenyu Hu, National University of Singapore, 15 Kent Ridge Drive, Mochtar Riady Building, BIZ1 8-69, Singapore, 119245, Singapore, bizhuz@nus.edu.sg, Javad Nasiry

Behavioral pricing and revenue management aims to incorporate realistic consumer behavior into firms' pricing and inventory models. The key input to these models is market demand, which is often assumed to inherit the characteristics of consumer behavior—as when, for example, one assumes that a market consisting of loss-averse consumers is more responsive to losses than to gains. The empirical evidences on loss-sensitive demand, however, are frustratingly mixed. We offer one explanation on why gain-sensitive demand and loss-averse consumers can coexist by accounting for the heterogeneity in consumer valuation and examine its implication on firm's optimal pricing policies.

4 - Loss Aversion and Uniform Pricing: Are they Related?
Ningyuan Chen, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, nychen@ust.hk, Javad Nasiry

We study the optimality of price markdowns when consumers are loss averse. We show that even if the overall demand function is more sensitive to losses than to gains, the firm may find it optimal to offer periodic discounts to maximize its profits.

■ SD41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Liqun Lu, University of Illinois at Urbana-Champaign, Urbana, IL, United States, liqunlu2@illinois.edu

1 - Evidence Based Optimal Control Method with Heuristic in Clinical Treatment
Kaiming Bi, PhD Student, Kansas State University, 2061 Rathbone Hall, 1701 D.Platt St., Manhattan, KS, 66502, United States, bikaiming@ksu.edu, John C.Wu, Yuyang Chen

In real disease clinic dynamic system, both the system or measurment errors are inevitable, thus it is necessary to consider it into treatment strategy. This research addresses a general problem with considering uncertain errors in disease system, since the traditional control methods frequently is not able to provide precise control strategies for disease treatments or medigation when uncertain errors are involved. A new Evidence Based Optimal Control approach is presented combining both traditional optimal control and machine learning methods. Four machine learning algorithms were tested and the most suitable approach were then combined with the traditional optimal control.

2 - Improving Out-of-hospital Response Time with a Dynamic Ambulance Relocation Model: the Case of Emergency Medical Services in Antofagasta, Chile
Hernan Caceres, Assistant Professor, Universidad Catolica del Norte, Avenida Angamos 0610, Antofagasta, 1270709, Chile, hcaceres@ucn.cl, Carlos Olivos, Rajan Batta, Qing He

In this research, we focus on the problem of locating ambulances to improve out-of-hospital response time, and thus, survival rates. The emergency medical service in Antofagasta keeps its ambulances at their bases, and the effectiveness of their location has not been assessed. We developed a dynamic relocation model that considers stochastic demand dependent on the time of day, the day of the week, traffic and emergency type. Mathematical formulations for this problem are developed and analyzed. Results from a case study along with algorithmic computational results will be presented.

3 - Nonlinear Optimization for Nonparametric Image Segmentation
Maduka R. Balasooriya, Southern Illinois University-Edwardsville, Box 1653, Edwardsville, IL, 62026, United States, mbalaso@siue.edu, Sinan Onal, Xin W. Chen

Precise object boundary detection for automatic image segmentation is critical for image analysis. However, such detection traditionally uses model and model-free based approaches requiring selection of optimal parameters. Identifying optimal parameter values requires time-consuming multiple runs and provides results that vary by user expertise. We are proposing a nonparametric model, in which the problem is formulated as a nonlinear program and solved using brute force search technique. The proposed model can be applied to any image datasets without using any preprocessing steps.

4 - Epidemic Control with Targeted Screening Policy
Liqun Lu, University of Illinois at Urbana-Champaign, 205 N.Mathews Ave., Urbana, IL, 61801, United States, liqunlu2@illinois.edu, Yanfeng Ouyang

Contagious diseases always pose threats to human society, and high social connectivity in the modern era further exacerbates epidemic propagation. This study establishes a modelling framework to describe epidemic dynamics in a multi-group social network, and then proposes and optimizes a control strategy to mitigate disease propagation via targeted screening. The effectiveness of such a control policy is demonstrated with numerical examples.

■ SD42

360A

Additive Manufacturing I

Invited: Advanced Manufacturing

Invited Session

Chair: Qiang Huang, University of Southern California, Los Angeles, CA, 90089, United States, qiang.huang@usc.edu

1 - Predictive Model Building Across Different Process Conditions and Shapes in 3D Printing
Arman Sabbaghi, Assistant Professor, Purdue University, 150 N. University Street, West Lafayette, IN, 47907, United States, sabbaghi@purdue.edu, Qiang Huang

Predictive deformation models constitute an important component in quality control for 3D printing. However, model building is made difficult by the wide variety of process conditions and shapes. A methodology that can make full use of data on different shapes and conditions is necessary. We develop a new Bayesian procedure based on effect equivalence and modular deformation features that incorporates all data for the systematic construction of deformation models. Our method is applied to model the multiple deformation profiles in cylinders with different cavities. Ultimately, our Bayesian approach unifies quality control in 3D printing across different process conditions and shapes.

2 - A Convolution Formulation to Learn Complex Inter-layer Bonding Effects in Additive Manufacturing
Qiang Huang, University of Southern California, Dept of Industrial & Systemes Engineering, 3715 Mcclintock Avenue, Ger 240, Los Angeles, CA, 90089, United States, qiang.huang@usc.edu, Yuan Jin, Zhengyu Zhang

In the lay-to-layer Additive manufacturing (AM) processes, there is insufficient understanding of interactions among layers and its effect on geometry deformation. This study establishes a convolution formation to analyze the interlayer interactions through learning from experimental data.

3 - Quality Monitoring and Control in Additive Manufacturing for Metal Products
Bianca Maria Colosimo, Professor, Politecnico di Milano, Milano, Italy, biancamaria.colosimo@polimi.it

This contribution describes quality issues in metal additive manufacturing. Possible strategies for in-situ monitoring and process control are presented.

■ SD43

360B

Financial Incentives and Health System Performance

Sponsored: Public Sector OR

Sponsored Session

Chair: Dimitrios Andritsos, Paris, France, andritsos@hec.fr

1 - Incentive Programs for Reducing Readmissions when Patient Care is Co-produced
Dimitrios Andritsos, HEC Paris, Departement MOSI, 1 Rue De La Liberation, Jouy-en-Josas, 78351, France, andritsos@hec.fr, Christopher S. Tang

To compare the effectiveness of three different hospital reimbursement schemes (i.e., Fee-for-Service, Pay-for-Performance and Bundled Payment) in reducing readmissions, we develop a "health co-production" model in which the patient's readmission is "jointly controlled" by the efforts exerted by both the hospital and the patient.

2 - Something from Nothing: Financial, Operational, and Social Benefits of Need-based Free Healthcare
Vikrant Vaze, Dartmouth College, 14 Engineering Drive, Murdough Center, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu, Srinagesh Gavirneni, Omkar D. Palsule-Desai, Sobhan Asian

Need-based free healthcare is an emerging business model that is delivering greater social benefits concurrently with higher financial gains due to its underlying innovative operational, marketing, and philanthropic features. Using Aravind Eye Hospital in India as the setting, we evaluate the role of operational learning, spill-over effects of marketing, and customer segmentation in enabling the success of this philosophy that is increasingly attractive in communities with rampant inequality commonly found in developing countries.

3 - The Business of Healthcare: Physician Integration in Bundled Payments

Turgay Ayer, Georgia Institute of Technology, School of Industrial and Systems Engineering, Groseclose 417, Atlanta, GA, 30332, United States, ayer@isye.gatech.edu, Jan Vlachy, Mehmet U.S. Ayvaci, Srinivasan Raghunathan

Under the prevailing fee-for-service payments, incentives of hospitals and physicians are misaligned, leading to large inefficiencies. Bundled payments unify payments to the hospital and physicians and are expected to encourage care coordination and reduce costs. However, as hospitals differ in their relationships with physicians in influencing care level of physician integration, it remains unclear what spectrum of physician integration will facilitate bundling. We study (1) the impact of the level of integration between the hospital and physicians in the uptake of bundled payments, (2) the consequences of bundling with respect to overall care quality and costs/savings.

4 - Hospital Quality, Medical Charge Variation, and Operational Performance: Implications for Bundled Payment Reform Models

Seokjun Youn, Texas A&M.University, 320 Wehner Building, 4217 Texas A&M.University, College Station, TX, 77840-4217, United States, syoun@mays.tamu.edu, Gregory R. Heim, Subodha Kumar, Chelliah Sriskandarajah

The premise of a bundled payment is to aggregate a number of care delivery services around an episode of care, and to set a priori reimbursement irrespective of actual cost. As such, the bundled payment aims to concomitantly "decrease variability," resulting in reduced and predictable costs. However, a fundamental question, whether the lower variability in practice can leads to better operational performances, is unexplored. We tackle this issue preceded by measuring practice variation based on fee-for-service medical charges of inpatients in NY and FL. We provide implications for designing incentives of bundled payment programs.

■ SD44

360C

Pro Bono Analytics

Sponsored: Public Sector OR

Sponsored Session

1 - Pro Bono Analytics Panel Session

David T. Hunt, Oliver Wyman, One University Square, Suite 100, Princeton, NJ, 08540, United States, david.hunt@oliverwyman.com

Pro Bono Analytics (PBA) is an INFORMS program to match analytics professionals who are willing to volunteer their skills with nonprofit organizations that would benefit from analytical techniques. This panel session will begin with a brief description of some actual PBA projects, and will then focus on a discussion by volunteers and nonprofit representatives about the experiences and challenges of introducing analytics solutions into nonprofit organizations. The discussion will include defining the project outcome, overcoming data problems, and implementing the project results.

2 - Panelist

Vineet Madasseri Payyappalli, University at Buffalo, 38 Embassy Square Apt 7, Tonawanda, NY, 14150, United States, vineet.mp86@gmail.com

3 - Panelist

Adam Clark, U.S. Department of Defense, Washington, DC, United States, adamclark.usa@gmail.com

4 - Panelist

Scott Arthur, Star of Hope, Houston, TX, United States, sarthur@sohmission.org

5 - Panelist

Jason Lau, DePelchin Children's Center, Houston, TX, jlau@depelchin.org

■ SD45

360D

JFIG Paper Competition I

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: Jose Luis Walteros, University at Buffalo, SUNY, 413 Bell Hall, Buffalo, NY, 14260, United States, josewalt@buffalo.edu

1 - JFIG Paper Competition I

Jose Luis Walteros, University at Buffalo, SUNY, 413 Bell Hall, Bu, NY, 14260, United States, josewalt@buffalo.edu

The 2017 JFIG paper competition features paper submissions from a diverse array of talented junior faculty members. The prize committee evaluated submissions based on the importance of the topic, appropriateness of the approach, and significance of the contribution. After careful review, the prize committee selected a group of finalists to present their research in one of the two JFIG sessions. For information on the finalists and their papers, please refer to the online program.

2 - Optimal Signaling Mechanisms in Unobservable Queues

David Lingenbrink, Cornell University, Ithaca, NY, United States, d.lingenbrink@gmail.com, Krishnamurthy Iyer

We consider the problem of optimal information sharing in the context of a service system. In particular, we consider an unobservable single server queue offering service at a fixed price to a Poisson arrival of delay-sensitive customers. The service provider can observe the queue, and may share information about the state of the queue with each arriving customer. The customers are Bayesian and strategic, and incorporate any information provided by the service provider into their beliefs about the queue size before deciding whether to join the queue or leave without obtaining service. We pose the following question: which signaling mechanism should the service provider adopt to maximize her revenue? We establish that, in general, the optimal signaling mechanism requires the service provider to strategically conceal information from the customers to incentivize them to join. In particular, we show that a signaling mechanism with two signals and a threshold structure is optimal. Furthermore, for the case of linear waiting costs, we obtain analytical expressions for the thresholds of the optimal signaling mechanism. Finally, we prove that the optimal signaling mechanism under the optimal fixed price can achieve the revenue of the optimal state-dependent pricing mechanism. This suggests that in settings where state-dependent pricing is not feasible, the service provider can effectively use optimal signaling to achieve the optimal revenue. Our work contributes to the literature on Bayesian persuasion in dynamic settings, and provides many interesting directions for extensions.

3 - Optimization of Tree Ensembles

Velibor Misic, UCLA Anderson School of Management, 110 Westwood Plaza, Suite B406, Los Angeles, CA, 90095, United States, velibor.v.misic@gmail.com

Tree ensemble models such as random forests and boosted trees are among the most widely used and practically successful predictive models in applied machine learning and business analytics. Although such models have been used to make predictions based on exogenous, uncontrollable independent variables, they are increasingly being used to make predictions where the independent variables are controllable and are also decision variables. In this paper, we study the problem of tree ensemble optimiza- tion: given a tree ensemble that predicts some dependent variable using controllable independent variables, how should we set these variables so as to maximize the pre- dicted value? We formulate the problem as a mixed-integer optimization problem. We theoretically examine the strength of our formulation and exploit the structure of the problem to develop two large-scale solution methods, one based on Benders decom- position and one based on iteratively generating tree split constraints. We test our methodology on a real data set in the domain of drug design, where we show that our methodology can efficiently solve large-scale instances to near or full optimality and outperforms solutions obtained by heuristic approaches. Moreover, specific to the drug design context, our approach can be used to efficiently identify candidate compounds that optimally trade-off predicted performance and novelty with respect to existing, known compounds.

■ SD46

360E

Project Management 2

Invited: Project Management and Scheduling

Invited Session

Chair: Vera Tilson, University of Rochester, Rochester, NY, 14627, United States, Vera.Tilson@simon.rochester.edu

1 - Project Scheduling under the Threat of Disruption

Joseph Szmerekovsky, North Dakota State University, NDSU. Dept 2420, P.O. Box 6050, Fargo, ND, 58108-6050, United States, Joseph.Szmerekovsky@ndsu.edu, Prahalad Venkateshan, Peter D. Simonson

The problem of scheduling a project under the threat of disruption is studied. Objectives include expected net present value, maximum possible loss at a give time, and minimum possible loss at a given time. Mathematical programming formulations and complexity results are presented. Railcar and roadrunner strategies are investigated.

2 - Markovian Pert Networks: New CTMC and Benchmark Results

Stefan Creemers, IESEG School of Management, Rue de la digue 3, Lille, 59000, France, sc@cromso.com

Stefan Creemers, KU. Leuven, Leuven, Belgium, sc@cromso.com

Markovian PERT networks were first studied by Kulkarni and Adlakha (1986), who use a CTMC to determine the exact distribution of the completion time of a project where activities have exponentially-distributed durations. All existing work on Markovian PERT networks adopts the CTMC of Kulkarni and Adlakha (1986). We define a new CTMC that drastically reduces memory requirements. Our CTMC can be used to develop scheduling procedures for a wide variety of problems. We outperform the current state-of-the-art in optimal project scheduling procedures, and are able to solve instances of the PSPLIB J90 and J120 data sets.

3 - A Mixed-integer Linear Programming Formulation of the RCPSP Based on Explicit Assignment and Sequencing Decisions

Norbert Trautmann, University of Bern, FM Quantitative Methoden, Bern, 3012, Switzerland, norbert.trautmann@pqm.unibe.ch, Tom Rihm

The resource-constrained project-scheduling problem RCPSP consists in determining start times for a set of precedence-interrelated activities that require time and scarce resources during execution such that the project makespan is minimized. We present a novel MIP formulation of the RCPSP which is based on explicit assignment and sequencing decisions. The computational results indicate that the novel formulation outperforms two state-of-the-art models known from the literature in particular when the resource capacities are very scarce.

■ SD47

360F

E-Business

Sponsored: EBusiness

Sponsored Session

Chair: Yingda Lu, Rensselaer Polytechnic Institute, Rensselaer Polytechnic Institute, Troy, NY, 12180, United States, luy6@rpi.edu

1 - Informative or Emotional? Examining the Spillover Effect of Online Video Ads

Liang Zhao, Rensselaer Polytechnic Institute, Troy, NY, United States, zhaol11@rpi.edu, Yingda Lu, Chaoqun Deng

In this study we examine the mechanism of spillover among online ads in the context of Youtube.com. We use the Super Bowl videos on YouTube in 2016 and investigate the role of informative and emotional elements in these ads in spillover process. We propose that there are short term as well as long term spillover among online video clips, and informative and emotional elements have different impact on these two types of spillover mechanism. Implications for researchers and managers will be discussed.

2 - Gender Differences in Equity Crowdfunding

Mingfeng Lin, University of Arizona, 1130 E. Helen St, Tucson, AZ, 85721, United States, mingfeng@eller.arizona.edu

This paper studies gender biases and differences in the context of online equity crowdfunding, using proprietary data from a leading platform.

3 - Innovation, Innovation Spillover and Economic Growth: Evidence from China

Bob Liao, Peking University, Beijing, China, bobliaobo@gmail.com, Fei Ren

This paper specifically investigates the innovation spillover phenomenon, which refers to the inter-regional mutual influence through innovation investment. Based on conventional spatial econometric model, our research verifies the existence of innovation spillover effect in the context of China's institution. Further, we extend the classical Cobb-Douglas productivity function and figure out the economic consequence from innovation spillover. As suggested by our empirical result, we can firmly conclude that a region's innovation investment can stimulate others' innovation input but innovation spillover plays a significant negative role in the economic growth.

■ SD48

361A

Behavioral Aspects of Managing Innovation

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Stephen Leider, University of Michigan, Ann Arbor, MI, 48109, United States, leider@umich.edu

Co-Chair: Evgeny Kagan, Ann Arbor, MI, 48103, United States, ekagan@umich.edu

1 - Designing Incentives in Startup Teams: Form and Timing of Equity Contract

Evgeny Kagan, University of Michigan, 701 Tappan Ave, Ross School of Business, Office R5425, Ann Arbor, MI, 48103, United States, ekagan@umich.edu, Stephen Leider, William S.Lovejoy

The conventional logic in the entrepreneurial press is that equal division of startup equity encourages free riding among the founders. Our experimental results confirm the link between equal splits and depressed effort, but suggest a different causal sequence relative to the conventional wisdom. Rather than the contract form being the primitive and the behavior the derived consequence, our results suggest the reverse. The differences in contract performance are driven primarily by the sorting of high contributors into non-equal contracts and of low contributors into equal contracts. However, delaying the contracting mitigates these sorting effects reducing the effort gap between contracts.

2 - Institutional Designand the Creative Process: An Experimental Study

Vish Krishnan, University of California-San Diego, Rady School of Management MC0553, Otterson Hall, La Jolla, CA, 92093-0553, United States, krishnan@alum.mit.edu, Lakshminarayana Nittala, Sanjiv Erat

The process of Innovation often takes the form of problem solving and requires creative insights for achieving success. In an experimental setting we use tasks that are representative of such problems and study the role of institutional design on the creative output and the underlying search process.

3 - Leaps in Innovation

Joel Wooten, University of South Carolina, 1014 Greene St., Columbia, SC, 29208, United States, joel.wooten@moore.sc.edu

Search over a landscape of possibilities is central to innovation contest solution generation. Using 25,898 distinct attempts at innovation for a set of Kaggle contests, we look at how agents respond to both incremental and discontinuous progress.

4 - Motivating Innovation: the Effect of Loss Aversion on the Willingness to Persist

Yaroslav Rosokha, Purdue University, 403 W. State Street, Room 410, West Lafayette, IN, 47907, United States, yaroslav.rosokha@gmail.com, Kenneth Younge

We investigate the willingness of individuals to persist at exploration in the face of failure. Prior research suggests that a "tolerance for failure" may motivate individuals to select more exploratory courses of action. Little is known, however, about how individuals persist at exploration when confronted by prolonged periods of negative feedback. To examine this question, we design a two-dimensional maze game to capture the essential trade-offs between exploration and exploitation, develop predictions for the game using computational models of reinforcement learning, and run a series of randomized experiments with human subjects in the game.

■ SD49

361B

What is Behavioral Aspects of OR?

Invited: InvitedBehavioral Aspects of OR

Invited Session

Chair: Martin Kunc, University of Warwick, University of Warwick, Coventry, CV4 7AL, United Kingdom, martin.kunc@wbs.ac.uk

1 - Moderator

Martin Kunc, University of Warwick, WBS.Social Studies Building, Office E1.07, Coventry, CV4 7AL, United Kingdom, martin.kunc@wbs.ac.uk

The panel will discuss three aspects that differentiate behavioral operations research (OR) from behavioral operations management. Firstly, "content" oriented Behavioral OR. Secondly, "process" oriented Behavioral OR. Thirdly, the "effect" of behavioral and cognitive factors on the activity of analysis and modelling itself. The panel will also discuss how these aspects can form a bridge between both perspectives.

2 - Panelist

Leroy White, University of Bristol, School of Eonomics Finance and Accounting, 12 Priory Road, Bristol, BS8 1TU, United Kingdom, leroy.white@bristol.ac.uk

3 - Panelist

Sally C. Brailsford, University of Southampton, School of Management, Southampton, S017 1BJ, United Kingdom, s.c.brailsford@soton.ac.uk

4 - Panelist

Oliva Rogelio, Texas A&M.University, Mays Business School, College Station, TX, United States, roliva@mays.tamu.edu

■ SD50

361C

Sustainable Travel Incentives

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Bilge Atasoy, MIT, MIT, Cambridge, MA, 02139, United States, batasoy@mit.edu

1 - Reward Allocation for Maximizing Energy Saving in a Transportation System

Adewale Oduwole, University of Massachussets, Amherst, MA, 01002, United States, aoduwole@umass.edu, Song Gao, Hyoshin Park, Moshe Ben-Akiava

We study the optimal reward allocation problem to maximize energy saving in a transportation system. In the first version, no personalized menu optimization is considered. In the second version, a bi-level optimization problem is formulated where the high level optimization aims at maximizing system-wide energy saving, while a low-level consumer surplus maximization problem is solved for each user. Numerical tests are carried out study the effects of an array of system parameters, e.g., token budget and menu length, on the solutions. An array of parameterized token allocation strategies are proposed, and their performances against the optimal solution are investigated.

2 - Developing a Multi-scale and Multi-modal Agent-based Modeling Framework for Assessing Network-wide Energy/Fuel Consumption Impacts of Travel Incentive Strategies

Hesham Rakha, Professor of Civil and Environmental Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061, United States, hrakha@vt.edu

This presentation will describe the various building blocks of the PARC and VTTI's proposed modeling tool, that include: (a) traveler behavior modeling; (b) modeling of train dynamics; (c) agent-based modeling of driver and vehicle longitudinal and lateral movement; (d) modeling of multi-modal energy/fuel consumption (light duty gasoline vehicles, electric vehicles, plugin hybrid electric vehicles, trucks, Compressed Natural Gas (CNG) buses, and electric trains); (e) integration of microscopic and mesoscopic traffic modeling into a fully-integrated multi-scale multi-modal agent-based modeler.

3 - The COPTER System: An Overview and Preliminary Testing in the Greater LA Area

Matthew Klenk, PARC, 3333 Coyote Hill Rd, Palo Alto, CA, 94304, United States, Matthew.Klenk@parc.com

COPTER identifies the energy-efficient routes most likely to be adopted by a traveler. The COPTER project brings together expertise in behavioral modeling and analytics algorithms to understand travel needs of users, their constraints, and how likely they are to respond to suggested travel options. In this talk, we describe our approach, the key design decisions of the system, and our interactions with the city of Los Angeles and commercial entities around fielding the technology.

4 - Personalized Menu Optimization for an Incentivized Smart Mobility Solution

Bilge Atasoy, MIT, 77 Massachusetts Avenue, MIT.1-180, Cambridge, MA, 02139, United States, batasoy@mit.edu, Xiang Song, Mazen Danaf, Moshe Ben-Akiva

We present a personalized menu optimization model for an app-based travel incentive system, Tripod. For each traveler arriving to the system, a customized set of options are presented based on the preferences of the traveler in real-time. The preferences are updated as the traveler performs new trips through an MCMC procedure. Therefore, the personalized menu is based on the most up to date behavioral update. Incentives are allocated based on the guidance from a system optimization model that minimizes network wide energy consumption. Different formulations are evaluated under different scenarios in order to show the added value of personalized nature of the model and the updated preferences.

5 - incenTrip: A Real-Time Personalized Information and Incentivization Tool as a Smart-Mobility Solution

Chenfeng Xiong, University of Maryland-College Park, 149 Westway, Apartment 201, Greenbelt, MD, 20770, United States, cxiong@umd.edu, Lei Zhang

Different types of incentives in the transportation systems have recently drawn increasing attention to form smart-mobility solutions. Instead of using presumed and fixed amount of incentives, we develop an integrated, personalized and real-time traveler information and incentive technology, incenTrip, to incentivize more energy efficient travel, such as eco-driving, flex-time departures, and ride-sharing. Available in Android and iOS systems, incenTrip smartphone app provides precise and predictive traffic information, coupled with personalized and pro-social incentives, to help its users make smarter travel decisions. Driven by a computationally efficient agent-based modeling system modeling, incenTrip technology simulates the entire transportation systems in real-time and employs artificial-intelligence algorithms to predict the traffic evolution. This online modeling leverages real-time transportation big-data streams supplied by one of the biggest transportation data warehouses in the U.S., the Regional Integrated Transportation Information System (RITIS), hosted at the University of Maryland. Then a control optimization system is developed based on behavior research, travel intent prediction, and incentive optimization, in order to provide optimized incentives and route/departure time guidance.

■ SD51

361D

Digital Markets and Platforms

Sponsored: Information Systems

Sponsored Session

Chair: Yan Huang, University of Michigan, yphuang@umich.edu

1 - Data-driven Promotion Planning for Mobile Applications

Manqi Li, University of Michigan, 710 Tappan Avenue, Ann Arbor, MI, 48105, United States, manqili@umich.edu, Yan Huang, Amitabh Sinha

The mobile app market is one of the fastest growing markets. In this work, we propose a two-step analytical approach to optimize the price promotion strategy for mobile apps. In the first step, we empirically estimate the immediate and long-term effects of price promotions on app download volume. The estimation results reveal two interesting characteristics: (1) promotion effect; and (2)visibility effect. Based on the estimated download function, we then formulate a longest-path problem to solve for optimal policy. The resulting optimal promotion strategy makes the best use of visibility effect and significantly increases developers' long-term revenue compared with their current practice.

2 - Linking Clicks to Bricks: Estimating Causal Effects of Email Ads on Offline Sales

Mi Zhou, Carnegie Mellon University, 4800 Forbes Ave, Pittsburgh, PA, 15213, United States, mzhou1@andrew.cmu.edu, Vibhanshu Abhishek, Ritwik Sinha, Nikos Vlassis

Online advertising market is soaring and has attracted the attention of many researchers. However, research in this area has almost entirely focused on consumers' online behaviors and has not incorporated their decision-making in the offline setting, which may lead to incomplete understanding of online advertising effectiveness in today's multi-channel world. In this paper, we use a Big Data which links consumers' online behaviors to their purchase records offline, and find that email ads have non-linear positive effects on offline sales. Further, we use a supervised Machine Learning method to estimate heterogeneous effects of email ads in different subpopulations partitioned by causal trees.

3 - The Centre Cannot Hold: Fragmentation in Multisided Markets

Abhishek Roy, University of Texas-Austin, 2110 Speedway Stop B6500, Austin, TX, 78712-1277, United States, abhishek.roy@utexas.edu, Edward G. Anderson, Geoffrey Parker

Existing literature on multi-sided markets, or platforms, examine the effect of opening up the platform to third-party developers on the platform sponsor. However, in some cases, opening up of certain aspects of a platform results in a fragmented platform that causes negative externalities on other third-party developers or sellers. We develop a model to analyze the effect of such fragmentation in the context of mobile operating systems, where the device side of the ecosystem is opened up, on the application developers, and in turn, on the platform itself.

4 - Ad-Blockers, Advertisers & Internet - Economic Implications of Ad Blocking

Abhishek Ray, Purdue University, 401S, Grant Street, West Lafayette, IN, 47907, United States, ray52@purdue.edu, Hossein Ghasemkhani, Karthik Kannan

The rise of ad-blockers as two-sided platforms has prompted discussions on whether ad-blockers are good for the online ecosystem. Considering the structure of interactions among the end-users, ad-blockers charge advertisers membership fees for certifying quality of their ads (whitelisting) and letting them through, but are free for the users. Our main research question is to study this mechanism and investigate whether it is optimal. Using a game-theoretic model using which we provide answers to questions such as which side (user or advertiser) should be charged by the ad-blocker, the impact of optimal price structure on end-user participation and overall implications for ad quality online.

■ SD52

361E

Recent Innovations in Last-Mile Urban Deliveries

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Bo Zou, University of Illinois, Chicago, IL, 60607, United States, bzou@uic.edu

1 - Designing Mechanisms for Efficient Crowdsourced Urban Parcel Delivery

Bo Zou, University of Illinois at Chicago, 2073 Engineering Research Facility, 842 W. Taylor Street, Chicago, IL, 60607, United States, bzou@uic.edu, Nabin Kafle

This paper presents a mechanism design based approach to crowdshipping. A Delivery Service Provider solicits private information from individuals such as willingness-to-ship and available time window, based on which to assign shipments with minimum total shipping cost. The mechanisms recognize that individuals can misreport private information to gain self-interest, and devise joint shipment assignment-payment schemes to incentivize truthful participation of individuals. Both static and dynamic cases are investigated. Numerical results with a case study of the near north side of Chicago demonstrate the cost advantage of the mechanisms over the state-of-the-practice crowdshipping.

2 - Crowdshipping Consolidation in Urban Logistics

Jane Lin, University of Illinois-Chicago, 842 W. Taylor Street (M/C 246), Chicago, IL, 60607, United States, janelin@uic.edu, Sudheer Ballare

Crowdshipping involves making use of everyday individuals with spare time and capacity to fulfill the variable delivery demand generated by e-commerce. This study performs preliminary investigation of an existing crowdsourcing delivery company with respect to the operational factors such as package size, delivery distance, demand frequency and distribution, the user characteristics including customer and driver profiles, and the pricing model. We further investigate the opportunities of consolidating crowdshipping tasks to further reduce cost and environmental impact. The findings will shed light on the market demand trending and growth opportunities in crowdsourcing deliveries.

3 - Reliability and the Edge of Vulnerability in Crowdsourced Shipping

Alireza Ermagun, Post-doc, Northwestern University, 2145 Sheridan Rd, Evanston, IL, United States, Alireza.ermagun@northwestern.edu, Amanda Stathopoulos

This study introduces reliability indices to measure the vulnerability of crowd-shipping as an innovative urban delivery system. This is a critical matter in the start-up phase of crowd-shipping services, as failing in providing a reliable system discourages registered customers and dissuades other potential customers to use the service. The results are informative to understand the caveats of the system in detail and to implement effective policies to augment the reliability where it is needed and leverage the resources across the system.

4 - Multi-channel Network Planning

Vincent Karels, Eindhoven University of Technology, Eindhoven, Netherlands, V.C.G.Karels@tue.nl

Investigations are made on whether different channels (e-tail, detail and retail) can be better integrated in planning, scheduling and execution. Resources can be effectively shared over and within the three channels. A framework facilitating this integration, with an emphasis on routing, is introduced. This framework is subsequently applied on test- and real-life instances. From these instances it can be shown that integration leads to large benefits.

5 - Bidding, Accepting, and Delivering: On Performance Assessment of Crowd-shipping

Alireza Ermagun, Northwestern University, Evanston, IL, United States, alireza.ermagun@northwestern.edu, Amanda Stathopoulas

This study assesses the performance of crowd-shipping as an innovative urban delivery system. We develop a set of hazard-based duration models to explore socioeconomic, built-environment, and intra-system characteristics that describe the bidding, accepting, and delivering status of packages as a function of time. The results from a real crowdshipping market operating over two years are informative to design policies and incentives relating to prediction, pricing, or promotion for delivery performance, and thereby to improve the efficiency and acceptability of crowd-shipping systems.

■ SD53

361F

Emerging Data Sources and Travel Demand Modeling II

Invited: TSL, Intelligent Transportation Systems (ITS)

Invited Session

Chair: Ali Arian, University of Arizona, 415 N Park Avenue, Tucson, AZ, 85719, United States, arian@email.arizona.edu

1 - Real Time Transportation Mode Detection with Wearable Devices and Neural Networks

Young-Ji Byon, Associate Professor, Khalifa University of Science Technology, 216F Al Saada St and Muroor Rd, P.O. Box 127788, Abu Dhabi, 127788, United Arab Emirates, youngji.byon@kustar.ac.ae, Chung-Suk Cho, Jun Su Ha, Heungjo An, Taeyeon Kim

For traffic monitoring purposes, Departments of Transportation collects data from various dedicated sensors and probe vehicles throughout the road networks. If the modes of transportation the users of smartphones are in can be determined, DOTs can collect mode-specific data from the users as if they are probes themselves. In general, a smartphone is embedded with an accelerometer and a GPS sensor. Emerging wearable devices can provide multiple streams of acceleration values that can enhance mode-detection performances. It is found that having access to acceleration values of multiple parts of the body of a traveler helps identifying the modes

2 - Community Detection with Similar and Dissimilar Travel Activity Patterns

Ali Arian, University of Arizona, 415 N. Park Avenue, Tucson, AZ, 85719, United States, arian@email.arizona.edu, Alireza Ermagun, Yi-Chang Chiu

This research introduces a model to detect communities benefiting from the similarities and dissimilarities in the activity patterns of individuals based on an activity-network. We test a set of community detection methods trip information of 438 individuals using an incentive-based mobility app, Metropia, over 300 days in Tucson, Arizona. The model is validated in predicting the carpooling behavior of users.

3 - Travel Behavior Classification with Social Networkand Deep Learning

Yu Cui, University at Buffalo, 204c Ketter Hall, 429-7333, SUNY Buffalo, NY, 14228, United States, ycui4@buffalo.edu, Qing He, Alireza Khani, Qian Wang

We build a social network for all travelers and employ community detection algorithm to cluster travelers based on the identified similarities of travel patterns. We further create an image of activity map from each traveler's activity matrix. Finally, a deep learning approach with convolutional neural network is employed to classify travelers into corresponding groups according to their activity maps.

4 - Passenger Behavior Analysis in Beijing Metro Network using AFC Data and Agent-based Simulation

Alireza Khani, University of Minnesota, Minneapolis, MN, United States, na, Kai Lu, Baoming Han

AFC data in Beijing metro system has both entry and exit time and location stamps for each passenger. This study based on Beijing AFC data, calibrates the parameters for trip chaining model with the statistical and cluster methods and finds out the passenger trip chain pattern in Beijing network.

■ SD54

362A

Agricultural Analytics

Invited: Agricultural Analytics

Invited Session

Chair: Jack M Kloeber, Kromite, LLC, 82 Nelson Drive, Churchville, PA, 18966, United States, jkloeber@kromite.com

Co-Chair: David Krahl, Kromite LLC, 243 N Union Street, Lambertville, NJ, 08530, United States, dkrahl@kromite.com

1 - Optimization of a Supply Chain for the Production of Biofuel from Corn Stover

Hernan Chavez, University of Texas at San Antoni, San Antonio, TX, United States, chavezpaurhc@ornl.gov, Krystel Castillo-Villar, Erin Webb

Second generation biomass exhibits more variability on its physical properties than first generation. Hence, the quality of feedstock does not always meet the specifications demanded by the conversion processes. This research aims to quantify the cost of imperfect feedstock quality in a biomass-to-biorefinery supply chain (SC) and to develop a model that supports the tactical decisions related to the design and execution of operations that have relevant effects on the physical properties of the biomass. The proposed simulation-based optimization model is based on an extension from the Integrated Biomass Supply and Logistics (IBSAL) simulation model. We present a case study in Ontario, Canada.

2 - Discrete Rate Simulation of Combine Harvester Operations

David Krahl, Kromite LLC, 243 N.Union Street, Lambertville, NJ, 08530, United States, dkrahl@kromite.com

A combine harvester is a moving factory. As the combine moves through a field harvesting grain, one or more external carts transfer the grain from the harvester's internal buffer storage to a roadside semi-trailer. An ExtendSim model will be presented that uses discrete-rate simulation for the process of harvesting grain, filling the combine's internal storage, and transferring the storage to the carts, and discrete-event simulation to represent the availability of carts. The goal of the model is to balance the desired operation of the combine with the number of carts.

3 - Smart Farming: Howthe Internet-of-Things will Spark a Data Revolution in Agriculture

Jay Ham, Colorado State University, Ft. Collins, CO, United States, jay.ham@colostate.edu

The Internet of Things (IoT) is rapidly migrating onto the farm and food supply chain. New sensor technology coupled with improved connectivity in rural areas (LoRa, cellular gateways) will stream farm data to the cloud at unprecedented rates. This presentation will highlight Ag-IoT projects at Colorado State University and show how innovations in data science are needed to fully profit from the coming revolution in Ag technology.

■ SD55

362B

Machine Learning for Finance

Sponsored: Financial Services

Sponsored Session

Chair: Chaithanya Bandi, Northwestern University, 2001 Sheridan Rd, 566, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

1 - Machine Learning Based Robust Optimization Models for Limit Order Books to Predict Price Movements

Chaithanya Bandi, Northwestern University, 2001 Sheridan Rd, 566, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

This paper develops a machine learning based robust optimization model to estimate structure of limit order books. The new architecture yields a low-dimensional model of price movements deep into the limit order book, allowing more effective use of information from deep in the limit order book (i.e., many levels beyond the best bid and best ask). Due to its more effective use of information deep in the limit order book, the spatial neural network especially outperforms the standard neural network in the tail of the distribution, which is important for risk management applications.Our data-driven approach offers new benefits for practical applications.

2 - Machine Learning and Portfolio Optimization

Gah-Yi Ban, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, gban@london.edu, Noureddine El Karoui, Andrew Lim

We adapt two machine learning methods, regularization and cross-validation, for portfolio optimization. We introduce performance-based regularization (PBR), where the idea is to constrain the sample variances of the estimated portfolio risk and return, which steers the solution toward one associated with less estimation error in the performance. We show that the PBR models can be cast as robust optimization problems with novel uncertainty sets and establish asymptotic optimality of PBR solutions. We find PBR dominates all other benchmarks for two out of three Fama-French data sets where parameters are calibrated using a new, performance-based k-fold cross-validation algorithm.

3 - Interpreting Neural Networks

Enguerrand Horel, Stanford University, Stanford, CA, United States, ehorel@stanford.edu, Kay Giesecke

Although neural networks can provide highly accurate predictions, they are often considered as opaque "black boxes". The difficulty of interpreting their predictions often prevents their use in financial practice, where regulators and auditors often insist on model explainability. In this project, we formulate the objectives of interpretability and define it for neural networks. We then consider the interplay between network architecture, identifiability, and interpretability. Considering neural networks as nonparametric models, we show how to use nonparametric variable significance tests to assess the importance of covariates. Tests using mortgage data illustrate our results.

■ SD56

362C

Non-standard Applications of Location Methods

Sponsored: Location Analysis

Sponsored Session

Chair: Dmitry Krass, University of Toronto, University of Toronto, Toronto, ON, M5S 3E6, Canada, krass@rotman.utoronto.ca

1 - Online Grocery Retail and its Environmental Impact

Ekaterina Astashkina, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, ekaterina.astashkina@insead.edu, Elena Belavina, Simone Marinesi

We build a stylized model for traditional and online grocery retail chains to understand the drivers of the consumer and retailer carbon footprint, including emissions that come from food waste and transportation. In our model, consumers make endogenous choices between different channels and the associated food-buying policies, while retailers optimally manage their inventory replenishment. We find that, in most cases, the availability of an online retailer reduces the emissions associated with the grocery sector in a city. We also consider the effectiveness of alternate policy instruments including sales and carbon taxes, and identify actions that improve the behavior of the worst offenders.

2 - Competitive Store Location Models Considering Comparison-shopping

Vladimir Marianov, Professor, Pontificia Universidad Catolica de Chile, Department of Electrical Engineering, Vicuna Mackenna 4860, Santiago, 782-0436, Chile, marianov@ing.puc.cl, H.A. Eiselt, Armin Lüer-Villagra

Consumers' behavior strongly influences the location patterns of retail stores. In competitive settings, firms locate their stores to take advantage of this behavior to maximize their market share. A common behavior is comparison-shopping, by which consumers visit more than one store selling products that are mutual substitutes, before making their purchase decision. We include comparison-shopping into competitive facility location models, and compare the obtained results with those of current models.

3 - Optimal Scheduling of Bridge Maintenance using Geometric Brownian Motion Process

Tsuyoshi Nobata, Tokyo University of Tokyo, Ce-408, 4-6-1, Komaba, Tokyo, Japan, t-nobata@iis.u-tokyo.ac.jp, Yudai Honma

It is well known that there are many studies using Markov chain model in considering uncertainty in bridge asset management. However, there are only a few studies that consider the degradation process of bridges as a continuous model. In addition, considering the scheduling on multiple bridges is very important. In this paper, we propose a degradation model using the geometric Brownian motion and formulate a scheduling strategy for inspection and repair of multiple bridges.

4 - Understanding the Impact of Complexity on Facility Location
Mozart Batista de Castro Menezes, Kedge Business School - Bordeaux, Office: 1449, Talence, 33405, France, mozart.menezes@me.com, Diego Ruiz-Hernandez

Facility location problems are well known problems in the combinatorial optimization field of study, where the objective is to minimize the cost incurred to serve customer from a set of facilities. Our study brings to the field of facility location the concept of operations complexity, opening up a new research line within the field. When defining facility location one should aim not only to reduce operational costs but also to keep complexity in what we call complexity comfort range in which tactical and operational decisions are at their bests. The preliminary (empirical) results suggest that ignoring complexity matters may hurt that same bottom line that the locational problem is trying to improve.

■ SD57

362D

Enhanced Estimation and Sampling in Multi-model Setting

Sponsored: Simulation

Sponsored Session

Chair: Giulia Pedrielli, Arizona State University, Tempe, AZ, 85281, United States, giulia.pedrielli.85@gmail.com

1 - Stratification in Debiased Multi-level Monte Carlo
Zeyu Zheng, Stanford University, CA, United States, zyzheng@stanford.edu, Peter W. Glynn

It has long been known, when dealing with a finite partition, that stratification can yield significant variance reductions. To apply this idea to debiased multi-level Monte Carlo (MLMC), we extend the framework to infinitely many strata. While new mathematical issues arise in the infinitely stratified setting, we are still able to develop a central limit theorem in this context that permits the construction of asymptotically valid confidence intervals. Furthermore, we suggest and theoretically justify sequential stopping procedures for such estimators that allow for easy recursive updating. This work is joint with Peter Glynn.

2 - Efficient Simulation Sampling Allocation using Multi-fidelity Models
Yijie Peng, George Mason University, VA, United States, pengy10@fudan.edu.cn, Jie Xu, Loo Hay Lee, Jian-Qiang Hu, Chun-Hung Chen

We present a new framework that integrates information from multi-fidelity models to increase computational efficiency for selecting the best high-fidelity systems. A Gaussian mixture model is proposed to capture important information contained in low-fidelity models that might not accurately approximate the performance of the high-fidelity simulation model. Posterior information obtained by Gaussian mixture model-based clustering analysis incorporates both cluster-wise information and idiosyncratic information for each design. A new budget allocation method is proposed to efficiently allocate high-fidelity simulation replications, utilizing posterior information.

3 - Parallel Simulation for Transportation Networks
Feliza Vazquez-Abad, CUNY, New York, NY, United States, felisav@hunter.cuny.edu

For simulation of a large public transportation network, we propose an accelerated method using nearly decomposable Markov Chains. This allows parallelization of the simulation, thus achieving great improvement in efficiency. The Kemeny constant is a measure of the strength of links for the stationary Markov chain. Its derivative an be used to assess the sensitivity of individual transitions (in the stationary operation). Using this information, we can decompose a Markov chain into smaller classes approximating the stationary regime. Each class is assigned a processor for simulation, but statistical corrections have to added in order for the parallel simulation to provide good estimates.

■ SD58

362E

Location Analysis

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Noor Alam, Northeastern University, md.alam@northeastern.edu

1 - Modeling Interdependent Transportation and Power Systems under Dynamic Supercharging Demand of Electric Vehicles
Liqun Lu, University of Illinois at Urbana-Champaign, 205 N.Mathews Ave., Urbana, IL, 61801, United States, liqunlu2@illinois.edu, Yanfeng Ouyang

With an increasing number of electric vehicles (EVs) and supercharging stations, the daily power load profile is experiencing a noticeable reshape caused by travel demand in the transportation network. This study proposes a modeling framework to find a market equilibrium between EV users and power generators under dynamic travel demand. It is shown that traffic flow on transportation network and electricity loads/generations in power grids have mutual impacts via EV users' routing decisions.

2 - An Algorithms to Measure Distance Between Irregular Regions
Ruilin Ouyang, Northeastern University, Boston, MA, United States, ouyang.ru@husky.neu.edu, Dinghao Ma, md.noor.e.alam

This talk will present an algorithm to measure distance between two irregular shapes regions used for location analysis.

3 - Datacenter Location Allocation Models
MD Noor. E. Alam, Northeastern University, 334 Snell Engineering Center, 360 Huntington Avenue, Boston, MA, MA 02115, United States, md.alam@neu.edu, Tasnim Ibn Faiz

A Datacenter facilitates high volume online transactions. Its location, capacity and configuration decisions are driven by customer demand volume, latency and uptime requirements respectively. An MILP model is presented that provides optimal decisions for meeting customer demand with required service levels. A second MILP model is presented to meet replication demand associated with each customer. A two-stage decision algorithm is proposed for making global optimal decisions by solving two models sequentially. Numerical results show that the models are scalable and the algorithm is efficient.

■ SD59

362F

Joint session RAS/Practice: RAS Problem Solving Competition

Sponsored: Railway Applications

Sponsored Session

Chair: Yanfeng Ouyang, U. of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, yfouyang@illinois.edu

1 - RAS Problem Solving Competition
Yanfeng Ouyang, U. of Illinois at Urbana-Champaign, 205 N.Mathews Ave, 1209 Newmark Lab, MC-250, Urbana, IL, 61801, United States, yfouyang@illinois.edu

This session is reserved for the finalists of the RAS Problem Solving Competition: "Data Analytics for Railroad Empty-to-Load Peak Kips Prediction." The presenters and their abstracts will be determined the Judging Committee by early October. More information about the Competition is available at http://connect.informs.org/railway-applications/awards/problem-solving-competition.

■ SD60

370A

Joint session ANA/EDU: Building a Market-Relevant Analytics Program

Sponsored: INFORMEd

Sponsored Session

Chair: Jeffrey D Camm, Wake Forest University, Wake Forest University, Winston-Salem, NC, 27109, United States, cammjd@wfu.edu

1 - Moderator

Jeffrey D. Camm, Wake Forest University, School of Business, PO.7897, Winston-Salem, NC, 27109, United States, cammjd@wfu.edu

In this panel, we discuss market-driven curricula in business analytics. We compare and contrast a variety of programs, including an undergraduate major and several different MS in Business Analytics programs. We will discuss what works and potential pitfalls to avoid in developing an analytics program.

2 - Panelist

Melissa R. Bowers, University of Tennessee-Knoxville, 242 Stokely Management Center, Statistics, Operations, & Management Science, Knoxville, TN, 37996, United States, mrbowers@utk.edu

3 - Panelist

Michael Fry, University of Cincinnati, Cincinnati, OH, United States, fryml@ucmail.uc.edu

4 - Panelist

Goutam Chakraborty, Oklahoma State University, Stillwater, OK, United States, chakraborty@okstate.edu

■ SD61

370B

Joint Session MIF/HAS: Decision Making in Healthcare

Sponsored: Minority Issues

Sponsored Session

Chair: Shannon Harris, The Ohio State University, Columbus, OH, 43212-3085, United States, harris.2572@osu.edu

1 - Emergency Department Capacity Planning and Scheduling Decisions within a Large Multi-facility Network

Krista Foster, University of Pittsburgh, 1622 Beechwood Boulevard, Apt 1, Pittsburgh, PA, 15217, United States, kmf88@pitt.edu, Jennifer S.Shang

The growing trend of emergency department (ED) consolidation in the US has intensified the complexity of managing emergency physicians. Large-scale physician groups are simultaneously challenged with capacity planning and scheduling decisions across many facilities. We propose a model to optimally staff facilities throughout the network with emergency physicians and advanced practice providers.

2 - The Benefit of Waiting: A Bayesian MDP to Evaluate Mode of Delivery

Karen T. Hicklin, University of North Carolina at Chapel Hill, 308 Bynum Hall, Chapel Hill, NC, 27599, United States, khicklin@email.unc.edu, Julie Simmons Ivy

Optimal mode of delivery decisions lead to better short- and long-term health outcomes for mothers and children. When a woman enters labor, she will either have vaginal or cesarean delivery. However, at the onset of labor, the delivery outcome is unknown. Patients who have slow or stalled labor progression are considered failure-to-progress thus leading to the need for a C-section. In this model formulation, we combine Bayesian updating into a Markov decision process to determine under what circumstances it is appropriate to gather more information before making a decision regarding mode of delivery as a function of cervical dilation progression and patient type (i.e., failure-to-progress or not).

3 - Standardized Patient Mentoring Program for Kidney Transplant Patients

Yeojun Chun, The Ohio State University, 4438 Mobile Dr #306, Columbus, OH, 43220, United States, chun.159@osu.edu

Approximately 1 in 3 post-transplant kidney recipients are readmitted to the hospital within 30 days of initial discharge. Patient anxiety and lack of adherence to post-transplant discharge instructions contribute to readmission rates. To minimize patient anxiety and occurrence of preventable readmissions, a standardized patient mentoring program was designed and tested in a randomized controlled experiment. Standardization focused on the interactions specific to post-transplant adherence to the medical regimen. Preliminary analysis of the first two months of data will be shared.

■ SD62

370C

City Logistics Advances

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Tom Van Woensel, Eindhoven University of Technology, Eindhoven University of Technology, Mb Eindhoven, NL5600, Netherlands, t.v.woensel@tue.nl

1 - Coordinated Delivery to Nanostores in Traditional Retail Channel

Ruidian Song, Tsinghua University, Tsinghua University, Beijing, China, srd13@mails.tsinghua.edu.cn, Lei Zhao, Tom Van Woensel, Jan C.Fransoo

Tens of thousands of traditional mom-and-pop grocery stores (nanostores) aggregately remain a major retail channel in megacities in emerging economies. However, these independently operated stores also create a large amount of high frequency, small size, and uncoordinated replenishment orders. We model, study, and compare various coordination strategies to delivery to these stores and study the impact of delivery coordination.

2 - The Pickup and Delivery Problem with Transfers

Lucas Petrus Veelenturf, Eindhoven University of Technology, School of Industial Engineering (PAV.F.12), P.O. Box 513, Eindhoven, 5600 MB, Netherlands, l.p.veelenturf@tue.nl, Afonso Henrique Sampaio Oliveira, Martin W. P.Savelsbergh, Tom Van Woensel

In this research we include transfer opportunities in the pickup and delivery problem with time windows to construct more cost-effective and robust transportation plans. Transfer points are locations in the network where requests can be transferred between vehicles and temporarily stored. Hence, more than one vehicle can be used to serve a request, e.g., a request may be picked up at its origin by one vehicle, then dropped off at a transfer point where another vehicle (with other characteristics) will pick it up and drop it off at its destination. The introduction of transfer opportunities allows serving more requests with a given set of vehicles and/or serving a given set of requests with fewer vehicles.

3 - Business-to-consumer E-commerce: Home Delivery in Megacities

Martin W. P.Savelsbergh, Georgia Institute of Technology, School of Industrial and Systems Engineering, Atlanta, GA, 30332-0205, United States, martin.savelsbergh@isye.gatech.edu, Lei Zhao, Yixiao Huang

We study the design and deployment of two-echelon logistics systems for home delivery in megacities. We show that by restricting the set of potential routes deployed in one or both of the echelons, it is possible to significantly reduce the complexity of the delivery operations without sacrificing performance.

4 - An Exact Solution Approach for the Multi-commodity Two-echelon Vehicle Routing Problem with Time Windows

Tom Van Woensel, Eindhoven University of Technology, Industrial Engineering, Den Dolech 2, Pav F08, Mb Eindhoven, NL5600, Netherlands, t.v.woensel@tue.nl

The two-echelon vehicle routing problem (2E-VRP) is a two-echelon distribution system where goods are transferred to customers by using intermediate facilities (called satellites). We take non-substitutable demands into account by introducing commodities: a commodity consists of the destination customer, origin depot, a specific volume, and a time window which the delivery should take place within. The described problem is referred as the multi-commodity two-echelon vehicle routing problem with time windows (MC-2E-VRPTW). Numerical results are presented.

■ SD63

370D

Energy and Climate 4

Invited: Energy and Climate

Invited Session

Chair: Peter Larsen, Lawrence Berkeley National Laboratory, PHLarsen@lbl.gov

1 - Sequencing Distributed and Central Power Supply in Systems with Low Electricity Access and Low Reliability: An Application of the GAP Model

Juan Pablo Carvallo, University of California-Berkeley, CA, United States, jpcarvallo@lbl.gov, Daniel Kammen, Duncan Callaway

Over 1.1 billion people do not have access to electricity, 600 million in Africa alone. We develop a novel and spatially explicit approach to jointly assess the sequencing and pacing of centralized, distributed, and off-grid electrification strategies. We develop and employ the linear program and network optimizer Grid Access and Planning (GAP) model. Contrary to existing results, we find that optimal electrification strategies involve co-existence of grid and off-grid technologies. We assess the impact of several variables in defining the strategy and suggest policy frameworks for their implementation.

2 - Impact of High Variable Renewable Energy Penetrations on Demand and Supply Side Decisions

Andrew Mills, Lawrence Berkeley National Laboratory, CA, United States, admills@lbl.gov

Many long-lasting decisions for supply- and demand side electricity infrastructure and programs are made based on historical observations or assuming a business-as-usual (BAU) future. As the share of variable renewable energy (VRE) increases, however, fundamental characteristics of the power system will change. Decisions related to the supply of or demand for electricity made based on an assumed BAU future may not achieve their intended objective in a high VRE future. We highlight how the potential shift to high VRE futures can impact wholesale prices in ways that should be considered in decisions related to long-lasting supply- and demand-side electricity infrastructure and programs.

3 - Scenarios with and with out Overshoot for End of Century Climate Goals

Felipe A. Feijoo, Pacific Northwest National Laboratory, 5825 University Research Court, Suite 3500, College Park, MD, 20740, United States, felipe.feijoo@pnnl.gov

Over 3000 scenarios for global temperature over the 21st century were generated by a single integrated assessment model (GCAM) to explore pathways that either do not exceed a global average temperature target or reach that target in 2100. All scenarios reached above 1.8 C in 2050. Temperature pathways from present to 2045 were found to be less sensitive to climate policy assumptions (carbon price in GCAM) than uncertainty in Earth system modeling. Following 2045 pathway diverge to reach in 2100 from just 0.75 C to 3.5 C (reference case) in 2100 (1.5 to 3.5 C when CCS is excluded).

4 - Quantifying the Contribution of Water and Environmental Management to the Economies of Developing Countries

Brent Boehlert, Industrial Economics, Inc., Cambridge, MA, United States, bboehlert@indecon.com

Brent Boehlert, Massachusetts Institute of Technology, Cambridge, MA, United States, bboehlert@indecon.com, Kenneth M. Strzepek, Kenneth M. Strzepek, James Thurlow

Most developing countries face increasing challenges to management of water and environmental resources. To ensure these resources are sustainably managed, it is important to clearly articulate their contribution to economic growth and development. We present a modeling framework that evaluates the macroeconomic implications of investments in water and environmental resources through a series of impact channels that link biophysical model outputs to an economy-wide model. For illustration, we focus on the case of the Ugandan economy, and find that enhanced investment in management of these resources can increase per capita GDP by 9% in 2040.

■ SD64

370E

Joint session DM/QSR: Process Monitoring for Diverse Types of Data

Sponsored: Data Mining

Sponsored Session

Chair: Youngseon Jeong, China, youngseonjeong@gmail.com

Co-Chair: Behnam Tavakkol, Rutgers University, 5200 BPO Way, Piscataway, NJ, 08854, United States, btavakkol66@gmail.com

1 - Detection Method of Abnormal Condition in Fabrication Process using Wafer Gradient Vector Based on Semiconductor EDS Chip Data

Dongkyu Jeon, Samsung Electronics, 1, Samsungjeonja-ro, Hwaseong-si, 18448, Korea, Republic of, jdkclub85@gmail.com, BokYoung Kang, ByongHun Cho, Jung-Chan Ahn, ChiYong An, Kil Soo Kim, Seung Hoon Tong

In general, abnormal condition detection in a Fabrication process uses wafer-level representative statistics summarizing EDS (Electrical Die Sorting) data that exist in each semiconductor chip unit. However, this conventional method has a limitation in that the numerical discrimination power of the wafer defects in a specific area decreases in the statistical summarization process. In this research, we propose a methodology to detect abnormal condition in fabrication process through Density based Clustering Algorithm using Wafer Gradient Vector based on EDS chip data. In addition, we verified the proposed algorithm through real-life cases.

2 - Online Bayesian Learning Process Monitoring and Control

Sangahn Kim, Rutgers University, 1050 George St. Apt. 6B, New Brunswick, NJ, 08901, United States, sk1389@scarletmail.rutgers.edu, Myong Kee Jeong, Elsayed Elsayed

Conventional statistical process control and monitoring methodologies in Phase II commonly assume that the parameters obtained in Phase I are fixed over time and sufficient to test whether the process is normal or out of control. However, as new observations become available in Phase II, they are incorporated in monitoring as prior knowledge through a Bayesian framework and the parameters obtained in Phase I are continuously updated. In this presentation, we introduce a new process control scheme in which we update the prior distribution at every sampling point. A Bayesian hierarchical model enables us to apply the proposed method in monitoring of high-dimensional processes with sparse mean shifts.

3 - Clustering Validity Indices for Uncertain Data Objects

Behnam Tavakkol, Rutgers University, 5200 BPO.Way, Piscataway, NJ, 08854, United States, btavakkol66@gmail.com, Myong Kee Jeong, Susan L.Albin

In cluster analysis, clustering validity indices are the main tools of evaluating the quality of the formed clusters. In this study, we develop a few clustering validity indices for a type of data objects known as uncertain data. Uncertain data objects can be considered as probability density functions or samples of observations. To our best knowledge, in the existing literature, there is not any clustering validity index for uncertain data.

4 - A Low-Rank Multivariate General Linear Model for Multi-Subject fMRI Data and a Non-Convex Optimization Algorithm for Brain Response Comparison

Minh Pham, University of Virginia, 1555 Montessori Terrace, Charlottesville, VA, 22911, United States, mtp9b@eservices.virginia.edu, Tingting Zhang

The focus of this talk is on identifying brain regions with different responses using stimulus-evoked functional magnetic resonance imaging (fMRI) data. To jointly model many brain voxels' responses to designed stimuli, we present a new low-rank multivariate general linear model for stimulus-evoked fMRI data. We show that the proposed method can outperform several existing voxel-wise methods by achieving both high sensitivity and specificity. We apply the proposed method to the fMRI data and identify anterior dACC to have different responses to a designed threat and control stimuli.

5 - Group Classification Methods for SAR Imagery Data

Mariya Naumova, Rutgers University, 640 Bartholomes Road, Piscataway, NJ, 08854, United States, mnaumova@rci.rutgers.edu

Given a finite number of learning samples from several populations (groups) and a collection of samples from the union of these populations, we classify the entire collection (not a single sample) to one of the groups. Such problems often arise in medical, chemical, biological and technical diagnostics, classification of signals, etc. We consider different parametric statistical methods of solving the problem and make comparison of their quality based on numerical results. We give an illustrative example with SAR imagery data to demonstrate the effectiveness of the classification methods.

■ SD65

370F

Data Mining in Churn Decision Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Roy Jafari Marandi, Mississippi State University, rj746@msstate.edu

1 - A New Algorithm for Segmented Modeling: An Application in Customer Churn Prediction

Arno De Caigny, IÉSEG School of Management, France, a.de-caigny@ieseg.fr, Kristof Coussement, Koen W. De Bock

Heterogeneity between customers poses a challenge for churn prediction models. Therefore a new algorithm, the logit leaf model, has been developed to better classify data that is characterized by heterogeneous groups. Logit leaf modeling consists of two stages: a segmentation phase and a prediction phase. In the first stage customer segments are identified using decision rules while in the second stage a model is created for every leaf of this tree. This approach is benchmarked against ensembles, statistical approaches and decision trees with regards to the predictive performance and comprehensibility.

2 - Churn Prediction in Telecommunication: Sampling, Feature Selection and Ensemble Methods

Adnan Idris, The University of Poonch, Rawalakot, District Poonch, Pakistan, adnanidris@upr.edu.pk

Efficient churn prediction is helpful for Telecommunication industry to retain customers. Development of any efficient churn prediction system depends upon the appropriate selection of sampling, feature selection and classification methods due to enormous nature of telecom datasets. In this bid, various feature selection, sampling and classification methods have been explored to efficiently tackle this challenging research problem. Minimum Redundancy and Maximum Relevancy based feature extraction, PSO based intelligent undersampling along with tree based ensembles ,Genetic Programming(GP) and AdaBoosting based ensemble methods attain improved prediction performance.

3 - Profit Driven Comparison of Social Network Analytics Methods for Predicting Customer Churn in TELCO

María Óskarsdóttir, KU. Leuven, Naamsestraat 69, Leuven, Belgium, maria.oskarsdottir@kuleuven.be

Social network analysis is being used in telco to build profit driven applications for predicting customer churn. In this benchmarking study, a unique number of call-detail record data sets from across the world is used to statistically evaluate the effect of relational classifiers and collective inference methods on the predictive power of relational learners. In addition, using the Expected Maximum Profit measure, we evaluate the performance of various models where relational learners are combined with traditional methods of predicting customer churn in order to find the optimal model.

4 - Customer Decision Making Dynamics in a Multichannel Context

Wenyu Jiao, ESSEC Business School, Cergy, France, wenyu.jiao@essec.edu, Nicolas Glady

This paper aims at understanding the purchase channel dynamic on the customer-firm relationship and the Customer Lifetime Value(CLV). To this purpose, we address two important research questions in a multichannel context: (i) how does the customers' channel usage history dynamically impact the components of the CLV, and (ii) are the multichannel customers who start from offline channels and those who start from online channels equally valuable? We propose a hidden Markov model to understand the customer-firm relationship dynamic in a multichannel setting and to estimate the CLV. Our dynamic model is necessary in order to account for the evolution of customer behavior across different states.

5 - Optimum Churn Decision Making by Cost-sensitive SOED ANN in Telecommunication Industry

Roy Jafari Marandi, Mississippi State University, 260 McCain Engineering Buildin, Mississippi, Mississippi State, MS, 39762, United States, rj746@msstate.edu, Brian K. Smi

Churn prediction can only be as good as the hidden pattern in the dataset used for prediction. Attempting to captures the individuality of each customer before arriving at a prediction decision can bring about another dimension in the improvement of churn prediction decisions. The existing data analysis techniques only extract different patterns existing in datasets and apply them to all of the rows of the data in the same manner. In reality, every row is very different and have a different level of importance when it comes to making a final decision. This presentation will introduce Cost-Sensitive SOED Artificial Neural Network which has assuaged these shortcomings.

■ SD66

371A

Facility Layout

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Sadan Kulturel-Konak, Penn State Berks, Reading, PA, 19610, United States, sadan@psu.edu

1 - Are Curved Racks Better than Straight Racks for Retail Layouts?

Pratik J. Parikh, Wright State University, 3640 Colonel Glenn Highway, 207 Russ Engineering Center, Dayton, OH, 45435-0001, United States, pratik.parikh@wright.edu, Bradley R. Guthrie

Because retail shopper's will only purchase products on a shopping trip that they see, designing retail layouts with product visibility as a key priority has been widely discussed in literature. To this extent, we have developed analytical and computational models for the dynamic interaction between a shopper's field of view and a layout of racks in 3D. We focus on two design variables: (i) rack orientation and (ii) rack curvature. Based on an experimental study with varying values of shopper head rotation, rack height, and traffic patterns, we find that curved racks can offer an improvement in exposure over traditional straight racks.

2 - Placement of M Finite-size Rectangular Facilities in an Existing Layout: Lower Bounds and Dominance Results

Rakesh Nagi, University of Illinois at Urbana-Champaign, Department of Industrial & Enterprise Systems, 117 Transportation Building, MC-238, Urbana, IL, 61801, United States, nagi@illinois.edu, Aishwarya Anandan, Ketan Date

We study the problem of optimally placing M new finite size rectangular facilities (NFs) in a layout with N existing rectangular facilities (EFs). Interactions are present between different pairs of EFs and NFs, serviced through the Input/output points located on the facility boundary. We present a dominance procedure utilizing different lower bounding techniques, which is shown to outperform the explicit enumeration procedure.

3 - Dynamic Facility Layout with Input / Output Points

Sadan Kulturel-Konak, Penn State Berks, Tulpehocken Road, P.O. Box 7009, Reading, PA, 19610, United States, sadan@psu.edu

When the locations of the departments in a facility have to be decided where there are multiple planning periods and the interdepartmental material flows change over the planning periods, the problem in concern is called the Dynamic Facility Layout Problem (DFLP). The main challenge in the DFLP is that there are two conflicting objectives of the problem: minimizing the material handling cost and the rearrangement cost. The proposed approach, a new matheuristic, considers determining relative department locations, their dimensions, as well as input/output (I/O) points concurrently for the first time in the literature.

4 - Optimal Unit Load Warehouse Designs by using Visibility Graph

Sabahattin Gokhan Ozden, Pennsylvania State University, Jenkintown, PA, 19046, United States, sgo7@psu.edu, Alice E. Smith, Kevin R. Gue

We introduce the visibility graph as a new way of estimating the length of a route traveled by order pickers in a warehouse. Following aisle centers leads to longer travel distances when an order picker picks items within picking aisles which have angles other than 90 degrees between cross aisles. We present optimal/near-optimal designs by solving single and double cross aisle designs. We compare them with the optimal designs by using aisle centers as the length of a route estimation method (i.e. Chevron and Leaf layouts).

■ SD67

371B

Panel Discussion on Publishing in QSR Journals: The Editors' Perspective

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Adel Alaeddini, University of Texas at San Antonio, San Antonio, TX, 78249, United States, adel.alaeddini@utsa.edu

1 - Publishing in QSR Journals: the Editors' Perspective

Kamran Paynabar, Georgia Institute of Technology, Georgia Tech, H. Milton Stewart School Of Isye, Atlanta, GA, 30332-0205, United States, kamip@umich.edu

This panel brings QSR journal editors to provide their perspectives and experiences with the audience, and answer their questions pertaining to publication in these journals.

2 - IIE Transactions
Jianjun Shi, Georgia Institute of Technology, H. Milton Stewart School of, Industrial and Systems Eng, Atlanta, GA, 30332-0205, United States, jianjun.shi@isye.gatech.edu

3 - Journal of Quality Technology
Fugee Tsung, HKUST, Clearwater Bay Road, Hong Kong, Hong Kong, season@ust.hk

4 - Technometrics
Daniel Apley, Northwestern University, Dept of IEMS, Room C150, Tech Institute, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States, apley@northwestern.edu

5 - Quality Engineering
Murat Caner Testik, Hacettepe University, Muhendislik Fakultesi, Endustri Muhendisligi Bolumu, Ankara, 06800, Turkey, mtestik@hacettepe.edu.tr

6 - Quality Technology and Quantitative Management
Jing Li, Arizona State University, School of Computing Informatics & Decision Sy, P.O. Box 878809, Tempe, AZ, 85287-8809, United States, jing.li.8@asu.edu

■ SD68

371C

High-dimension Spatio-Temporal Analysis I

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Jian Liu, University of Arizona, Tucson, AZ, 85721, United States, jianliu@email.arizona.edu

Co-Chair: Shyam Ranganathan, shyam81@vt.edu

1 - A Flexible Method for Building Degradation Index from Multivariate Degradation Signals
Yili Hong, Virginia Tech, 213 Hutcheson Hall, Department of Statistics, Blacksburg, VA, 24061, United States, yilihong@vt.edu, Zhongnan Jin, Zhiyang Zhang, Xinwei Deng, Ran Jin, Sam Davanloo Tajbakhsh

Most of the existing research on degradation modeling assumes that the degradation index is provided. Modern sensor technology allows one to collect multi-channel sensor data that are related to the underlying degradation process, which may not be sufficiently represented by any single channel. Thus, constructing a degradation index is a fundamental step in degradation modeling. In this paper, we develop a general approach for degradation index building based on an additive-nonlinear model with variable selection. The approach is more flexible than a linear combination of sensor signals, and it can automatically select the most informative variables to be used in the degradation index.

2 - A Predictive Analytic Methodology via Modeling High-dimensional Signals with Missing Observations
Xiaolei Fang, Georgia Institute of Technology, 1546 Woodlake Dr NE, Apt F, Atlanta, GA, 30329, United States, xfang33@gatech.edu, Kamran Paynabar, Nagi Gebraeel

Many complex engineering systems operate in harsh environments that often have a significant impact on the quality of the raw sensor data due to errors in data acquisition, communication, read/write operations, etc. Consequently, the resulting degradation signals often contain significant levels of missing and corrupt observations. In this talk, we present a scalable prognostic methodology capable of modeling poor quality (ultra)high-dimensional degradation signals to predict residual lifetime. Numeric studies are used to evaluate the performance of the proposed model.

3 - Detecting and Locating Pipe Burst with Spatial and Temporal Analysis
Yifei Yuan, University of Arizona, Tucson, AZ, United States, yifeiyuan@email.arizona.edu, Jian Liu, Kevin Lansey

A pipe burst is a major water distribution system failure and will result in lower water pressures at customer taps. A large number of meters are usually installed in the pipe systems to continuously monitor the water pressure, from spatially distributed locations. The data collected from these meters forms a spatial and temporal information stream. In this research, a spatio-temporal data analysis method is proposed to effectively and efficiently detect and locate the pipe burst. A simulation based case study was conducted to validate the method.

4 - Neighborhood Vector Autoregressive Model for High-dimensional Time Series
Shyam Ranganathan, Department of Statistics, Virginia Tech, Blacksburg, VA, United States, shyam81@vt.edu, Xinwei Deng

Vector autoregression (VAR) models are popular for studying multiple dependent timeseries, with broad applications in analyzing sensor data, imaging data, and network data. One key challenge for VAR models in high dimensions is on how to insightfully explore the inherent dependency in the data to enable meaningful interpretation, and accurate prediction. To tackle this challenge, we present a neighborhood VAR model to explore meaningful sparse structures induced by underlying interactions among multiple time series, thus achieving accurate prediction with low computational cost. Numerical examples are shown to evaluate the performance of the proposed method.

■ SD70

371E

Big Data

Contributed Session

Chair: Iman Vasheghani Farahani, North Carolina State University, Raleigh, NC, United States, ivasheg@ncsu.edu

1 - Application of a Novel Nonlinear Support Vector Machine Based Feature Selection Algorithm for Fault Detection & Diagnosis
Melis Onel, Texas A&M.Energy Institute, College Station, TX, United States, melis@tamu.edu, Chris A.Kieslich, Yannis A. Guzman, Christodoulos A. Floudas, Efstratios N. Pistikopoulos

We present a new data-driven framework for fault detection and diagnosis, a critical task in industry processes to attain a safe operability and minimize loss of productivity and profit. Central to the framework are novel theoretical and algorithmic developments in nonlinear support vector machine (SVM)-based feature selection which encapsulates highly nonlinear relationships between features, thus improving fault detection model accuracy and guiding fault diagnosis. We present results of a recent extensive benchmark dataset consisting 90,400 batches with numerous and diverse fault types.

2 - Energy Optimization in Water and Wastewater Cycle
Ali Reza Asadi, PhD Candidate, Wayne State University, 4815 Fourth Street, Room 2033, Detroit, MI, 48201, United States, ali.asadi@wayne.edu

Implementation of big data techniques in the water/wastewater treatment cycle provide grounds for minimization of overall energy consumption as well as improvements in food and water safety. This methodology allows consideration of new threats such as water reservoir pollution, microorganisms and antibiotics resistance in to the optimization model.

3 - Estimating an Inverse Mean Subspace
Jiaying Weng, Graduate Student, University of Kentucky, 300 Alumni Drive, Apt 179, Lexington, KY, 40503, United States, jiaying.weng@uky.edu, Yin Xiangrong

We develop a new sufficient dimension reduction method called Fourier transformation inverse regression to capture the directions in the central subspace. Under linearity condition, the space spanned by Fourier transformation inverse regression would be in the central subspace. By forming a kernel matrix using Fourier transformation, we construct asymptotic dimensional test via weighted chi-squared distribution. Our new method performs better than existing methods in the simulation study and real data analysis. In addition, we further develop our new method for variable selection and for large p and small n problems.

4 - An Investigation into Online Video Sharing as a Source of Consumer Safety Hazard Reports
Leila Nasri, Virginia Tech, Blacksburg, VA, United States, leilan@vt.edu, Alan S. Abrahams, Johnathon P. Ehsani

This study focuses on online video-based product reviews as possible sources to detect safety hazard issues. Reviewing over 15,000 possible product reviews from YouTube, we show that the set of smoke words are a more accurate predictor of safety hazards in video-based product reviews than sentiment words.

5 - Time Series Classification using Normalized Subsequences
Iman Vasheghani Farahani, North Carolina State University, 400 Daniels Hall, Raleigh, NC, 27695-7906, United States, ivasheg@ncsu.edu
Iman Vasheghani Farahani, SAS.Institute Inc, 100 SAS.Campus Dr, Cary, NC, 27513, United States, ivasheg@ncsu.edu, Alex Chien, Russell Edward King

In time series classification problems, finding normalized subsequences, whose distances from a time series indicates its label, requires a prior information on the length of the subsequence and a similarity measure between series. This may require a costly search be performed on the entire dataset. To address this problem, we examine the efficiency of data transformation using symbolic aggregate approximation. This transformation keeps the local structure of a time series, that enables us to find similar subsequences repeated in samples time series. We use decision trees classifiers and information gain as the criterion to grow the tree.

■ SD71

371F

Journal of Global Optimization: INFORMS Issue

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Sergiy Butenko, Texas A&M University, College Station, TX, 77843-3131, United States, butenko@tamu.edu

1 - Parallel Distributed Block Coordinate Descent Methods Based on Pairwise Comparison Oracle
Kota Matsui, Nagoya University, Nagoya, Japan, matsui.k@med.nagoya-u.ac.jp, Wataru Kumagai, Takafumi Kanamori

We present a block coordinate descent method to solve unconstrained optimization problems. Our algorithm uses only pairwise comparison of function values, which tells only the order of function values over two points. In our algorithm,a Newton-type search direction is estimated and then a numerical solution is updated along the direction. The computation in the direction estimate can be easily parallelized, and thus, the algorithm works efficiently. Also, we theoretically derive an upper bound of the convergence rate for our algorithm and show that it achieves the optimal query complexity for specific cases. In numerical experiments, we show that our method outperforms some existing methods.

2 - Geodesic and Contour Optimization using Conformal Mapping
Ricky Fok, York University, Toronto, ON, Canada, ricky.fok3@gmail.com, Aijun An, Xiaogang Wang

We devise the shadow casting scheme, in which global basins of attraction are mapped to a much larger space and recovered by a reverse mapping. Under certain criteria, the enlarged space can be as larger the search space. We also introduce a novel trajectory method that couples to the shadow casting scheme. Local search methods such as Newton-Ralphson are employed to find the global optimum. Experimental results indicate that our proposed method can outperform recent derivative-free DIRECT variants in number of function/gradient evaluations on functions with many optima or when the global optimum is very close to a local one.

3 - Igreen: Green Scheduling for Peak Demand Minimization
Shaojie Tang, TX, United States, Shaojie.Tang@utdallas.edu, Jing Yuan, Zhao Zhang, Ding-zhu Du

Home owners are typically charged differently when they consume power at different periods within a day. Specifically, they are charged more during peak periods. Thus, in this paper, we explore how scheduling algorithms can be designed to minimize the peak energy consumption of a group of homes served by the same substation. We study both offline and online models.

4 - Solving Linear Optimization Over Arithmetic Constraint Formula
Li Chen, Institute of Software, Chinese Academy of Sciences, Beijing, China, chenli@nfs.iscas.ac.cn, Yongji Wang

Since Balas extended linear programming problem to disjunctive programming (DP) problem, researchers explored this optimization under various scenarios such as generalized disjunctive programming (GDP) and optimization modulo theories (OMT). In this paper, we convert linear DP/GDP model and linear-arithmetic OMT problem into an equivalent form referred to as linear optimization over arithmetic constraint formula (LOACF). A branch-and-bound based algorithm named RS-LPT for LOACF is proposed. We evaluate RS-LPT against two DP/GDP methods, three OMT solvers, and disjunctive transformation based method on different benchmarks. Our results favor RS-LPT especially for large scale cases.

5 - Incorporation of Delivery Times in Stereotactic Radiosurgery Treatment Optimization
Dionne Aleman, University of Toronto, 5 King's College Road, Toronto, ON, M5S.3G8, Canada, aleman@mie.utoronto.ca, Hamid R.Ghaffari, David A.Jaffray, Mark Ruschin

Although mathematical optimization can greatly improve the quality of treatment plans in radiation therapy, one complication is the clinically unrealistic nature of optimized treatments. The difficulty arises from long treatment times and machine limitations that govern the minimum amount of radiation delivery time, which requires binary variables. We examine these issues within the penalty-based sector duration optimization (SDO) model for Elekta's Leksell Gamma Knife Perfexion and the combined SDO and isocentre location model to reduce beam-on time and to ensure machine limitations are met.

■ SD72

372A

Network Flow Problems in Applications

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Alexander Nikolaev, University at Buffalo, Buffalo, NY, 14260-2050, United States, anikolae@buffalo.edu

1 - Monotonicity and Conformality in Multicommodity Network-flow Problems
Frieda Granot, Sauder School of Business, Vancouver, BC, Canada, frieda.granot@sauder.ubc.ca

We present a monotonicity theory for the important class of minimum convex-cost parametric multicommodity network-flow problems defined over general graphs. The results determine when it is possible to predict, without numerical computations, the direction of change of optimal multicommodity flows resulting from changes in arc-commodity parameters. In particular, we provide necessary and sufficient conditions that for every cost function satisfying a submodularity-convexity-compactness hypothesis there exists an optimal multicommodity flow for which the flow of a commodity in a given arc a is nondecreasing (resp., nonincreasing) in the parameter of a distinct commodity in arc b.

2 - A Mesoscopic Model to Evaluate the Evacuation Dynamics in a University Campus
Jorge Huertas, Universidad de los Andes, Calle 115 No 55 C.- 54, Bogota, 11111, Colombia, ja.huertas1845@uniandes.edu.co, Jony A. Zambrrano, Andres Medaglia

In this work we integrate a macroscopic and a microscopic model to evaluate the evacuation dynamics in a university campus. The macroscopic approach is a network optimization model that determines the optimal evacuation paths. The microscopic model is a discrete event simulation that models the congestion on the paths determined by the first model. We propose an iterative process in which the output of one model is the input of the other one, achieving a convergence on the evacuation time. The result is a mesoscopic model that considers bottlenecks, direction of flows, speed fluctuations, and congestion during an evacuation. Finally, we compare our results with real evacuation exercises in the campus.

3 - Reach Maximization for Direct Incentive-Driven Pro-Environmental Social Programs
Alexander Nikolaev, University at Buffalo, 409 Bell Hall, Buffalo, NY, 14260-2050, United States, anikolae@buffalo.edu, Jose Walteros

While exploiting the power of network-based social influence for the societal benefit is a breakthrough in itself, further research is required to boost the impact of such programs with direct incentives. We present investigations into the design and planning of randomized incentive programs — social lotteries — that inform consumers of their peers behaving pro-environmentally while being rewarded for doing so. We conduct calculated maximization of the "reach" of such a program or policy, exploiting column generation in mixed-integer programming.

■ SD74

372C

Emerging Computational Optimization Techniques

Sponsored: Computing

Sponsored Session

Chair: Chris Lourenco, Texas A&M University, clouren@tamu.edu

1 - Roundoff-Error-Free Framework for the Exact Solutions of Sparse Linear Systems

Christopher J.Lourenco, Texas A&M.University, Dept. of Industrial and Systems Engineering, 3131 Tamu, College Station, TX, 77843, United States, clouren@tamu.edu, Adolfo Raphael Escobedo, Erick Moreno-Centeno, Timothy A.Davis

LU factorizations are the key tool used to solve the sparse systems of linear equations that arise in many classes of mathematical programs. In many documented cases however, roundoff errors accrued during the implementation of these factorizations can cause solvers to output infeasible or suboptimal solutions, especially for numerically unstable instances. To address this, we developed an exact left-looking LU framework to solve sparse linear systems in which all operations are performed entirely in integer arithmetic. Also presented are computational results, which show that the novel left-looking LU framework significantly outperforms modern state-of-the art sparse exact solvers.

2 - Optimization for L1-norm Error Fitting via Data Aggregation

Young Woong Park, Iowa State University, Ames, IA, United States, ywpark@iastate.edu

We propose a data aggregation-based algorithm with monotonic convergence to a global optimum for a generalized version of the L1-norm error fitting model. The proposed algorithm can solve multi-dimensional fitting problems with arbitrary constraints on the fitting coefficients. Any model following the form can be solved optimally using the proposed algorithm. The generalized problem includes popular models such as regression, principal component analysis, and the orthogonal Procrustes problem. The results of the computational experiment show that the proposed algorithms are faster than the state-of-the-art benchmarks for the problems and data sets studied.

3 - Mining High-Quality Solutions to Learn Effective and Interpretable Heuristics

Michele Samorani, Santa Clara University, 500, El Camino Real, Santa Clara, CA, 95053, United States, msamorani@scu.edu, Manuel Laguna

We propose a method to automatically design effective and interpretable heuristic algorithms. Our method employs data mining to analyze the optimal solutions of a training set of problem instances. Then, it finds an interpretable rule that can be applied at each step of a constructive algorithm to tackle new instances. We test our method on a variety of binary optimization problems, such as the knapsack and the max-cut problems.

4 - Improved Basic Procedure for Chubanovs Algorithm

Carlos Deck, University of California-Berkeley, 2100 Channing Way, Apartment 316, Berkeley, CA, 94704, United States, cgdeck@berkeley.edu

This work improves Chubanov's projection algorithm for the linear feasibility problem of finding a non-negative vector in Ker(A). This is done by working in the original space of the x-variables instead of solving the alternative system. By changing the solution space, we can focus on solutions within the unit simplex instead of the unit hypercube, which strengthen the cuts provided by Chubanov and Roos. We show how to perform the rescaling in this setting, given that the feasible region is no longer homogeneous. Our computational experiments show a significant improvement compared to Chubanov and Roos' variants of this algorithm in practice.

■ SD75

372D

Distributed Optimization

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Necdet Serhat Aybat, University Park, PA, 16802, United States, nsa10@psu.edu

1 - Proximal-proximal-gradient Method

Ernest Kang Ryu, UCLA, 10910 Wellworth Ave., Apt. 310, Los Angeles, CA, 90024, United States, ernestryu87@gmail.com

We present the proximal-proximal-gradient method (PPG), a novel optimization method that is simple to implement and simple to parallelize. PPG is applicable to minimization problems written as a sum of many differentiable and possibly non-differentiable convex functions. We furthermore present a related variation, which we call stochastic PPG (S-PPG). S-PPG can be interpreted as a generalization of Finito and MISO. We present many applications that can benefit from PPG and S-PPG and prove convergence for both methods. A key strength of S-PPG is its ability to directly handle a large sum of non-smooth non-separable functions with a constant stepsize independent of the number of functions.

2 - When Cyclic Coordinate Descent Outperforms Randomized Coordinate Descent

Nuri Denizcan Vanli, Graduate Student, Massachusetts Institute of Technology, Cambridge, MA, 02141, United States, denizcan@mit.edu, Mert Gurbuzbalaban, Asuman Ozdaglar

Coordinate Descent (CD) method is a classical optimization algorithm that has seen a revival of interest. The state-of-the-art convergence rate estimates suggest randomized coordinate descent (RCD) performs better than cyclic coordinate descent (CCD), although numerical experiments do not provide clear justification for this comparison. We provide problem classes for which CCD is faster than RCD in terms of asymptotic worst-case convergence. We present lower and upper bounds on the amount of improvement on the rate of CCD relative to RCD. We also provide a characterization of the best deterministic order in terms of the combinatorial properties of the Hessian matrix of the objective function.

3 - Multi-agent Constrained Optimization of a Strongly Convex Function over Time-varying Directed Networks

Erfan Yazdandoost Hamedani, Pennsylvania State University, 310 Leonard Building, Pennsylvania State University, University Park, PA, 16802, United States, evy5047@psu.edu, Necdet Serhat Aybat

We consider cooperative multi-agent consensus optimization problems over time-varying directed communication networks. The objective is to minimize the sum of agent-specific composite convex functions subject to agent-specific conic constraint sets. Assuming the sum function is strongly convex, we propose a distributed primal-dual algorithm, DPDA-TV. While each agent's function can still be merely convex, we provide O(1/k^2) convergence rates for suboptimality, infeasibility and consensus violation of the ergodic iterate sequence in the iteration number k where the k-th iteration of DPDA-TV requires O(log(k)) local communication rounds with the neighboring nodes.

4 - Zeroth Order Nonconvex Multi Agent Optimization

Davood Hajinezhad, Iowa State University, 62 B.Schilletter village, Ames, IA, 50010, United States, dhaji@iastate.edu, Mingyi Hong, Alfredo A.Garcia

We consider distributed optimization problems over a multi-agent network, where each agent can only partially evaluate the objective function, and it is allowed to exchange messages with its immediate neighbours. Differently from all existing works, our focus is given to optimizing a class of difficult non-convex problems, and under the challenging setting where each agent can only access the zeroth-order information of its local functions. For different types of network topologies, we develop a number of efficient distributed algorithms and rigorously analyze their convergence and rate of convergence.

■ SD76

372E

Optimization Society Award Session

Sponsored: Optimization

Sponsored Session

Chair: David Morton, Northwestern University, IEMS Department, 2145 Sheridan Road, Evanston, IL, 60208, United States, david.morton@northwestern.edu

1 - Khachiyan Prize Recipient

Robert J.Vanderbei, Princeton University, Operations Research & Financial Engineering, 209 Sherrerd Hall, Princeton, NJ, 08544, United States, rvdb@princeton.edu

This prize will be awarded with a short presentation, that is not available.

2 - Farkas Prize Recipient

Kim-Chuan Toh, National University of Singapore, Singapore, Singapore, mattohkc@nus.edu.sg

This prize will be awarded with a short presentation, that is not available.

3 - Young Researchers Prize Recipients

Alberto Del Pia, University of Wisconsin–Madison, Madison, WI, United States, delpia@wisc.edu, Aida Khajavirad

This prize will be awarded with a short presentation, that is not available.

4 - Student Paper Prize Recipient

Frans de Ruiter, Tilburg University, H.R.Holststraat 48, Tilburg, 4103 VB, Netherlands, f.j.c.t.deruiter@uvt.nl

This prize will be awarded with a short presentation, that is not available.

■ SD77

372F

Recent Advances in Computational Optimization

Sponsored: Optimization, Computational Optimization and Software

Sponsored Session

Chair: Robert J Vanderbei, Princeton University, Princeton, NJ, 08544, United States, rvdb@princeton.edu

Co-Chair: John W Chinneck, Carleton University, Systems and Computer Engineering, 1125 Colonel By Drive, Ottawa, ON, K1S 5B6, Canada, chinneck@sce.carleton.ca

1 - Fast Approximate Solution of Very Large Linear Programs

John W. Chinneck, Carleton University, Systems and Computer Engineering, 1125 Colonel By Drive, Ottawa, ON, K1S.5B6, Canada, chinneck@sce.carleton.ca

It can be useful to find an approximate solution quickly for huge linear programs, e.g. for screening options or providing an advanced start for an accurate solver. I present a method that optimizes a combined objective function that has a quadratic penalty term for constraint violations, a movement direction based on simultaneous projection and a quadratic approximation to the combined objective function. Initial points are scattered over a gradually shrinking box surrounding the current best solution. Empirical results show that the method often provides good approximate solutions in seconds for models which require hours of computation for an accurate solution via commercial LP solvers.

2 - High Performance Computing with GAMS

Frederik Fiand, GAMS.Software GmbH, Augustinusstr. 11b, Frechen-Koenigsdorf, Germany, ffiand@gams.com, Michael Bussieck

BEAM-ME is a project addressing the need for new and improved solution approaches for energy system models of vast size. The focus is on large-scale LPs having a block structure that is not well exploited by state-of-the-art LP solvers. Without considering this structure the models quickly become intractable. We develop new solution algorithms that exploit the block structure and utilize HPC environments. We discuss extensions to GAMS that allow annotations specifying block structure, as well as other challenges overcome to produce some initial results.

3 - Geometric Visualization of Linear Programming Algorithms

Robert J.Vanderbei, Princeton University, Operations Research & Financial Engineering, 209 Sherrerd Hall, Princeton, NJ, 08544, United States, rvdb@princeton.edu

Algorithms for linear programming can be described both algebraically and geometrically. While the geometrical view is highly compelling, it is hard to grasp in dimensions higher than three. In this talk, I will provide a geometric perspective to some optimization algorithms as they apply to problems that have thousands of variables but the stem from a physical problem in two or three dimensional space. Viewing the progression of these algorithms in this highly comprehensible low dimensional space provides some interesting insights into the nature of the various algorithms.

■ SD78

381A

ENRE Award Session

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30312, United States, andy.sun@isye.gatech.edu

ENRE will announce the winners of its Best Publication Awards in Environment and Sustainability, Energy, and Natural Resources as well as the Young Researcher Prize and the Student Best Paper Award at this session. The winners will be invited to give presentations on their work.

■ SD78B

380B

Analytic Hierachy Process

Contributed Session

Chair: Xiaojun (Gene) Shan, UHCL, Houston, TX, United States, shan@uhcl.edu

1 - Sustainable Public Administration

Yuji Sato, Professor, Chukyo University, 101 Yagotohonmach, Showa, Nagoya, Aichi, 466-8666, Japan, ysatoh@1988.jukuin.keio.ac.jp

This paper considers sustainable public administration. Based on the property of public services and the characteristic of public sector quantified by the AHP, the best matching between public services and their responsible organization will be considered, in which properties of each public service and characteristics of alternative sectors is quantified. The results imply the scheme of sustainable public administration.

2 - Comparing Traditional, Online and Hybrid MBA with Analytic Hierarchy Process

Xiaojun (Gene) Shan, University of Houston Clear Lake, Houston, TX, United States, shan@uhcl.edu, Saranya Sarika

This paper compares the different modes of instruction in the MBA class (traditional, online, and hybrid) with analytic hierarchy process. The important criteria for the comparison were identified based on literature review and then a survey was conducted to derive sub criteria considering the previous research as well as the students' opinions. The survey data was analyzed and was applied to the criteria and sub criteria. The best mode of MBA instruction was determined to be traditional teaching. This supports that though technology has developed beyond imagination, classroom teaching is still the best medium for a student to understand, participate and learn from the MBA class.

3 - Selection of Solid Waste Management Program for the University of Houston - Clear Lake using Analytic Hierarchy Process

Xiaojun (Gene) Shan, University of Houston Clear Lake, Houston, TX, United States, shan@uhcl.edu, Krishna Deep Kambhampati

As a university grows, there is an increase in waste generated on campus. If the waste is not properly disposed of, it could lead to health hazards for both humans and other lives and disrupt the ecosystem of the campus. Therefore, it is important for educational institutions to implement a Solid Waste Management (SWM) program. This paper studies the different kinds of SWM programs that are currently in use. The objective of this paper is to identify the best SWM practice suitable for the University of Houston Clear Lake (UHCL). To evaluate the different SWM practices, the Analytic Hierarchy Process (AHP) is used. The results show that waste reduction is the most appropriate SWM program for UHCL.

4 - Courier Delivery Services Company Selection using Analytical Hierarchy Process and Data Envelopment Analysis

Xiaojun (Gene) Shan, University of Houston Clear Lake, Houston, TX, 77058, United States, shan@uhcl.edu, Sindhuja Yerroju

Business owners face the challenge of choosing the best third-party logistics provider among many alternatives. This problem could be formulated as a multi-criteria decision making problem. In this study, we apply analytical hierarchy process (AHP) to select the best provider in terms of the types of services provided, the number of depots, and delivery mode. The results from the analytical hierarchy process are evaluated against the results of data envelopment analysis (DEA). In DEA, the various Decision Making Units (DMU's) are evaluated considering number of depots, number of employees and amount of equipment as inputs and revenue as an output.

5 - Using Analytical Hierarchy Process (AHP) to Select the Best Thermo Scientific Co2 Incubator

Xiaojun (Gene) Shan, UHCL, houston, TX, United States, shan@uhcl.edu, Juilee Shukla

Incubators are used in the tissue culturing laboratories to maintain a stable environment for the growth of cells, cultures and antibodies. Since incubators involve significant investment, it is important to select the best incubator for the purpose. The purpose of this study is to find the best incubator among the four Thermo Scientific CO2 Incubators, using Analytical Hierarchy Process (AHP) with five criteria. Each Incubator has its own range of precision to control the temperature suitable for tissue cell growth, humidity to maintain a stable environment, CO2 range to avoid the desiccation of the cells and the number of shelves, which signifies the storage volume available inside the incubator.

■ SD79

381B

5:15 - 6:00 Lumina Decision Systems

Invited: Vendor Tutorial

Invited Session

1 - Why Go "Beyond the Spreadsheet" with Analytica 5.0?

Max Henrion, Lumina Decision Systems, Inc, Los Gatos, CA, United States, henrion@lumina.com

Practitioners of analytics and OR increasingly recognize spreadsheets as an obstacle to clear and scalable modeling. They are moving to visual modeling tools like Analytica using influence diagrams to structure models at the same level that you conceptualize them. You identify key decisions, uncertainties, objectives, and constraints. You define relationships between these objects, which may be multidimensional rather than at the level of cells. Analytica models are typically 10 to 100 times simpler than equivalent spreadsheets, and correspondingly faster to build, understand and audit. This tutorial is a rare chance to see Max Henrion, the originator of Analytica, using influence diagrams to structure a problem. He will demonstrate agile development, using Intelligent Arrays to scale models and integrate Monte Carlo simulation and optimization. Max will also show what's new in release 5.0 of Analytica, including an updated interface, parallel processing, and web deployment on the Analytica Cloud Player.

■ SD80

381C

Multi-Item and Multi-Location Revenue Management Models II

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Candace Arai Yano, University of California-Berkeley, IEOR Department, 4141 Etcheverry Hall, Berkeley, CA, 94720-1777, United States, yano@ieor.berkeley.edu

1 - Managing Revenue via Inventory Allocation for a Multi-location Retailer with Planned Price Promotions

Kevin Li, University of California—Berkeley, Berkeley, CA, 94720, United States, kbl4ew@berkeley.edu, Candace Arai Yano

We address a retailer's choice of the initial order quantity from a distant supplier and the policy for allocating inventory to stores over a multi-period horizon for a short lifecycle product when there are planned price promotions. We characterize the optimal inventory allocation policy given a fixed initial order quantity and stochastic multiplicative demand and present a near-optimal heuristic policy. We then investigate the optimal initial order quantity. We also present examples that provide insights into how promotional patterns affect optimal inventory allocations.

2 - Optimal Pricing under Diffusion-choice Models

Hongmin Li, Arizona State University, WP.Carey School of Business, Dept of Supply Chain Management, Tempe, AZ, 85287, United States, hongmin.li@asu.edu

We develop a solution approach to the centralized pricing problem of a firm managing multiple substitutable products. Demands of these products undergo a diffusion process and customers choose among the products, with the choice probability of each product given by the logit model. We examine the firm's optimal pricing problem when product demand can be described by such "diffusion-choice" models. In particular, we focus on two models with proven merits, proposed by Jun and Park (1999) and Weerahandi and Dalal (1992) respectively. We establish the uniqueness of the optimal solution, propose an efficient solution approach, in addition to characterizing the optimal prices and their time trend.

3 - Car Rental Network Revenue Management

Zhan Pang, City University of Hong Kong, Hong Kong, zhan.pang@cityu.edu.hk, Dong Li

We consider a general car rental network of multiple stations. Customers can book round trips or one-way rentals from any station to another station for a time periods within a finite time window. The operator makes shuttling and booking limit decisions jointly to maximize its total discounted profit over an infinite horizon. We formulate this problem as a stochastic dynamic program and develop two approximate dynamic programming heuristics. We conduct a numerical study and apply our approach in case study using a sample of real world data to explore some practical insights.

■ SD81

382A

Chance-Constrained Optimization and Applications

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Ruiwei Jiang, University of Michigan, University of Michigan, Ann Arbor, MI, 48109, United States, ruiwei@umich.edu

1 - An Algorithm for Binary Chance Constrained Problems using Infeasible Irreducible Systems

Bernardo Kulnig Pagnoncelli, Universidad Adolfo Ibáñez, Diagonal Las Torres 2540, Santiago, Chile, Gianpiero Canessa, Lewis Ntaimo

We propose an algorithm based on Infeasible Irreducible Systems (IIS) to solve general binary chance-constrained problems. By leveraging on the problem structure we are able to generate good quality upper bounds to the optimal value early in the algorithm, and the discrete domain is used to guide us efficiently in the search of solutions. We test our methodology on instances of a vaccine problem, and in versions of the probabilistic set covering problem. In most cases the number of nodes visited by the algorithm is drastically reduced when compared to commercial solvers.

2 - Distributional Robust Chance-constrained Optimal Power Flow with Wasserstein Ambiguity Set

Yuanyuan Guo, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States, yuanyg@umich.edu, Ruiwei Jiang

The uncertain renewable energy creates new challenges for the power system operators to ensure network constraints. The chance-constrained program is a convenient method to ensure the constraints are satisfied with a high probability. However, it is hard to accurately estimate the joint distribution of all the random variables. We study a distributionally robust chance-constrained optimal power flow model with the Wasserstein ambiguity set, which can provide powerful out-of-sample performance guarantee. The model can be reformulated as a linear or a second-order cone programming depending on the choice of the Wasserstein metric. Our approach is compared with two benchmark approaches.

3 - An Adaptive Model with Joint Chance Constraints for a Hybrid Wind-Conventional Generator System

Bismark Singh, University of Texas at Austin, 2501 Lake Austin Blvd, Apt F203, Austin, TX, 78703, United States, bismark.singh@utexas.edu, David Morton, Surya Santoso

We analyze scheduling a hybrid wind-conventional generator system to make it dispatchable. Our models ensure that with high probability we satisfy the day-ahead power promised, using combined output of the conventional and wind generators. We consider two scenarios—whether the conventional generator must commit to its schedule prior to observing the wind or has flexibility to adapt in real-time to these realizations. The adaptive model is a two-stage stochastic integer program with joint chance constraints. We develop an iterative regularization scheme in which we solve a sequence of sample average approximations under a growing sample size to dramatically reduce computational effort.

4 - Ambiguous Chance-constrained Bin Packing under Mean-covariance Information

Ruiwei Jiang, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48109, United States, ruiwei@umich.edu, Yiling Zhang, Siqian Shen

We study chance-constrained bin packing with random item weights and assume that only the mean and covariance matrix of the uncertainty is available. Using two types of ambiguity sets, we equivalently reformulate this model as 0-1 second-order cone (SOC) programs. We further exploit the submodularity of the 0-1 SOC constraints under special and general covariance matrices, and utilize the submodularity to derive extended polymatroid inequalities to strengthen the 0-1 SOC formulations. We demonstrate the computational efficacy of our approaches on various test instances.

■ SD82

382B

Online Algorithms and Applications

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Shashank Goyal, University of Minnesota, Minneapolis, MN, 55414, United States, goyal030@umn.edu

1 - Time-indexed Relaxations for the Online Bipartite Matching Problem

Alfredo Torrico, Georgia Institute of Technology, 201 16th Street NW, Apartment 1, Atlanta, GA, 30363, United States, atorrico3@gatech.edu, Alejandro Toriello

We study an i.i.d. model of the classical online bipartite matching problem, in which one side of the bipartition is fixed and known in advance, while vertices from the other side appear sequentially as i.i.d. realizations of a uniform distribution. Each one of these arrivals must be matched or discarded. We study several relaxations in a time-indexed space. We derive valid inequalities for the polyhedron of achievable matching probabilities, and discuss when they are facet-defining. In contrast to previous works, we show that our inequalities either theoretically dominate the constraints presented before, or provide empirically superior bounds.

2 - Online Covering with Norm Objectives and Applications

Xiangkun Shen, University of Michigan, Ann Arbor, MI, 48109, United States, xkshen@umich.edu, Viswanath Nagarajan

We consider fractional online covering problems with lq-norm objectives. The covering constraints arrive online over time. We provide an online log-competitive algorithm. This is based on the online primal-dual framework where we use the dual program. Our result expands the class of convex objectives that admit good online algorithms: prior results required a monotonicity condition on the objective which is not satisfied here. This result is nearly tight even for the linear special case. As direct applications, we obtain (i) improved online algorithms for non-uniform buy-at-bulk network design and (ii) the first online algorithm for throughput maximization under lq-norm edge capacities.

3 - Online Algorithms for Rental Requests

Shashank Goyal, University of Minnesota, 1071 17th Ave SE, Minneapolis, MN, 55414, United States, goyal030@umn.edu, Diwakar Gupta

Web platforms such as Airbnb and Craigslist provide individuals the ability to post availability of a resource they own and rent it to different customers for short periods of time. A customer can place a request with the owner, indicating the desired rental start time and duration. The owner must then decide whether to accept or decline the request. A key trade-off that the owner confronts is the reward he earns from the current request and the potential loss of reward from a higher-value future requests that may clash with the current one. We propose online algorithms for the problem that have provable worst-case performance and also present bounds on the best performance that any algorithm can achieve.

4 - Online Optimization of Google Ad-click Auctions

Donghun Lee, Princeton University, 9 Lawrence Drive, Apt 202, Princeton, NJ, 08540, United States, donghunl@princeton.edu, Warren B. Powell

We present online optimization framework to maximize the return of advertisement campaign through repeated real-time bidding auctions under budget constraints.

The framework learns the properties of the auction environment online, and makes on-the-fly optimization with optimal learning algorithms.

We test the performance of the framework by testing on real-time bidding auction simulator based on Google Adwords platform history of placing hotel advertisements on the web.

■ SD83

382C

Stochastic Integer Programming

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Jim R Luedtke, University of Wisconsin-Madison, Madison, WI, 53706, United States, jim.luedtke@wisc.edu

1 - Dual Decision Rules for Stochastic Integer Programming

Jim R.Luedtke, University of Wisconsin-Madison, 3236 Mechanical Engineering, 1513 University Ave, Madison, WI, 53706, United States, jim.luedtke@wisc.edu, Merve Bodur

We consider decision rules for multi-stage stochastic integer programming problems. We investigate techniques for using these decision rules to obtain bounds on the optimal solution, and compare the strength of the relaxation from different techniques. Numerical results will be presented.

2 - Stochastic Dual Dynamic Integer Programming

Shabbir Ahmed, Georgia Institute of Technology, 765 Ferst Drive, Atlanta, GA, 30332, United States, sahmed@isye.gatech.edu

We extend the Stochastic Dual Dynamic Programming (SDDP) algorithm to solve multistage stochastic integer programs with binary state variables. Various case studies in energy systems is discussed.

3 - Two-stage Stochastic MIPS with Structured Non-linear Programs

Yingqiu Zhang, Graduate Student, Virginia Tech., Blacksburg, VA, 24060, United States, yqzhang7@vt.edu, Manish Bansal

We present our recent developments for solving two stage stochastic mixed integer programs with structured mixed integer non-linear programs in the second stage. We utilize globally valid parametric cuts within Benders' decomposition to tighten the second stage programs, and provide results of our computational experiments.

Monday, 8:00 - 9:30AM

■ MA01

310A

Strategic Decisions

Sponsored: Decision Analysis

Sponsored Session

Chair: Dharma Kwon, University of Illinois at U-C, University of Illinois at U-C, Champaign, IL, 61820, United States, dhkwon@illinois.edu

Co-Chair: Youngsoo Kim, University of Illinois at Urbana-Champaign, Champaign, IL, 61820, United States, ykim180@illinois.edu

1 - It is Time to Get Some Rest

Manel Baucells, University of Virginia, Darden School of Business, 100 Darden Boulevard, Charlottesville, VA, 22903, United States, mbaucells@gmail.com, Lin Zhao

We introduce the fatigue disutility model in continuous-time. It captures in a precise way the notion that fatigue accumulates with effort, decays with rest, and increases marginal instant disutility. While prescriptive, the model rationalizes several behavioral anomalies. Under very general conditions the most efficient temporal profile of effort exhibits a high-low-high pattern. We examine the optimal management of fatigue and productivity under various scenarios. We bring the model to the data and provide a calibration that predicts well the speed profiles observed in swimming competitions.

2 - Product Management and Innovation in a Supply Chain

Junghee Lee, University of California, San Diego, 9500 Gilman Drive, #0553, La Jolla, CA, 92093-0553, United States, junghee.lee@rady.ucsd.edu, Hyoduk Shin, Vish Krishnan, Oleksiy Viktorovych Mnyshenko

How can we achieve broader market coverage for innovative products, i.e., inclusive innovation? Grounded in industrial practice, we show that deliberately choosing the contract leader and the investor in a multi-tiered supply chain can have a significant impact on market coverage. We discuss leadership handovers along the product life cycle.

3 - Audit and Remediation Strategies in the Presence of Evasion Capabilities

Shouqiang Wang, The University of Texas at Dallas, Naveen Jindal School of Management, 800 W. Campbell Rd, Richardson, TX, 75080, United States, Shouqiang.Wang@utdallas.edu, Francis E. De Vericourt, Peng Sun

Companies often have means and incentive to conceal a negative issue, which, if not addressed promptly, is likely to result in detrimental consequences. Such evasive actions render audits no longer effective in revealing such an issue. We Examine how to uncover and remedy it in the presence of evasive actions.

4 - Strategic Investment in Shared Suppliers with Quality Deterioration

Youngsoo Kim, University of Illinois at U-C, 1206 South Sixth Street, 350 Wohlers Hall, Champaign, IL, 61820, United States, ykim180@illinois.edu, Dharma Kwon, Anupam Agrawal

Motivated by manufacturers' quality investment in shared suppliers, we study an investment game with spillover and uncertainty. Each manufacturer repeatedly decides either to invest in the declining quality of the supplier or to wait for the other to do so. We find that a unique mixed strategy equilibrium exists if and only if asymmetry in investment costs is not too large. Moreover, a mixed strategy equilibrium disappears if investment opportunities are not repeated. We then consider Nash bargaining as a resolution for the potential inefficiency from a mixed strategy equilibrium. Using the field-collected data, we demonstrate the efficacy of bargaining to avoid a mixed strategy equilibrium.

■ MA02

310B

Military Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: Greg Parnell, University of Arkansas, gparnell@uark.edu

1 - Lessons Learned from Adaptive Red Team System Assessments

Simon Goerger, PhD, ERDC, CEERD-IE, 3909 Halls Ferry Road, Vicksburg, MS, 39180-6199, United States, Simon.R.Goerger@usace.army.mil, Niki C.Goerger, Michael Rainey, Randy K.Buchanan, John R.Burt

The Adaptive Red Team draws from a portfolio of methods to identify potential vulnerabilities in emerging technologies designed for Soldier use in contested environments, with interoperability challenges, adaptability needs, and training constraints. This presentation describes novel data collection and assessment system developed to support live experiment data collection. It shows the connection to resilient system designs by identifying hidden vulnerabilities introduced by the physical environment, congestion and frequency overload, and electronic warfare and computer network attacks.

2 - Considering System Resilience as Active and Passive Response Strategies to Perturbations Over Time

Randy K. Buchanan, ERDC-Vicksburg, MS, 3909 Halls Ferry Road, Vicksburg, MS, 39180, United States, randy.k.buchanan@erdc.dren.mil, Adam M. Ross, Christina Rinaudo

Despite no widely-accepted definition of resilience, the need for developing systems that can deal with the potential impact of uncertainties (i.e. perturbations) is a real one. In this research, we propose a practical approach toward framing, eliciting, and guiding analysis of tradeoffs for implementing aspects of resilience in military systems. The approach involves partitioning resilience into four related components: 1) assessing response coverage of perturbations, 2) assessing active strategies (e.g. flexibility), 3) assessing passive strategies (e.g. versatility), and 4) assessing timescale of responses.

3 - Using Process Improvement Techniques to Develop an Innovation Pipeline Procedure

Niki Goerger, Business Development Director, U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS, Postal code39180-619, United States, Maria.N.Goerger@usace.army.mil, Christina Rinaudo, Simon Goerger

An enterprise innovation pipeline process can provide an organized and structured methodology to ensure that new ideas are continuously generated, evaluated, and matured. Process improvement techniques were used to develop and refine a baseline innovation pipeline process. This presentation explores process improvement methods and techniques used to develop an enterprise innovation pipeline process at the Engineer Research and Development Center.

4 - Quantifying Resilience for Engineered Systems

Gregory S. Parnell, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States, gparnell@uark.edu

A resilient engineered system is able to successfully complete its planned mission(s) in the face of environmental and adversarial threats, and has capabilities allowing it to flexibly adapt to future missions with evolving threats. We use this definition to propose four methods to assess resilience for military systems: updated mission chain calculations for each performance measure; a Value-Focused Thinking Model with mission and platform resilience measures; a multiple objective value model with mission resilience value measures; and two separate value models: one including mission reliance and one for platform resilience.

■ MA03

310C

Introduction to Disaggregate Demand Models

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, 77204, United States, jopeng@Central.uh.edu

Co-Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Introduction to Disaggregate Demand Models

Michel Bierlaire, EPFL, Lausanne, Switzerland, michel.bierlaire@epfl.ch, Virginie Lurkin

Demand information is an input for a great deal of operations research models. Assumed as given in many problem instances addressed in the literature, demand data are difficult to generate. In this tutorial, we provide an introduction to disaggregate demand models that are designed to capture in detail the underlying behavioral mechanisms at the foundation of the demand.

■ MA03A

Grand Ballroom A

Cloud Computing and Data Centers in Applied Probability II

Sponsored: Applied Probability

Sponsored Session

Chair: Siva Theja Maguluri, IBM, Sleepy Hollow, NY, 10591, United States, siva.theja@gmail.com

1 - Dynamic Resource Provisioning in Data Centers via Robust Queueing Theory

Chaithanya Bandi, Northwestern University, 2001 Sheridan Road, Suite 566, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu, Vineet Goyal, Omar El Housni

We consider the problem of dynamic resource provisioning and use tools from robust queueing theory and multi-stage optimization to present tractable solutions.

2 - Efficient Redundancy in Cloud Systems

Gauri Joshi, Carnegie Mellon University, Pittsburgh, PA, United States, gaurij@andrew.cmu.edu

The throughput (rate of task completion) of a multi-server system is typically the sum of the service rates of individual servers. Recent works show that task replication can boost the throughput, in particular if the service time distribution has high variability. This paper seeks to find the fundamental limit of the throughput boost achieved by task replication, which is an open problem. The optimal replication policy can be found using a Markov Decision Process framework, which is hard to solve in general. We obtain a converse bound on the service capacity, and propose a close-to-optimal replication policy based on it.

3 - Bounds on Coflow Scheduling in Datacenter Networks

Javad Ghaderi, Columbia University, jghaderi@ee.columbia.edu

In many data-parallel computing frameworks, intermediate parallel data is often produced which needs to be transferred among servers in the datacenter network. Coflow is a networking abstraction to capture such communication patterns. We consider the problem of efficiently scheduling coflows with release dates in a shared datacenter network so as to minimize the total weighted completion time of coflows. We present a deterministic algorithm with approximation ratio of 5, which improves the prior best known ratio of 12. For the special case when all coflows are released at time zero, we obtain a deterministic algorithm with approximation ratio of 4 which improves the prior best known ratio of 8.

4 - Joint Congestion Control and Scheduling for Optimal Delay in Stochastic Processing Networks

Qiaomin Xie, Massachusetts Institute of Technology, 32-D771B, 32 Vassar Street, Cambridge, MA, 02139, United States, qxie@mit.edu, Devavrat Shah

We consider the problem of designing and analyzing joint congestion control and scheduling mechanisms for large-scale stochastic systems, exemplified by datacenter networks, the Internet and wireless networks. We propose a scheme that guarantees a per-flow end-to-end delay bound of O(# of hops). Designing such a scheme involves two subproblems: rate control and packet scheduling. We design a flow-level rate control policy by using an insensitive rate allocation policy in so-called bandwidth-sharing networks. A packet-level scheduling scheme is obtained by adapting the Last-In-First-Out Preemptive-Resume policy.

■ MA03B

Grand Ballroom B

Choice-based Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Gustavo Jose Vulcano, Universidad Torcuato di Tella, Universidad Torcuato di Tella, Buenos Aires, na, Argentina, gvulcano@utdt.edu

1 - Demand Modeling in the Presence of Unobserved Lost Sales

Pavithra Harsha, IBM.Research, 1101 Kitchawan Rd, Room 34-225, Yorktown Heights, NY, 10598, United States, pharsha@us.ibm.com, Shivaram Subramanian

We present an integrated optimization approach to parameter estimation for discrete choice demand models where data for one or more choice alternatives are censored. We employ a mixed-integer program to jointly determine the prediction parameters associated with the customer arrival rate and their

substitutive choices. This approach enables us to recover proven, near global optimal parameter values with respect to the chosen loss-minimization objective function. We test the method on simulated and real data, and present results for a variety of single- and multi-item demand prediction scenarios, and for learning the unobserved market shares of competitors.

2 - Demand Estimation under the Multinomial Logit Model from Sales Transaction Data

Tarek Abdallah, New York University, Stern School of Business, New York, NY, United States, tabdalla@stern.nyu.edu, Gustavo Jose Vulcano

We study a multinomial logit (MNL) model of demand when customers arrive over time in accordance to a non-homogeneous Poisson process. The model is suitable for retail settings where only sales and product availability data are recorded, not all products are displayed in all periods, and the seller has information about her own aggregate market share. We characterize conditions under which the model is identifiable and the maximum likelihood estimates are consistent. We propose a Minorization-Maximization (MM) algorithm that is guaranteed to converge to the global optimal solution when the model is identifiable.

3 - Salesforce Incentives for Managing Product Returns

Rashmi Sharma, Pennsylvania State University, University Park, PA, United States, rashmi.sharma@psu.edu, Aydin Alptekinoglu

We study a setting where product sales and returns are effort-dependent and the selling activity is conducted by a salesforce. We investigate the effect of salesforce behavior on net sales and compare different incentive schemes to identify optimal incentive strategies.

4 - An Expectation-maximization Algorithm to Estimate the Parameters of the Markov Chain Choice Model

A. Serdar Simsek, University of Texas-Dallas, Naveen Jindal School of Management, 800 W. Campbell Road, Richardson, TX, 75080, United States, serdar.simsek@utdallas.edu, Huseyin Topaloglu

We develop an expectation-maximization algorithm to estimate the parameters of the Markov chain choice model (MCCM). We prove theoretical convergence guarantees and our computational experiments show that the MCCM, coupled with our expectation-maximization algorithm, can yield better predictions of customer choice behavior when compared with other commonly used alternatives.

■ MA03C

Grand Ballroom C

Behavioral Modeling in Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Andrew M. Davis, Cornell University, Ithaca, NY, 14853, United States, adavis@cornell.edu

1 - Heterogeneity of Reference Effects in the Competitive Newsvendor Problem

Anton Ovchinnikov, Queen's School of Business, 143 Union Street, Kingston, ON, K7L.3N6, Canada, ao37@queensu.ca, Sam Kirshner

This paper examines two recently-proposed reference effect formulations for the newsvendor problem and extends them to a competitive setting. The analysis of the resultant game shows that the heterogeneity of newsvendors' reference effects can explain multiple regularities observed in recent experimental studies of newsvendor competition. Specifically, the observations that a behavioral newsvendor may effectively ignore the orders of the competitor, receive a significantly smaller profit, and over-order when there is no expected demand overow can all be attributed to the heterogeneous reference effects in our model's equilibrium.

2 - Omnichannel Service Operations with Online and Offline Self-order Technologies

Fei Gao, Indiana University, Bloomington, IN, United States, fg1@iu.edu, Xuanming Su

Many restaurants have recently implemented self-order technologies across both online and offline channels. We study the impact of both online and offline self-order technologies on consumer demand, employment levels, and restaurant profits.

3 - Predicting Order Variability in Inventory Decisions: A Model of Forecast Anchoring

Dayoung Kim, Cornell University, 201D Sage Hall, Ithaca, NY, 14853, United States, kdy928@gmail.com, Andrew M. Davis, Li Chen

We develop a forecast anchoring model that explains and predicts order variability behavior in a multi-period newsvendor problem. Our model assumes that people anchor on random point forecast and insufficiently adjust toward the profit-maximizing quantity. We apply GMM to fit our model across different experimental data sets, and further conduct our own experiment for a robustness check. Our results show that the order variability at the individual level and the variability at the aggregate level is caused by different sources of behavior. By providing better predictions, our model can help firms better anticipate the order variability from the downstream buyers.

4 - How Bounded Rationality Generates Bias in Demand Forecasting and Product Choice

Jordan Tong, University of Wisconsin-Madison, Madison, WI, United States, jordan.tong@wisc.edu, Daniel Feiler

Humans are boundedly rational and make random error. Can initial random error, even if it is unbiased, generate future systematic decision bias? We uncover and model an important operations context for which the answer is yes: when managers both choose which product to sell and make a forecast for their chosen product, random error (and failure to account for it statistically) causes them to systematically forecast too high. Two experiments, one with managers in a single-period setting and the other with students in a periodic review setting, test the behavioral model's predictions - illustrating how and why human random error causes bias and illuminating mitigation techniques.

■ MA04

320A

Operations in Electricity Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Ozge Islegen, Kellogg School of Management, Kellogg School of Management, Evanston, IL, 60208, United States, o-islegen@kellogg.northwestern.edu

Chair: Asligul Serasu Duran, Kellogg School of Management, Kellogg School of Management, Chicago, IL, 60657, United States, a-duran@kellogg.northwestern.edu

1 - An Analysis of Demand Response Programs in the Wholesale Electricity Market

Asligul Serasu Duran, Kellogg School of Management, 825 W. Cornelia Avenue, Apt GDN, Chicago, IL, 60657, United States, a-duran@kellogg.northwestern.edu, Baris Ata, Ozge Islegen

This project explores the impact of the participation and compensation of demand response (DR) providers in the wholesale electricity market on the electricity supply, electricity prices, generators and DR providers' profits, and consumer welfare. Specifically, we model a supply function equilibrium for generators and DR providers where DR resources offer "negawatts" in the wholesale market. Then, we analyze the change in the electricity supply, and in the welfare of the market participants due to the varying compensation rates of DR providers. We show that generators' profits decrease, and consumers' energy bills may increase with the entry of DR providers to the wholesale electricity market.

2 - Government Financing for Clean Technology Development

Seung Hwan Jung, Washington University in St. Louis, 1552 E. Swan Cir., Brentwood, MO, 63144, United States, seunghwan.jung@wustl.edu, Lingxiu Dong

We study government financing for a firm's clean technology development under a financial constraint. The main interest of this paper is to investigate the impact of government financing on environment and the firm's bankruptcy risk when market uncertainty exists. Our analysis shows that government financing improves environment, compared to bank financing. Surprisingly, the government financing, however, exposes the firm to higher bankruptcy risk. However, our analysis further shows that the government financing benefits both the firm and consumers. Hence, our results also shed light on the benefit of the government financing.

3 - Mind the Gap: Coordinating Energy Efficiency and Demand Response

Eric Webb, PhD Student, Indiana University, 2915 W. Winterberry Ct., Bloomington, IN, 47404, United States, eric.michael.webb@gmail.com, Owen Wu, Kyle D.Cattani

Traditionally, energy demand-side management programs are each designed in isolation. Breaking with this tradition, we examine the interactions between long-term energy efficiency upgrades and daily demand response participation at an industrial firm. Upon re-examining the long-studied energy efficiency gap, we find that the gap is typically smaller when demand response is considered. Policies aiming to close or reduce the energy efficiency gap, such as investment subsidies and carbon taxes, may fail to achieve their desired outcomes when firms participate in demand response.

4 - Supply Function Equilibria in Electricity Markets under Uncertainty

Chaithanya Bandi, Northwestern University, 2001 Sheridan Rd, 566, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu, Ermin Wei, Yuanzhang Xiao

We study a two-stage electricity market with renewables. Each energy producer in the market has a portfolio of both renewable and conventional energy generators. In the real-time market, each producer tries to fulfill its DA committed energy with (zero-cost) renewables. We study the robust supply function equilibrium (SFE) where each producer has incomplete information about the other producers' marginal costs and the distribution of renewable energy, and performs worst-case optimization. We fully characterize the unique robust SFE, and study the impact of the feed-in tariff on the equilibrium outcome.

■ MA05

320B

Analytics & Optimization in Chronic Disease Screening and Management

Sponsored: Health Applications

Sponsored Session

Chair: Turgay Ayer, Georgia Institute of Technology, Atlanta, GA, 30332, United States, ayer@isye.gatech.edu

Co-Chair: Caglar Caglayan, Georgia Institute of Technology, 765 Ferst Drive, Atlanta, GA, 30332, United States, ccaglayan6@gatech.edu

1 - Analytics for Personalized Healthcare using Mobile Devices

Anil Aswani, UC Berkeley, 8 10th St, Apt 1704, San Francisco, CA, 94103, United States, aaswani@berkeley.edu, Elena Flowers, Yoshimi Fukuoka, Ken Goldberg, William Haskell, Philip Kaminsky, Yonatan Mintz, Eric Vittinghoff, Mo Zhou

Mobile technologies hold much promise for management of chronic diseases. However, algorithm design requires careful consideration of the data-transmission and computational capabilities of mobile technologies. This talk describes the development of a personalized physical activity intervention. First, we describe the results of a clustering analysis of objectively measured physical activity patterns in women. Insights from this analysis are used in development of a ROGUE bandit algorithm for the design of personalized physical activity interventions. A key innovation of our ROGUE bandit model is the ability to capture habituation that occurs with repeated exposure to a single treatment.

2 - A Comparative Analysis of Data Mining Approaches to Characterize Colorectal Cancer Screening Behavior Trajectories

Maria Esther Mayorga, North Carolina State University, 400 Daniels Hall, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu, Rachel M. Townsley

Patient behavior patterns can heavily impact outcomes and policy efficacy in the context of cancer screening, but are difficult to replicate in health policy simulation models. Using censored claims data we investigate the validity of common screening behavior assumptions and their impact on relevant individual health outcomes in the context of colorectal cancer (CRC). We compare data driven strategies for modeling trajectories of screening behavior over time.

3 - Assessing Multi-Modality Screening Policies for Women at High Risk of Breast Cancer

Caglar Caglayan, Georgia Institute of Technology, 765 Ferst Drive, Atlanta, GA, 30332, United States, ccaglayan6@gatech.edu, Turgay Ayer, Donatus U. Ekwueme

Women with breast density, family history of breast or ovarian cancer, or BRCA1 and BRCA2-mutation-carriers are at higher risk of breast cancer. For such women, non-mammographic modalities such as ultrasound or MRI, adjunct to or instead of mammogram, can overcome the limitations of mammogram and hence, be beneficial. Currently there is no consensus on the optimal use of these modalities in high-risk women. We study multi-modality breast cancer screening problem for the high-risk population and identify practical and cost-effective optimal screening policies. Our results show that screening with ultrasound is cost-effective and optimal over a wide range of budget levels in young high-risk women

4 - Identifying Factors that Influence Outcome for Prostate Cancer Patients

Eva Lee, Professor and Director, Georgia Tech, Ctr for Operations Research in Medicine, Atlanta, GA, 30332-0205, United States, eva.lee@gatech.edu

This work is joint with Kaiser Permanente. We analyze 10 years of prostate cancer patients to investigate factors that influence the outcome. Unsupervised learning will be performed to uncover outcome patterns and to subgroup patients according to their outcome and health similarities. Machine learning is then performed to identify factors that are critical for achieving treatment outcome. Modeling and computational challenges will be discussed.

■ MA06

320C

Health Data Analytics for Policy Making

Sponsored: Health Applications

Sponsored Session

Chair: Ilbin Lee, PhD, Georgia Tech, 755 Ferst Drive, Atlanta, GA, 30332, United States, ilee79@gatech.edu

1 - Quantifying the Cost of Pediatric Depression in the Medicaid Population

Erin Garcia, Auburn University, Auburn, AL, United States, eg3gatech@gmail.com

Co-morbid depression often results in increased health care costs and worse outcomes in studies focused on particular conditions and groups of people. To determine the long term cost of pediatric depression in the Medicaid population, we identify the population of children with and without depression from the CMS data files. Each child with depression is matched to a child without depression based on a set of socioeconomic and health factors so that we can treat the data as paired samples. Healthcare utilization and cost data for each child in the final sample are computed from the CMS data, and pairwise analysis is conducted to identify differences between the populations with and without depression.

2 - Spatial Access to Psychotherapy Services for Publicly-insured Children

Pravara M.Harati, Georgia Tech, Atlanta, GA, United States, pharati3@gatech.edu

Access to specialty care is typically worse for publicly-insured children than for privately-insured. We estimate local level spatial access, including provider congestion and average travel distance, to child psychotherapy services by first using CMS Medicaid claims data to obtain the locations and annual capacities of mental health professionals who have provided psychotherapy to publicly-insured children. We then estimate the local level prevalence of mental health conditions using a simulation model based on demographic data. Finally we match the demand to supply in an optimization model to obtain the access measures, from which we can identify geographic areas needing improvement.

3 - Using Infusion Pump Data Analytics to Study Medication Safety Issues

Kang-Yu Hsu, Purdue University, Gerald D. and Edna E. Mann Hall, 203 S Martin Jischke Drive, Lafayette, IN, 47907, United States, hsu66@purdue.edu, Poching DeLaurentis, Yuehwern Yih, Yuval Bitan, Dan Degnan

An infusion pump is a medical device used to intravenously deliver fluids into a patient's body in controlled amounts and rates. These infusion pumps have safety features incorporated in a software program known as Dose Error Reduce Systems (DERS) that uses customized Drug Limit Library (DLL). DLLs in infusion pumps may not be updated efficiently. The inconsistency between DLL in pumps and the most current DLL may put patient safety at risk such as dosage/rate miscalculation, false alerts and missed alerts. In this study, we quantify the impact of adopting out-of-date DLL through investigating infusion logs, and examine infusions which potentially jeopardized patient safety with outdated DLL usage.

4 - The Longitudinal Trajectories of Medication Adherence for Patients with Chronic Conditions

Shan Xie, Purdue University, 315 N. Grant Street, W. Lafayette, IN, 47907, United States, xie34@purdue.edu, Alan Zillich, Yuehwern Yih

Poor adherence to medication has been associated with increased healthcare costs and adverse health outcomes, thus improving medication adherence is important to realize the full benefit of medication therapies. The current claims-based quality reporting measures only provide an aggregate number to estimate patients' adherence level over a long-term period, which are easy to implement but lack the ability to distinguish between different adherence patterns. Therefore, we used group based trajectory models to stratify patients into groups with distinct longitudinal adherence trajectories. We hope to provide useful insight to help design targeted and tailored interventions.

■ MA07

322A

Modeling for Complex Conditions

Sponsored: Health Applications

Sponsored Session

Chair: Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States, jsivy@ncsu.edu

1 - Modeling Complex Trajectories in Patients with Sepsis

Nisha Nataraj, North Carolina State University, 111 Talisman Way, Apt 220, Raleigh, NC, 27615-4958, United States, nnatara@ncsu.edu, Julie Simmons Ivy, Muge Capan, James R. Wilson, Jeanne Marie Huddleston, Ryan Arnold

Sepsis, infection plus systemic manifestations of infection, is the leading cause of in-hospital mortality. The lack of a gold-standard diagnostic test makes sepsis difficult to diagnose and necessitates timely intervention. The trajectory of sepsis is difficult to clearly define and recent definition changes have complicated matters further. This research uses inpatient electronic health record data over multiple visits from a large hospital system to study the implications of different definitions and guidelines on the diagnosis and treatment of septic patients with comorbidity via a simulation-based framework.

2 - Decision Modeling in Sepsis Patients

Shadi Hassani Goodarzi, North Carolina State University, Raleigh, NC, United States, shassan3@ncsu.edu

Sepsis is a complication caused by body's overwhelming response to an infection. It can lead to organ failure and death. According to NIH, more than one million Americans are diagnosed with sepsis each year, about 28% to 50% of which result in mortality. Due to the fast progression of sepsis, a timely apt intervention is critical before sepsis causes organ failure which can result in long-term complications and increased chance of death. We used EHR to develop a Markov decision process to optimize intervention timing minimizing the chance of organ failure and death caused by sepsis.

3 - Sepsis and Organ Failures: A Single Center Study of Prevalence and Mortality

Muge Capan, Christiana Care Health System, Wilmington, DE, 19801-3082, United States, mcapan@ncsu.edu, Stephen Hoover, Julie Simmons Ivy, Jeanne Marie Huddleston, Ryan Arnold

Increasing incidence and mortality rate mark sepsis, a life-threatening organ dysfunction caused by response to infection as a significant healthcare burden. Considering the uncertainties in sepsis diagnosis and treatment, inpatients with a presumed infection may exhibit various trajectories of sepsis-induced episodes. Utilizing electronic health records allows identifying factors associated with organ dysfunction associated with sepsis episodes. We present a systematic approach to identify the impact of organ dysfunction on mortality based on clinical physiology in sepsis populations by investigating all-cause inpatient mortality among nested subgroups (N=210,289 visits).

■ MA08

322B

Stochastic Modeling in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Murat Kurt, Merck & Co., Inc., 351 N. Sumneytown Pike., North Wales, PA, 19454, United States, murat.kurt@merck.com

Co-Chair: Iakovos Toumazis, Stanford University, Stanford, CA, United States, iakovos.toumazis@stanford.edu

1 - Optimal Static Risk-based Group Testing

Hrayer Y. Aprahamian, Virginia Tech, 1145 Perry Street, Blacksburg, VA, 24060, United States, ahrayer@vt.edu, Ebru Korular Bish, Douglas R. Bish

Group testing, where multiple subjects are tested simultaneously with a single test, is an essential tool for classifying a large number of subjects for a binary characteristic. An important decision is the testing design, i.e., group sizes needed to test a set of subjects, each with a given risk profile. The testing design is a tactical decision, and has to be made under uncertainty on both the number of subjects to be tested and their risk profile. We model this problem as a two-stage stochastic programming problem and characterize key structural properties of optimal testing designs. Our case study establishes the effectiveness of optimal risk-based testing within a public health framework.

2 - Impact of False Positives on the Cost-effectiveness of Lung Cancer Screening

Iakovos Toumazis, Stanford University, Stanford, CA, United States, iakovos.toumazis@stanford.edu, Emily Tsai, Ayca Erdogan, Summer Han, Ann Leung, Sylvia Plevritis

We assess the benefits and costs of various screening strategies for lung cancer (LC) using a data driven microsimulation model. We simulate individuals' LC progression in the presence and absence of screening strategies, which vary in terms of starting and stopping age, screening frequency, and smoking exposure. We identify the efficiency frontier and show that the cost-effectiveness of LC screening is significantly affected by the management of false-positive results. We examine the effect of the number of subsequent exams and disutility associated with false-positives and conduct univariate sensitivity analyses to test the robustness of our findings to changes in key input model parameters.

3 - Determining Effective and Practical Colonoscopy Screening and Surveillance Policies

Gizem Nemutlu, PhD Candidate, University of Waterloo, Faculty of Engineering University of Waterloo Carl A. Pollock Hall 4323 200 University Avenue West, Waterloo, ON, N2L.3G1, Canada, gsnemutlu@uwaterloo.ca, Fatih Safa Erenay, Oguzhan Alagoz

Efficient colonoscopy screening and surveillance policies are desired to cost-effectively reduce colorectal cancer incidence and mortality. We developed a partially observable Markov decision process model to dynamically schedule colonoscopy operations based on accumulated risk of having advanced lesions and other risk-factors. However, clinicians may find such optimal policies too complex to adopt. Using a stochastic model, we derive simple yet effective dynamic colonoscopy screening policies which perform closely to the optimal policies and are easy-to-implement in clinical practice.

4 - Dynamic Classification Approach for Classifying Patient in Chronic Disease: with Application to Glaucoma

Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, MI, United States, keyvan@umich.edu, Mark P.Van Oyen, Joshua Stein, Mariel Lavieri

We design a dynamic classification method for patient types in Glaucoma. Our first goal is to effectively identify which patient is "fast" versus "slow" progressor meaning that he/she is experiencing relatively rapid or slow Glaucoma progression. To this aim, we combine machine learning methodologies with Kalman filter method to dynamically classify patients into different categories. Our second purpose is to accurately predict/estimate the quantities of the state variables for future testing periods of each patient.

■ MA09

330A

Interface of Operations, Finance, and Risk Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Jiri Chod, Boston College, Chestnut Hill, MA, 02467, United States, chodj@bc.edu

1 - A Signaling Theory of In-Kind Finance

Jiri Chod, Boston College, 140 Commonwealth Avenue, Fulton Hall, Chestnut Hill, MA, 02467, United States, chodj@bc.edu, Nikolaos Trichakis, Gerry Tsoukalas

We argue that by borrowing in kind (e.g., through trade credit) rather than in cash (e.g., through bank credit), firms may be able to convey private information about their fundamental value to creditors more efficiently. This is because borrowing illiquid, and potentially perishable, goods, constitutes a more credible commitment, and hence a stronger signal of a firm's quality. Our theory rationalizes preference for supplier financing under information asymmetry, and, unlike existing explanations, it does so without ascribing any prior informational advantage to the supplier and without relying on buyer opportunism/moral hazard.

2 - Cancelability in Trade Credit Insurance

S. Alex Yang, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, sayang@london.edu, Nitin Bakshi, Christopher J.Chen

Trade credit insurance (TCI) is a risk management tool commonly used by suppliers to guarantee against payment default by buyers. Unlike insurance policies in other sectors, TCI policies often allow the insurer to cancel this "guarantee" during the insured period. In this paper, we offer an economic rationale of this phenomenon. We also explain the shortcoming of this type of contract, and thus shedding light on the recent emergence of non-cancelable contract.

3 - Optimal Timing of Inventory Decisions with Price Uncertainty
Nikolay Osadchiy, Emory University, 1300 Clifton Rd Ne, Atlanta, GA, 30322, United States, nikolay.osadchiy@emory.edu, Vishal Gaur, Sridhar Seshadri, Marti Subrahmanyam

We study the problem of optimal inventory order timing when the selling price and demand are random and their forecasts improve with time. We derive the structure of the ordering policy and study the value of order timing flexibility.

4 - Inventory Operations under the Shadow of Company Stock Price
Qi Wu, Case Western Reserve University, Cleveland, OH, United States, qxw132@case.edu, Guoming Lai

Inventory management is one central problem of operations. The classical inventory theories typically focus on the operational tradeoffs to optimize the inventory decisions. In practice, however, many firms are public that often have short-term interests in their market value. Our analysis reveals that public firms may install more inventory in equilibrium to influence their earnings. We discuss the determinants of such an effect as well as the empirical evidence.

■ MA10

330B

Revenue Management and Service Platforms

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Laurens G Debo, Dartmouth College, Hanover, NH, 03755, United States, laurens.g.debo@tuck.dartmouth.edu

Co-Chair: Luyi Yang, University of Chicago, Chicago, IL, 60615, United States, lyang6@chicagobooth.edu

1 - Vicarious Goal Pursuit Outweighs Herding in Crowdfunding: Evidence from Kickstarter.com
Dennis Zhang, Washington University in St. Louis, 8342 Delcrest Drive, Apt 328, University City, MO, 63124, United States, denniszhang@wustl.edu, Hengchen Dai

We examine backers' contribution patterns using a novel dataset on 26,516 projects at 10-minute resolution from Kickstarter - the largest crowdfunding website where creators only receive capital committed by backers and deliver rewards if they reach a specific funding goal.

2 - Online Product Support Forums: Customers as Partners in the Service Delivery
Konstantinos Stouras, Post-doctoral Research Fellow, The Darden School, University of Virginia, 100 Darden Boulevard, Charlottesville, VA, 22903, United States, kostas@virginia.edu

Firms increasingly provide service to their customers via an online product support forum in which service delivery is partially delegated to an active community of firm customers (community users). Our results establish that it may be to the best interest of the firm to strategically reduce its service rate to boost a faster response rate from the community of users.

3 - The Impact of Fintech on Consumer Consumption: Evidence from Credit Card Data
Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, United States, lillian.xyq@gmail.com, Anindya Ghose, Binqing Xiao

The recent development of FinTech has expanded the traditional banking channels. In this paper, we use a detailed consumer credit card transaction data set which contains both transactions made through traditional banking channels as well as transactions through FinTech (Alipay) Channels. We analyze the impact of the introduction of FinTech Channels on consumer consumption behaviors.

4 - Strategic Provision of Inventory Information under Competition
Katherine Ashley, Montclair State University, 36 Valley Rd Apt 215, Montclair, NJ, 07042, United States, ashleyk@montclair.edu

Firms in many industries provide customers with real-time inventory availability information, which is typically unverifiable by consumers. We use a game-theoretic model to characterize the information provision strategies that emerge in equilibrium when two firms compete and both customers and firms act strategically in sending and interpreting messages.

■ MA11

332A

Economics of Service Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Guillaume Roels, UCLA, Los Angeles, CA, 90095, United States, groels@anderson.ucla.edu

1 - Payment Models to Coordinate Healthcare Providers with Limited Accountability
Sampath Rajagopalan, University of Southern California, Marshall School of Business, 3670 Trousdale Pky Bridge Hall 400D, Los Angeles, CA, 90089, United States, raj@marshall.usc.edu, Chunyang Tong

This work studies a referral based healthcare system in which general practitioners refer patients to specialist, whose capacity is limited. Moreover, it may not be possible to hold the specialist fully accountable for patient outcomes. We evaluate the effectiveness of different payment systems, including bundled and unbundled payments, in coordinating the decisions of the general practitioner and specialist by a single payer which impact referrals, specialist workload and care quality. We show how limited accountability of specialists for service outcomes interacts with payment systems to distort referral and specialist decisions and impact various quality and cost metrics.

2 - Peer-to-peer Trading of Usage Allowances
Behrooz Pourghannad, University of Minnesota, Minneapolis, MN, United States, behrooz@umn.edu, Saif Benjaafar, Jian-Ya Ding

A growing number of businesses are being built around a model that provides customers access to a product or a service up to a specified amount or allowance. Examples include cloud-based data storage, mobile phone service plans, and fractional ownership of vacation homes, jets, and boats. We study the impact of allowing customers to trade among themselves unused portions of their allowances and examine conditions under which this is beneficial to both the firms and consumers.

3 - Designing New Services: How Much Should Customers Co-create?
Stylianos Kavadias, University of Cambridge, Judge Business School, Trumpington Street, Cambrige, CB2 1AG, United Kingdom, s.kavadias@jbs.cam.ac.uk, Ioannis Bellos

Service blueprints vary significantly across industries and they range all the way from minimal service provider involvement (self-service systems) to heavy engagement between the provider and the customer. How should service providers consider the "right" blueprint for the customer types they aim to attract? This presentation adopts a widely used structure in designing services (customer journeys) to identify how the structural features of the possible service touchpoints, as well as the capabilities of the service providers and the customers, shape different eventual service blueprints.

4 - Optimal Practice Processes for Performance
Guillaume Roels, UCLA, 110 Westwood Plaza, Gold Hall Suite B511, Los Angeles, CA, 90095, United States, groels@anderson.ucla.edu

We consider a practice process with a defined objective, such as arises in learning processes (e.g., studying for an exam) or training processes (e.g., training for a marathon). We introduce an analytical model that captures nonlinear returns of effort on performance, fatigue and strength accumulation, and reference effects and we characterize the optimal practice process that maximizes performance. We find that the optimal process can be N-shaped or alternate sessions of high intensity with sessions with low intensity. We validate our model with running data.

■ MA12

332B

Resource Allocation and Matching

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Weihua Zhang, University of British Columbia, Vancouver, BC, V6T 2G9, Canada, icystrawberry@hotmail.com

Co-Chair: Yichuan Ding, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada, daniel.ding@sauder.ubc.ca

1 - Advance Service Reservations with Heterogeneous Customers

Xinshang Wang, Columbia University, New York, NY, United States, xw2230@columbia.edu, Clifford Stein, Van-Anh Truong

We study a model of resource allocation in which a finite number of resources must be assigned in an online manner to a heterogeneous stream of customers. The customers arrive randomly over time according to known stochastic processes. Each customer requires a specific amount of capacity for each of the resources. The system must find a feasible assignment of each customer to a resource or must reject the customer. The aim is to maximize the total expected capacity utilization of all the resources. We present online algorithms with bounded competitive ratios. Our algorithms perform extremely well compared to common heuristics as demonstrated on a real data set from a large hospital system in New York City.

2 - Ohm's Law Approximation for FCFS Stochastic Matching

Edward H.Kaplan, Beach Professor of Operations Research, Yale University, Evans Hall, 165 Whitney Avenue, New Haven, CT, 06511, United States, edward.kaplan@yale.edu, Mohammad Fazel-Zarandi

The FCFS stochastic matching model developed from queueing problems addressed by Kaplan (1984) for public housing assignments. The goal of this model is to determine the matching rates between eligible customer and server types. This model was solved in a beautiful paper by Adan and Weiss (2012), but the resulting equation for the matching rates is quite complicated, involving the sum of terms over all permutations of the server types. Here we develop approximations for the matching rates based on Ohm's Law. As our approximations only require the solution of a system of linear equations along with the identification of a small number of terms, they provide a tractable alternative to the exact solution.

3 - A Novel KPD Mechanism to Increase Transplants when Some Candidates have Multiple Willing Donors

Tuomas W. Sandholm, Carnegie Mellon University, Gates Center for Computer Science, Pittsburgh, PA, 15213, United States, sandholm@cs.cmu.edu, Gabriele Farina, John Dickerson, Ruthanne Leishman, Darren Stewart, Richard Formica, Carrie Thiessen, Sanjay Kulkarni

Most current kidney exchanges allow candidates to list multiple willing donors, but only one will donate if the candidate is matched. There are cases where multiple donors would be willing to donate if that resulted in their intended candidate being transplanted. We conducted a dynamic simulation (using real UNOS kidney exchange data) to study the effects of having two donors donate in such cases. The new approach yielded more than a 10% gain in the number of priority-weighted transplants. This also means shorter wait times. Future research includes simulating other variants, studying the candidates' and donors' incentives, and considering the ethics.

4 - A Centralized Allocation Mechanism for Public Housing

Weihua Zhang, University of British Columbia, Mailbox 66 0, 6335 Thunderbird Crescent, Vancouver, BC, V6T.2G9, Canada, weihua.zhang@sauder.ubc.ca, Yichuan Ding, Daniel Granot, Mahesh Nagarajan

In 2014, US programs of federal rental assistance helped nearly five million families. We model the affordable housing allocation problem as a centralized decision problem. The HA strives to accommodate move-in requests as well as requests of transfer between housing types. We assume that households list the housing types that they would accept without specifying their complete preference order. We further assume that the housing units of each type are homogeneous. For minimizing vacancy rate and maximizing portability (the responsiveness of the HA to households' accommodation requests), we formulate the problems as network flow problems and characterize the optimal solutions.

■ MA13

332C

Health Care, Processes

Contributed Session

Chair: Haoqiang Jiang, Florida International University, 800 SW 104th Ct A-105, Miami, FL, 33174, United States, jhq820422@hotmail.com

1 - The Effect of Failure on Individual Performance Over Time

Emmanouil Avgerinos, Assistant Professor, IE Business School, c/ María de Molina, 13, CIF.- G81711459, Madrid, 28006, Spain, emmanouil.avgerinos@ie.edu, Bilal Gokpinar

Learning from past failures constitutes a key factor in modern organizations. While the phenomenon has been widely studied, the effect of failure over time has received little attention. More importantly, little is known about what management should do right after a failure is experienced by its employees in terms of team and task allocation. Using a unique dataset of 4,306 cardiac surgery operations from the cardiac unit of a private hospital in Europe we investigate the effect of failure over time and propose new ways for managers to help their employees recover from their recent failures.

2 - A Bayesian Approach for Estimating Out-of-network Referral Patterns in Accountable Care Organizations

Iulian Ilies, Northeastern University, 360 Huntington Avenue, 1200 - 177, Boston, MA, 02115, United States, i.ilies@neu.edu, Parth R. Vadera, James C. Benneyan

Outside utilization (patients receiving care from out-of-network providers) considerably limits the ability of accountable care organizations to coordinate care, ensure quality standards are followed, and reduce costs. We developed a Bayesian method for inference of referral links between care providers from historical insurance claims records, and evaluated this approach on synthetic data generated from provider networks of different sizes and topologies. Our approach was able to reconstruct the network structure with high accuracy, thereby providing an avenue to adjust referral patterns and reduce outside utilization.

3 - Implication of Codified Knowledge Sharing on Operational Failures

Bilal Gokpinar, UCL, Management Science/Innovation, Gower Street, London, WC1E 6BT, United Kingdom, b.gokpinar@ucl.ac.uk, Mecit Can Emre Simsekler

Focusing on codified knowledge sharing among healthcare personnel in the form of written guidance documents, we examined the role of codified knowledge on operational failures in healthcare. We used a unique dataset from hospitals in England and employed text-mining techniques to investigate the impact of documents on operational failures.

4 - Development and Evaluation of Context-based Work Planning Policies for Inpatient Care

Lucy Aragon, Student, Wichita State University, 1845 Fairmount Street, Wichita, KS, 67260, United States, lgaragon@shockers.wichita.edu, Lucy Aragon, Student, Pontificia Unviersidad Catolica del Peru, Lima, Peru, lgaragon@shockers.wichita.edu, Laila Cure

The short-term inpatient care work planning problem consists of assigning tasks to hourly rounds. Due to the fast pace of healthcare systems and the cognitive limitations of humans, work planning strategies are often static and may be inadequate on particular workdays. This research studies work planning policies that can be applied by healthcare workers using limited computational resources. The problem was formulated as a variation of the 0-1 generalized assignment problem with nonlinear capacity constraints. Current, optimal, and practical work planning strategies were evaluated in terms of quality and added workload to the provider.

5 - Integrated Forecasting Simulation Approach for Call Center Workforce Management

Mohammadsadegh Mikaeili, Binghamton University, 1815 Kater Street, Philadelphia, PA, 19146, United States, mmikaei1@binghamton.edu

Call center operations management has been a challenging task due to rising cost of operations. Major source of loss in the call center expenses is associated with poor staffing, such as over-staffing or under-staffing. The call center staffing is challenging because of a random and stochastic behavior of the demand, that is, the inbound call volume. This research aims to create a practical, robust, and flexible decision making framework for more efficient and effective planning of the staffing and scheduling in contact centers. This framework is based on demand forecasting and a simulation model of the call center operations combined with the forecasting data.

6 - Multi-objective Workload Balancing for Subjective Tasks
Haoqiang Jiang, PhD Candidate, Florida International University, 11200 S.W. 8th Street, Miami, FL, 33193, United States, hjian006@fiu.edu, Debra VanderMeer

Resource-task assignment is a critical problem in operations management. Many studies focus on workload balance across available working units using quantitative measures. However, familiarity with a work case can help individual to perform better in subjective tasks, which rely on personal judgement for unique task instances. We propose work assignment methods for subjective workloads that aim to simultaneously satisfy quantitative workload balance goals and maximize benefits of case familiarity. We study our methods in a simulated healthcare setting focused on nurse-patient assignment.

■ MA14

332D

Empirical Healthcare and Service Operations

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Diwas S KC, Emory University, Atlanta, GA, 30322, United States, diwas.kc@emory.edu

1 - Task Scheduling under Worker Discretion
Maria Ibanez, Harvard Business School, Boston, MA, United States, mibanez@hbs.edu, Michael Toffel

Scheduling research investigates the optimal allocation of scarce resources (e.g., a worker) to tasks' completion over time, typically overlooking the role of worker discretion. In practice, workers are often involved in these processes, influencing and being affected by job schedules. We examine how scheduling choices impact operational performance empirically using data from the field.

2 - The Impact of Buffer Location on Patient Satisfaction
Dawson Kaaua, Wharton, 3730 Walnut Street, Suite 500, Philadelphia, PA, 19104, United States, kaaua@wharton.upenn.edu, Christian Terwiesch

Service operations research has typically focused on a customer's wait time without taking into account the fact that customers often wait in multiple locations before completing a service of interest. We examine how the location of waits can impact patient satisfaction in an ambulatory perioperative setting at a hospital. Specifically, we find that patients prefer to wait in the reception area versus the pre-operative area. Given this finding, we suggest that a CONWIP (pull) system could serve as a solution to managing the flow of patients. Finally, we uncover that the hospital is not using a pull system and could thus benefit from implementing one.

3 - Measuring Primary Care Performance using ED-Level Data
Sandra Suelz, Erasmus University Rotterdam, Rotterdam, 50931, Netherlands, sulz@bmg.eur.nl, Nicos Savva

Measuring access and clinical quality of GP care is difficult either due to data unavailability, low frequency of data collection, or inconsistent data collection across GPs. ED-level data, however, exists and is comparable across hospitals. We use UK-based data to analyze whether ED-level data can be used to assess GP performance thereby distinguishing between accessibility for acute conditions and management of long-term care conditions.

4 - Predicting Custom Product Returns
Hailong Cui, University of Southern California, Marshall School of Business, Data Sciences and Operations, Los Angeles, CA, 90089-0809, United States, Hailong.Cui.2019@marshall.usc.edu, Sampath Rajagopalan, Amy R.Ward

Product returns are a major issue for many firms and especially for those making custom goods. We develop a model for predicting returns at a leading manufacturer of custom car accessories. The model takes into account product, retailer and production process characteristics. Several model specifications are explored and tested, including high dimension models. We identify the model specifications that do very well in out-of-sample prediction. Our analysis is useful to the firm in operational planning as well as in investigating products, retailers and other characteristics that tend to have high returns and return rates.

■ MA15

332E

Interface of Finance Risk and Operations Management

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: William Schmidt, Cornell University, Ithaca, NY, 14850, United States, wschmidt@cornell.edu

1 - Mitigating Disruption Risks in Delivery Supply Chains to Serve Contracted Customers
Mert Hakan Hekimoglu, Rensselaer Polytechnic Institute, 110 8th Street, Pittsburgh Building, Troy, NY, 12180, United States, hekimm@rpi.edu, John H.Park, Burak Kazaz

Motivated by an implementation in a Fortune 150 company, we examine the role of risk aversion on capacity decisions in a delivery supply chain in the presence of supply disruptions. The delivery supply chain involves fulfillment centers that are responsible for delivering orders within the next day. The proactive capacity decisions are coupled with reactive contingency routing decisions to mitigate the effects of disruptions.

2 - Suppliers as Liquidity Insurers
Panos Markou, Cambridge Judge Business School, Cambridge, United Kingdom, p.markou@jbs.cam.ac.uk, Daniel S. Corsten, Reint Gropp

We examine how financial constraints in portfolios of suppliers affect customer cash holdings. Using a data set of private and public firms and their suppliers, we show that customers rely on unconstrained suppliers to provide them with backup liquidity and stockpile around 10% less cash than customers with constrained suppliers. We further show that customers with unconstrained suppliers simultaneously receive more trade credit; that the reduction in cash holdings is greater for firms with stronger ties to their unconstrained suppliers; and that customers reduce cash holdings following a significant relaxation in their suppliers' financial constraints through an IPO.

3 - Inaccurate Durations and Supply Chain Disruptions
William Schmidt, Cornell University, 314 Sage Hall, Ithaca, NY, 14850, United States, wschmidt@cornell.edu, Mili Mehrotra

We quantify the performance impact of inaccurate disruption duration estimates using the supply chain data from a multinational division of a Fortune 100 manufacturing firm. We find that inaccurate information on the duration of a disruption can significantly increase the cost of the disruption. In many of those cases we find that a disruption will only be materially costly to the firm if the disruption duration is misestimated. These costs are (1) incremental to the cost of a disruption whose duration is accurately estimated, (2) are incurred regardless of whether the disruption duration is initially over-estimated or under-estimated, and (3) can be large even for small estimation errors.

4 - Worker Poaching in a Supply Chain: Enemy from with in?
Evan Barlow, Weber State University, Goddard School of Business & Economics, 1337 Edvalson St, Ogden, UT, 84408, United States, evanbarlow@weber.edu, Gad Allon, Achal Bassamboo

Poaching workers has become a universal practice. We explore worker poaching between firms linked in a supply chain. We show that the classical intuition from labor economics is insufficient in explaining poaching between supply chain partners. We also show how and under what conditions worker poaching can actually improve supply chain performance. Finally, we show how the equilibrium identity of the supply chain bottleneck depends on the interaction between hiring, poaching, and productivity.

■ MA16

332F

Inventory Management

Contributed Session

Chair: Stef Lemmens, KU Leuven, Naamsestraat 69 Box 3555, VAT BE 0419.052.173, Leuven, 3000, Belgium, stef.lemmens@kuleuven.be

1 - Joint Replenishment Problem with Batch Ordering

Ana Muriel, University of Massachusetts Amherst, Dept of Mechanical & Industrial Eng, 160 Governors Drive, Amherst, MA, 01003, United States, muriel@ecs.umass.edu, Michael Prokle

Motivated by industrial partners who are exploring the benefit of coordinating the ordering and shipping of a variety of parts sold in boxes of a given size, we study the JRP with batch ordering. Given a constant reorder interval, we determine the length of a regeneration period and derive a closed-form expression for the average inventory. We find the optimal constant reorder interval and show the savings relative to an uncoordinated strategy and the joint EOQ policy. The optimal ordering policy under constant demand, however, requires a non-constant reorder interval. We propose a MIP to determine the optimal policy and explore the relative quality of constant reorder interval policies.

2 - The Impact of Political Preference on Inventory Decisions

Yi Tan, University of Kansas, 1654 Naismith Drive, Lawrence, KS, 66045, United States, vieiraty0113@gmail.com, Yaoyi Xi

We conduct an empirical investigation of whether and how CEO political ideology affects firm inventory strategies. Using a panel that contains quarterly data from 1991 to 2016 for 2,745 unique U.S. firms covered by Compustat, we find that firms tend to hold more inventories when the Party their CEOs prefer holds the Presidency. We perform further analyses on firm financial performance to investigate the underlying mechanisms for this finding.

3 - Global Dual Sourcing and Order Smoothing

Stephen M.Disney, Professor of Operations Management, Cardiff Business School, Aberconway Building, Colum Drive, Cardiff, CF10 3EU, United Kingdom, disneysm@cardiff.ac.uk, Robert Boute, Jan A.Van Mieghem

Companies often experience non-stationary demand as products evolve over their life cycle. We investigate a tractable family of single and dual sourcing policies tailored to such demand environment. We adopt a conventional discrete time inventory model with a linear control rule that smooths orders and allows an exact analytical analysis of an easy to implement dual sourcing policy.

4 - Not Centralizing your Inventory? It may be Fine

Bo Li, Assistant Professor, Ningbo Supply Chain Innovation Institute China, Ningbo, China, libo@alum.mit.edu, Antonio Arreola-Risa, Mark L. Spearman

Centralizing inventory, especially safety stocks, is often a proposed solution to cut inventory. In this talk, we consider a two-tier production-inventory system and illustrate how the benefit of centralizing inventory can be negligible under certain situations.

5 - Performance Measurement of a Rotavirus Vaccine Supply Chain by Integrating Production Capacity into the Guaranteed Service Approach

Stef Lemmens, KU. Leuven, Naamsestraat 69 Box 3555, VAT.BE 0419.052.173, Leuven, 3000, Belgium, stef.lemmens@kuleuven.be, Nico Vandaele, Catherine Jenny Decouttere, Mauro Bernuzzi, Amir Reichman

Previous research has integrated multi-echelon inventory management into the design of a responsive supply chain by the use of the guaranteed service approach. We model the production capacity with a queuing network to handle the variability of the batch production processes as well as the demand variability. The focal point is the tail of the lead time distribution which has an impact on the supply chain safety stock. We apply our model to the rotavirus vaccine supply chain. The impact of modelling capacity on lead times and thus safety stocks and working capital is significant.

■ MA17

340A

Quantitative Trading and Optimal Execution

Sponsored: Applied Probability

Sponsored Session

Chair: Ciamac Cyrus Moallemi, Columbia University, New York, NY, 10027, United States, ciamac@gsb.columbia.edu

Chair: Costis Maglaras, Columbia University, New York, NY, 10027, United States, c.maglaras@columbia.edu

1 - Microfoundations of Multifactor Model for Trading Volume in Speculative Market

Seungki Min, PhD Candidate, Columbia University, 1 16th St Broadway, New York, NY, 10027, United States, smin20@gsb.columbia.edu

The joint distribution of trading volume across multiple securities, as a stochastic model of liquidity, needs to be considered in the execution of portfolio transactions. We propose a microstructural model that explains trading volume with the investors' activity responding to sequential information arrival. Only with idiosyncratic investors, our model restores 'Market Microstructure Invariance' hypothesis of Kyle and Obizhaeva (2016). With factor portfolio investors, it suggests a factor structure in trading volume which we observe empirically for U.S. equities. We also observe the increase in factor investment during the recent years that implies the growth of passive investing.

2 - A Separation Principle for Dynamic Portfolio Optimization

Ciamac Cyrus Moallemi, Columbia University, Columbia Business School, 3022 Broadway Uris 416, New York, NY, 10027, United States, ciamac@gsb.columbia.edu, Benjamin Van Roy

We consider multi-period portfolio optimization problems in the presence of predictablereturns. In our setting, we establish that that the term structure of future conditional meanreturns is a sufficient statistic for optimal decision making. This provides a separationprinciple that partitions optimal trading into two natural steps: (1) forecast the term structureof future expected returns; (2) compute the optimal trading decision by solving a single-period,deterministic Markowitz-style mean-variance optimization problem, but with an endogenouslydetermined effective time horizon.

3 - Robust Wasserstein Profile Inference in Distributionally Robust Mean-variance Model

Lin Chen, Columbia University, New York, NY, 10025, United States, lc3110@columbia.edu, Jose Blanchet, Xunyu Zhou

This project is concerned with a distributionally robust mean-variance model. By solving its dual problem, we can get a data driven model with penalty on norm of portfolio. We use RWPI method to choose the regularization parameter without the use of cross validation and then design an algorithm to solve the optimization problem. Numerically experiments are given to compare the performance of portfolio obtained by traditional Markovitz model and RWPI method.

■ MA18

340B

Stochastics and Behavioral Operations

Sponsored: Applied Probability

Sponsored Session

Chair: Yash Kanoria, Columbia Business School, New York, NY, 10027, United States, ykanoria@gmail.com

1 - Traffic Scheduling:Large Population Optimality

Harsha Honnappa, Purdue University, 315 N. Grant Street, West Lafayette, IN, 47906, United States, honnappa@gmail.com

We solve the problem of scheduling appointments for a finite customer population to a service facility with customer no-shows to minimize customer waiting time and server overtime costs. We study the problem in fluid and diffusion frameworks. We find that it is optimal to schedule traffic so that the system is in critical load. That is, heavy-traffic is obtained as a result of optimization rather than as an assumption. Our proposed schedules are proved to be asymptotically optimal for a finite horizon in the fluid scaling and for large and finite horizon in the diffusion scaling. We also provide some initial results on solving the finite horizon problem.

2 - Strategic Open Routing in Service Networks
Andrew E. Frazelle, Duke University-Fuqua School of Business, 2616 Erwin Rd, #1302, Durham, NC, 27705, United States, andrew.frazelle@duke.edu, Alessandro Arlotto, Yehua Wei

We study the behavior of strategic customers in an open-routing service network with multiple stations. When a customer enters the network, she is free to choose the sequence of stations that she visits, with the objective of minimizing her expected total system time. We propose a two-station game with all customers present at the start of service and deterministic service times, and we find that strategic customers "herd," i.e., in equilibrium all customers choose the same route. We find that the herding behavior is also prevalent in many other congested open-routing service networks, including those with arrivals over time, those with stochastic service times, and those with more than two stations.

3 - Dynamic Decision Making under Customer Abandonment Risk
Jiaqi Lu, Columbia Business School, c/o Clara Magram, 30 22 Broadway, New York, NY, 10027, United States, jlu20@gsb.columbia.edu, Yash Kanoria, Ilan Lobel

We consider a firm repeatedly interacting with a customer. At any time, the firm has to choose between a risky and a safe mode of service. The customer has a propensity to leave if her "happiness", an average of recent rewards, is low. The hazard rate is a step function that drops to zero at what we call "happiness threshold". We study how the firm can maximize (discounted) rewards over the customer lifetime by optimally trading off between myopic rewards and the risk of customer abandonment in future. The optimal policy uses the service mode with higher average reward rate everywhere *except*, being risk-averse just above the threshold and risk-seeking just below the threshold.

4 - Choice Paralysis on Operational Decision Making
Rene A. Caldentey, The University of Chicago, Booth School of Business, 5807 S.Woodlawn Ave, Chicago, IL, 60637, United States, rene.caldentey@chicagobooth.edu

We empirically investigate the notion of Choice paralysis (i.e., too many options can paralyze a consumer and make them more prone to not purchasing) and study its implications on assortment and inventory decisions. We propose a modification to the nested logs model to incorporate the choice paralysis effect.

■ MA19

342A

Merchant Commodity and Energy Operations

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Selvaprabu Nadarajah, University of Illinois at Chicago, College of Business, Chicago, IL, 60607, United States, selvan@uic.edu

Co-Chair: Nicola Secomandi, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, ns7@andrew.cmu.edu

1 - Networked Resources and Market Interactions
John R. Birge, University of Chicago, Booth School of Business, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States, John.Birge@ChicagoBooth.edu

Networked resources, such as electricity, gas, and data, often involve multiple markets that apply to flows (input and output) and to capacity. Large producers or consumers can often exercise market power that is reduced in the presence of financial traders. Interactions across markets, however, can subvert the goals of financial trader participation and allow for market manipulation. This talk will discuss the design of markets to avoid such situations.

2 - A Spectrum of Optimal Policies for Risk-averse Electric Vehicle Charging
Daniel Jiang, University of Pittsburgh, 1002 Benedum Hall, 3700 O'Hara Street, Pittsburgh, PA, 15261, United States, drjiang@pitt.edu, Warren B.Powell

We consider the sequential decision problem faced by the manager of an electric vehicle (EV) charging station who faces stochastic spot prices and present new methodology that generates an approximate "spectrum" of risk-averse policies under dynamic risk measures. We investigate the connection to the more traditional risk vs. reward framework.

3 - Managing Aluminium Smelter Robustness
Stein-Erik Fleten, Norwegian University of Science & Technology, Dept of Ind Econ & Tech Mgmt, Trondheim, Norway, stein-erik.fleten@iot.ntnu.no, Alessio Trivella, Selvaprabu Nadarajah, Denis Mazieres, David Pisinger

Commodity and energy production assets face shutdown risk due to fluctuations in input/output prices and exchange rates. We formulate a new shutdown-specific risk-averse model able to handle the risk of shutdown by operational hedging. An approximate dynamic programming method, the regress-later variant of Least-squares Monte Carlo, is extended to compute risk-averse operating policies. We tested the new model on a real application related to an aluminium smelter with mothballing and shutdown flexibility. Our results show that the new shutdown risk-averse policy outperforms CVaR-based policies, providing more efficient trade-offs between asset value and shutdown probability.

4 - Optimal Custom Hedge of Quantity Risk
Andrea Roncoroni, ESSEC Business School, Cergy-Pontoise, France, roncoroni@gmail.com

Commodity-linked positions often exhibit a combined exposure to both market prices and nontradable terms (e.g., harvest, volume, load). We provide a general theory of customized contract design aimed at optimally hedging the corresponding joint risk. Tailored hedges are derivatives written on the underlying tradable and any quoted variable exhibiting statistical dependence on the quantity term. Given agent's beliefs, mean-variance preferences, and a copula-based setting, we derive analytical solution sought among two-asset contingent claims and numerical solutions for portfolios of one-asset customized hedges. Closed-form solution are computed under separable copula densities.

■ MA20

342B

Emerging Issues in Innovation Management

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Bilal Gokpinar, b.gokpinar@ucl.ac.uk

1 - Shifts in the Counts of Employees and Locations: Impact on Startup Survival
Berke Emre Guzelsu, Boston University, 595 Commonwealth Avenue, Boston, MA, 02215, United States, bguzelsu@bu.edu, Nitin Joglekar, Moren Levesque

Fifty percent of business startups survive after five years, while about one third survive after ten years. To improve their survival odds, startups must pay attention to changes in their workforce size and in the number of locations in which they operate during their initial unsettled years. We use annual panel data and hazard rate models to analyze the impact of these operational factors on startup survival rates.

2 - Search and Sequential Innovation in Mobile App Development
Nilam Kaushik, B-116, Tufnell House, London, N70EG, United Kingdom, uceikau@ucl.ac.uk

The process of search, identification, and acquisition of new knowledge is essential for the success of new products. We explore how firms search for ideas in sequential product development through the highly competitive and dynamic setting of mobile application development. Using novel text-mining techniques, we derive measures of similarity between a focal app's update and updates made by competitor apps and study performance implications thereof. We also explore the performance implications of the dissimilarity of an app's update with respect to its past updates.

3 - The Impact of Asymmetric Information in Procurement Auctions
Joel Wooten, University of South Carolina, 1014 Greene St., Columbia, SC, 29208, United States, joel.wooten@moore.sc.edu

Web-based technologies have enabled new possibilities in procurement auctions. We investigate asymmetric information conditions and the behavior of participants with respect to these in an experiment around bids for construction projects.

4 - Dual Innovation, Innovation Abandonment and Innovation Performance
Sriram Narayanan, Michigan State University, 632 Bogue Street, Room N357 North Business College Complex, East Lansing, MI, 48824, United States, narayanan@broad.msu.edu, Adrian S.Choo, Ravi Srinivasan, Soumodip Sarkar

In this study, we focus on investigating the impact of firms thta undertake dual innovations (both products and services) and innovation abandonment on innovation performance. We perform a large sample investigation to examine this problem using a unique set of archival data with 11,558 manufacturing and service firms located in 11 countries in Europe. We find that dual innovation positively influences a firm's innovation performance. Innovation performance are measured by sales turnovers and product introductions that are new to the market and new to the firm.

■ MA21

342C

Supply Chain Finance

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Lingxiu Dong, Washington University, Saint Louis, MO, 63130-4899, United States, dong@wustl.edu

1 - Supplier Diversification under Buyer Risk

Gerry Tsoukalas, Wharton School of Business, 3730 Walnut Street, 567 Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, gtsouk@wharton.upenn.edu, Jiri Chod, Nikolaos Trichakis

Arguably the most common explanation of supplier diversification is hedging against supplier risks. We provide an alternative explanation based on buyer risks: In the presence of information asymmetry regarding buyer creditworthiness, buyers may take costly action to signal their quality to suppliers. We find that while signaling is effective at overcoming initial information asymmetry, under single sourcing, it leaves the supplier with an information monopoly that leads to hold-up in future periods. In this context, we show that ex ante supply base diversification can be effective at alleviating ex post informational holdup, but also comes at the expense of higher upfront costs.

2 - A Supply Chain Theory of Factoring and Reverse Factoring

Fasheng Xu, Washington University in St. Louis, Saint Louis, MO, 63130, United States, fasheng.xu@wustl.edu, Panos Kouvelis, Wenhui Zhao

To free up supplier's liquidity inhibited by retailer's payment deferral, factoring contracts are often used as post-shipment financing schemes. We find that in a pull system the benefits of recourse factoring are limited, but non-recourse factoring achieves surprisingly better performance by eliminating market frictions and reducing the cash-to-cash cycle. Further, we show how the retailer can help shoulder the supplier's financial burden through reverse factoring contracts with payment guarantee. We find it's not always optimal to extend payment term and the optimally designed reverse factoring contract can coordinate the decentralized supply chain with arbitrary profit allocation.

3 - Financing SME Sellers via E-commerce Platform

Lingxiu Dong, Washington University, Campus Box 1156, One Brookings Drive, Saint Louis, MO, 63130-4899, United States, dong@wustl.edu, Long Ren, Dennis Zhang

Small-business sellers selling products via e-retailing platforms often face capital constraints that limit their ability to build inventory and expand product offerings. E-commerce platform steps up with new financing scheme to help these sellers to grow. We consider sellers' financing issue with e-commerce platform intervention, in both monopoly and competition scenarios. We show that although in the monopoly setting both the seller and the platform benefit from the platform's loan, in the competition setting the platform's loan may intensify the seller competition. We suggest alternative loan offerings to dampen the competition.

■ MA22

342D

Topics in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Dragos Florin Ciocan, INSEAD, INSEAD, Fontainebleau, France, florin.ciocan@insead.edu

1 - Near-optimality of Myopic Markdowns in the Presence of Strategic Consumers

Anton Ovchinnikov, Stephen J.R. Smith School of Business, Queen's University, anton.ovchinnikov@insead.edu, Dragos Florin Ciocan

Much of the research on dynamic pricing with strategic consumers assumes that all consumers are strategic. The empirical data, and the experimental results, however, show that a non-insignificant proportion of consumers behave myopically. Our paper demonstrates that in such situations pricing as if all consumers are myopic often leads to higher revenues than pricing as if all consumers are strategic.

2 - Operational Challenges for Decentralized Manufacturing

Andre Du Pin Calmon, INSEAD, Boulevard de Constance, Fontainebleau, 77300, France, andre.calmon@insead.edu, Victor Araman, Anton Ovchinnikov

Motivated by a social enterprise in Kenya that manufactures fashion accessories using a distributed network of artisans, we analyze the operational challenges of managing a decentralized "virtual" factory. The artisans have limited budgets, capabilities, and varying production quality, while the company faces uncertain demand. We investigate various operational issues that emerge in this unique business model.

3 - Non Stationary Online Macthing

Victor Araman, American University in Beirut, Lebanon, va03@aub.edu.lb, Dragos Florin Ciocan

We consider a number of nodes and an input traffic. Each arrival needs to be matched with one node out of a subset that is selected following a nonstationary distribution. We suggest a simple online allocation policy that performs extremely well.

4 - Optimal Pricing and Introduction Timing of New Virtual Machines

Spyros Zoumpoulis, INSEAD, 15 Rue Daubenton, Paris, 75005, France, spyros.zoumpoulis@insead.edu, Ian Kash, Peter Key

We characterize the optimal pricing and timing of introductions of new virtual machines for a cloud service provider in the face of customers who are averse to upgrading to improved offerings. We show that a simple policy of periodic introductions and Myerson pricing is near optimal in many situations.

■ MA23

342E

Pricing for Logistics and Distribution

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Sila Cetinkaya, sila@lyle.smu.edu

1 - Can Dynamic Pricing Reduce What Consumers Pay?

Naveed Chehrazi, McCombs School of Business, 2110 Speedway, Stop B6000, Austin, TX, 78712, United States, naveed.chehrazi@mccombs.utexas.edu, Yannis Stamatopoulos, Achal Bassamboo

We illustrate that when pricing decisions are made in conjunction with other operational decisions, dynamic pricing can result in increased system efficiencies, which can pass-through to consumers. To demonstrate this point, we equip the traditional economic order quantity (EOQ) setting with a rich demand model and compare social outcomes under two alternatives, dynamic and static pricing. We show that dynamic pricing Pareto-dominates static pricing: it generates higher profit and sales rate for the retailer, while it reduces the average price paid per unit sold for consumers.

2 - Delivery Pricing Strategies for Competing Retailers

Chinmoy Mohapatra, University of Texas at Austin, Austin, TX, United States, smilingchin@gmail.com, Anant Balakrishnan, Shankar Sundaresan

We study competition between two retailers who can offer consumers different delivery pricing choices: a pay-for-delivery option and/or a subscription option with limited free deliveries. Using a novel utility-based framework with heterogeneous consumers, we demonstrate that the firms can avoid aggressive price competition by offering complementary delivery pricing options in a Stackelberg equilibrium. We characterize the equilibrium delivery pricing policies for both retailers and develop interesting insights.

3 - Smart Logistics in E-commerce - Pricing in Last Mile Delivery

Lan Lu, HKUST, Dept. of IELM, Clear Water Bay, Hong Kong, Hong Kong, 00000, Hong Kong, na, Chung-Yee Lee, Chung Piaw Teo

We consider a delivery service pricing problem in the view of an e-commerce platform which coordinates the deliveries of many logistics companies. The objective is determining a parcel delivery price to each area to balance the worst-case profits of the couriers. We use the method of optimal transport to model the distributional uncertainty in delivery locations, and propose a cutting plane approach to solve for the optimal set of prices.

4 - A Mathematical Model for Short Term Liquefied Natural Gas (LNG) Delivery

Fatih Mutlu, Qatar University, Doha, Qatar, fatihmutlu@qu.edu.qa

LNG suppliers prepare approximate annual plans for the delivery of LNG contracts. During the implementation stage, short-term portions of these plans should be adjusted so as to finalize the exact loading days and assigned vessels and to exploit the additional sales opportunities that recently arose. We develop a comprehensive mathematical model for maximizing the revenues from additional sales minus the penalty costs associated with deviating from the annual plan. Through a comprehensive numerical study, we analyze the sensitivity of profit on vessel capacity and demand-to-capacity ratio.

5 - Coordination via Pricing in the Reverse Channel

Sila Cetinkaya, SMU, Dallas, TX, United States, sila@smu.edu, Elif Akcali, Yi Zhang

In this paper, we study an extension of the traditional channel coordination problem that arises in the context of a reverse supply chain that is comprised of a collector-remanufacturer pair. We investigate effective pricing mechanisms enhancing the efficiency of collection logistics under a general stochastic return process.

■ MA24

342F

Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Srikanth Jagabathula, NYU Stern School of Business, New York, NY, 10012, United States, sjagabat@stern.nyu.edu

1 - Can Managers Plan Assortments? An Experimental Study

Yulia Vorotyntseva, University of Texas at Dallas, Richardson, TX, United States, Yulia.Vorotyntseva@utdallas.edu, Elena Katok, Dorothee Honhon

Assortment planning can be a very complex problem due to product interaction effects, such as cannibalization and inventory pooling benefits. We want to find out if human decision makers have an intuitive understanding of such effects, and whether they can gain it with practice. To do this, we develop and conduct a behavioral experiment, where the subjects are repeatedly picking assortments in a simplified environment. We find that the subjects perform better when the profit maximizing assortment consists of fewer products and that subjects improve their decisions over time.

2 - Group Conversion: A Better KPI to Compare Stores

Anup Hanamant Walvekar, INSEAD, 1 Ayer Rajah Avenue, PhD Office, Singapore, 138676, Singapore, anup.walvekar@insead.edu, Nils Rudi, Serguei Netessine

Conversion rate is an important KPI for a retail store that captures the fraction of sales opportunity that the store was able to capture. As a group of people shopping together seldom have multiple transactions, the number of groups visiting the store is a more appropriate measure of sales opportunities than the number of individuals. Identifying groups in traffic using video footage is a laborious and expensive task. In this paper, we mathematically model the customer arrival process and derive methods to identify of groups in traffic data obtained from simple counters.

3 - A Model-based Projection Technique for Segmenting Customers

Ashwin Venkataraman, New York University, New York, NY, United States, ashwin@cs.nyu.edu, Srikanth Jagabathula, Lakshminarayanan Subramanian

We consider the problem of segmenting a population of customers into non-overlapping groups with similar preferences, using diverse signals such as purchases, ratings, clicks, etc., over a large universe of items. We propose a model-based projection technique, which transforms the diverse observations into a comparable scale and deals with missing data by projecting the transformed data onto a low-dimensional space. We then cluster the projected data to obtain the customer segments. Our method achieves upto 84% improvement in the accuracy of new movie recommendations on the MovieLens data set and 6% improvement for similar item recommendations algorithm on an offline dataset at eBay.

4 - Building Optimized and Hyperlocal Product Assortments: A Nonparametric Choice Approach

Srikanth Jagabathula, NYU. Stern School of Business, 44 W. 4th St, Kmc Rm 8-74, New York, NY, 10012, United States, sjagabat@stern.nyu.edu, Vivek Farias, Devavrat Shah

Fashion retailers want to "hyper-localize" product assortments, i.e., customize offerings to the preferences of customers visiting each store, to increase sales. The challenge is demand prediction because of the large variety. To address this challenge, we propose: (a) a nonparametric choice modeling technique that uses purchase transactions tagged by customer IDs and (b) an optimization framework that uses our demand predictions to optimally allocate merchandise to different stores. In a controlled experiment at a large US fashion retailer (~$3B annual revenue and ~300 stores), our methods resulted in additional 7% revenue growth (~$200M profit impact) over the current method.

■ MA25

350A

Topics in Entrepreneurship and Innovation

Invited: New Product Development

Invited Session

Chair: Pascale Crama, Singapore Management University, Singapore, 178899, Singapore, pcrama@smu.edu.sg

1 - The When and How of Outsourced Technology Scouting

Sasa Zorc, INSEAD, 1 Ayer Rajah Avenue, PhD Office, Singapore, 138676, Singapore, sasa.zorc@insead.edu, Sameer Hasija, Ilia Tsetlin

A pharmaceutical firm seeks to conduct a search for acquisition opportunities. We consider the decision of whether to outsource this process or do it in-house, and model it in dynamic principal-agent framework. The optimal contract is shown to have a purchase rights structure: agent is paid a retainer plus a bonus each time the principal makes an acquisition based on the agent's lead. The size of this bonus is decreasing in time and depends on probability of finding a suitable opportunity but not on its value. The outsourcing decision is complex and depends on several factors, with information and cost asymmetries being most important. Delaying outsourcing for later parts of search is shown to be optimal.

2 - Breaking the Stalemate: Signaling, Experience, and Value Creation in Technology Licensing

Pascale Crama, Singapore Management University, 50 Stamford Road, Singapore, 178899, Singapore, pcrama@smu.edu.sg, Reddi Kotha, Phillip Kim

We address the question of how signals can be employed to broker technology licensing agreements when information asymmetry prevents risk-averse parties from working together. In our setting, inventors and licensee firms are brought together by licensing managers (LM) to commercialize new technologies. We argue that experienced LM intentionally alter contractual payment structures to signal value creation to the licensee based on ability and need. With experience, LM gain the ability to create value based on selecting promising inventions and matching them to capable licensing partners. In addition, experienced negotiators weaken and amplify signals as needs to address uncertainties vary.

3 - Truth or Funds? Human Behavior under Competition for Resources in R&D

Özge Tüncel, Singapore University of Technology and Design, 8 Somapah Rd, Singapore, tuncel_ozge@mymail.sutd.edu.sg, Niyazi Taneri, Nektarios Oraiopoulos, Jochen Schlapp

Self-interested project managers working on R&D projects compete for their firm's limited resources. This may lead to misreporting of project prospects (adverse selection) and distort both the efforts made by project managers (moral hazard) and the firm's resource allocation decision in the absence of carefully designed incentive mechanisms. We study how human behaviour further complicates this process and suggest remedies to alleviate the problem.

4 - Behavioral Responses in the Multi-armed Bandit Model

Fabian J. Sting, University of Cologne, Albertus-Magnus-Platz, c/o WiSo-Sekretariat Universitaetsstrasse 91, Cologne, 50923, Germany, sting@wiso.uni-koeln.de, Mirko Kremer, Andolhossein (Navid) Ghayazi

How do human decision makers respond to changing business landscapes, e.g., in project portfolio management? Toward answering that question we investigate the well-studied multi-armed bandit model—-yet enriched with disruptions, i.e., changes in the stochastic processes that yield the arms' payoffs. We compare normative results from comprehensive simulation studies with behavioral results from lab experiments.

■ MA26

350B

DEA Methodological Extensions and Applications

Invited: Data Envelopment Analysis

Invited Session

Chair: Mehdi Toloo, Technical University of Ostrava, Czech Republic, VŠB-TU Ostrava, Faculty of Economics, Sokolská tr. 33., Ostrava, 701 21, Czech Republic, m_toloo@yahoo.com

1 - Extended DEA Efficiency Model of Rice Growing Farmers with Undesirable Output and Interval Data

Azizul Baten, Shahjalal University of Science and Technology, Sylhet, Bangladesh, baten_math@yahoo.com

An extended Data Envelopment Analysis model based on Directional Distance Function approach considering undesirable outputs, climatic factors and interval data is developed. The inclusion of these factors enables to represent the actual production environment. The interval data approach is used to model the uncertainties in the production environment and obtain the interval efficiency score of rice farmers who produces undesirable outputs and operates under uncertainty. The optimistic and pessimistic cases are considered to estimate the upper and lower bound of the efficiency score for each farmers as this model cannot be solved in its original form.

2 - Measuring Nursing Home Quality Performance using DEA

Christine Pitocco, Stony Brook University, 6 Essex Drive, Ronkonkoma, NY, 11779, United States, christine.pitocco@stonybrook.edu

A primary concern of consumers as they select a nursing home is the quality of care provided by the home. No single quality measure exists to evaluate nursing home performance; therefore a multidimensional approach is required. We illustrate the use of Data Envelopment Analysis using nine quality indicators to evaluate 589 nursing homes in New York State in 2015.

3 - The Efficiency Measurement of Colombian Higher Education Institutions using Data Envelopment Analysis with Flexible Measures

Sepideh Abolghasem, Universidad de los Andes, Carrera 1 Este #19A-40, Bogota, 11001000, Colombia, ag.sepideh10@uniandes.edu.co, Linas Navas, Felipe Montes, Mehdi Toloo, Andrés Useche, Ricardo Salas, Andrés Medaglia, Roberto Zarama

It is vital to assess the efficiency of universities for effective allocation and utilization of educational resources. This work explores the performance efficiency of higher education institutions (HEIs) in Colombia using a data envelopment analysis (DEA) model. We examine the efficiency of HEIs in terms of their achievement, applicability and research using a variant of DEA where we include flexible measures. To measure efficiency, we consider the results of the national exam after completing higher education studies, graduates' employability rate, the number of published articles, the total number of academic staff, the percentage of PhD and the total number of undergraduate students. The application of DEA enables HEI to identify deficient activities and take appropriate actions accordingly for improvement.

■ MA27

350C

Social Media Analytics for Disaster Management

Invited: Social Media Analytics

Invited Session

Chair: Jun Zhuang, University at Buffalo, SUNY, 317 Bell Hall, Buffalo, NY, 14260, United States, jzhuang@buffalo.edu

Co-Chair: Samiul Hasan, University of Central Florida, Orlando, FL, 32816, United States, samiul.hasan@gmail.com

Co-Chair: Arif Mohaimin Sadri, Purdue University, West Lafayette, IN, 47906, United States, asadri@purdue.edu

1 - Get Insight into Social Media Analysis and Incident Detection

Ying Chen, Northwestern University, 600 Foster St, Evanston, IL, 60208, United States, y-chen@northwestern.edu, Archak Mittal, Hani S.Mahmassani

The feasibility of using social media data for detecting traffic incidents is evaluated. The presented framework consists of three main components, Twitter data mining, location extraction and traffic management. The approach is implemented using data from the Chicago area; using on-line simulation-based traffic estimation and prediction tools, traffic management strategies developed to reduce the impact of incidents are evaluated. The results confirm the potential of Twitter posts to complement and improve the effectiveness of dynamic traffic management approaches for incident conditions.

2 - Crisis Communication and Rumor Management using Social Media During Disasters

Jun Zhuang, University at Buffalo, SUNY, 317 Bell Hall, Buffalo, NY, 14260, United States, jzhuang@buffalo.edu, Bairong Wang

Social media has been used by organizations and private citizens for crisis communication during disasters. However, few research has studied the users' behavior when facing rumors and debunking information. We first study the effectiveness of crisis communication and how re-tweet and mention could help improve crisis information impression. Second, we investigate four cases of rumor responding and corresponding debunking behaviors of Twitter users during Hurricane Sandy in 2012 and Boston Marathon bombings in 2013. Finally, we discuss the optimal debunking strategies dealing with potential rumor information, and the corresponding consequences on the downstream information sharing.

3 - Understanding the Effectiveness of Social Media Communication During Disasters using Twitter Data from Hurricane Sandy

Kamol Chandra Roy, University of Central Florida, Orlando, FL, United States, roy.kamol@Knights.ucf.edu, Samiul Hasan

Rapid communication during a natural disaster is one of the critical aspects of effective disaster management strategies. Online social media provides a tremendous opportunity to communicate information during disasters. In this study, around 52.5 million tweets related to hurricane Sandy have been analyzed to assess the effectiveness of information spreading in social media. Our study reveals that information spreading capacity depends on user follower count, user category, bot score (controlled by human or machine) and activity levels.

4 - Analysis of User-Specific Communication Patterns of Hurricane Sandy using Twitter Data

Arif Mohaimin Sadri, Purdue University, 149 Arnold Drive Apt 12, West Lafayette, IN, 47906, United States, asadri@purdue.edu

Hurricane Sandy was one of the strongest and costliest in the history of hurricanes. Many people used social media to communicate during this period while lacking access to traditional information sources. In this study, we analyzed raw data (~52 M tweets, ~13 M users, Oct 14 -Nov 12, 2012) obtained from Twitter. First, we identify different communities from the subgraphs of Twitter that was active before, during, and after Sandy's landfall. Then, we extract different crisis communication topics evolved in these subgraphs while Hurricane Sandy was approaching.

5 - Revisiting Collaborative Activity and its Impact on Peer-produced Content

Srikar Velichety, University of Memphis, 395 S.Highland Street, Suite 128, Apt#301, Memphis, TN, 38111, United States, svlchety@memphis.edu

We provide a bottom-up view of collaboration in peer-produced content. Using the dictionary definition of collaboration, we identify aspects of collaboration that the present research on online communities does not consider. We introduce and define the concept of implicit collaboration and then identify two dimensions and four possible areas of collaboration. In each area, we identify the relevant social network that captures collaboration. Using customized metrics on these networks that capture various aspects of collaboration in each of the four different areas, we quantify the impact of collaboration on article quality. We also measure the usefulness of these metrics in predicting quality.

■ MA28

350D

Auctions and Market Design

Invited: Auctions

Invited Session

Chair: Elena Katok, University of Texas at Dallas, Richardson, TX, 75080, United States, ekatok@utdallas.edu

Co-Chair: Cuihong Li, University of Connecticut, Storrs, CT, 06269, United States, cuihong.li@uconn.edu

1 - The Reference Price Effect of Reserve and Bin Prices

Ernan E.Haruvy, University of Texas-Dallas, School of Management, SM.34 Box 830688, Richardson, TX, 75083-0688, United States, eharuvy@utdallas.edu

Reserve prices and BIN prices can serve as reference prices for bidders and in turn influence bidder entry and willingness to pay. We first quantify the dual impact and implied trade-off of price floors and BINs on the number of bidders and auction revenue. Second, we distinguish the reference price effect of reserve prices from the better known truncation and entry effects of reserve prices. Third, we examine robustness of the reserve price effect to the introduction of BINs and seek to characterize the relative reference pull of a reserve price relative to a BIN on the final price. We find that reserve prices have a smaller impact than BIN on final price and that the impact of reserve price is robust to BINs.

2 - The Influence of Social Media on Charitable Fundraising

Peter T. Popkowski Leszczyc, University of Alberta, 4-30 F Faculty of Business Blg, Edmonton, AB, T6G 2R6, Canada, ppopkows@ualberta.ca

We investigate the combined power of auctions and social media to raise funds for charity. Auctions are uniquely positioned to price unique art, and social media is uniquely positioned to generate demand for that art. We auctioned off artwork created by teams of under-privileged youth with unique stories and goals, and used social media, with a focus on Facebook and Facebook likes to disseminate word of mouth about these auctions. We find that social media increases prices in charity auctions by affecting (1) impressions (i.e., the number of times a Facebook posting displayed) which in turn affect bidding intensity and then price and (2) through Facebook likes which affect price directly.

3 - Procurement Mechanisms with Post-auction Cost-reduction Investigations

George Chen, University of Texas at Dallas, Richardson, TX, United States, georgeqc@umich.edu, Damian Beil, Izak Duenyas

Consider the following procurement setting: After seeing suppliers' bids, the buyer can choose to investigate some suppliers to identify cost-reduction opportunities; the investigated suppliers' costs will decrease by the identified cost-reductions; the buyer then awards the contract. We characterize the optimal first-price sealed-bid mechanism, as well as an optimal mechanism among a wider class of mechanisms. For ex-ante symmetric suppliers, incorporating investigations create an ex ante win-win situation for everyone. The win-win may break down when suppliers are sufficiently asymmetric, but no supplier has the incentive to unilaterally block investigation.

4 - Supplier Cost Reduction: Competition and Endogenous Information Asymmetry

Cuihong Li, University of Connecticut, School of Business, 2100 Hillside Road, Storrs, CT, 06269, United States, cuihong.li@uconn.edu

Consider a hold-up problem in which suppliers exert cost-reduction efforts before the buyer offers contracts. We study the impact of supplier competition and endogenous information asymmetry generated by mixed strategy of suppliers.

■ MA29

350E

Machine Learning & Data Mining

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Ravi Aron, Johns Hopkins University, Baltimore, MD, 21202, United States, raviaron@jhu.edu

1 - Predicting Complex Outcomes using Machine Learning: A Dimensionality Reduction Approach

Praveen Pathak, Warrington College of Business, University of Florida, Gainesville, FL, 32611, United States, praveen.pathak@warrington.ufl.edu

Machine learning techniques are useful in many business domains and specifically to predict outcomes in big data. However big data inherently has a variety of features. The efficacy of machine learning algorithms might be reduced give these many features. But machine learning techniques can be used to do feature selection out of these myriad of features. Such feature selection leads to reduction in dimensionality of features. We use machine learning techniques for dimensionality reduction and show how complex outcomes could be predicted.

2 - Predicting Safe Handoffs, using Data Mining to Determine the Factors that Predict Safer Hand off Behaviors in Inpatient Settings

Phillip Phan, Alonzo and Virginia Decker Professor, Johns Hopkins Carey Business School, Baltimore, MD, 21202, United States, pphan@jhu.edu, Soo-Hoon Lee

This study seeks to discover a multi-level recursive model of organizational and process factors that determine the adoption and use of electronic hand-off tools in clinical settings.

3 - So Far So Good? Predicting Patient State Transition in Chronic Care using Machine Learning

Ravi Aron, Johns Hopkins University, Carey Business School, 100 International Drive, Baltimore, MD, 21202, United States, raviaron@jhu.edu

We address the problem of predicting state transition in chronic diseases. We use techniques drawn from Machine Learning - in specific ensemble learning techniques - to predict a patient's likelihood of state transition. We contrast our approach with traditional estimation models and find that our method based on ensemble learning outperforms these methods.

■ MA30

350F

Social Network Analytics

Invited: Social Media Analytics

Invited Session

Chair: Peng Xie, Georgia Institute of Technology, Atlanta, GA, 30309, United States, peng.xie@scheller.gatech.edu

1 - A Deep Look into Helpful Online Physician Reviews

Lina Zhou, University of Maryland-Baltimore County, 1000 Hilltop Circle, Baltimore, MD, 21250, United States, zhoul@umbc.edu, Nujood Alodadi

Compared with online reviews of other types of products, physician reviews have been much less studied. Much remains to understand what constitutes a helpful online physician review. A few extant studies are focused on analyzing word-level features by leveraging general purposed lexicons. These methods are unable to address domain-specific characteristics of physician reviews such as embedded semantics. They also overlooked social network features of online reviews. This research is aimed to advance our knowledge about helpful online physician reviews by incorporating semantics and social network information.

2 - Revealing Puzzles of the Effect of Online Brand Community Participation on Purchase Frequency

Xuehua Liao, Ph.D, Sun Yat-sen Business School, Guangzhou, China, liaoxueh@mail2.sysu.edu.cn, Kang Xie, Jinghua Xiao

Numerous studies on how online brand community engagement affects purchase generate mixed findings, but slim evidence deep into the contradiction. This study tries to reveal it from perspective of uncertainty reduction theory. Realistic engagement and purchase behavior data are collected to test our hypotheses. Results show that whether users reduce their uncertainty about the firm or product through communication with others plays an important role. This study enriches uncertainty reduction theory by extending its application condition from bilateral to trilateral relation. Also, it puts forward a fresh analytical perspective to shed light on the engagement-purchase effect confusion.

3 - Strategic Information Dissemination in Healthcare Workers Network

Xiaowei Mei, University of Florida, 1454 Union Road, #11, Gainesville, FL, 32603, United States, xmei@ufl.edu

How adoption of new healthcare management practices among healthcare workers can be promoted by disseminating information through their work related network? We examine this phenomenon by studying the adoption of a new medicine in a large hospital in the US. We construct a comprehensive work related network of doctors and other supporting healthcare staff based on their past collaboration over one year period. Then we examine the diffusion of new medicine in this network over time. We find that good health care management practices can be promoted by strategically seeding information about them in the work related network of health care workers.

4 - A Novel Literature Retrieval Model Based on Wisdom of Crowds in the Citation Network

Ruiyun Xu, City University of Hong Kong, Kowloon Tong, Hong Kong, ruiyunxu2-c@my.cityu.edu.hk, Hailiang Chen, J. Leon Zhao

We develop an innovative retrieval model by leveraging the wisdom of crowds embedded in the citation network to enable a fast and comprehensive article search. Instead of keywords, an abstract is used as query input to better capture a user's information need. To assess the relevance between the query and each article in the corpus, we borrow from the research community's aggregate opinion by looking at whether other articles that are topically similar to the query cite the article or not. We conduct experiments on the dataset collected from the three leading IS journals (ISR, JMIS, and MISQ) from 1977 to 2016. Our retrieval model has achieved better performance compared with the baseline models.

5 - Network Structure and Predictive Power of Social Media for the Bitcoin Market

Peng Xie, Georgia Institute of Technology, Room 907, 100 10th Street, Atlanta, GA, 30309, United States, peng.xie@scheller.gatech.edu

Following the recent discovery of social media's predictive power for financial markets, we try to advance the literature by evaluating the role of social media network structure in distinguishing between value-relevant information and noises. Using data from the Bitcoin market, we provide empirical evidence that loosely-connected social media discussion networks are more accurate in predicting future returns. Although social media information linkages cause information free riding and damage the overall network prediction accuracy, they nevertheless serve as landmarks for identifying informed social media participants.

■ MA31

351A

Academic Job Search Panel

Invited: INFORMS Career Center

Invited Session

Chair: Warren Hearnes, Cardlytics, General Session Session, Atlanta, GA, 30308, United States, whearnes@hotmail.com

1 - Academic Job Search

Warren Hearnes, Cardlytics, Atlanta, GA, whearnes@hotmail.com

This panel discusses the academic interview process and do's and don'ts associated with the job search. In addition to comments by current and former search chairs, time will be provided for questions and answers.

■ MA32

351B

Expertise versus Skill in Human Prediction

Invited: Forecasting and Prediction

Invited Session

Chair: Pavel Atanasov, PhD, New York University, Pytho LLC, 866 President Street, Brooklyn, NY, 11215, United States, pavel@pytho.io

1 - On the Evaluation of Beliefs: A Method for Assessing Credibility in Subjective Probability Judgment

Josh Baker, University of Pennssylvania, Philadelphia, PA, 19103, United States, jbak@sas.upenn.edu

In the face of uncertainty, decision makers must base their choices on subjective beliefs. Consequently, decision making under uncertainty requires decision makers to infer the quality of the beliefs at their disposal. In the absence of an objective criterion, drawing such inferences can be challenging. The purpose of this research was to develop a method for assessing the quality of beliefs when normative benchmarks are unknown. We demonstrate that simple models of belief credibility (individuals vs. wisdom of the crowds) can be used to improve the accuracy of an individual's beliefs ex ante."

2 - The Robust Bayesian Truth Serum

Jens Witkowski, ET.H.Zurich, Rotbuchstrasse 30, Zurich, 8037, Switzerland, jensw@inf.ethz.ch, David C.Parkes

The Bayesian Truth Serum (BTS), due to Prelec (2004), allows the truthful elicitation of private signals (e.g., experiences, or opinions) in regard to a true world state when this ground truth is unobservable. However, BTS ensures proper incentives only in the limit, i.e. as the number of respondents n goes to infinity. We present the Robust Bayesian Truth Serum (RBTS), which is incentive compatible for every $n \geq 3$, taking advantage of a particularity of the quadratic scoring rule. RBTS is the first peer prediction mechanism to provide strict incentive compatibility for every $n \geq 3$ without relying on knowledge of the common prior. Moreover, RBTS is numerically robust and ex-post individually rational.

3 - Identifying Latent Structures in Human Performance Data using COREX

KSM.Tozammel Hossain, USC-Information Sciences Institute, 4676 Admiralty Way #1001, Marina Del Rey, CA, 90292, United States, tozammel@isi.edu

We present an approach to analyzing human performance data using correlation explanation. A key step in our method is to identify latent cognitive factors from users' responses over various psychological, political, and skill tests. The proposed method harnesses these factors to design effective cognitive tests, forecast users' problem-solving performance, and compose optimal team for tackling problems. We demonstrate the effectiveness of our method on forecasters' performance data collected in a geopolitical forecasting tournament for Good Judgement Project.

4 - Small Steps to Prediction Accuracy

Pavel Atanasov, New York University, New York, NY, 10007, United States, pavel@pytho.io

Pavel Atanasov, Pytho, 866 President Street, Brooklyn, NY, 11215, United States, pavel@pytho.io, Jens Witkowski, Barbara Mellers, Lyle Ungar, Philip Tetlock

Under-reaction and over-reaction to new information are the Scylla and Charybdis of belief updating. We show that highly accurate forecasters successfully navigate these hazards by making frequent, small belief updates of their probabilistic estimates. Updating frequency and magnitude were reliable, valid out-of-sample indicators of accuracy across four seasons of a geopolitical forecasting tournament. Frequent updaters tended to consume more news, and scored higher on cognitive reflection, numeracy and fluid IQ tests. Cognitive training caused smaller, more incremental belief updating. Update magnitude may indicate how forecasters process information from multiple sources.

■ MA33

351C

Advanced Analytics Models in Aviation

Sponsored: Aviation Applications

Sponsored Session

Chair: Shervin Beygi, Boeing, Seattle, WA, 98109-2155, United States, shervin@umich.edu

1 - Modeling Crew Itineraries and Delays in the National Air Transportation System

Vikrant Vaze, Dartmouth College, 14 Engineering Drive, Murdough Center, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu, Keji Wei

We propose, optimize and validate a methodological framework for estimating the extent of crew-propagated delays and disruptions. We identify factors that influence propagation, and incorporate them into a robust crew scheduling model. We develop a fast heuristic for solving the inverse of this model to generate crew schedules similar to real-world scheduling samples. Extensive out-of-sample validation tests using four large real-world airline networks demonstrate that the crew schedules produced by our approach generate propagation patterns similar to those observed in the real world. Moreover, parameters calibrated for one network are found to perform reasonably well for other networks.

2 - It's Not Just Luck: Evidence of Impact Operational Improvements and Buffers on Performance from the U.S. Airline Industry

Milind Sohoni, Indian School of Business, Ac4 Level 1, Isb Campus Gachibowli Hyderabad 500032, Hyderabad, 500032, India, milind_sohoni@isb.edu, Vinayak V. Deshpande, Chandrasekhar Manchiraju

Amongst others, airline on time performance (OTP) is impacted by three important factors: (i) Factors outside an airline's control such as weather, (ii) passive actions taken by airlines to improve OTP such as schedule padding, and (iii) active actions taken by airlines to improve operations. We analyze how each of these three affect OTP and airline rankings.

3 - Estimating Occupancy Rates at Delta Sky Clubs

Emmanuel Carrier, Delta Air Lines, 5155 Vernon Springs Trl NW, Atlanta, GA, 30327, United States, emmanuel.carrier@delta.com, Keith Becker, Liming Yao

One of the most common complaint about airport lounges is over-crowding. However, many lounge operators do not have accurate estimates of actual occupancy as exits are typically not recorded. In this presentation, we explore how to estimate occupancy rates by leveraging existing data sources such as lounge entry and aircraft boarding scans. Our results show that a more precise estimate of occupancy rates can improve customer satisfaction in two ways: by managing demand across lounges at airports with multiple locations and by increasing revenues through dynamic pricing during off-peak periods.

4 - Competition Policy, Privatization, and Efficiency: Evidence From the Global Airline Industry

Hao Su, University of Maryland-College Park, 3346 Van Munching Hall, College Park, MD, 20743, United States, haosu@rhsmith.umd.edu, Nicola Volta, Davide Scotti, Megersa Abate, Martin E. Dresner

This paper will examine how competition policy and airline privatization affect the efficiency of global airlines. We apply stochastic frontier models to a panel dataset including the largest worldwide airlines in the period 2005-2015. Our results will reveal the impact of state ownership on airline efficiency, as well as how government competition policy, such as open skies, impacts efficiency.

■ MA34

351D

Adversary-focused Military Applications

Sponsored: Military Applications

Sponsored Session

Chair: Brian J. Lunday, Air Force Institute of Technology, Air Force Institute of Technology, WPAFB, OH, 45433, United States, brian.lunday@afit.edu

1 - A Bilevel Programming Model for Integrated Air & Missile Defense Location Planning

Aaron M. Lessin, United States Air Force, 2950 Hobson Way, Department of Operational Sciences, WPAFB, OH, 45433, United States, aaron.lessin@afit.edu, Brian J. Lunday, Raymond R. Hill

The U.S. military must understand antiaccess/area-denial strategies using air defense weapons systems. We propose a bilevel programming formulation to locate weapons systems to maximize the minimum exposure of the aerial penetration path. We compare the result to three alternative metric-specific penetration paths, and illustrate that the proposed asset location strategy is robust with respect to each intrusion metric. A sensitivity analysis is also conducted to examine the effect of several model parameters on solution quality and required computational effort.

2 - Integrated Air and Missile Defense Design via Game Theoretic Models & Heuristics

Brian J. Lunday, Air Force Institute of Technology, 2950 Hobson Way, Department of Operational Sciences, WPAFB, OH, 45433, United States, brian.lunday@afit.edu, Randi Williams, Matthew J.D. Robbins, PhD

We consider a trilevel optimization formulation to locate air defense radars and interceptor batteries, given subsequent (optimal) missile launches by an attacker and interceptor responses by a defender, in direct competition over the expected survival value of targets. Considering the game theoretic view of this two-player, three-stage, extensive form game, we examine its normal-form representation. We test and develop a construction heuristic and tune two variants of an improvement heuristic to identify the best attacker solution, given a defender's best response, and we demonstrate them on a representative scenario.

3 - A Heuristic and Metaheuristic Approach to the Static Weapon Target Assignment Problem

Alexander Kline, Air Force Institute of Technology, Wright Patterson AFB, OH, United States, akline@afit.edu, Darryl K. Ahner, Brian J.Lunday

The problem of targeting and engaging individual missiles (targets) with an arsenal of interceptors (weapons) is known as the weapon target assignment problem and is NP-Complete. We propose and test a metaheuristic having a previously developed heuristic as a subroutine and that iteratively blocks exiting assignments to an initial feasible solution, allowing superior solutions to those that would otherwise be identified via a greedy selection process. We find solutions that are, at worst, within 2% of optimality and, at best, up to 64% better than the solutions reported to be optimal by BARON.

■ MA35

351E

Supply Chain Management

Contributed Session

Chair: Nadezhda Kozlovskaia, Saint Petersburg, Russian Federation, kknn@yandex.ru

3 - Mitigating Contagion Risk under Uncertainty

Alireza Azimian, Lazaridis School of Business and Economics, Unit 103, 55 Hickory St. E, Unit 103, Waterloo, ON, n2j 3j5, Canada, azim9110@mylaurier.ca

Operational failure of a rival can adversely affect an industry. Earlier studies shows that in a planning horizon investing in the safety of unsafe firms by safe firms can mitigate this risk. This study explores whether Gaussian Processes can be applied to create a successful automated safety investment strategy for multiple planning horizons.

4 - Risk Assessment in Sustainable Freight Transportation System

Ravi Shankar, Indian Institute of Technology Delhi, New Delhi, 110016, India, r.s.research@gmail.com, Divya Choudhary

This research aims to identify and prioritize risks involved in sustainable freight transportation system (SFTS). A novel methodology integrating fuzzy set theory, evidential reasoning algorithm and expected utility theory has been used to quantify and prioritize the identified risks. The results of this study provide significant managerial implications for the better management of disruptions in SFTS.

2 - An Empirical Analysis of Supply Chain Finance Adoption

David Wuttke, EBS.Universität, Burgstr. 5, Oestrich-Winkel, 65375, Germany, david.wuttke@ebs.edu, Eve Rosenzweig, H. Sebastian Heese

We empirically test hypotheses derived from the literature on adoption of Supply Chain Finance (SCF). We identify supply chain finance value and supplier size as important drivers of adoption speed. We complement these drivers with institutional pressures. We also derive suggestions for buyers who seek to implement SCF.

1 - The Start-up Remanufacturing Problem

Nadezhda Kozlovskaia, Saint Petersburg State University, 7/9 Universitetskaya nab., Saint Petersburg, 199034, Russian Federation, kknn@yandex.ru, Nadezhda Pakhomova, Knut Richter

A two stage deterministic inventory EOQ model for manufacturing of new products and remanufacturing cores is considered. The supplier is supposed to manufacture new products, delivered to the buyer according to exponential growing demand. He is also capable of remanufacturing used products, returned back by the buyer after some variable time interval T. If the remanufactured products are finished the manufacturing process starts to cover the remaining demand for the time interval. The processes of manufacturing and remanufacturing of the products are instantaneous.

■ MA36

351F

Simulating Complex Service Systems

Sponsored: Service Science

Sponsored Session

Chair: Ashkan Negahban, Pennsylvania State University, Malvern, PA, 19355, United States, anegahban@psu.edu

1 - Using Simulation to Improve Radiology Appointment Schedules and Patient Service Levels

Kayse Lee Maass, Mayo Clinic, Rochester, MN, United States, maass.kayse@mayo.edu, Maria G. Martinez, Mustafa Y. Sir, Kalyan Pasupathy, Michelle Nordland, Stacy R. Schultz, Brian J. Bartholmai

Medical imaging facilities perform a variety of services including diagnostic magnetic resonance imaging, computed tomography, and interventional procedures for a diverse set of patient groups (e.g., pediatric/adult, inpatient/outpatient/emergency). Some equipment may have special capabilities or limitations, and therefore may only serve patients with a particular subset of characteristics. Using data from a large hospital, we developed a simulation model to assess the design of an appointment schedule based on service and patient type, with priority rules for admitting patients into service in real-time. Effects on wait time, on-time starts and equipment utilization are discussed.

2 - Using a Simulation-optimization Approach to Optimize Patients Scheduling- A Table-experiment Approach

Mohammad Dehghanimohammadabadi, Northeastern University, m.dehghani@northeastern.edu, Mandana Rezaeiahari

In this study, a table-experiment framework is used to simulate and optimize patient scheduling at a Breast Cancer Center. The objective of this paper is to sequence the patients such that minimum average flow time is achieved for two types of patients including follow up and consult patients. Each patient type has different service time and follows different care pathways. A semiheuristic framework is developed by integrating MATLAB, SIMIO, and EXCEL to easily perform the table-experiment in a simulation environment. The obtained results from this framework are further analyzed by comparing five heuristic appointment scheduling approaches.

3 - An Incentive-based Rebalancing Scheme for Large Bike-sharing Systems

Ashkan Negahban, Pennsylvania State University, 30 E. Swedesford Road, Malvern, PA, 19355, United States, anegahban@psu.edu, Samarth Patel, Robin Qiu

The goal of this research is to explore the benefits of an incentive-based rebalancing scheme for large bike-sharing systems. In the proposed scheme, riders are offered incentives (such as discounted rates) to drop off their bike at a station other than but close to the original destination that is empty or expected to run out of bikes in the near future. A discrete event simulation model of New York City's CitiBike system is developed to assess the trade-off between bike redistribution cost and reduced profit due to such discounts.

■ MA37

352B

Best Service Science Cluster Award Paper Competition #I of II

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Pennsylvania State University, Malvern, PA, 19355, United States, robinqiu@psu.edu

1 - Service System Design under Information Uncertainty: Insights from an M/G/1 Model

Juan Ma, Turner Broadcasting System, Inc, Atlanta, GA, United States, juliema1205@gmail.com, Ying Tat Leung, Manjunath Kamath

We consider designing a service system in which the service provider performs an operation on incoming transactions for a client. An important task for the service provider is to decide on the capacity of the service system based on information available. In many cases, some input parameters to the capacity planning problem are uncertain at design time. Nonetheless, violating the service level requirement during actual operation may incur a penalty. We model this problem using a standard M/G/1 queue and analytically derive the optimal capacity under the assumption that transaction arrival rate is only known to a range. Several insights on the impacts of demand information uncertainty are derived.

2 - Understanding Smart Service Systems through Text Mining
Chiehyeon Lim, UC Merced; POSTECH, 790-784, Engineering Building #4-316, San 31, Hyoja-Dong Nam-Gu, Gyungbuk, Korea, Republic of, chlim@unist.ac.kr, Paul Maglio

Despite the widespread application and research on smart service systems, understanding of such systems is limited. We analyze text data related to smart service systems to develop a unified understanding. Using a combination of metrics and machine learning algorithms, we identify important features, 16 research topics, 4 technology factors (connection, collection, computation, and communications), and 13 application areas from 5,378 scientific articles and 1,234 news articles. We also develop conceptual frameworks of smart service system based on the analytics result. Our contribution is to establish common ground for understanding smart service systems based on a data-driven approach.

3 - A Ranking Algorithm for Shipping in the Spot Market
Max R. Biggs, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, maxbiggs@mit.edu, Georgia R. Perakis

We study a problem in the tramp shipping industry where a broker has to choose from a set of available cargoes but does not know what cargoes will be available for subsequent voyages. Solving the naïve dynamic programming formulation is hard for realistic problem sizes due to the number of available cargo combinations being exponential in nature. Instead we propose a ranking algorithm that is polynomial in the number of cargoes available, and prove this is equivalent to solving the DP optimally. We run simulations to show that the ranking algorithm outperforms the other common heuristics by a minimum of 5% and the current market performance by 4-32%.

■ MA38

352C

Complex Multi-criteria Decision Making Problems 1

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Murat Mustafa Koksalan, Middle East Technical University, Middle East Technical University, Ankara, 06531, Turkey, koksalan@metu.edu.tr

Chair: Banu Lokman, Middle East Technical University, Middle East Technical University, Ankara, 06800, Turkey, lbanu@metu.edu.tr

1 - Distribution-based Representative Sets for Multi-objective Integer Programs
Banu Lokman, Middle East Technical University, Department of Industrial Engineering, Universiteler Mahallesi, Ankara, 06800, Turkey, lbanu@metu.edu.tr, Sami Serkan Ozarik, Murat Mustafa Koksalan

Finding a set of points that represent the nondominated set for Multi-objective Integer Programs (MOIPs) is an important research area and has many applications. In this study, we search for common properties of the distributions of nondominated points in various MOIPs and show that the distribution of nondominated points may be critical in defining the desired properties of the representative subset. We introduce a density measure and analyze typical distributions of nondominated points for different MOIPs. We categorize the nondominated set into regions based on their estimated densities. We then generate distribution-based representative sets for different MOIPs.

2 - A Web Application for Solving Multi-objective Integer Programming Problems
Gokhan Ceyhan, Middle East Technical University, Orta Dogu Teknik Universitesi, Endustri Muhendisligi Bolumu No 319, Ankara, 06800, Turkey, gokhanceyhan01@gmail.com, Murat Mustata Koksalan, Banu Lokman, Murat Mustata Koksalan

In this study, we will first briefly present our approaches to generate all or representative nondominated points for multi-objective mixed integer linear programming (MOMILP) problems. Then, we will demonstrate our web application where users can input their MOMILP problems, select different solver options based on the type of the output required and use different visualization tools available.

3 - GoNDEF: An Exact Algorithm to Find Non-dominated Solutions of Multi-objective MILP as Points, Line Segments and Facets
Seyyed Amir Babak Rasmi, PhD Student, KOC University, Rumeli feneri st, KOC University, ENG212, Istanbul, 34450, Turkey, srasmi14@ku.edu.tr, Metin Turkay

The Generator of Non-Dominated and Efficient Frontier (GoNDEF) finds exact Pareto solutions represented as points, line segments, and facets consisting of Extreme/non-Extreme Supported/Unsupported Non-dominated solutions for Multi-Objective MILPs. A large group of real-life decision problems involving more than one conflict criterion can be presented as MOMILPs. GoNDEF applies the Screening and the Generative Approaches to extract the non-dominated frontier from a given set of integer solutions and without a given set of integer solutions, respectively.

■ MA39

352D

Emerging Concepts II

Sponsored: Analytics

Sponsored Session

1 - Deep Reinforcement Learning
Daewoo Chong, Booz Allen Hamilton, Washington, DC,

Machine intelligence is becoming more and more prevalent in our everyday lives. Andrew Ng, a leader in the field, calls it the new electricity. Many of the gains have come from a family of methods including convolutional and recurrent neural networks called deep learning. These methods have become crucial to the improvements in digital assistants, machine translation systems, and self-driving cars, and this seems to be only the beginning. Join this talk on deep reinforcement learning to learn about how using deep convolutional neural networks on games may be able transform the automation industry.

2 - Is Analytics in Professional Sports Making a Difference?
Walter DeGrange, CANA Advisors, Chapel Hill, NC, wdegrange@canallc.com

This presentation covers the impact of analytics on team performance in the top four sports in the United States (Major League Baseball (MLB), National Football League (NFL), National Basketball Association (NBA) and the Nation Hockey League (NHL)) over the past three years. Several analytics projects with professional teams and the issues with implementing solutions are also presented. Projects include developing models for an NHL team and a Major League Lacrosse (MLL) team.

■ MA41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Buyannemekh Munkhbat, University of Massachusetts-Amherst, Amherst, MA, United States, bmunkhbat@umass.edu

1 - Characterizing Obstructive Sleep Apnea a Descriptive Analytics Approach
Rupesh Agrawal, Research Assistant, Oklahoma State University, 700 N. greenwood ave., Rm#313, Tulsa, OK, 74106, United States, rupesh.agrawal@okstate.edu, Dursun Delen, Bruce Benjamin

Increasing adoption of EHR/EMR, propagated via affordable healthcare act of 2009, have opened new opportunities to improve health and healthcare outcomes. Obstructive sleep apnea (OSA) is a very common health condition, the existence of which would increase manifestations of deadly diseases such as heart failure. Despite proven adverse effects, the true understanding of the OSA is still in nascent stages. Hence, using a large and feature-rich EHR dataset, this analytics study aimed at characterizing OSA by identifying and analyzing associated comorbidities, and also developing a comprehensive taxonomy of OSA and related health conditions.

2 - The Impact of Health Information Exchange on Patient Mobility and Hospital Competition
Xinxin Guo, Southeast University, 2 Sipailou, Nanjing, 210096, China, bzhmgx@163.com, Haiyan Wang

The potential benefit of health information exchange (HIE) for patients is that reduces the costs patients face to switch providers. This paper examines the impact of the adoption of HIE on health care quality and hospital profits as patients, especially those experienced patients, have the freedom to choose the provider they receive treatment. We develop a two-period duopoly model in which health care quality is differentiated and patients are heterogeneous. We give conditions under which the adoption strategy benefits or hurts providers and social welfare.

3 - Building Multiscale Models for Predicting Spatial Changes between Serial Functional Images of Lung Cancer Patients
Chunyan Duan, Tongji University, Room1114, Tongji Building Block A, No. 1 Zhangwu Road, Shanghai, 200092, China, duanchunyan77@163.com
Chunyan Duan, University of Washington, 1959 NE Pacific St. Box 356043, Seattle, WA, 98105, United States, duanchunyan77@163.com, Stephen R. Bowen, W. Art Chaovalitwongse, Daniel S. Hippe, Daehan Won, Jianxin You, Jianxin You

Lung cancer response varies spatially during therapy. We are modeling serial functional cancer imaging changes from statistically independent regions within lung tumors by cluster analysis and spatial autocorrelation. Features of multiscale cancer regions are trained, cross-validated, and tested in our models to predict spatial changes during and after therapy. This represents a powerful approach to assess local therapeutic efficacy.

4 - Uncertainty Analysis of Species Distribution Models
Xi Chen, University of Texas at Austin, 3500 Greystone Drive, Apt 271, Austin, TX, 78731, United States, carol.chen@utexas.edu

Species distribution models (SDM) are commonly used to predict the geographic distributions of animals or plants species. However, most of SDM methodology produces point estimates. We present two strategies for quantifying the uncertainty of maximum entropy SDM methods: a bootstrap method, and an analytic method. We describe both methods, and compare and contrast their performance on two examples of different sizes. Both Dengue importation probability and Aedes aegypti mosquito suitability examples show that the methods generate comparatively the same results and the novel analytic method we introduce is dramatically faster than the bootstrap method.

5 - A Multi-attribute Optimization Approach for Post-acute Provider Selection
Ashkan Hassani, Texas A&M.University, 4050 ETB, College Station, TX, 77840, United States, ashkanhassani@tamu.edu, Hossein Badri, Maryam Khatami, Mark Alan Lawley

In this study a decision making approach is developed for Post-Acute Care Provider (PACP) selection problem. This approach includes two stages. In the first stage, some quality metrics are used in a TOPSIS method to calculate the closeness coefficients of each candidate PACP to short-stay patient's and long-stay patients. In the second stage, these coefficients are used in a mathematical programming model, along with some other cost and service level metrics to select the best PACP's for both short-stay and long-stay patients. The proposed approach is implemented for PACP selection problem in the city of Houston, TX, and the results are presented and analyzed.

6 - A Multi-dimensional Evolving Contact Network Approach for Modeling Dynamics of Contagious Disease Spread
Buyannemekh Munkhbat, University of Massachusetts-Amherst, 165E Brittany Manor Drive, Amherst, MA, 01002, United States, bmunkhbat@umass.edu, Chaitra Gopalappa, Hari Balasubramanian, Dylan Shepardson, Song Gao

Current simulation models for outbreaks of re-emerging infectious diseases (EIDs) take an individual-level or a population-level approach to modeling contact dynamics. Each modeling technique is a trade-off between increased accuracy versus computational efficiency. We propose a novel Multi-dimensional Evolving Contact Network (MECN) algorithm that combines the attributes of both simulation modeling techniques. Considering the uncertainty in type and origin of future EIDs, our proposed methodology will be suitable for analyses of a range of potential EIDs for an integrated approach to disease prevention in low- and middle- income countries.

■ MA42

360A

Internet of Manufacturing Things

Invited: Invited OR and Advanced Manufacturing

Invited Session

Chair: Hui Yang, Pennsylvania State University, University Park, PA, 16801, United States, huy25@psu.edu

1 - The Internet of Additive Manufacturing Things on IBM Watson
Gayathri Magie, IBM, Kansas City, MO, United States, gayathri@us.ibm.com, Prahalad Rao

Learn about IBM's Watson Internet of Things platform can connect additive manufacturing to the cloud. A road map for implementation at University of Nebraska-Lincoln to register, manage and control the sensor embedded metal additive manufacturing (AM) machine will be revealed. The intent is to send the layer-by-layer sensor data to the cloud, store the data, and use Watson Analytics to detect and predict build failures (currently 1 in 4 parts typically fail to print). This information is used as a repository for part qualification - leading to the certify-as-you-build paradigm in AM.

2 - Parallel Computing and Network Analytics for Fast Industrial Internet-of-things Machine Information Processing and Condition Monitoring
Soundar Kumara, Pennsylvania State University, University Park, PA, 16803-2050, United States, skumara@psu.edu, Chen Kan, Hui Yang

Rapid advancement in sensing and communication brings a new wave of Industrial Internet of Things (IIoT) technology. IIoT integrates a large number of sensors for smart and connected monitoring of machine conditions. However, existing approaches are limited in their ability to extract pertinent knowledge about manufacturing operations from large volumes of IIoT data. This paper presents new parallel algorithms for large-scale IIoT machine information processing, network modeling, condition monitoring, and fault diagnosis. Experimental results show that our algorithm efficiently and effectively characterizes variations of machine signatures for network modeling and monitoring.

3 - Outlier Detection Based on Minimum Spanning Tree and its Application to Manufacturing
Imtiaz Ahmed, Texas A&M.University, College Station, TX, 77843, United States, imtiazavi@tamu.edu, Yu Ding

Outliers are points or clusters of points which lie away from the neighboring points and clusters and inconsistent with the overall pattern of the data. The process of identifying outliers become complicated in absence of the labeled training data. Consequently, a supervised learning cannot be used to learn a rule to classify future observations. Minimum Spanning Tree (MST) is a measure, capable of capturing the relative connectedness of data points/clusters and thus can be utilized to identify the potential outliers of a data set in an unsupervised setting. In this work, an MST based outlier detection algorithm is developed and demonstrated using examples in manufacturing processes.

4 - IIoT Automation or Autonomous Manufacturing
Thomas Paral, TE Connectivity Ltd, Baden-Württemberg, Germany, thomas.paral@te.com

First of all there is no IIoT or Industry 4.0 protocol yet available. There are many initiatives around the globe all speak about IIoT/ Industry 4.0 but most of them are still talking about automation and OEE improvements through transparency not through intelligent autonomous (digital) guided processes along the value chain including life cycle.

■ MA43

360B

Internet of Things: Promises, Challenges and Analytics

Sponsored: The INFORMS Section on Practice

Sponsored Session

Chair: Patricia Neri, SAS Institute, Inc., Cary, NC, 27519, United States, patricia.neri@sas.com

Co-Chair: Anna Olecka, Honeywell, St Petersburg, FL, 33703, United States, annao007@gmail.com

1 - Internet of Things: Promises, Challenges and Analytics
Patricia Neri, SAS.Institute, Inc., 104 Grandtree Ct., Cary, NC, 27519, United States, patricia.neri@sas.com

IoT is a technological innovation taking place in key areas: healthcare, transportation, energy production, smart cities and connected factories to name just a few. IoT is possible because of the decreasing cost of sensors and storage, the Cloud and Analytics. Connected devices gather vast amounts of data, which is analyzed, optimized and turned into insight and information. IoT technology is in early development and multiple challenges must be addressed: data availability and ownership, resistance to adoption, data privacy and data security. In this session we will discuss these challenges and specific IoT applications, as well as, jobs that are being created by IoT and the skills required for those jobs.

2 - Panelist
Bill Groves, Honeywell, Morris Plains, NJ, United States, William.Groves@Honeywell.com

■ MA44

360C

Behavioral Operations

Contributed Session

Chair: Matthew Walsman, Rutgers Business School, Berkeley Heights, NJ, United States, mwalsman@business.rutgers.edu

1 - Decision Support for Airport Surface Operations: A Sociotechnical Systems Approach
Elizabeth M. Argyle, Research Fellow, University of Nottingham, Nottingham, United Kingdom, elizabeth.argyle@nottingham.ac.uk, Jason Atkin, Geert De Maere, Robert J. Houghton, Terry Moore, Herve P. Morvan

Demand for airspace capacity is increasing, placing additional pressures both on physical infrastructure and human resources. We present a sociotechnical systems approach for developing a decision support system (DSS) to assist the ground controllers with the complex scheduling and routing tasks at a major European airport. We discuss the role of human behavioral research during the development of search-based algorithms for taxiway routing and departure scheduling and consider the insights that this research has provided into how human operators approach these tasks.

2 - Can Good Jobs be Profitable in Low Cost Services? A Systemic Model and Estimation

Hazhir Rahmandad, Associate Professor, MIT, 100 Main Steet, E62-442, Cambridge, MA, 02142, United States, hazhir@mit.edu

Can profit maximizing firms offer good jobs in low cost services? In a dynamic model of service operations we capture feedbacks, managerial decisions, costs, and benefits related to viability of good jobs. Using data from Borders bookstores and utilizing extended Kalman filtering with latent variables we estimate this model. We find evidence for significant benefits of employee quality and building capabilities as well as notable managerial biases in allocating resources between customer service and capability building. The results point to potential viability of good jobs in low cost services and offers a method for assessing these costs and benefits.

3 - Estimating Customer Spillover Learning of Service Quality

Andres I.Musalem, U. de Chile, Beauchef 851, Santiago, 8370456, Chile, amusalem@dii.uchile.cl, Yan Shang, Jing-Sheng, Jeannette Song

"Spillover" learning is defined as customers' learning about the quality of a service (or product) from their previous experiences with similar yet not identical services. In this paper, we propose a novel, parsimonious and general Bayesian hierarchical learning framework for estimating customers' spillover learning. We apply our model to a one-year shipping/sales historical data provided by a world-leading third party logistics company. Our empirical results are consistent with information spillovers driving customer choices. We also develop policy simulation studies to show the importance of accounting for customer learning when a firm considers service quality improvement decisions.

4 - Investigating the Influencing Factors of Continuous Usage Behavior in Internet Broadcast

Xiaoxi Luan, Tongji University, Shanghai, 200092, China, luanxiaoxi@163.com, Haifeng Zhao

This study aims to investigate what, why and how a cohesive set of factors influence the continuous usage behaviors of Live show users.The model of ECM-IT is applied to the study to help build the Theoretical Model of Continuous Usage Behavior of Internet Broadcast Users. In the model, we set Perceived Usefulness, Perceived Ease of Use, Expectation Confirmation, Perceived Pleasure, and Perceived Trust as independent variables, Satisfaction and Continuous Use Intention as intermediate variables, Continuous Usage Behavior as the dependent variable, and Habit as the regulated variable. We introduce the method of SEM and the technology of AMOS21.0 to analyze the collected data.

5 - Do Advisers Give Bad Advise Experimental Evidence from Consulting

Matthew Walsman, Assistant Professor, Rutgers Business School, 28 Cambridge Dr, Berkeley Heights, NJ, 07922, United States, mwalsman@business.rutgers.edu

In this study, we use a behavioral experiment in a consulting context to investigate the impact of decisions that advisers and clients make and their influence on each other. Specifically, we test the impact of client initiated estimates on their consultant's subsequent recommendations and the resulting client decisions and satisfaction. We test for this effect with both trained and novice clients. We find that when clients interfere with the process by providing their consultants with an initial estimate, expert consultants don't 'take the bait', but instead are more likely to give a differentiated opinion, even when the client's initial input was right.

■ MA45

360D

JFIG Paper Competition II

Sponsored: Junior Faculty JFIG

Sponsored Session

Chair: Jose Luis Walteros, University at Buffalo, SUNY, 413 Bell Hall, Bu, NY, 14260, United States, josewalt@buffalo.edu

Co-Chair: Canan Gunes Corlu, Boston University, 808 Commonwealth Avenue, Boston, MA, 02215, United States, canan@bu.edu

1 - Joint Pricing and Inventory Management with Strategic Customers

Yiwei Chen, Singapore University of Technology and Design, 8 Somapah Road, Singapore, 487372, Singapore, ywchen@mit.edu, Cong Shi

We consider a model wherein the seller sells a single indivisible product to customers over an infinite horizon. At each time, the seller decides a set of purchase options offered to customers and the inventory replenishment quantity. Each purchase option specifies the price and the product delivery time. Customers stochastically arrive to the system according to a Poisson process. Customer product valuations are randomly drawn from a distribution and are heterogeneous. A customer's arrival time and product valuation are his private information. Customers are forward-looking, i.e., they strategize their purchasing times. A customer incurs delay disutility from postponing to make the purchasing decision and waiting for the product delivery. A customer's delay disutility rate is perfectly and positively correlated with his valuation. The seller has zero replenishment lead time. The seller incurs fixed ordering cost and inventory holding cost. The seller seeks a joint pricing, delivery, and inventory policy that maximizes her long-run average expected profit. We propose a simple policy under which the dominant equilibrium is that customers behave myopically. We show that this policy is asymptotically optimal in the regime wherein customer arrival rate and the seller's fixed ordering cost proportionally grow large. We adopt a mechanism design approach to prove these results.

2 - Posterior Sampling for Markov Decision Processes: Worst-case Regret Bounds

Shipra Agrawal, Columbia University, Industrial Engineering and OR, 423 S. W. Mudd Building, New York, NY, 1002 7, United States, ashipra@gmail.com, Randy Jia

We consider discrete-time communicating Markov Decision Processes (MDP) with finite state space and action space. We present a posterior sampling (aka Thompson sampling) based algorithm for adaptive learning and decision making in such MDPs when the underlying transition matrix is unknown. Our main result is a high probability worst-case regret upper bound of $\tilde{O}(D\sqrt{SAT})$ for this algorithm, for any communicating MDP with finite diameter D, S states, A actions, and $T \geq S^5A$. Here, regret compares the total reward achieved by the algorithm to the total expected reward of an optimal infinite-horizon undiscounted average reward policy, over a time horizon T. This result improves over the best previously known upper bound of $\tilde{O}(DS\sqrt{AT})$ achieved by any learning algorithm in this setting, and closes the crucial gap of S from the known lower bound of $\Omega(DSAT)$ for this problem. Our analysis involves deriving some novel results about the anti-concentration of Dirichlet posteriors, which may be of independent interest.

3 - Ambiguous Risk Constraints with Moment and Unimodality Information

Bowen Li, University of Michigan, Ann Arbor, MI, United States, libowen@umich.edu, Ruiwei Jiang, Johanna Mathieu

Optimization problems face random constraint violations when uncertainty arises in constraint parameters. Effective ways of controlling such violations include risk con- straints, e.g., chance constraints and conditional Value-at-Risk (CVaR) constraints. This paper studies these two types of risk constraints when the probability distribu- tion of the uncertain parameters is ambiguous. In particular, we assume that the distributional information consists of the first two moments of the uncertainty and a generalized notion of unimodality. We find that the ambiguous risk constraints in this setting can be recast as a set of second-order cone (SOC) constraints. In order to facil- itate the algorithmic implementation, we also derive efficient ways of finding violated SOC constraints. Finally, we demonstrate the theoretical results via a computational case study on power system operations.

■ MA47

360F

eBusiness

Sponsored: EBusiness

Sponsored Session

Chair: Jong Seok Lee, PhD, University of Memphis, Memphis, TN, 38152, United States, jslee4@memphis.edu

1 - Modeling Retail and Online Channel Allocation Decisions

Roshanak Mohammadivojdan, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611, United States, rmohammadivojdan@ufl.edu, Joseph Geunes

Consider a retailer who sells items via both a retail store and an online channel. Space limitations in each channel require judicious selection of items and the allocation of these items to the two channels. We model these assortment and channel selection decisions via a stylized mathematical model that accounts for economic inventory replenishment decisions in each channel. The resulting model corresponds to a specially structured two-knapsack problem. Analysis of this problem permits gaining insights on key decision drivers and characteristics of optimal decisions.

2 - The Disruptive Effects of Digital Platform's Entry on Non-high-tech Industry: A Text Mining and Econometric Approach

Sungjin Yoo, University of Memphis, Memphis, TN, United States, syoo3@memphis.edu

In this study, we examined the effect of digital platform entry on the landscape of competition in non-high-tech industry. Using the accommodation industry as our empirical setting, we identify how the incumbents' competitive action portfolio change in response to the entry and how such action differs between the high-end companies and the low-end companies. By analyzing a longitudinal data set of competitive actions of incumbents in the industry, our finding shows that incumbents not only implement more competitive actions but also adapt diverse strategies which are deviant from the industry norm. Furthermore, high-end companies attempt to respond more actively than low-end companies.

3 - Contextually Sensitive Privacy Aware E-commerce Systems

Faruk Arslan, University of Houston Clear Lake, Clear Lake, TX, United States, Arslan@UHCL.edu, Radu Vlas

The purpose of this research is to develop a contextually sensitive solution, which is aimed to reduce the dependency on e-commerce system users to specify and maintain their respective privacy policies for their personal data. To achieve this, we propose a multi-level model to predict whether a certain personal data category (e.g. financial, medical, tastes, etc.) is deemed by the user as personal (or not). We present the application of this model on financial and medical data categories given that the definition of these two data categories as personal, vary across the countries within our sample. Then, we discuss how this predictive model can be embedded into e-commerce systems.

■ MA48

361A

Behavioral Issues in Contracting and Inventory

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Elena Katok, University of Texas at Dallas, Richardson, TX, 75080, United States, ekatok@utdallas.edu

1 - Project Management under Risk-sharing Contracts

Sina Shokoohyar, The University of Texas at Dallas, 800 W. Campbell Rd SM.30, Richardson, TX, 75080, United States, sxs137430@utdallas.edu, Elena Katok, Anyan Qi

We analyze the risk-sharing contract in which the contractors are paid at the end of the project. We show that for a project with parallel tasks, there exist multiple Pareto-ranked equilibria, where all contractors exert the same efforts, and the worst project delay is observed when the contractors play the secure equilibrium. To mitigate this coordination failure, we propose an information feedback policy, and show that the contractors' efforts in the secure equilibrium increase in the information feedback frequency. To test our theoretical findings, we conduct behavioral experiments, and the result confirms our theoretical findings.

2 - Should Retailers or Suppliers Exercise Effort to Increase Demand?

Anna-Lena Sachs, University of Cologne, Albertus-Magnus-Platz, Cologne, 50923, Germany, anna-lena.sachs@uni-koeln.de, Yingshuai Zhao, Ulrich Thonemann

Demand promotion activities, such as advertisements, enlarge market size and accordingly increase sales profit. In a supply chain, promotion activities can be exercised by any echelon member. We consider a supply chain which is composed of two members, a supplier and a retailer. We investigate whether the supplier or the retailer should exercise the effort of demand promotion activities. We conduct laboratory experiments and compare supply chain performance for retailers or suppliers exercising effort under a Stackelberg game framework or a negotiation framework.

3 - Negotiating Transshipments Prices for Improving Supply Chain Coordination

Sebastian Villa Betancur, University of Los Andes, Bogotá, Colombia, s.villab@uniandes.edu.co, Elena Katok

We use a simplified model of a single-supplier two-retailer supply chain to experimentally understand how retailers simultaneously set transshipment prices and order quantities. We study how these two decisions deviate from the theoretical channel-coordinating benchmarks. Our experiment manipulates two factors: profitability and sequence of decisions. Results show how average order quantities with transshipment are between optimal orders and mean demand (pull-to-center behavior). In addition, participants ignore the critical ratio when they negotiate transshipment prices. Finally, we show how the sequence of decision may affect the probability of agreement between both retailers.

4 - What Can We Learn from Brain Imaging Newsvendors?

Kay-Yut Chen, University of Texas at Arlington, Arkington, TX, United States, kychen@uta.edu, Sridhar P.Nerur, Wendy Casper, Hanli Liu

The current literature on newsvendor behavior relies on "guessing" the underlying cognitive and/or psychological mechanisms from observations, without any direct physical evidence. Functional near infrared spectroscopy (fNIRS) allows researchers to examine brain functions by measuring hemodynamic responses associated with neural activities. We show that newsvendor performances are correlated with neural activations in an area (Brodmann area 43) that has been associated with cognitive effort. In addition, we find negative correlation between neural activations and past profits, which is consistent with satisficing behaviors expected of boundedly rational decision-makers.

■ MA49

361B

Behavioral Topics in Facilitated Modelling

Invited: InvitedBehavioral Aspects of OR

Invited Session

Chair: Vincent de Gooyert, PhD, Institute for Management Research, P.O. Box 9108, 6500 HK, Nijmegen, Netherlands, v.gooyert@fm.ru.nl

1 - Behavioral Factors Affecting Facilitated Modelling of Strategic Issues

Martin Kunc, University of Warwick, WBS.Social Studies Building, Office E1.07, Coventry, CV4 7AL, United Kingdom, martin.kunc@wbs.ac.uk, Kenneth Huh

This study reports in-depth research into the use of resource mapping, within a group based setting, a tool to identify an organization's strategic resources. Specifically, this paper explores the behavioral factors affecting the group dynamic processes through a quantitative and qualitative analysis of different groups' processes. The research identified a number of variables influencing group dynamics: deliberateness, cognitive overload, and cognitive and affective conflicts.

2 - Connecting Community-Based System Dynamics with Collective Impact

Donald R. Greer, Principal, Greer Black Company, P.O. Box 3607, Bozeman, MT, 59772-3607, United States, drgreer@greerblackcompany.com
Donald R. Greer, Principal, Rapid City Collective Impact, 529 Kansas City Street, Suite 207, Rapid City, SD, 57701, United States, drgreer@greerblackcompany.com, Laura Black, Albert Linderman

Collective impact projects seek to improve a region's quality of life through ongoing collaborations across nonprofit, private, governmental and social-service organizations. This paper describes the roles a causal loop diagram played as a shared visual in anchoring, focusing, and connecting nine community work-streams formed during the Rapid City Collective Impact initiative. We propose that causal representations act as effective project-structuring tools in non-traditional projects characterized by ambitious but under-specified outcomes, emergent processes for accomplishing outcomes, diverse resources, and volitional engagement of participants rather than lines of authority.

3 - A Dynamic Theory of the Effect of Facilitated Modeling on Self-efficacy

Vincent de Gooyert, Institute for Management Research, P.O. Box 9108, Nijmegen, 6500 HK, Netherlands, v.degooyert@fm.ru.nl

Previous studies report mixed findings regarding the effect of facilitated modeling (FM) on proximal and distal outcomes, and the responsible mechanisms are not fully known. We focus on the effect of FM on self-efficacy and propose a dual pathway theory. On the one hand, FM can increase self-efficacy when the intervention increases the participant's knowledge about solutions for the problem at hand. On the other hand, FM can decrease self-efficacy when the intervention reveals that the problem is much more complex than initially thought. If multiple FM workshops are held, we expect that over time, firstly the negative pathway will be dominant, and secondly the positive.

4 - Behavioral Analytics: Beginnings of a Body of Work

Martin Kunc, University of Warwick, WBS.Social Studies Building, Office E1.07, Coventry, CV4 7AL, United Kingdom, martin.kunc@wbs.ac.uk, Michael Mortenson

Following the growing interest in analytics and the rise of behavioral approaches in analytical fields (behavioral economics, behavioral OR), this research investigates the development of behavioral analytics, a field at the intersection of these trends. The paper identifies two areas: upstream behavioral analytics, where behavioral patterns act as the stimulus and subject of analytics; and downstream behavioral analytics, where approaches such as visualization are used to give analytics and data science greater influence on the behavior of decision makers. Using a computational literature review, these areas are analysed and compared, and directions for future research are offered.

■ MA50

361C

Modeling and Analysis of Emerging Mobility Services II

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Yafeng Yin, University of Michigan, Ann Arbor, MI, 48109, United States, yafeng@umich.edu

Co-Chair: Yu Nie, Northwestern University, Evanston, IL, 60208, United States, y-nie@northwestern.edu

1 - Operational Strategies for Electrical Car-sharing Systems

Yang Liu, National University of Singapore, Department of Industrial & Systems Engineerin, Singapore, 117576, Singapore, iseliuy@nus.edu.sg, Dong Zhang, Shuangchi He

For one-way electric vehicle (EV) car-sharing model, we proposed two operational strategies to improve its performance.The aim of two operational strategies is to utilize the battery of EVs in a more efficient manner. Two novel network flow models are proposed based on these two strategies, respectively. To satisfy the quick response requirement in the operational level, we further propose an efficient solution algorithm to solve the models. Experimental results reveal that the performance gap between the EV car-sharing system and the traditional car-sharing system can be very small if efficient operational strategies are implemented.

2 - Modeling the Operations of Electric Autonomous Taxis in New York City

Liang Hu, PhD Student, Iowa State University, Ames, IA, United States, lianghu@iastate.edu, Jing Dong

This paper explores the potential of replacing conventional taxis with electric autonomous vehicles (EAVs) in New York City. Customer requests, in terms of pick-up and drop-off locations with time stamps, are extracted from GPS tracked taxi trip data. Local interaction rules are designed to dispatch EAVs to serve customer requests and coordinate their charging activities. The simulation results show that using EAVs can improve taxi operational efficiency and reduce fleet size.

3 - Mobility Pattern Analysis of Free-floating Bike Sharing and Insights on System Operations

Yu Zhang, University of South Florida, Tampa, FL, United States, yuzhang@usf.edu, Aritra Pal

We study historical biking trajectory data of bike sharing users for understanding their mobility patterns and the correlations with environment variables and the interactions of those variables. The outcomes provide insights on system design and operations, e.g. hub regions of bike sharing program, time for conducting static or dynamic rebalancing, and time available for such rebalancing, etc.

4 - Same-day Delivery Planning with Store Fulfillment

Ming Ni, University at Buffalo, The State University of New York, 326 Bell Hall, Buffalo, NY, 14260, United States, mingni@buffalo.edu, Qing He, Jose Luis Walteros, Xuan Liu, Arun Hampapur

This study identifies a seasonal order fulfillment plan for delivering local online orders from nearby retailing stores that minimizes the overall panning and operational costs. It aims to develop optimization models and solution algorithms about store location selection, fleet-sizing for transportation, and inventory planning. Our methodology integrates outer search tree based on mix integer programming and local branching, optimization-based algorithm for initial lifting constraints, with accelerated Benders decomposition method to solve large-scale real supply chain planning problem.

5 - Optimal Design of Urban Taxi Fleet Electrification: A Simulation-Based Optimization Approach

Fang He, Tsinghua University, Shunde Building, N502, Tsinghua University, Beijing, 100084, China, fanghe@tsinghua.edu.cn, Yinghao Jia, Zuojun Max Shen

Transportation management agencies in urban cities are electrifying taxi fleets. How to allocate limited resources to optimize the benefits of taxi fleet electrification deserves thorough investigation. This research gathers the real-time vehicle trajectory data of 39,053 urban conventional taxis and 408 suburban electric taxis in Beijing to extract the customers' travel demand distribution and electric taxi drivers' behavior pattern. We derive a data-driven simulation model to reflect the operations of electric taxi fleet and further propose a simulation-based optimization framework to optimize the deployment of charging infrastructure and the configuration of electric taxi fleet.

■ MA51

361D

8:00 - 8:45 IBM/8:45 - 9:30 Palisade

Invited: Vendor Tutorial

Invited Session

1 - Generic Callbacks in CPLEX, A New Approach

Xavier Nodet, IBM, 1681 Route des Dolines, Valbonne, 06600, France, xavier.nodet@fr.ibm.com

During this tutorial, you will learn how to use a new Generic Callback framework in CPLEX Optimizer. These callbacks allow users to benefit from all the CPLEX features without restriction, and offer a simple API to either get information from CPLEX, or drive CPLEX behavior.

2 - Quantitative Risk Analysis in Excel with @RISK

Rafael Hartke, Palisade Corporation, Ithaca, NY, United States, rhartke@palisade.com

This tutorial will guide you in the use of @RISK for analyzing historical data, and for making forecasts and better decisions in an uncertain business environment. @RISK is part of Palisade's DecisionTools Suite, and runs within the familiar MS Excel environment. It provides all the features you need to quantify and understand risks, along with graphical capabilities and reports to help you present the risk analysis results to a non-technical audience

■ MA52

361E

Energy

Contributed Session

Chair: Yue Zhao, Stony Brook University, Stony Brook, NY, United States, yue.zhao.2@stonybrook.edu

1 - Distributed Transactive Operation of Micro-grid Cluster using a Stochastic Model Predictive Control Algorithm

Yang Chen, University of Illinois at Chicago, Chicago, IL, United States, ychen429@uic.edu, Mengqi Hu

To enable efficient transactive operation among multiple interconnected micro-grids (aka micro-grid cluster), a bi-level distributed decision framework is proposed. A two-stage stochastic optimization model is developed for each micro-grid at the subsystem level with consideration of solar and energy load uncertainties, while a guided particle swarm optimizer is employed at the system level to coordinate transactive operations for all the micro-girds. A stochastic model predictive control algorithm is employed to solve the two-stage stochastic model for real-time operation. A case study of a cluster of four micro-grids is developed to evaluate the effectiveness of the proposed approach.

2 - Multi-period Energy Procurement Policies with Deferrable Demand and Supplementary Uncertain Power Supplies

Tian Wang, Zhongnan University of Economics and Law, Number 182, Nanhu Road, Donghu District, Wuhan, 430073, China, wangtian3261@gmail.com

We analyze a multi-period energy procurement problem for an energy aggregator who is responsible for centralized controlling of energy procurement and consumption. To decide the optimal procurement amount, the aggregator makes trade-offs between two supplies, traditional energy with variable prices vs. free renewable energy with uncertain supplies. We show the optimal procurement policy is to procure traditional energy only when the price is less than a certain threshold, which depends on the statistics of the day-ahead real time prices, the wind energy distribution and the time left to the end of horizon. Numerical studies with real wind data are conducted.

3 - Self Scheduling of a Virtual Power Plant in Energy and Reserve Electricity Markets

Ana Baringo, Universidad de Castilla-La Mancha, Ciudad Real, Spain, Ana.Baringo@uclm.es, Luis Baringo, José Arroyo

We propose an approach for the self scheduling of a virtual power plant that participates in both energy and reserve electricity markets. The virtual power plant comprises flexible demands, a conventional power plant, and a wind-power unit, which participate in the markets as a single entity to optimize the use of their energy resources. Uncertainties in wind-power production and reserve deployment are modeled using confidence bounds, while uncertainties in market prices are modeled using scenarios. This allows us to formulate the self-scheduling problem as an adaptive robust optimization problem, which is efficiently solved using a column-and-constraint algorithm.

4 - A New Approach to Estimate Renewable Energy Potential in a Particular Location

Tunde O.Aderinto, Texas A&M.University-Kingsville, Kingsville, TX, United States, tunde.aderinto@Students.tamuk.edu, Hua Li

The renewable energy potential of a particular location is usually estimated through independent resource assessment of different renewable energy sources.

It may overestimate its potential of the particular location if simply adding up different energy sources' potentials. A new approach is proposed to estimate the renewable energy potential of a particular location by considering the influences among different renewable energy sources during their harvesting processes. The new approach also considers possible option of harvesting different types of renewable energy sources at the same time to seek for the best combination and highest potential of a particular location.

5 - Ex-post Stable and Fair Payoff Allocation for Renewable Energy Aggregation

Yue Zhao, Stony Brook University, 261 Light Engineering, Stony Brook, NY, 11794, United States, yue.zhao.2@stonybrook.edu, Hossein Khazaei

Aggregating statistically diverse renewable power producers (RPPs) is an effective way to reduce the uncertainty of the RPPs. The key question in aggregation of RPPs is how to allocate payoffs among them. In this paper, a payoff allocation mechanism (PAM) with a simple closed-form expression is proposed: It achieves stability (in the core) and fairness both in the "ex-post" sense, i.e., for all possible realizations of renewable power generation. Furthermore, this PAM can in fact be derived from the competitive equilibrium in a market. The proposed PAM is evaluated in a simulation study with ten wind power producers in the PJM interconnection.

■ MA53

361F

Traveler Information Provision and its Impacts

Invited: TSL, Intelligent Transportation Systems (ITS)

Invited Session

Chair: Dong Yoon Song, PhD, Purdue University, School of Civil Engineering, West Lafayette, LA, 47907, United States, song50@purdue.edu

1 - A Two-stage Strategy for Improving the Efficiency of a Traffic Network by Providing Value-added Atis Services

Jingjing Liang, Miss, Tongji University, Room 1413, Tongji Buliding Block A, Zhangwu Road, Shanghai, 200082, China, gina_liang@tongji.edu.cn, Xiaoning Zhang

From the perspective of the traffic management agency, we propose a two-stage strategy for improving the efficiency of a traffic network by providing VATIS services. In the first stage, the traffic management agency selects several ATIS service providers, then offers seed fund to each of them for encouraging VATIS services providing in traffic networks. In the second stage, the traffic management agency announces a fixed target of the total market penetration of VATIS services, and asks service providers to work together to achieve it. If they could complete or partially complete the task, compensations will be paid or partially paid.

2 - Most Reliable Flight Itinerary Problem

Michael Redmond, University of Iowa, Iowa City, IA, 52242, United States, michael-a-redmond@uiowa.edu, Ann Melissa Campbell, Jan Ehmke

With the high amount of uncertainty in airline travel, our research aims to provide airline customers with information about the reliability of their itineraries and help identify the Most Reliable Flight Itinerary (MRFI). We use data from the U.S. Bureau of Transportation to model the distribution of departure and arrival times for flights. We use these distributions to compute the reliability of flight itineraries, which is the likelihood the itinerary will get the passenger to the destination given a start time and travel time budget. We implement a network search algorithm to find the most reliable itinerary and utilize a number of shortcuts in order to find this itinerary in an efficient way.

3 - Quantifying Impacts of Real-time Travel Information on Route Choice Behavior using Psychophysiological Analysis: A Driving Simulator-based Study

Shubham Agrawal, Purdue University, West Lafayette, IN, 47907, United States, shubham@purdue.edu, Irina Benedyk, Dong Yoon Song, Srinivas Peeta

This study develops an analytical framework to quantify the impacts of real-time travel information in driver's route choice decision-making process considering information characteristics (for example, amount, content and source), driver's cognitive state (for example, engagement level and mental workload), situational factors and individual characteristics (for example, age and gender). The driver's cognitive state is estimated by performing psychophysiological analysis based on the data collected using electroencephalogram (EEG), electrocardiogram (ECG) and wearable eye tracking glasses while driving in an interactive driving simulator environment.

4 - Understanding Satisfaction with Travel Experience under Real-Time Travel Information Provision - A Latent Variable Modeling Approach

Dong Yoon Song, PhD Student, Purdue University, West Lafayette, IN, 47907, United States, song50@purdue.edu, Srinivas Peeta

This study investigates travelers' satisfaction with travel experience including the benefits from travel time savings and psychological effects while traveling under real-time travel information provision. A structural equation model is proposed with latent variables for human factor considerations in information perception and multiple dimensions of psychological benefits. Travelers' behavioral data and stated preference data collected through interactive driving simulator experiments and the associated surveys are used to estimate the model.

■ MA54

362A

Food Supply Chain Innovations

Invited: Agricultural Analytics

Invited Session

Chair: Changrui Ren, IBM Research - China, IBM, Beijing, 100193, China, rencr@cn.ibm.com

1 - A Spatiotemporal Approach to Accelerate the Investigation of Food-borne Illness Outbreak using Retail Scanner Data

Kun Hu, IBM.Research, 5224 union ave, San Jose, CA, 95124, United States, khu@us.ibm.com, Shanshan Cao, James Kaufman

Nowadays, foodborne illness caused by salmonella, E. Coli and norovirus is a global challenge due to an altered worldwide food supply chain and increased emergence of new foodborne pathogens. When prevention efforts fail, it is essential to rapidly identify the contaminated product and alert the public. The aim of this study is to demonstrate a new analytic approach that employed big data from retail scanner. After receiving as few as 10 lab confirmed case reports, it is possible to narrow to a subset of 12 suspect products with 90% accuracy for over 80% of food products in the dataset.

2 - Blockchain Enabled Food Supply Chain Traceability and Safety Management

Changrui Ren, IBM.Research - China, Building 19 Zhongguancun Software Park, 8 Dongbeiwang Westroad, Haidian District, Beijing, 100193, China, rencr@cn.ibm.com, Bo Zhang, Dingding Lin, Yongqing Xue, Xin Shi, Mingchao Wan, Miao He

Today's food supply chain is longer and more complex than at any time in history. There is an urgent need for transparency. In our research, we propose a new blockchain enabled approach to construct food supply chain traceability and safety management system. A pilot study has been conducted in China with collaboration from industrial partners, the result of which demonstrate the authenticity, trust and robustness brought by the blockchain technology to the traceability system.

3 - Raw Material Variability in Food Manufacturing

Brian Bourquard, Purdue University, West Lafayette, IN, United States, bbourqua@purdue.edu, Gemma Berenguer, Allan W. Gray, Paul V. Preckel

We characterize the operational decisions of a food manufacturing firm facing raw material variability, that is uncertainty about the characteristics of the raw material inputs to the production process. We link the operational decisions to the firm's strategic decisions, such as supply chain management and firm boundaries. Our goal is to provide managerial insights into how firms facing raw material variability consider and select among their strategic options to improve efficiency and reduce waste. We contribute to the literature by showing that firms facing operational challenges need to consider their strategic options as integral to the manufacturing process.

4 - The Application of Lateral Transshipment to Perishable Inventory Management in Fresh Food Industry

Dilupa Nakandala, Western Sydney University, Paramatta, Australia, D.Nakandala@westernsydney.edu.au, Henry Lau

Product perishability is one of the primary reasons causing more stockouts across the fresh food supply chain and justifies considering lateral transshipment as a managerial response. The proposed model considered the four key cost components of purchasing, backordering, holding, and spoilage costs for minimising the total inventory costs. The optimal balance of lateral transshipment and supplier order can moderate the tendency to over-order. Otherwise, the associated higher level of inventory position to manage any emerging stockout would result in higher spoilage costs as a higher volume of perishable product expires, but without improving the customer service level.

■ MA55

362B

Financial Econometrics

Sponsored: Financial Services

Sponsored Session

Chair: Markus Pelger, Stanford University, Stanford, CA, 94305, United States, mpelger@stanford.edu

1 - Taming the Factor Zoo

Dacheng Xiu, PhD, Chicago Booth, Chicago, IL, United States, Dacheng.Xiu@chicagobooth.edu

The asset pricing literature has produced hundreds of potential risk factors. Organizing this "zoo of factors" and distinguishing between useful, useless, and redundant factors require econometric techniques that can deal with the curse of dimensionality. We propose a model-selection method to systematically evaluate the contribution to asset pricing of any new factor, above and beyond what a high-dimensional set of existing factors explains. Our procedure selects the best parsimonious model out of the large set of existing factors, and uses it as the control in making statistical inference about the contribution of new factors and estimating their price of risk.

2 - Efficient Parameter Estimation for Multivariate Jump-diffusions

Gustavo Schwenkler, Boston University, 595 Commonwealth Ave, Boston, MA, 02215, United States, gas@bu.edu, François Guay

This paper develops an unbiased Monte Carlo estimator of the transition density of a multivariate jump-diffusion process. The coefficient functions are allowed to be state-dependent and non-affine. Our estimator facilitates the parametric estimation of multivariate jump-diffusion models based on discretely observed data. The parameter estimators we propose have the same asymptotic behavior as maximum likelihood estimators as the number of data points grows, but the observation frequency of the data is kept fixed. Our density and parameter estimators are found to be highly accurate and computationally efficient in a numerical study.

3 - Functional Autoregression for Sparsely Sampled Data

Daniel R.Kowal, Cornell University, Ithaca, NY, United States, drk92@cornell.edu

Daniel R.Kowal, Rice University, Houston, TX, United States, drk92@cornell.edu, David S. Matteson, David Ruppert

We develop a hierarchical Gaussian process model for forecasting and inference of functional time series data. The latent process is dynamically modeled as a functional autoregression with Gaussian process innovations. For the dynamic innovation process, we propose a fully nonparametric dynamic functional factor model, with broader applicability and improved computational efficiency over standard Gaussian process models. Extensive simulations demonstrate substantial improvements in forecasting performance and recovery of the autoregressive surface over competing methods. We apply the proposed methods to forecast nominal and real yield curves using daily U.S. data.

4 - Asset Pricing Testing for Many Assets

Markus Pelger, Stanford University, 312 Huang Engineering Center, 475 Via Ortega, Stanford, CA, 94305, United States, mpelger@stanford.edu, Luyang Chen

We derive the asymptotic inferential theory for cross-sectional asset pricing testing when both the number of time observations T and number of assets N are large. After proper normalization the time-series and cross-sectional test statistics are asymptotically normal distributed in contrast to the chi-squared distribution for fixed N. Conventional time-series and cross-sectional tests can lead to contradicting conclusions for large N. Even for moderately sized cross-sections with N = 75 conventional test statistics are strongly biased, while our test statistics have good power and size properties.

■ MA56

362C

Fueling Station Location and Routing Decisions for Alternative Fuel Vehicles

Sponsored: Location Analysis

Sponsored Session

Chair: Ismail Capar, Texas A&M University, College Station, TX, 77843-3367, United States, capar@tamu.edu

Co-Chair: Ibrahim Capar, Bowling Green State University, Bowling Green, OH, 43403, United States, icapar@bgsu.edu

1 - The Recharging Infrastructure Design Problem with Capacitated Recharge Stations and Stochastic Demands

Baris Yildiz, Koc University, Istanbul, 34450, Turkey, byildiz@ku.edu.tr, Evren Olcaytu

We study recharging infrastructure design problem for the urban areas. Considering the investor and consumer viewpoints along with the inherent uncertainty about the recharging demand, we approach to this problem from a broad perspective to obtain significant managerial insights that can help decision makers to shape long term strategies to take advantage of the new opportunities offered by the emerging electric vehicle technologies. We present a branch and cut algorithm to find optimal infrastructure design that minimizes the total investment cost while guaranteeing a target quality of service level that is crucial for the transportation and logistic use of electric vehicles.

2 - Patrol Routing with Hybrid Electric Vehicles

Burcu B. Keskin, University of Alabama, 4138 Meretta Lane, Tuscaloosa, AL, 35406, United States, bkeskin@cba.ua.edu, Mesut Yavuz

In this work, we study highway patrol by state troopers, which differs from police patrol in regards to (i) geographical coverage, (ii) miles traveled by a vehicle, and (iii) the higher probability of involvement in high-speed, long-distance chases. Specifically, for a given mixed patrol fleet consisting of traditional (gasoline or diesel) vehicles and HEVs, we investigate optimal patrol routes to visit time-critical hot spots. Our overall goal is to maximize the visibility of the state troopers while minimizing the costs associated with utilization of troopers. We analyze mathematical properties of the problem to offer analytic solutions or transformations to polynomially-solvable problems.

3 - Random Utility Model for Electric Vehicle Movement with Respect to Multiple Charging Stops

Yudai Honma, The University of Tokyo, Ce405, Komaba 4-6-1, Meguro-ku,, Tokyo, 153-8505, Japan, yudai@iis.u-tokyo.ac.jp, Shigeki Toriumi

This research focuses on the EV-support infrastructure of charging facilities in terms of EV route-decision behavior and multiple charging stops. When considering the movements of long-distance trips, it is very important to incorporate the route of EV movements because there is not only a simple and shortest path from origin to destination, but also several alternative paths. Furthermore, it is also essential to consider an EV's multiple stops at EV-recharging facilities. An elegant mathematical model to analyze the EV-support infrastructure with respect to multiple routes and multiple-charging stops will be discussed.

4 - A Heuristic Method to Solve Large-scale Flow-refueling Location Model

Ibrahim Capar, Bowling Green State University, Department of ASOR, 355 Business Administration Building, Bowling Green, OH, 43403, United States, icapar@bgsu.edu, Ismail Capar

In this research, we propose a new heuristic model for flow-refueling location model for alternative fuel vehicles. One of the challenges many organizations face is using existing exact and heuristic algorithms to solve large scale real-world problems. We present a heuristics approach to solve these larger scale problem consisting of real-world data set obtained from an organization located in Europe. We discuss the heuristic in detail and share the results from numerical experiments.

■ MA57

362D

Joint Session SIM/ OPT under Uncertainty: Sample Average Approximation (SAA): Applications and Methodology

Sponsored: Simulation

Sponsored Session

Chair: Dashi Singham, Naval Postgraduate School, Naval Postgraduate School, Monterey, CA, 93943, United States, dsingham@nps.edu

1 - Sample Average Approximation for Continuous Principal Agent Problems

Dashi Singham, Naval Postgraduate School, 1411 Cunningham Road, Operations Research Department, Monterey, CA, 93943, United States, dsingham@nps.edu, Wenbo (Selina) Cai

We study a sample average approximation for estimating the solution to a continuous-demand principal-agent problem. This approach uses discrete samples from the demand distribution to solve a deterministic demand version of the problem. A special case of the continuous-demand problem where the solution is known motivates the problem. The broader issue is the convergence of functional solutions to SAA problems.

2

- Variance Reduction in Sequential Sampling for Stochastic Programming

Guzin Bayraksan, The Ohio State University, 210 Baker Systems, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, bayraksan.1@osu.edu, Jangho Park, Rebecca Stockbridge

We investigate the use of variance reduction techniques Latin Hypercube Sampling (LHS) and Antithetic Variates (AV) in sequential sampling for stochastic programming. Sequential sampling takes a sequence of solutions (obtained by any method) and assesses its quality by sequentially increased sample size. We update the theoretical results for LHS and perform computational experiments for both LHS and AV. Our results indicate that the use of AV and LHS in a sequential setting leads to tighter confidence intervals on the solutions obtained with reduced computational effort.

3 - Optimization-based Quantification of Input Uncertainty

Huajie Qian, University of Michigan, Ann Arbor, MI, United States, hqian@umich.edu, Henry Lam

We study the empirical likelihood approach to construct statistically accurate confidence bounds for stochastic simulation under nonparametric input uncertainty. The approach is based on positing distributionally robust optimization problems with suitably averaged divergence constraints to provide asymptotic coverage guarantees. We present the theory giving rise to the constraints and their calibration, and demonstrate how the approach compares to existing methods such as the Bootstrap and the Delta method in terms of computational effort and stability.

4 - Quantifying Uncertainty in Sample Average Approximation via the Empirical Likelihood

Henry Lam, University of Michigan, 1205 Beal Avenue, Industrial & Operations Engineering, Ann Arbor, MI, 48109, United States, khlam@umich.edu, Enlu Zhou

We discuss the use of empirical likelihood in the statistical uncertainty quantification of stochastic objectives and constraints, and its connection to robust optimization. We compare this approach to some classical methods in obtaining performance bounds for stochastic optimization and discuss other recent related works.

■ MA58

362E

Reliant Populations and Disrupted Systems

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Elise Miller-Hooks, George Mason University, GMU, Silver Spring, MD, na, United States, miller@gmu.edu

Co-Chair: Jyotirmoy Dalal, Indian Institute of Management Lucknow, Prabandh Nagar, IIM Road, Uttar Pradesh, Lucknow, 226013, India, jyotirmoy.dalal@gmail.com

1 - Real-time Transit Demand Estimation during Disruptive and Emergency Events

Tuan Le, George Mason University, Fairfax, VA, United States, tle34@masonlive.gmu.edu, Vadim Sokolov, Kuilin Zhang, Hubert Ley, James Garner

We present Bayesian models and methods for analyzing transit data in problems of inference about demand for transit system in real time. The goal is to develop short-term (a few hours) forecasts during disruptive events, such as flooding, tornadoes, blizzards and man-made emergencies. In this work, we solve a variant of the origin-destination flow problem. Our models allow for explicit representation of measurement uncertainties and incorporation of prior knowledge about demand patterns, e.g. historically observed origin-destination flows. Historical data is modeled as a prior, and noisy measurements of boardings and alighting are modeled via a likelihood.

2 - Modeling Transit-Communication Interdependencies for Resilience Computation

Neza Vodopivec, George Mason University, Fairfax, VA, United States, nvodopiv@gmu.edu, Elise Miller-Hooks

Resilience to transit disruptions depends not only on a technical system's performance, but also on the ability of individuals to adapt to disruptions. To make well-informed decisions, individuals depend on effective communication. We introduce an integrated socio-technical system model capturing functional dependencies between a system's engineered and social components. We present algorithms used to evaluate component criticality in system performance and identify mechanisms of failure and failure propagation paths.

3 - An Integrated Framework for Assisted Evacuation of Remote Habitats

Jyotirmoy Dalal, Assistant Professor, Indian Institute of Management Lucknow, House No. 422, IIM Lucknow Campus, Lucknow, 226013, India, jyotirmoy.dalal@iiml.ac.in

In the wake of a disaster, automobile based self-evacuation is not always an option for many remote, economically backward population. Even in case of an assisted-evacuation, a lack of proper road infrastructure makes the mass-transit movement unsafe during the disaster. We propose an integrated, centralized, time- and cost-effective mass evacuation and sheltering problem. Given the habitat and shelter locations, our model makes the necessary location, capacity and allocation decisions for a certain number of evacuee-pickup points under various supply and demand side constraints.

■ MA59

362F

Joint Session RAS/Practice: Railroad Machine Learning & Component Failure Analysis

Sponsored: Railway Applications

Sponsored Session

Chair: Roochi Mishra, BNSF Railway Company, Fort Worth, TX, 76131, United States, roochi.mishra@bnsf.com

Co-Chair: Qing He, University at Buffalo, SUNY, Buffalo, NY, 14260, United States, qinghe@buffalo.edu

1 - Data-driven Railway Track Deterioration Model

Qing He, University at Buffalo, SUNY, 313 Bell Hall, Buffalo, NY, 14260, United States, qinghe@buffalo.edu, Amjad Aref

This study proposes an ensemble track deterioration model based on both stochastic mechanics modeling and Big Data machine learning techniques to capture the growth of defects, including both geometry defects and rail defects. The proposed model has been validated by real-world track data from North America Class I railroads.

2 - A Machine Learning Approach to Generate Track Surfacing Plan Based on Geometry Car Test Data

Pooja Dewan, PhD, BNSF Railway, Fort Worth, TX, 76137, United States, pooja.dewan@bnsf.com

In railroad, geometry car provides foot by foot track surface measurements as basic guide line for railway road master to make surfacing plan. Traditionally, we use rule based or threshold based method to indicate the area required to do maintenance. In this presentation, we will present a machine learning based approach to generate track surfacing plan from geometry car test data. Details from data preparation, training data collection to model implementation and deployment will be discussed.

3 - Bearing Failure Analysis

Landon Smith, BNSF Railway, BNSF Railway, Fort Worth, TX, United States, landon.smith@bnsf.com, Hark Braren

In transportation via rail, a roller bearing failure on a car in a train generally leads to catastrophic derailments. For many years, railroads have utilized Hot Box Detectors (HBD) to generate system alerts for bearings that approach a high temperature state. Although this method is somewhat effective, it does not catch ALL failing bearings, and these non-alerted bearings cause various issues impeding smooth operations, such as setouts, service interruptions, and derailments. In this presentation, we will discuss the technology used for timely identification of failing bearings as well as mapping the failure progression modes for different types of bearing failures.

4 - Prediction of Arrival Times of Freight Trafficon US Railroads using Support Vector Regression

Daniel Work, University of Illinois, Chicago, IL, United States, dbwork@illinois.edu, William Barbour

Variability of travel times on the United States freight rail network is very high, which poses operational challenges if the nature of variability is not predictable. This work proposes a data-driven approach to predict estimated times of arrival (ETAs) of individual freight trains based on the properties of the train, network, and conflicting traffic. The problem is posed as a series of location-specific machine learning regression problems and solved using support vector regression trained on over two years of data. We present details on feature engineering, findings on the most predictive factors for ETA, and preliminary ETA improvements exceeding 20% over baseline statistical methods.

■ MA60

370A

Software Tips for the Analytics Classroom

Sponsored: INFORMEd

Sponsored Session

Chair: Thomas G. Groleau, Carthage College, Kenosha, WI, 53140-1994, United States, tgroleau@carthage.edu

1 - Software Tips for the Analytics Classroom

Nilakantan Sundara Raman Narasinganallur, K.J. Somaiya Institute of Management Studies & Research, B 602 Tulip Rachna Garden, Mulund Colony, Mumbai, 400082, India, nilakantan@somaiya.edu

Data analytics has come into limelight especially with voluminous data being generated. Big data requires new techniques in analytics and new softwares. Whether prescriptive or predictive, analytics requires faster integration and implementation. When we teach analytics in the classroom, we need to impart understanding with many shortcuts and tips to make the experience useful and skill-building. The presentation will touch upon the presenter's experience with teaching predictive and prescriptive analytical methods to MBAs in India.

2 - The Role of Simulation Games in the Analytics Classroom

Vincent Hargaden, University College Dublin, School of Mechanical & Materials Engineering, Engineering & Materials Science Centre, Belfield, Dublin 4, Ireland, vincent.hargaden@ucd.ie

We describe the use and impact of an internet based supply chain simulation game to teach topics in analytics to graduate engineering and business school students. This well-known game from Responsive Learning Technologies requires students to apply forecasting, inventory management, transportation and facility location concepts. Using data from 122 student groups since 2011, we compare performance between engineering and business school student cohorts.

3 - Excel is Great – Until it Isn't

Thomas G. Groleau, Carthage College, 2001 Alford Park Drive, Kenosha, WI, 53140-1994, United States, tgroleau@carthage.edu

Microsoft Excel's all-purpose flexibility makes it a commonly used tool for introductory business statistics or other analytics-oriented classes. However it becomes cumbersome for two or more sample inference and large data sets. While we start our business statistics classes with Excel, we transition to dedicated statistics software (SPSS) as the class progresses. This presentation covers when and how we make that transition.

4 - Faculty Resources on the INFORM-ED Website

Michael J. Racer, University of Memphis, 302 Fogelman College of Business, Memphis, TN, 38152, United States, mracer@memphis.edu, Palaniappa Krishnan

The purpose of the website is to provide a resource for faculty members in the operations research are. This website will include several items available for faculty members- sample curriculums to which any member can submit examples, cases, projects, software, etc.

■ MA61

370B

Optimization in Food-Energy-Water Nexus

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Masood Parvania, University of Utah, Salt Lake City, UT, 84112, United States, masood.parvania@utah.edu

Co-Chair: Sauleh Ahmad Siddiqui, Johns Hopkins University, Baltimore, MD, 21218, United States, siddiqui@jhu.edu

1 - Optimizing Water Energy Flexibility in Water Distribution Systems

Masood Parvania, Assistant Professor, University of Utah, 50 S. Central Campus Drive, Room 2110, Salt Lake City, UT, 84112, United States, masood.parvania@utah.edu, Konstantinos Oikonomou

We present a model for optimizing the energy flexibility of water distribution systems (WDS). The water distribution system operators are considered as energy savvy entities, who run the proposed WDS operation model to optimize the operation of water pumps and tanks for minimizing the operation cost of the WDSs, while respecting the hydraulic operating constraints for ensuring deliverability of the WDS energy flexibility. The power system operator, then, optimizes final decisions on the contribution of WDS energy flexibility in power systems operation.

2 - Integrated Modeling to Answer Research Questions at the Intersection of Food-energy-water in Ethiopia

Sriram Sankaranarayanan, Johns Hopkins University, Baltimore, MD, 21218, United States, ssankar5@jhu.edu, Ying Zhang, Benjamin Zaitchik, Sauleh Ahmad Siddiqui

We present an integrated partial equilibrium model for food and energy markets that computes food production and trade volumes in Ethiopia, and models power generation and transmission from hydel and geothermal power stations. Coupling these models though prices and quantities along their supply chains, we asses shifts in welfare under policy scenarios. We run the model under improved irrigation capabilities, crop rotation strategies, and injection of food aid during crop failure.

3 - Opportunities for Energy Water Nexus Planning and Operation

Amro Farid, Dartmouth College, Hanover, NH, United States, Amro.M.Farid@dartmouth.edu

This presentation identifies and motivates several opportunities for integrated operations management and planning of the the energy-water nexus (EWN). First, an exposition of the EWN is given. This discussion focuses on the electric power, potable water, and wastewater distributions systems. Second, the paper shifts to opportunities in integrated operations management highlighted by an energy-water nexus supply-side economic dispatch illustration. Thirdly, the discussion shifts to planning opportunities for the energy-water nexus for the sustainable development of water and energy resources. A concluding section summarizes the policy implications of the identified opportunities.

4 - Optimization of Marine Hydro-Kinetic Devices for Electricity Systems

Alberto J. Lamadrid, Lehigh University, 621 Taylor Street, R451, Bethlehem, PA, 18015-3120, United States, ajl259@cornell.edu

In this work we formulate a proposal for wave farm owners to participate in deregulated electricity markets. Our proposal for the day ahead market allows for a closed form solution of the optimal offer. We establish a mapping between real time prices and profits considering uncertainty, and evaluate the revenue streams for wave energy producers.

■ MA62

370C

Journal of Quality Technology Invited Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Fugee Tsung, HKUST, Clearwater Bay Road, Hong Kong, HK, Hong Kong, season@ust.hk

1 - Robust Multivariate Control Chart Based on Goodness-of-fit Test

Nan Chen, National University of Singapore, Department of Industrial and System Eng, 1 Engineering Drive 2, Singapore, 117576, Singapore, isecn@nus.edu.sg, Chen Zhang, Changliang Zou

This paper proposes a distribution-free MSPC chart to detect general distributional changes in multivariate variables. The chart is based on a multivariate goodness-of-fit test, extensible to high dimensional observations. The chart also employs data-dependent control limits to ensure robust charting performance. The proposed chart is exactly distribution-free, and able to operate with unknown in-control distribution or limited reference samples. The chart also has satisfactory OC detection power for general changes without distributional assumptions.

2 - Change Detection in a Dynamic Stream of Attributed Networks

Mostafa Reisi Gahrooei, Georgia Institute of Technology, Georgia Tech, H. Milton Stewart School Of ISYE, Atlanta, GA, 30332-0205, United States, mostafa.reisi@gmail.com, Kamran Paynabar

While anomaly detection in static networks has been extensively studied, only recently, the attention has been focused on dynamic networks. This paper proposes a new methodology for modeling of dynamic attributed networks and for change detection in the network structure. In this methodology, generalized linear models are used to model static attributed network. This model is then combined with a state transition model to capture the dynamic behavior of the system and Extended Kalman filter is used estimate and update network parameters over time. Prediction residuals are then monitored using EWMA. The proposed method is examined through simulations and a case study.

3 - Using Curve-registration Information for Profile Monitoring

Bianca Maria Colosimo, Politecnico di Milano, Via La Masa, 1, Milan, I-20156, Italy, biancamaria.colosimo@polimi.it, Marco Grasso, Alessandra Menafoglio, Piercesare Secchi

The contribution presents a novel approach for profile monitoring, which combines the Functional Principal Component Analysis and the use of parametric warping functions. The key idea is to jointly monitor the stability over time of the registered profiles and the registration coefficients. This allows improving the capability of detecting unnatural pattern modifications, thanks to a better characterization of the overall natural variability.

■ MA63

370D

Systems Modeling Approaches to Energy Analysis

Invited: Energy and Climate

Invited Session

Chair: Benjamin D. Leibowicz, University of Texas-Austin, Austin, TX, 78712-1591, United States, bleibowicz@utexas.edu

1 - The Cost of Policy Uncertainty in Electric Sector Capacity Planning: Implications for Instrument Choice

Benjamin D. Leibowicz, University of Texas-Austin, ETC 5.128D, 204 E. Dean Keeton St. C2200, Austin, TX, 78712-1591, United States, bleibowicz@utexas.edu

The OSeMOSYS energy system optimization model is reformulated as a stochastic program and applied to electric sector capacity planning under climate policy uncertainty in the ERCOT area. Optimal hedging strategies are identified, and the costs of policy uncertainty under carbon taxes, carbon caps, and renewable portfolio standards are compared. Findings clearly indicate that uncertainty considerations favor price-based over quantity-based policy instruments.

2 - Optimal Pathways to Net-zero Emissions: A Study of Austin, Texas

Max Brozynski, University of Texas-Austin, Austin, TX, United States, brozynski@utexas.edu

We develop an integrated systems model of energy supply and demand at the urban scale, and use it to determine optimal decarbonization pathways. Our framework is integrated in that it represents all major energy end-use demands, and captures synergistic linkages among them. Examples of such linkages include electrification of transportation, vehicle-to-grid technologies, combined heat and power, and diverse uses of hydrogen. We apply our model to evaluate decarbonization strategies in Austin, Texas, which recently adopted a goal to achieve net-zero greenhouse gas emissions by 2050.

3 - Improving Solar Integration and Grid Utilization via Residential Cooling Thermal Energy Storage

Thomas Deetjen, University of Texas-Austin, Austin, TX, United States, tdeetjen@gmail.com

This study examines the potential for cooling thermal energy storage (CTES) in the residential sector to provide flexibility to the electric grid. A linear optimization model chooses the capacity and sub-hourly dispatch of chillers and CTES systems in a neighborhood with rooftop solar. The model tests whether CTES can reduce peak electric demand, lessen solar-induced ramp rates, and lower operation costs in the neighborhood and bulk transmission-grid. Results show that CTES operation can improve or worsen these outcomes, depending on how electricity rates have been structured.

4 - Optimal Dispatch and Equipment Sizing of a Community-scale Water Recycling Facility for Electric Demand Flexibility

Scott Vitter, University of Texas-Austin, scott.vitter@gmail.com, Thomas Deetjen, Bruk Berhanu, Michael Webber

This study explored tradeoffs between sizing, operating schedule, and electric load-shifting for a community-scale water recycling facility within a residential area. A mixed-integer linear program was formulated to represent a community system consisting of a batch recycling process, potable water storage, and sewer equalizing storage. Initial results indicate that operating a water recycling facility can reduce overall community costs under certain economic conditions, and that batch processes can be scheduled in response to signals that favor electric demand flexibility. Total water demand, water and sewer pricing, and equipment capital costs strongly influence the optimal solution.

■ MA64

370E

New Advancements in Using Data Analytics for Healthcare Applications

Sponsored: Data Mining

Sponsored Session

Chair: Talayeh Razzaghi, Department of Industrial Engineering, New Mexico State, Department of Industrial Engineering, New Mexico S, Las Cruces, NM, 88003, United States, talayehr@nmsu.edu

Co-Chair: Lisha Yu, City University of HongKong, City University of HongKong, Kowloon, Hong Kong, lishayu2-c@my.cityu.edu.hk

1 - L1-norm Subspace Estimation for Microbiome Data Analysis

Paul Brooks, Virginia Commonwealth Univ, Dept of Stat Sci and OR, P.O. Box 843083, Richmond, VA, 23284, United States, jpbrooks@vcu.edu

DNA from communities of microorganisms can be sequenced to provide a census of the species present. The resulting counts of DNA fragments form profiles that can be explored with clinical data understand host-microbiome interactions in human health. Subspace estimation forms the basis for many tools for discovering important patterns. Using the traditional sum-of-squared error criterion can lead to erroneous conclusions. We demonstrate the performance of a robust subspace fitting procedure in ordination of microbiome samples and as a subroutine in a subspace classification method.

2 - Dynamic Management of Healthcare Queues with Capacity Adjustment Delay Uncertainty

Sara Nourazari, California State University, Long Beach, 1250 Bellflower Blvd-MS.4904, HHS2-118, Long Beach, CA, 90840, United States, sara.nourazari@csulb.edu, Rifat Sipahi, James Benneyan

In spite of the incentives to improve outpatient access, many healthcare systems are still struggling with providing timely access to care, which takes its toll on the patients in need. This work provides a detailed analysis pertaining to Modified Smith Predictor, to develop a robust controller design in queue management problems to regulate queue length despite uncertain demand and delay mismatches between the model and the actual system. By illustrating how flexibility in capacity adjustment can effectively improve patient appointment access, the results of this study demonstrate the value of dynamic modelling in healthcare systems redesign initiatives.

3 - The Efficiency Loss Problem in Social Network Analysis Based on Stochastic Block Model

Peiwen Xu, City University of Hong Kong, 88 Tat Chee Avenue, Hong Kong, Hong Kong, peiwenxu-c@my.cityu.edu.hk, Tsui Kwok Leung

In this paper, we will investigate the efficiency loss for anomaly detection due to the conversion of count data to binary data in social network analysis, based on Stochastic Block Model(SBM), a benchmark for detecting changes of community structure in social network analysis. By applying statistical process control techniques to Stochastic Block Model, the loss of efficiency can be quantified by comparing the average run length (ARL) performance.

4 - Simulation-based Optimization of Prognostics and Health Management enabled Condition-Based Maintenance Policy

Omoleye Taiwo Joel, City University of Hong Kong, Kowloon, Hong Kong, jtomoleye3-c@my.cityu.edu.hk, Kwok Leung Tsui

The practical implementation of condition-based maintenance (CBM) is trailing behind the widespread theoretical benefits in the literature. This necessitates the growing concern about the effectiveness of CBM policy in industries implementing CBM. To overcome this, research is focusing on the value of Prognostics and Health Management (PHM) information in CBM policy. In this paper, simulation-based optimization is used to assess the benefits of PHM-enabled CBM policy under resource dependence. Also, a framework is developed, numerically illustrated, and compared with classic CBM, and traditional maintenance policies using ARENA-based discrete event simulation model.

■ MA65

370F

Design of Logistics Networks

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Sasha Zhijie Dong, Texas State University, San Marcos, TX, United States, sasha.dong@txstate.edu

1 - A Lagrangian Relaxation Approach to a Multi-Echelon Consolidation of Perishable Products

Christine Nguyen, Northern Illinois University, DeKalb, IL, 60115, United States, cnguyen@niu.edu

Our research focuses on a supply chain of suppliers with low demand for perishable products. By shipping through FTL units, the transportation cost would be less expensive than LTL shipments. The suppliers all ship to a shared consolidation center, where suppliers can experience the advantages of consolidating product. Transportation and inventory decisions are made at suppliers and the consolidation center. This problem is decomposed and solved using a Lagrangian Relaxation approach.

2 - Regional Logistics Network Design with Consider of Roadway Traffic Congestion and Service Decay

Mi Gan, Southwest Jiaotong University, Chengdu, China, taosiyu@swjtu.edu.cn, Si Chen, Siyu Tao

In order to solve the problem that the existed logistics network design models(LND) are lack of consideration on roadway traffic flow. The uncover degree function of logistics facility nodes based on impedance function was built. Then, integrated logistics network design models and corresponding algorithms were proposed on the basis of uncovering degree function. The comparison of general LND models and models we developed by actual case reveals the impact of roadway traffic flow on LND.

3 - Resilient Route Design for Collection of Material from Suppliers
Zhijie Dong, Assistant Professor, Texas State University, San Marcos, TX, 78666, United States, sasha.dong@txstate.edu

As production schedules of manufacturing operations change, the amounts of material to be picked up at individual suppliers can be quite volatile, but it is desirable to have relatively regular route structures in place so that the system can adapt to varying volumes without requiring complete redesign of collection routes every time there is a change in the production schedule at the manufacturing plant. Our model accomplishes this resilient design of routes using a stochastic version of a capacitated clustering formulation. The model is constructed as a two-stage stochastic mixed integer program.

4 - Service Network Design Problem on an Hierarchical Hub-and-Spoke Network for a Major Carrier
Yusuf Secerdin, University of Miami, 1251 Memorial Drive, McArthur Engineering Building, Coral Gables, FL, 33146, United States, yusufsecerdin@miami.edu, Murat Erkoc

In this study, we present mathematical models and solution procedures for the routing and scheduling of the Caribbean air feeder network of a major express cargo service provider. The problem is modeled as a service network design problem on a hierarchical hub-and-spoke network. The proposed solution methodology first executes an initial data processing that involves route generation and elimination in order to contain the size of the solution space for the mathematical model. We consider two versions of the proposed model based on two scenarios: dedicated runs and milk runs. We compare two approaches in terms of operational costs, flight hours, and fleet sizing.

■ MA66

371A

Network Resilience

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Yan Deng, Cornell University, Cornell University, 2406 Hasbrouck Apartment, Ithaca, NY, 14850, United States, yd256@cornell.edu

1 - Disaster Induced Traffic Network Analysis using Percolation Theory
Yaoming Zhou, University of Hong Kong, University of Hong Kong, Pokfulam, Hong Kong, Hong Kong, youngme910@hku.hk, Junwei Wang, Jiuh-Biing Sheu

The impact of traffic networks' structure change on operations management during disasters is usually ignored. We propose a stochastic mathematical framework utilizing percolation theory to systematically study how will different magnitude of disasters affect the global and local connectivity of traffic networks. This method also helps find out when and to what extent can the impacts be ignored. The impacts of natural and man-made disasters are compared. We discussed the application of our method to a real-world traffic network with some important insights.

2 - An Optimal Stopping Problem to Mitigate Productivity Losses of a Transportation System Utilizing Hurricane and Storm Surge Forecasts
Rodney Middlebrooks, Graduate Student, North Carolina A&T State University, Greensboro, NC, United States, middlebrooks.r@gmail.com

In the context of a transportation network, a system-wide operational shutdown can be ordered prior to the realization of expected hurricane landfall or storm surge inundation. The decision is binary, with the choice to either continue with routine operations or suspend them, initiating protective measures. The critical infrastructure decision problem is modeled as a finite-horizon optimal stopping problem. The objective is to minimize the loss of productive output of a transportation system, given real-time hurricane and storm surge forecast information.

3 - Vulnerability Assessment and Mitigation of Complementary Transportation Systems under Worst-case Saptially Localized Attacks
Liu Hong, Associate Professor, Huazhong University of Science and Technology, 1037 Luoyu Road, Wuhan, 430074, China, liu.hong@hust.edu.cn, Min Ouyang, Xin Zhong

Spatially localized attacks, caused by natural hazards or malicious attacks, can make serious loss to the transportation systems. This paper proposes an approach to assess and mitigate the vulnerability of complementary transportation systems under worst-case spatially localized attacks. The national level complementary railway and airline systems, and the urban level complementary bus and subway systems, are used as numerical experiments to illustrate the tractability and effectiveness of the proposed method.

4 - Socially Profitable Transport Infrastructure Investment Strategies under Demand Uncertainty: A Real Options Based Approach
Yan Deng, Cornell University, Cornell University, 2406 Hasbrouck Apartment, Ithaca, NY, 14850, United States, yd256@cornell.edu, Oliver Gao

This paper developed a real options based methodology to address the optimal transport investment strategies under travel demand volatility. A socially profitable demand threshold is derived under the market share and competition. The methodology is subsequently applied to the High Speed Rail investment in the United States. The results compared the investment criteria from real options with the NPV valuation approach, and illustrated the investment returns from consumer, producer and environmental surplus. Sensitivity analysis was carried out to examine the characteristics of the optimal transport investment rules and the policy implications under the effects of key parameters.

■ MA67

371B

Diagnostic/Predictive Data Analytics and Data-Driven Decision Making for Smart and Connected Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Raed Al Kontar, University of Wisconsin-Madison, 1513 Mechnaical Engineering Building Room 3255, Madison, WI, 53706, United States, alkontar@wisc.edu

Co-Chair: Shiyu Zhou, University of Wisconsin-Madison, Madison, WI, 53706-1572, United States, szhou@engr.wisc.edu

1 - A Novel Pattern-frequency Tree Approach for Dynamic Transition Analysis
Cheng-Bang Chen, Pennsylvania State University, 310 Leonhard Building, University park, PA, 16802, United States, czc184@psu.edu, Hui Yang, Soundar Kumara

This paper presents a novel methodology of pattern-frequency tree for transition analysis in dynamic nonlinear systems. First, we propose Hyperoctree State space Aggregation Segmentation to delineate the high-dimensional dynamic processes in a continuous state space. Then, we develop a pattern-frequency tree to characterize and model the pattern distribution. Finally, we leverage pattern-frequency distribution information to develop a k-Maximin deviation algorithm for e ective and e cient detection of process anomalies. Experimental results show that the proposed method performs better than the conventional methods in multi-sensor settings and high-dimensional environments.

2 - Contamination Source Identification Based on Sequential Bayesian Approach for Water Distribution Network with Stochastic Demands
Chao Wang, University of Wisconsin-Madison, Rm. 3255, ME building 1513 University Ave., Madison, WI, 53706, United States, cwang436@wisc.edu, Shiyu Zhou

The contamination source identification problem in the water distribution network is studied under the Bayesian framework. Simulations for the contamination propagation are conducted, where sensor alarms are recorded to establish the observation probability distributions. Then, the posterior probability of each possible source can be calculated. Finally, the contamination source is identified based on the ranking of the posterior probability. The contribution of this work is that the observation probability distributions are organized into hierarchical tree structures and the challenge of combinatorial explosion is avoided. The effectiveness of this method is verified by a case study.

3 - Active Learning for Gaussian Process Classification using a Data-based Kernel
Hang Li, Pennsylvania State University, University Park, PA, 16803, United States, hul180@psu.edu, Enrique del Castillo, George Runger

Active learning and semi-supervised learning are important techniques in the machine learning field, especially when the labeled instances are very difficult, time-consuming or expensive to obtain. In this presentation we discuss a Gaussian Process Classification (GPC) model with a data-based kernel that exploits the manifold structure hidden in the labeled and unlabeled data. Based on the GPC model, we develop an uncertainty-based active learning scheme which queries the most informative instances to label. We also investigate the hyperparameters learning problem by maximizing the likelihood of labeled data. Promising experimental results are presented for synthetic data and real world classification problems.

4 - Nonparametric Prognostics using Convolution Processes: An Alternative Approach Based on Transfer Learning

Raed Al Kontar, University of Wisconsin-Madison, 1513 University Avenue, Room 3255, Madison, WI, 53706, United States, alkontar@wisc.edu, Shiyu Zhou

In this paper, an alternative view on modeling condition monitoring (CM) signals is proposed. This view draws its roots from multitask learning and is based on treating each CM signal as an individual task. Each task is then expressed as a convolution of a latent function drawn from a Gaussian process (GP), and the transfer of knowledge is achieved through sharing these latent functions between historical and in-service CM signals. As a result, all task are represented through a functional graphical model. Aside from being non-parametric, the individualistic approach in our model is able to account for heterogeneity in the data and automatically infer the commonalities between different signals.

■ MA68

371C

Joint Session QSR/ENRE Electricity: Data-driven Systems Engineering Approaches in Wind Power Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Eunshin Byon, University of Michigan, 1205 Beal Avenue, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States, ebyon@umich.edu

Co-Chair: Hoon Hwangbo, Texas A&M University, College Station, TX, 77840, United States, hhwangbo@tamu.edu

1 - Contextual Bayesian Ascent Algorithm for Cooperative Wind Farm Control

Jinkyoo Park, jinkyoo.park@kaist.ac.kr

We discuss a probabilistic optimization method for identifying the joint optimal operational conditions of wind turbines in a wind farm for varying wind condition. We developed a Contextual Bayesian Ascent (CBA) algorithm, an extended version of Bayesian Optimization (BO) that can find an optimum of a target function through the iterative learning and sampling procedure. CBA takes into account context information that modifies the target function and restricts the searching space so that it can rapidly find an optimum. The results from simulation studies using an analytical wind farm power function show that the CBA algorithm can achieve an almost optimum control policy.

2 - Assessment of Wind Parameter Sensitivity on Ultimate and Fatigue Wind Turbine Loads

Latha Sethuraman, National Renewable Energy Laboratory, National Wind Technology Center, 15013 Denver West Parkway, Golden, CO, 80401, United States, Latha.Sethuraman@nrel.gov, Amy Robertson

Wind turbines are designed using a set of simulations to ascertain the structural loads that the turbine could encounter, but the only probabilistic variable considered is the mean wind speed. Other wind parameters, such as turbulence spectra, sheer, veer, spatial coherence, and component correlation are deterministic values that in reality could vary vastly in time and between sites and have a significant effect on the loads. This paper seeks to assess the sensitivity of different wind parameters on the resulting turbine ultimate and fatigue loads during normal operational conditions. Eighteen different wind parameters are screened using an Elementary Effects approach with radial points.

3 - Wake Effect Parameter Calibration in Wind Power Systems

Bingjie Liu, bingjiel@umich.edu, Matthew Plumlee, Eunshin Byon

In design and operations in wind power systems, physical interactions among wind turbines, called wake effects, is one of the significant factors that affect power generation performance. Among several wake modeling approaches, physics-based engineering models have been widely used due to its simplicity. The accuracy of engineering wake models, however, highly depends on the parameters. This talk proposes a calibration approach for estimating the relationship of wake parameters and environmental factors.

4 - Multivariate Power Curve Estimation an Adaptive Kernel Method Reflecting the Domain Knowledge

Hoon Hwangbo, Texas A&M.University, 522 Southwest Parkway, Apt A, College Station, TX, 77840, United States, hhwangbo@tamu.edu, Yu Ding

Accurate estimation of wind turbine power curve improves wind power prediction and hence economic assessment of existing or potential wind energy projects as well as operational controls and condition monitoring of turbines. Deviating from the predominant practice of univariate power curve modeling, a recent study introduced a multivariate power curve model utilizing additive multivariate kernels, which significantly improves the prediction accuracy. In this study, we further strengthen the multivariate power curve model by allowing adaptive bandwidths and enhancing the additive structure maintained between the multivariate kernels that ultimately reflect the domain knowledge better.

■ MA69

371D

Learning and Optimization for Resilient Power Grids

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Yury Dvorkin, New York University, Seattle, WA, 98115, United States, dvorkin@nyu.edu

Co-Chair: Yu Zhang, University of California, Santa Cruz, Albany, CA, 94706, United States, zhangy@ucsc.edu

1 - T&D Integration: Value of Learning about Consumers

Yury Dvorkin, Assistant Professor, New York University, 5 Metrotech Center, New York, NY, 11201, United States, dvorkin@nyu.edu

We will present a modeling framework to analyze techno-economic interactions between transmission and distribution electrical grids. This framework intends to allocate flexibility of distributed energy resources between transmission and distribution grid support services. Since availability of some distributed energy resources is constrained by socio-economic behavior of electricity consumers, we will use a learning-compatible approach to account for behavioristic aspects that cannot be considered using formal models. The usefulness of the proposed framework will be illustrated on benchmark transmission and distribution systems.

2 - Learning through Power Distribution Grid Probing

Vassilis Kekatos, Virginia Tech, Blacksburg, VA, United States, kekatos@vt.edu

Although power distribution grids are challenged by limited observability, many nodes are equipped with smart meters collecting voltage and power injection readings. The key idea here is to engage the smart power electronics to probe the grid and infer non-metered loads. Probing can be accomplished by commanding inverters to fluctuate their (re)active power injections. Recording the incurred voltages at actuated and metered nodes can unveil injections at non-metered nodes. It is analytically shown that probing over two time instances is successful if and only if non-metered nodes can be matched to metered nodes through vertex-disjoint paths as numerically corroborated using actual data too.

3 - Modeling and Optimization of Complex Buildings with Deep Neural Networks

Yuanyuan Shi, University of Washington, Seattle, WA, United States, yyshi@uw.edu, Yize Chen, Baosen Zhang

Buildings are responsible for 40% of the global energy consumption and aroused serious economical and environmental concerns. Previous model-based optimization and control methods for building energy management either involves tedious modeling processes or cannot fully capture the exact dynamics of sophisticated buildings. Here we propose an alternative approach which is model-free and data-driven. By utilizing high volume of data coming from advanced sensors, we train a deep neural network which could accurately represent the operation dynamics of buildings. The trained network is then directly fitted into a constrained optimization problem to find the optimal control strategies.

4 - Black Start Allocation for Power System Restoration

Georgios Patsakis, University of California Berkeley, 1460 Cedar St, Berkeley, CA, 94702, United States, gpatsakis@berkeley.edu, Deepak Rajan, Shmuel S.Oren

Extended blackouts of the power system, even though rare, can have a very high cost impact. System operators use heuristically predefined sequences for restoring the grid back to its initial state, based on units with the ability to start autonomously, called Black Start (BS) units. Recent literature tries to optimize over such candidate sequences. In light of pending BS unit retirements, we instead aim to optimally allocate BS units on the grid, while also extending current optimization models to include grid considerations. Scenarios corresponding to partial outages of the grid are considered and a decomposition algorithm is utilized to solve the problem. A test case is simulated.

■ MA70

371E

Big Data

Contributed Session

Chair: Anushka Chandrababu, International Institute of Information Technology, Bangalore, Bangalore, India, anushka.babu@iiitb.org

1 - IoT Security

Michael Chuang, SUNY New Paltz, 1 Hawk Drive, New Paltz, NY, 12561, United States, mikeychuang@gmail.com

Internet of Things, a global infrastructure enabling services by interconnecting physical and virtual things based on interoperable information and communication technologies, has emerged in business applications in various industrial areas, and will reshape tomorrow's business and technology development.

2 - Individual Social Behavior and Intraday Patterns in Market Movements

Keli Xiao, Stony Brook University, College of Business, Stony Brook, NY, 11794, United States, keli.xiao@stonybrook.edu, Gaoshan Wang, Gaoshan Wang, Jishun Wang, Feiran Li, Xiaoyan Ding

In this study, we investigate the intraday patterns of individual investors' social behavior and the stock market dynamics with several new technical attempts including (1) developing an investor engagement index (IEI) using stock forum activity data based on the customer engagement theory, and (2) proposing a multi-source forecasting framework that combines both time series models and machine learning algorithms. With the IEI and transaction data of each stock, the relationship between IEI and stock movement is investigated and discussed. Based on the data collected from a famous Chinese stock forum, we benchmark the performance of our approach with several classic baselines.

3 - The Sequence Effects of Customer Experiences on Customer Perceived Value in Wellness-centric vs. Standard Hotel Stays: A Structural Econometric Analysis

Min Kyung Lee, Clemson University, 100 Sirrine Hall, Clemson, SC, 29634, United States, minl@g.clemson.edu, Aleda Roth, Bernardo F. Quiroga, Rohit Verma

We explore emerging market trend of wellness industry that provides service offerings or products reactively to healthy people to make them feel even healthier. Our work specified a structural econometric model to explore the theoretical importance of the service process sequencing for wellness-centric rooms versus exactly similar standard rooms. Specifically, we account for customers' experiences from hotel check-in to room stay to check-out on their satisfaction and likelihood to recommend for both wellness-centric rooms and standard rooms. We demonstrate that the wellness-centric service offering produces more perceived customer value added, when benchmarked against identical rooms.

4 - Neural Network Predictions of NYC Traffic Collisions

Anirudh Madhusudan, Graduate Student, University of Illinois-Urbana Champaign, 909S.Fifth Street, 120A Sherman Hall, Champaign, IL, 61820, United States, anirudh2@illinois.edu, Harshad Rai

The NYPD Motor Vehicle Collision dataset offers information on the traffic collisions and fatalities that have occurred in NYC since 2012. Also since 2012, the Vision Zero initiative has been trying to incorporate road-safety measures to reduce traffic incidents. This projects uses several visualizations and machine learning algorithms including Logistic Regression and Neural Network to learn and predict the occurrences of collisions and fatalities usings the dataset. The project also studies the impact of the treatments offered by Vision Zero to alleviate the condition of New York traffic.

5 - Dependency Discovery and Quality Improvement in Multistage Manufacturing Processes

Andi Wang, Georgia Institute of Technology, Atlanta, GA, United States, andi.wang@connect.ust.hk, Hao Yan, Jianjun Shi

Many modern fabrication processes such as semiconductor fabrication involve a large number of stages. Massive data are generated from each stage for quality improvement. Although the correlation structure between stages can be very complex, existing methods either analyze the data acquired from each stage independently or apply a state-space model that only captures the dependency of subsequent stages. In this research, we aim at detecting and modeling the complex dependency structure of data from multi-stages processes, which will provide great opportunity for further quality improvement.

6 - Convex Model Database – An Extension to Transportation Networks

Anushka Chandrababu, PhD Candidate, International Institute of Information Technology, Bangalore, 26/C, Electronic City, Bangalore, India, anushka.babu@iiitb.org, Srinivasa Prasanna

We present our extensions to the Convex Model Database (CmdB) suitable for summarizing structured or unstructured big-data and used for answering queries for convex optimization problems. We will specifically show how the database can be used to solve problems pertaining to one of the largest railway networks in the world. The database will store data as polytopes derived from historical and apriori structural relationships and compresses the infinite possibilities of train arrival or departure, into a very compact representation. We will show how the database can answer business use cases such as conflicts in train schedules through relational algebraic operations on the polytopes.

■ MA71

371F

Journal of Global Optimization: INFORMS Issue

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Sergiy Butenko, Texas A&M University, Texas A&M University, College Station, TX, 77843-3131, United States, butenko@tamu.edu

1 - Global Optimization with Surrogate Approximation of Constraints

Juliane Mueller, Lawrence Berkeley National Lab, 2453 Bonar Street, Berkeley, CA, 94702, United States, juliane.mueller2901@gmail.com, Joshua Woodbury

We introduce GOSAC, a global optimization algorithm for problems with computationally expensive black-box constraints and cheap objective functions. GOSAC first finds a feasible point by solving a multi-objective optimization problem in which the constraints are minimized simultaneously. Subsequently, GOSAC aims at improving the feasible solution. We use cubic radial basis function surrogate models to approximate the constraints. We iteratively select sample points by minimizing the cheap objective function subject to the constraint function approximations. We assess GOSAC's efficiency on cheap test problems with integer and continuous variables and two environmental applications.

2 - A Lagrangian Search Method for the P-median Problem

Jiming Peng, University of Houston, Houston, TX, United States, jopeng@Central.uh.edu

In this talk, we present a new method for the P-median problem. We first recast the P-median problem as a global optimization problem over the set of Lagrangian multipliers. Then we present a stochastic search method to find the Lagrangian multipliers corresponding to the optimal solution of the original P-median problem. Numerical experiments show that our method can effectively find a global optimal or very good suboptimal solution to the underlying P-median problem, especially for P-median problems with a large gap between the original problem and its Lagrangian relaxation.

3 - Strong Valid Inequalities for Boolean Logical Pattern Generation

Hong Seo Ryoo, Professor, Korea University, 145 Anam-Ro, Seongbuk-Gu, Seoul, 02841, Korea, Republic of, hsryoo@korea.ac.kr, Kedong Yan

0-1 multilinear programming (MP) captures the essence of pattern generation in Logical Analysis of Data (LAD). This paper utilizes graph theoretic analysis of data to discover useful neighborhood properties among data for data reduction and multi-term linearization of the common constraint of an MP pattern generation model in a small number of stronger valid inequalities. This means that, with a systematic way to more efficiently generating Boolean logical patterns, LAD can be used for more effective analysis of data in practice. Mathematical properties and the utility of the new valid inequalities are illustrated on small examples and demonstrated with 12 real-life data mining datasets.

■ MA72

372A

Network Optimization 5

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Shanshan Hou, University of Arizona, University of Arizona, 1127 E James E. Rogers Way, Room 323D, Tucson, AZ, 85721, United States, shanshanh@email.arizona.edu

1 - Clinic Appointment Scheduling for Integrated Practice Units

Pengfei Zhang, The University of Texas at Austin McCombs School of Business, Austin, TX, 78731, United States, pz@utexas.edu, Douglas Morrice, Jonathan F.Bard

Clinic appointment scheduling is very important for clinic management because it affects the providers' time usage and patients waiting time. It is important that we have a schedule that can balance providers' time usage and patients' waiting. We consider a clinic appointment scheduling problem with multiple types of providers and two types of patients. The objective is to minimize the clinic closing time while restrain the patients' waiting time to be within a certain range. We propose a new model for the problem, and develop heuristic method to solve it.

2 - Probabilistic Power Dominating Set Problem

Ou Sun, University of Arizona, 827 E Drachman St, Tucson, AZ, 85719, United States, suno@email.arizona.edu, Neng Fan

Power dominating set problem is widely used in power system. An important application in this area is the minimum Phasor Measurement Unit (PMU) Placement Problem which has zero-injection bus property. However, after sensor placement, there may be some unexpected failures occur on PMUs or transmission lines, which can affect the function of whole power system. Starting from this idea, we propose two methods to formulate the probabilistic coverage model under uncertainty of PMUs and lines given covering probability of each bus. One is changing the chance constraint into logarithm, another is calculating the covering probability of each bus in the network design graph.

3 - Optimization of Microgrid Operations with Renewable Energy Integration

Jose L.Ruiz Duarte, University of Arizona, Tucson, AZ, 85721, United States, jlruizduarte@email.arizona.edu, Neng Fan

The development and integration of new technologies to the traditional power grid are transforming it into a smart grid capable of responding to electricity demand growth and integration of renewable energy sources. Microgrids are important part of this approach. In this presentation, a mixed integer linear program is developed for operations of a microgrid, including unit commitment decisions, line connectivity decisions with network topology, power trade with main grid, islanding operations, energy storage systems, and solar energy integration. The uncertainty of solar power is captured by robust optimization, and problem is solved by Column-and-Constraint Generation algorithm.

■ MA73

372B

Ethics in AI and OR

Invited: Operations Research and the Future of Computing

Invited Session

Chair: Tae Wan Kim, PHD, Carnegie Mellon University, Posner #243, 500 Forbes Avenue, Pittsburgh, PA, 15213, United States, twkim@andrew.cmu.edu

1 - Autonomous Machines are Ethical

John Hooker, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States, jh38@andrew.cmu.edu

While many see the prospect of autonomous machines as threatening, autonomy may be exactly what we want in a superintelligent machine. There is a sense of autonomy, deeply rooted in the ethical literature, in which an autonomous machine is necessarily an ethical one. Development of the theory underlying this idea not only reveals the advantages of autonomy, but it sheds light on a number of issues in the ethics of AI. It helps us to understand what sort of obligations we owe to machines, what obligations they owe to us, and whether to assign responsibility to machines or their creators.

2 - The Missing Ingredient in Robotics and Artificial Intelligence: Intrinsic Values

Thomas Donaldson, PhD, The Wharton Schoo
l, University of Pennsylvania, Philadelphia, PA, United States, donaldst@wharton.upenn.edu

The rise of robotics and AI will force management organizations to take intrinsic values more seriously. Intrinsic values are non-derivative, impartial and synoptic. Non-intrinsic values, in contrast, are derivative, meaning that they derive either from mere postulation or from the perceptions of individual agents. New AI/robotics challenges frustrate traditional analyses that tend to use non-intrinsic values.

3 - Ethics and Accountability of Algorithms

Kirsten Martin, PhD, George Washington University, martink@email.gwu.edu

Recent headlines warn against the hidden and unchecked biases of algorithms used in advertising, sentencing, hiring, lending, etc. Hiding behind the apron of these headlines is a series of critical decisions about the design of the algorithm and the role of algorithms in decision making. The goal of this presentation is to explore how algorithms, which are developed, used, and sold by firms, can be biased and unjust, perform an important role in ethical decisions, and have implications for accountability in corporate responsibility. This paper offers a framework to examine the value-laden decisions when utilizing an algorithm to augment organizational and individual decision-making.

4 - Algorithmic Transparency, a Right to Explanation and Placing Trust

Tae Wan Kim, Tepper School of Business, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, twkim@andrew.cmu.edu, Bryan Routledge

A growing number of researchers and governmental bodies have called for algorithmic accountability. European Parliament and Council adopted General Data Protection Regulation, which will come into force in 2018. Authors debate whether GDPR, in addition to a right to be forgotten, grants EU residents another novel kind of protection, a so-called "right to explanation." Here we articulate a tripartite structure of the right, justify it, and explore possible models of an ex post explanation that companies can provide to data subjects. Since we explore the moral or ethical, not legal, foundations of a right to explanation, the implications of our work are beyond the European context.

■ MA74

372C

Graph Partitioning

Sponsored: Computing

Sponsored Session

Chair: Onur Seref, PhD, Virginia Tech, Virginia Tech, Blacksburg, VA, United States, seref@vt.edu

1 - Distributed Spectral Clustering and Applications

Shahzad Bhatti, University of Illinois at Urbana Champaign, 104 S Mathews Ave, Urbana, IL, 61801, United States, bhatti2@illinois.edu, Carolyn L.Beck

Clustering is fundamental to machine learning. Most clustering algorithms are tailored for data stored on a central machine and are inappropriate for large data distributed across machines. The scale of the data may also prohibit moving it to a central machine. Our approach employs two phases: 1) individual machines generate a set of representative points for local data and communicate these to a central machine; 2) the central machine performs spectral clustering on the representatives and communicates cluster assignments to the distributed machines. We have explored various algorithms to generate representatives and compared results. Our algorithm is easily cast in the MapReduce framework.

2 - An Extended Formulation of the Convex Recoloring Problem on a Tree

Minseok Ryu, University of Michigan, 1535 Pine Valley Boulevard, Apt 212, Ann Arbor, MI, 48104, United States, msryu@umich.edu, Sunil Chopra, Bartosz Filipecki, Kangbok Lee, Sangho Shim, Mathieu Van Vyve

We introduce a strong extended formulation for the convex recoloring problem on a tree, which has an application in analyzing phylogenetic trees. The extended formulation has only a polynomial number of constraints, but dominates the conventional formulation and the exponentially many valid inequalities introduced by Campelo et al. The solution time using the extended formulation is much smaller than that with the conventional formulation. Moreover, the extended formulation solves all the problem instances attempted in Campelo et al. (2016) and larger-sized instances at the root node of the branch-and-bound tree without branching.

3 - Automated Conjecturing for Integrality Gap Bounds

Craig Larson, Virginia Commonwealth University, VA, United States, clarson@vcu.edu

We explain how the open source CONJECTURING program can be used to generate conjectures for the integrality gap for IP problems. The conjectures are in the form of upper or lower bounds; these bounds are functions of user-input invariants that may come from the problem being modeled. We use the k-partite Balanced Tree Problem as an example of what is possible. The problem is to partition the vertices of a tree into k sets so that the number of edges with endpoints in different partitions is minimized. We present a variety of conjectured bounds, in terms of the order n, the size m, and other invariants, and discuss an iterative process of investigation—-which is applicable to any similar optimization problem.

5 - Balanced Tree Partitioning

Paul Brooks, Virginia Commonwealth Univ, Dept of Stat Sci and OR, P.O. Box 843083, Richmond, VA, 23284, United States, jpbrooks@vcu.edu

In this talk, we present two integer programming formulations for the k-Balanced Partitioning problem for trees. One is an adaptation of a formulation for all tree partitions. The other is a novel flow-based formulation with a smaller integrality gap. We describe solution strategies and present computational results comparing the formulations.

■ MA75

372D

Algorithms for Structured Optimization Problems II

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Shiqian Ma, Chinese University of Hong Kong, Shatin, Hong Kong, sqma@se.cuhk.edu.hk

Co-Chair: Yunan Zhou, University of Southern California, 2707 Portland Street, Apt 111, Los Angeles, CA, 90007, United States, yunanzho@usc.edu

1 - On the Pervasiveness of Difference-convexity in Optimization and Statistics

Maher Nouiehed, University of Southern California, Los Angeles, CA, United States, nouiehed@usc.edu, Jong-Shi Pang, Meisam Razaviyayn

This paper establishes the dc property of many well-known functions that appear in diverse engineering and statistical problems. Motivated by a quadratic programming (QP) based recourse function, we show that the (optimal) value function of a copositive QP is dc on the domain of finiteness of the program when the objective function's quadratic term matrix and the constraint matrix are fixed. We prove this using a dc decomposition of a piecewise LC1 function (function with Lipschitz gradient). Moreover, we show that many composite statistical functions in risk analysis, including expectation/value-at-risk (VaR)/conditional value-at-risk (CVaR)-based random deviation functionals, are all dc.

2 - Proximal Quasi Newton Methods for Convex Optimization

Hiva Ghanbari, PhD Candidate, Lehigh University, Bethlehem, PA, 18015, United States, hig213@lehigh.edu, Katya Scheinberg

In this work, we analyze the global convergence rate of proximal quasi-Newton algorithm for composite optimization problems, both in the exact and inexact setting, in the case when the objective function is strongly convex. We also investigate a practical variant of this method by establishing a simple stopping criterion for the subproblem optimization. Furthermore, we consider an accelerated variant, to the proximal quasi-Newton algorithm.

3 - On the Resolution of L0-minimization Problems via Alternating Lagrangian Schemes

Yue Xie, Pennsylvania State University, 445 Waupelani Dr, Philadelphia, PA, 16801, United States, yux111@psu.edu

We consider minimization of an objective function that contains l0-norm over a polyhedral set. This problem can be equivalently formulated as a mathematical program with complementarity constraints (MPCC). We prove that weak constraint qualifications hold at feasible points of MPCC, and KKT conditions are sufficient under suitable assumptions. The smooth MPCC formulation are resolved via an ADMM scheme and an augmented Lagrangian scheme. Despite the overall nonconvexity, each ADMM subproblem can be solved efficiently recognizing a hidden convexity property. Moreover, the limit point of both schemes satisfy KKT conditions. Preliminary numerics indicate that these approaches are promising.

4 - Stochastic Game with Chance Constraints: Lagrange Method

Yunan Zhou, University of Southern California, Los Angeles, CA, 90007, United States, yunanzho@usc.edu

In this paper, we study one algorithm for solving a non-cooperative game with expected value function in the constraints via a Lagrange formulation as a min-max game. The algorithm consists of 2 iterative loops. In the outer loop, an approximal point method is applied. And in the inner loop, the Lagrange method is used to relax constraints and then using sample average approximation method, we solve the problem iteratively. The convergence results of both loops are established in almost surely sense.

■ MA76

372E

Decision Diagrams for Optimization

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Thiago Serra, Carnegie Mellon University, Pittsburgh, PA, United States, tserra@cmu.edu

1 - Postoptimality of Mixed-integer Programs with Decision Diagrams

Thiago Serra, Carnegie Mellon University, 527-1/2 Gettysburg Street, Pittsburgh, PA, 15206, United States, tserra@cmu.edu, John Hooker

We consider what-if analyses on the set of near-optimal solutions of a mixed-integer linear program. For example, to determine the objective function impact of changing a variable or to find the combinations of assignments that define near-optimal solutions. In particular, we look at the role that decision diagrams can can play to operationalize MILP postopimality, since the required data can be compiled more concisely and then efficiently retrieved for different queries.

2 - A Binary Decision Diagram Based Algorithm for Solving a Class of Integer Two-stage Stochastic Programs

Leonardo Lozano, Clemson University, 423 Lindsay Road, Apt 104, Clemson, SC, 29631, United States, llozano@g.clemson.edu

We consider a class of two-stage stochastic integer programming problems with binary variables appearing in both stages and a set-covering structure in the second stage. Our approach uncovers strong dual formulations to the second-stage problems by transforming them into dynamic programming (DP) problems parameterized by first-stage variables. These DPs can be formed by use of binary decision diagrams (BDDs), which then yield traditional Benders inequalities. Moreover, we limit the size of the resulting BDDs using concepts related to the minimization of branchwidth on hypergraphs. We demonstrate the efficacy of our approach on a set of stochastic vertex cover problems.

3 - Novel Dynamic Programming Techniques for Discrete Multiobjective Optimization

Andre Augusto Cire, University of Toronto-Scarborough, Department of Management, UTSC, 1265 Military Trail, Toronto, ON, M1C-1A4, Canada, acire@utsc.utoronto.ca, David Bergman, Merve Bodur, Carlos Cardonha

In this talk we present a novel dynamic programming (DP) methodology for addressing discrete multiobjective optimization problems. Our technique applies typical decision-diagram operations to remove dominated solutions from the state-transition graph of a DP model, while exploiting its underlying recursive structure to derive more efficient labeling techniques. We apply this concept to enumerate the pareto frontier in multiobjective variants of the knapsack, set covering, and set partitioning problems, exhibiting orders of magnitude improvements over state-of-the-art general-purpose multiobjective optimization algorithms.

4 - An MDD-based Lagrangian Approach to the One-to-one Multi-commodity Pickup-and-delivery TSP

Margarita Paz Castro, University of Toronto, 5 King's College Road, Toronto, ON, Canada, mpcastro@mie.utoronto.ca, Andre Augusto Cire, Chris Beck

We address the one-to-one multi-commodity pickup and delivery traveling salesman problem (mPDTSP), a variant of the TSP that includes the delivery of a fixed set of commodities by a capacitated vehicle. We propose an approach that uses a discrete relaxation based on Multivalued Decision Diagrams (MDDs) to better represent the combinatorial structure of the problem. We enhance our relaxation by using the MDDs as a subproblem of a Lagrangian relaxation technique, leading to significant improvements both in bound quality and run time performance. Experimental results show that our approach outperforms state-of-the-art methodologies, closing 27 open instances from the literature.

■ MA77

372F

Joint Session OPT/Practice: Recent Progress in Optimization Software I

Sponsored: Optimization, Computational Optimization and Software

Sponsored Session

Chair: Hans Mittelmann, Arizona State University, Tempe, AZ, 85287-1804, United States, mittelmann@asu.edu

1 - Performance Improvements and New Features in the Gurobi Optimizer

Robert E. Bixby, CSO, Gurobi Optimization, Inc., 3733-1 Westheimer Road, Box 1001, Houston, TX, 77027, United States, bixby@gurobi.com

This talk will cover the latest developments in the Gurobi Optimizer, especially performance improvements on MIP and LP, such as new and improved cutting planes, presolve reductions, heuristics and symmetry handling.

2 - Recent Improvements in IBM ILOG CPLEX Optimizer

Andrea Tramontani, IBM.Italy, Via Martin Luther King, 38/2, Bologna, 40132, Italy, andrea.tramontani@it.ibm.com

This talk will cover the latest developments in the CPLEX Optimizer. We will present some of the new features and algorithmic techniques recently added to CPLEX, and we will give benchmark results to assess the performance improvements achieved in the latest CPLEX version.

3 - Stronger Relaxations for Bilinear Terms using Linear Constraints
Benjamin Mueller, Zuse Institute Berlin, Takustr 7, Berlin, 14195, Germany, benjamin.mueller@zib.de, Ambros Gleixner, Felipe Serrano

One of the most important techniques for relaxing nonconvex quadratic constraints are the well-known McCormick inequalities, which describe the convex envelope for a single bilinear term over a rectangular domain. However, it might not be the best choice when taking additional (e.g., linear) constraints into account. Following this line of thought, we use linear programming to obtain inequalities from the problem formulation that can be used to improve the McCormick relaxation of a bilinear term. We use the constraint integer programming framework SCIP to show the impact of the tighter relaxations on instances of the MINLPLib2.

4 - Latest Benchmarks of Optimization Software
Hans Mittelmann, mittelmann@asu.edu

We will report on selected of our benchmarks including on discrete problems and for both open source and commercial software.

■ MA78

381A

Decomposition Approaches for Power Systems Planning under Uncertainty

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Lim Gino, ginolim@central.uh.edu

Co-Chair: Aida Khayatian, University of Houston, Houston, TX, 77057-3197, United States, aida.khayatian@gmail.com

1 - Policymaking for Microgrid Expansion Planning in Electric Power Systems under Uncertainty
Aida Khayatian, University of Houston, 1801 Bering Dr, Apt 736, Houston, TX, 77057-3197, United States, aida.khayatian@gmail.com, Masoud Barati, Gino J. Lim

This paper integrates microgrid expansion planning with generation and transmission planning to study the potential advantages of the grid-connected microgrid. This planning problem faces several challenges such as the competitiveness of power investor companies, environmental restrictions, rural electrification, and uncertainty. To address these challenges via integrating microgrid, this study proposes long-term planning policies. These policies are established based on evaluating the performance of the microgrid in terms of the planning criterions. Computational results from two IEEE 6 and 118-bus test systems are presented to analyze the effectiveness of the proposed policies.

2 - Managing Stored Energy in Microgrids via Multistage Stochastic Programming
Arnab Bhattacharya, University of Pittsburgh, 6236 5th Avenue, Apt 102A, Pittsburgh, PA, 15232, United States, cfcarnabiitkgp@gmail.com, Jeffrey P. Kharoufeh

Energy storage systems can mitigate adverse effects of renewable sources in a microgrid where procurement and storage decisions are made under uncertain demand, renewable supply and prices. A multistage stochastic linear programming model is formulated to minimize the expected total costs in a microgrid, subject to power flow, storage capacity and supply-demand balance constraints. To improve computational tractability, a new regularized stochastic dual-dynamic programming (SDDP) algorithm is employed to obtain high-quality solutions within a reasonable time. A computational study highlights significant cost reductions and computational benefits.

3 - Power Management in Micro Grids with Renewable Source and Storage
Natarajan Gautam, Texas A&M.University, Dept of Industrial and Systems Engineering, Room 4012 Emerging Technologies Building, College Station, TX, 77843-3131, United States, gautam@tamu.edu, Soongeol Kwon

We consider a micro-grid scenario where a significant amount of energy is generated in-house from renewable sources. To combat uncertainty in demand, supply and smart pricing, we consider managing power consumption by the usage of storage devices, energy market and demand response. We formulate and solve a stochastic optimization problem.

■ MA78B

380B

Dynamic Programming/Control

Contributed Session

Chair: Xin Wang, University of Wisconsin-Madison, Middleton, WI, United States, xin.wang@wisc.edu

1 - Dynamic Expediting of an Urgent Order with Uncertain Progress
Luca Bertazzi, University of Brescia, Contrada Santa Chiara, 50, Brescia, 25122, Italy, luca.bertazzi@unibs.it, Riccardo Mogre

A supplier manages an urgent order with uncertain progress for which her client has set a deadline. The supplier observes in real time the order progress and chooses dynamically the effort level to expedite the order. The problem is to identify expediting policies to minimize the expected cost. We formulate a discrete stochastic dynamic programming problem. By conducting a worst-case analysis, we show that decreasing the level of flexibility may lead to a large increase in the cost. Then, we model the case in which the supplier takes into account the negative effects of late order completion. Finally, we compare the two policies using a computational study based on a car seat assembly case.

2 - Accurately Approximating the Value Function in Stochastic Dynamic Programming with Neural Networks
Kyle Perline, Cornell University, Ithaca, NY, 14850, United States, krp73@cornell.edu, Christine A.Shoemaker

In Approximate Dynamic Programming the value function can be approximated with neural networks. We develop a Unimodal Approximation Optimization (UAO) algorithm to tune the neural network architecture more efficiently than existing methods to create a more accurate value function approximation. In general, UAO can be applied to computationally expensive discrete domain optimization problems with noisy objective functions that have a unimodal, but not necessarily convex, mean. We demonstrate on hydropower control problems that this approach yields more accurate control solutions.

3 - How a Cities Open Data Portal Helps Drive the Local Economy
Abdulrahman Habib, Student, University of North Texas, 1404 Sombre Vista Dr, Denton, TX, 76205, United States, abdulrahmanhabib@my.unt.edu, Victor Prybutok

This study explores how the flow of information in smart cities improves the local economy. An open data portal allows municipalities to publish data for public and private analysis that drives decision making. The results of this study also provide insights into why providing data to citizens creates economic opportunity.

4 - Dynamic Pricing with Demand Learning and Reference Price Effect
Nenggui Zhao, University of Science and Technology of China, Jinzhai, He Fei, China, zhaoneng@mail.ustc.edu.cn, Cao Ping, Xiaoming Yan

In this paper, we consider a retailer selling a durable product over a finite horizon, with the objective of maximizing the expected total discounted revenue. In this problem, the customers' arrival rate is unknown and will be learned in a Bayesian way. Moreover, arriving customers' purchase behavior is affected by reference price. First, we analyze the structural properties of the optimal revenue function and the optimal pricing policy. Second, we find that the problem can be simplified in the case of sufficient inventory. Third, we investigate the value of market size and the effect of reference price. Finally, we conduct several numerical examples to justify our theoretical results.

5 - Dynamic Pricing in a Bike Sharing System
Mikhail Gordon, University of Pittsburgh, 241 Mervis Hall, Pittsburgh, PA, 15260, United States, m.gordon@pitt.edu

A bike sharing system is subject to rebalancing daily to keep each station operating at its potential. The use of dynamic pricing allows for incentives to be given to consumers for their starting and ending locations to be altered to lessen the amount of rebalancing necessary for a system.

6 - Optimal Pricing Strategy for Electric Vehicle Sharing Fleet
Xin Wang, University of Wisconsin-Madison, 8916 Red Beryl Drive, Middleton, WI, 53562-4278, United States, xin.wang@wisc.edu, Yuguang Wu

We investigate a dynamic pricing decision problem for an electric vehicle (EV) sharing system who faces time varying stochastic customer demand and electricity price. Demand in each time period reacts to the announced price (like Uber Surge Pricing), while the EV fleet operations and charging decisions are optimized to gain revenue. An approximate dynamic programming based algorithm is proposed to derive the optimal decision policy.

■ MA80

381C

Integrated Energy Markets From Operation to Planning

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Jalal Kazempour, echnical University of Denmark, Kgs Lyngby, 2800, Denmark, seykaz@elektro.dtu.dk

Co-Chair: Christos Ordoudis, Technical University of Denmark, Lyngby, Denmark, chror@elektro.dtu.dk

1 - An Elasticity Model for Joint Gas-grid Expansion Planning Optimization

Pascal Van Hentenryck, University of Michigan, 1813 IOE Building, 1205 Beal Avenue, Ann Arbor, MI, 48108-2117, United States, pvanhent@umich.edu, Russell Bent, Seth Blumsack

Recent trends in gas-fired power plant installation has increased the connections between the electric power and natural gas industries. As a result, undesired situations may arise, such as those experienced by both systems during the winter of 2013/2014 in the northeastern US. This talk considers these challenges and present a Combined Electricity and Gas Expansion (CEGE) planning model. The CEGE model minimizes the cost of meeting gas and electricity demand during high-stress conditions and introduces an elasticity model for analysis of gas-price volatility caused by congestion. We conduct an in-depth analysis on a case-study that include the New England area.

2 - Merchant Storage Investment in a Deregulated Electricity Industry

Afzal Siddiqui, University College London, Department of Statistical Science, Gower Street, London, WC1E 6BT, United Kingdom, afzal.siddiqui@ucl.ac.uk
Afzal Siddiqui, Stockholm University, Stockholm, Sweden, afzal.siddiqui@ucl.ac.uk, Ramteen Sioshansi, Antonio J. Conejo

We develop a bi-level programming model of an imperfectly competitive electricity industry with electricity generation and storage operations at the lower level and storage investment at the upper level. Our analytical results demonstrate that a relatively high (low) amount of market power by generators leads to low (high) storage capacity adoption by a profit-maximising merchant relative to a welfare-maximising ISO. Using a charge on generation ramping between off-peak and peak periods, we illustrate how to incentivise socially optimal storage investment even with a merchant.

3 - Stochastic Programming for Fuel Supply Planning of Combined Heat and Power Plants

Daniela Guericke, Technical University of Denmark, Kgs. Lyngby, Denmark, dngk@dtu.dk, Ignacio Blanco, Henrik Madsen, Juan M. Morales

The consumption of biomass to produce power and heat has increased due to the carbon neutral policies. Combined heat and power (CHP) plants often combine biomass with other fuels, e.g., natural gas. The negotiation process for supply contracts involves many uncertainties due to the long planning horizon. The demand for biomass is uncertain, and heat demand and electricity prices vary during the planning period. We propose a method using stochastic optimization to support the biomass and natural gas supply planning for CHP plants including short-term decisions for optimal market participation.

4 - An Integrated Market for Electricity and Natural Gas Systems with Stochastic Power Producers

Christos Ordoudis, Technical University of Denmark, Technical University of Denmark, Lyngby, Denmark, chror@elektro.dtu.dk, Pierre Pinson, Juan Miguel Morales

Gas-fired power plants can serve as a flexible component to ensure security of supply in energy systems with high shares of fluctuating renewables. In view of a tighter coupling between electricity and natural gas systems, we propose an integrated model that jointly optimizes their operation under uncertain power supply by applying two-stage stochastic programming. We use a formulation that properly models the dynamics of the natural gas system, which is essential in short-term operations to take full advantage of the flexibility of the integrated energy system. Our analysis shows the efficiency of the proposed model in accommodating high shares of renewables in a realistic case study.

■ MA81

382A

Chance-Constrained, Stochastic and Robust MIP and Applications

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Kibaek Kim, Argonne National Laboratory, 9700 South Cass Avenue, Lemont, IL, 60439, United States, kimk@anl.gov

1 - Cardinality Constrained Robust MIP and Submodular Polyhedron

Seulgi Joung, Korea Advanced Institute of Science & Technology, Daejeon, Korea, Republic of, sgjoung22@gmail.com, Sungsoo Park

We consider valid inequalities for the cardinality constrained robust knapsack problem, which can be used to solve the cardinality constrained robust mixed 0-1 programming problems. We define valid inequalities using submodularity of the cardinality constrained robust knapsack set function. We prove that these inequalities define the convex hull of robust continuous knapsack problem with a single continuous variable. In addition, the most violated inequality can be separated in polynomial time using a greedy algorithm. The computational experiments on the robust binary knapsack problem and the robust knapsack problem with continuous variables exhibit the effect of proposed inequalities.

2 - Parallel Dual Decomposition with Branch-and-Bound Method

Kibaek Kim, Assistant Computational Mathematician, Argonne National Laboratory, 9700 South Cass Avenue, Building 240, Lemont, IL, 60439, United States, kimk@anl.gov

We present a parallel dual decomposition that decouples a large-scale MIP problem into tractable smaller subproblems by the Lagrangian relaxation of coupling constraints in the problem. On top of it, we also develop a branch-and-bound method that ensures integer feasibility with respect to the primal integer variables. Unlike the one in Caroe and Schultz, our method branches on the primal integer variables characterized in the Dantzig-Wolfe decomposition space. Computational results are presented for various problem instances.

3 - A Stochastic Optimization Approach to Maintenance Turnaround Planning in Integrated Chemical Sites

Sreekanth Rajagopalan, Carnegie Mellon University, 5000 Forbes Avenue, Doherty Hall 4200, Pittsburgh, PA, 15213, United States, sreekanth@cmu.edu, Nikolaos Sahinidis, Satyajith Amaran, Scott Bury

An integrated chemical site is a network of processing plants that consume and produce a variety of chemical products. A maintenance turnaround is a capital and resource intensive maintenance project that requires a long planned outage. We investigate enterprise-wide approaches to plan turnarounds in an integrated chemical site on a medium-term horizon; specifically, we propose a stochastic optimization model that incorporates production reliability for simultaneous production and turnaround planning. We compare different policies for heuristics within a decomposition scheme.

4 - A Hybrid Constraint Removal Scheme in Scenario Approach for Chance-constrained Programs

Roya Karimi, University of Arizona, 1725 N.park Ave, #1E, Tucson, AZ, 85719, United States, royakarimi1993@email.arizona.edu

In this talk, we consider the constraint removal method in the scenario approach for solving chance constrained programming problems.We introduce two constraint removal schemes: one model-free and the other model-based, as well as the ideas behind them. Furthermore, to show the strength of our proposed methods, a comparison with other existing approaches is provided in an extensive numerical study on a semidefinite optimization problem in control theory.In addition, the proposed methods can be applied to solve a wide range of practical problems.

■ MA82

382B

Optimization and Learning in Decision Processes

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Mahshid Salemi Parizi, Seattle, WA, 98105, United States, msalemip@uw.edu

Co-Chair: Archis Ghate, University of Washington, University of Washington, Shoreline, WA, 98155, United States, archis@u.washington.edu

1 - Weakly Coupled Markov Decision Processes with Parametric Uncertainty

Mahshid Salemi Parizi, 3801 Brooklyn Ave NE, Apt M304, Seattle, WA, 98105, United States, msalemip@uw.edu

We consider a class of stochastic dynamic programs where multiple, otherwise independent, subproblems are linked via constraints. This problem class is known as weakly coupled Markov decision processes (MDP). We consider the case where transition probabilities for each subproblem are unknown to the decision maker. The decision maker thus attempts to balance learning (exploration) with reward maximization (exploitation). Tractable approximate dynamic programing methods rooted in the Bayesian learning framework will be presented.

2 - Backward ADP with Hidden Semi-Markov Information Models

Joseph L.Durante, Princeton University, Princeton, NJ, United States, jdurante@princeton.edu, Juliana Nascimento, Bolong Cheng, Warren B.Powell

We consider an energy storage problem involving a wind farm with a forecasted power output, a power demand, an energy storage device, and a connection to the larger power grid (with associated electricity prices). The stochastics are modeled using a novel hidden semi-Markov model which accurately replicates both forecast error distributions and the periods of time for which a process stays above or below its forecast. We derive near-optimal time-dependent policies using a technique we call backward approximate dynamic programming, which overcomes the computational hurdles of classical (exact) backward DP, and achieves higher quality solutions than the more familiar forward ADP methods.

3 - Optimal Learning with General Nonlinear Belief Models

Xinyu He, Princeton University, Princeton, NJ, 08544, United States, xinyuhe@princeton.edu, Warren B.Powell

We consider the problem of optimizing an unknown function over a multidimensional continuous space, where function evaluations are noisy and expensive. We assume that a globally accurate model of the function is not available, but there exist some parametric models that can well approximate the function locally. We propose an algorithm, using local approximation technique and optimal learning policies, to quickly learn the shape of the function and find the optimal design. Experiments on both synthetic problems and a real materials science application show the strong performance of our algorithm.

■ MA83

382C

Joint Session OPT/Practice: Stochastic Inventory Management

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Xiting Gong, The Chinese University of Hong Kong, Hong Kong, xtgong@se.cuhk.edu.hk

1 - Dynamic Inventory Management under Stockout Substitutions

Tianxiao Chen, The Chinese University of Hong Kong, ERB615, CUHK, Shatin, Hong Kong, chentx@se.cuhk.edu.hk, Xiting Gong

In this paper, we consider a periodic-review inventory control problem with two products which can be substituted if one of them is out of stock. We formulate the problem as a two-dimensional dynamic program and characterize the structure and asymptotic bounds of the optimal policy under a wide range of parameter settings.

2 - Dynamic Pricing and Inventory Management under Network Externalities

Renyu Zhang, Assistant Professor, New York University Shanghai, 1555 Century Avenue, Shanghai, 200122, China, renyu.zhang@nyu.edu, Nan Yang

We study the impact of network externalities on a firm's joint pricing and inventory policy under demand uncertainty. A customer's willingness-to-pay and, thus, the potential demand are increasing in the past sales of the product. We show that the presence of network externalities gives rise to the tradeoff between generating current profits and inducing future demands, thus having several important operational implications. For example, network externalities prompt the firm to provide better services to customers. We also propose a dynamic look-ahead heuristic policy with optimality gaps decaying exponentially in the forward-looking time length.

3 - Analysis of Ordering Strategies under Market Competition and Capacity Constraint

Weili Xue, Southeast University, Hankou Road 22, Nanjing, China, weili@seu.edu.cn

In this paper, we consider a supply chain with a manufacturer and two retailers, in which the two retailers compete in the same consumer market and the manufacturer has capacity constraint. Each manufacturer can order before or after demand uncertainty realization. We characterize the equilibrium ordering strategies and show that an asymmetric equilibrium may exist even for the symmetric setting when the supplier's capacity is constrained and the wholesale prices are exogenously determined. We further extend our result to the case when the capacity is unlimited and when the wholesale prices are endogenously determined.

Monday, 10:00 - 10:50AM

■ Monday Plenary

Hilton- Ballroom of Americas, Level 2

Optimization: Past, Present, Future

Plenary

Invited Session

1 - Sports Scheduling Meets Business Analytics

Bob Bixby, Gurobi

For the vast majority of business applications, optimization means linear and mixed-integer programming. Beginning with Dantzig's simplex method in 1947, optimization experienced a slow, uneven period of development into the mid 1980s. Then, beginning in the late 1980s, developments ensued that completely transformed optimization and its applications, driven by truly remarkable performance improvements in the underlying solvers. What's coming next may be even more exciting. Driven by an explosion in available business data, a new broad corporate focus on extracting value from that data, increased computing power, and the continually expanding power of optimization solvers, optimization promises to become an indispensable tool in managing the modern enterprise.

Monday, 11:00 - 12:30PM

■ MB01

310A

Risk Attitudes

Sponsored: Decision Analysis

Sponsored Session

Chair: Andrea Hupman Cadenbach, University of Missouri-St. Louis, St Louis, MO, 63121, United States, cadenbach@umsl.edu

1 - Risk Attitudes in Disaster Planning

Vicki Bier, University of Wisconsin, Madison, WI, United States, vicki.bier@wisc.edu

This talk discusses some implications of risk attitudes (specifically, risk aversion) for disaster planning. Surprisingly, if we take risk aversion seriously, it may mean that we are being overly protective against radiation-induced fatalities following nuclear incidents. However, "psychic numbing" may make it difficult to use risk aversion to encourage preparedness.

2 - Risk Attitude Modeling in Homeland Security Decisions

Ali E. Abbas, University of Southern California, OHE 310R, 3650 McClintock Ave, Los Angeles, CA, 90089, United States, aliabbas@usc.edu

Decision Analysis is a normative approach for making decisions in the face of uncertainty, and can be applied to a variety of decisions. The field of utility theory is often misused and replaced by other non-normative approaches under the umbrella of decision analysis. This talk will discuss an application of utility theory in homeland security decisions and discuss some widely used (and flawed) approaches.

3 - New Results on Risk Attitudes in Operations Decisions
Andrea Hupman Cadenbach, University of Missouri-St. Louis, 211 Express Scripts Hall, 1 University Boulevard, St Louis, MO, 63121, United States, cadenbach@umsl.edu

Previous results in the literature have shown that in repeated newsvendor decisions, the optimal ordering policy for a risk averse decision maker is approximately the same as for a risk neutral decision maker. These results, however, are based on an assumption of independent demand from one period to the next. In this talk, we present new results that show that in the presence of demand dependence, the optimal ordering policy for a risk averse decision maker differs from the optimal risk neutral policy. These results are extended to a general sequential decision making scenario.

4 - Theory of Generalized Risk Attitudes
Janne Gustafsson, Ilmarinen Mutual Pension Insurance Company, Porkkalankatu 1, Helsinki, 00018, Finland, janne.gustafsson@gmail.com

This paper develops a theory of risk attitudes that is based on the premise that a risk neutral decision maker (DM) is indifferent between a lottery and the average (in terms of preference) of the outcomes obtained from infinite repetition of the lottery. We show that a risk neutral DM seeks to maximize the expectation of measurable value. The results suggest that (i) the DM's risk attitude in expected utility theory is related to the transformation between the measurable value function and the von Neumann-Morgenstern utility function and (ii) the applicability of the conventional definitions of risk attitudes is limited to settings in which the DM's measurable value function is linear.

■ MB02

310B

Beliefs in Environmental Decision-making Processes

Sponsored: Decision Analysis

Sponsored Session

Chair: Melissa A Kenney, University of Maryland, College Park, MD, 20740, United States, kenney@umd.edu

1 - Finding Common Ground when Experts Disagree: Energy and the Environment
Erin Baker, University of Massachusetts-Amherst, MIE, 220 Elab, Amherst, MA, 01003, United States, edbaker@ecs.umass.edu, Ahti Salo, Valentina Bosetti

We address the problem of decision making under "deep uncertainty," introducing an approach we call Robust Portfolio Decision Analysis. We derive a set of portfolios that are non-dominated across beliefs; and then identify robust individual alternatives from the non-dominated portfolios. The process allows us to synthesize multiple expert- or model- based beliefs by uncovering the range of alternatives that are intelligent responses to the range of beliefs. We show that this method encompasses many of the robustness concepts in the literature. We illustrate our approach using a problem in the climate change and energy policy context: choosing among clean energy technology R&D portfolios.

2 - Effect of Decision Rules on Chemical Alternatives Assessment
Michael Gerst, University of Maryland, 1337 Meridian Place NW, Washington, DC, 20010, United States, mgerst@umd.edu, Melissa A.Kenney, Brett Howard

Alternatives assessment (AA) is an overarching term for the process of identifying, comparing, and selecting safer alternatives to chemicals that might pose a risk to humans or the environment. To date, many methods have been produced, each with foci that largely align with the discipline producing the method. We demonstrate the efficacy of a multi-criteria approach in an AA of 14 paint stripper chemicals by showing its flexibility compared to other decision rules.

3 - Characterizing the Evolution of Global Ground-water Stress
Roshanak Nateghi, Characterizing Global Ground Water Storage Trends, Purdue University, West Lafayette, IN, 47906, United States, rnateghi@purdue.edu, C. Bayan Bruss, Benjamin Zaitchik

Groundwater is a key element of global access to water resources; and has important implications for political stability, economic growth and public health in every society. Recent rapid population growth, and increased rates of urbanization have led to groundwater stress. Identifying the national-scale drivers of groundwater storage trends is the key first step for understanding water availability and devising sustainable water management policy in a changing climate. In this research we have conducted extensive data analyses to find the key predictors of the observed groundwater storage trends using agricultural, climate, demographic, land-use and economic variables in 81 countries.

4 - Decision Analysis Approach to Environmental Model Interpretation
Melissa A. Kenney, Associate Research Professor, University of Maryland, 5825 University Research Court, Suite 4001, College Park, MD, 20740, United States, kenney@umd.edu, Eva D. Regnier, Michael Gerst

Bayesian reasoning - asking what model output we ought to expect as a function of the possible realities - is rarely applied to the interpretation of the output from mechanistic models. Specifically, our framework treats the model as an evidence-generating process from which the analyst considers the joint relationship between reality and model output. This process yields a likelihood function that (i) serves to guide what questions should be asked in the model building and validation process and (ii) how insights should be updated given prior information and model outputs. To illustrate the approach, we discuss physical climate models and integrated assessment models.

■ MB03

310C

Humanitarian Logistics

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, 77204, United States, jopeng@Central.uh.edu

Co-Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Humanitarian Logistics
Bahar Yetis Kara, Bilkent University, Ankara, Turkey, bkara@bilkent.edu.tr, Sinem Sava er

Many incidents requiring humanitarian assistance, which can be categorized mainly as disasters and long term crises, have taken place in the recent years. Humanitarian logistics play a crucial role in managing these events because of the response time constraints, limited resource amounts and high levels of uncertainty. Therefore, it is apparent that the challenges faced in humanitarian logistics differ from the conventional challenges encountered in commercial logistics applications such as having conflicting goals for different parties, funding and political issues. In this tutorial, we provide an introduction to humanitarian logistics by defining its characteristics, application areas and challenges. Then, we analyze and synthesize relief logistics and development logistics literature based on Operations Research (OR) problems encountered in disaster management cycle while putting emphasis on the last 10 years. For various disaster management stages; namely preparedness and response phases, certain case studies will be discussed using a real life dataset from Kartal region of Istanbul. Moreover, for development logistics, a case study on providing healthcare in rural areas will be evaluated.

■ MB03A

Grand Ballroom A

Cloud Computing and Data Centers in Applied Probability I

Sponsored: Applied Probability

Sponsored Session

Chair: Alexander Stolyar, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, stolyar@illinois.edu

1 - On TTL Caching in Content Delivery Networks
Sanjay Shakkottai, University of Texas-Austin, ENS.437 ECE Department, Austin, TX, 78712, United States, shakkott@austin.utexas.edu, Soumya Basu, Aditya Sundarrajan, Javad Ghaderi, Ramesh Sitaraman

We study TTL caching in content delivery networks (CDNs). Using a stochastic approximation approach, we develop algorithms that adapt the time-to-live parameter to current workloads, and demonstrate performance gains over the state-of-art.

2 - Control of Parallel Server Systems with Learning
Yuan Zhong, University of Chicago, Booth School of Business, Chicago, IL, 60637, United States, Yuan.Zhong@chicagobooth.edu, Jean Walrand

We consider parallel server processing systems, where the service rates have dependence on both the job class and the server, and we are interested in control policies that do not assume knowledge of system parameters. First, we show that the classical max-weight policy, modified under certainty equivalence, is not throughput optimal, hence the necessity of forced learning. Then, we propose two classes of control policies that incorporate learning in different ways and prove that both classes are throughput optimal.

3 - Mixing Time and Structural Inference for Bernoulli Auto-regressive Processes
R. Srikant, UIUC, Urbana, IL, United States, rsrikant@illinois.edu, Carolyn Beck, Dimitris Katselis

We introduce a multivariate random process called a Bernoulli Autoregressive Process (BAR). A BAR process models a discrete-time vector random process where the components of the vector are represented by the nodes in a graph. We show that the BAR process mixes rapidly, by proving that the mixing time is O(log p). For a network with p nodes, where each node has in-degree at most d<<p, we provide a greedy algorithm that can efficiently learn the structure of the underlying directed graph with a sample complexity proportional to the mixing time of the BAR process.

4 - Large-scale Join-idle-Queue System with General Service Times
Alexander Stolyar, University of Illinois at Urbana-Champaign, Urbana, IL, United States, stolyar@illinois.edu, Sergey Foss

A parallel server system with n identical servers is considered. Customer service times are i.i.d. with finite mean 1/mu. Join-Idle-Queue routing algorithm is studied, under which an arriving customer is sent to an idle server, if such is available, and to a randomly uniformly chosen server, otherwise. We consider the asymptotic regime where n goes to infinity and the customer input rate is lambda n. Under the condition lambda/mu<1/2 we prove that the sequence of (appropriately scaled) stationary distributions concentrates at the natural equilibrium point, with the fraction of occupied servers being constant equal lambda/m. In particular, the steady-state probability of waiting vanishes.

■ MB03B

Grand Ballroom B

Trade-offs in Revenue-driven Marketplaces

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Yonatan Gur, Stanford University, Stanford, CA, 94305, United States, ygur@stanford.edu

1 - Revenue Management with Repeated Interactions
Dragos Florin Ciocan, INSEAD, Street 1, Fontainebleau, France, florin.ciocan@insead.edu, Andre Du Pin Calmon, Gonzalo Romero

We consider a revenue management problem where a platform interacts with a set of customers over a number of epochs. Unlike traditional network revenue management, we consider customers who maintain state over the epochs - their state depends on the quality of their past service with the platform. There is thus a non-trivial trade-off between the platform myopically maximizing short term revenues, versus maximizing the long term goodwill of its customers. We develop policies that are good approximations of the optimal for this problem.

2 - Revenue Loss under Constrained Allocations in Centralized Marketplaces
Xavier Warnes, Stanford University, Stanford, CA, United States, xwarnes@stanford.edu, Yonatan Gur, Dan Andrei Iancu

In many online marketplaces where consumers are assigned to providers, a centralized planner aims to maximize instantaneous revenue while accounting for various considerations that may impact long run sustainability. We formulate a broad class of constraints that includes fairness and discrimination among providers, and study the efficiency loss associated with these constraints.

3 - Revenue-maximizing Rankings for Online Platforms with Quality-sensitive Consumers
Nicolas Stier-Moses, Universidad Torcuato Di Tella, Buenos Aires, Argentina, nstier@utdt.edu, Pierre L'Ecuyer, Patrick Maille, Bruno Tuffin

When keywords are searched in search engines, classified ads websites, or online retailers, platforms can return any permutation of results. Two extreme rules are to use rankings based on estimated relevance (which improves customer experience in the long run because of quality) or on expected immediate revenue (which improves short-term revenue). A key question is what middle ground between them should be chosen. We introduce stochastic models that combine both strategies, anticipating that the rate of user visits depends on the quality provided by the ranking policy, and propose effective solution methods to compute rankings that optimize long-term revenues.

4 - Dynamic Collateral Management for a Prime Brokerage
Vivek Farias, MIT, 100 Main Street, Cambridge, MA, 02142, United States, vivekf@mit.edu, Eli Gutin

Ever since the 2008 financial crisis, collateral management for secured lending has assumed an important place in financial markets. In this work, we study the collateral management problem (CMP), faced by a prime brokerage, through the lens of multi-period stochastic optimization. We show that a simple dual price based algorithm is not only asymptotically optimal, but has constant additive loss relative to an optimal algorithm. We back-test the method on data from a prime brokerage and find material increases in revenue.

■ MB03C

Grand Ballroom C

MSOM Special Speaker: David Simchi-Levi

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Tunay Tunca, Unversity of Maryland, 8803 Courts Way, Silver Spring, MD, 20910, United States, ttunca@rhsmith.umd.edu

1 - Online Resource Allocation with Applications to Revenue Management
David Simchi-Levi, Massachusetts Institute of Technology, Dept of Civil and Environmental Engineering, 77 Massachusetts Avenue Rm 1-171, Cambridge, MA, 02139, United States, dslevi@mit.edu

Online resource allocation is a fundamental problem in OR and CS with applications such as offering products to customers, distributing jobs to candidates, assigning advertisers to ad slots, and matching drivers to passengers. These problems can be abstracted as follows: there are fixed resources, each of which can be sold at multiple known prices. These resources must be allocated on-the-fly, without assuming anything about future demand. In this talk we cover the CS and OR literature on the problem and in particular focus on two techniques: exploration and exploitation methods, as well as competitive analysis.

■ MB04

320A

Sustainable Food Supply and Food Waste

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Elena Belavina, University of Chicago Booth School of Business, Chicago, IL, 60637, United States, elena.belavina@chicagobooth.edu

1 - Design of Sales Force Compensation Schemes to Reduce Product Waste
Arzum E. Akkas, Boston University, 100 Memorial Drive, 8-11C, Cambridge, MA, 02142, United States, aakkas@bu.edu

We empirically examine sales-force compensation schemes of manufacturers that impact expiration of consumer-packaged-goods (CPG) at retailers to identify incentive-aligning compensation schemes. Using sales commission data from a CPG manufacturer, we investigate the impact of counterfactual schemes on manufacturer's profit and product waste based on our model of sales-force decision process.

2 - Dynamic Staffing of Volunteer Gleaning Operations
Erkut Sonmez, Boston University, 1496 Beacon St, Apt 4, Brookline, MA, 02446, United States, sonmez@bu.edu, Baris Ata, Deishin Lee

Gleaning programs organize volunteer gleaners to harvest leftover crops that are donated by farmers for the purpose of feeding food-insecure individuals. Thus, the gleaning process simultaneously reduces food waste and food insecurity. However, the operationalization of this process is challenging because gleaning relies on two uncertain sources of input: the food and labor supplies. We develop a model to capture the uncertainties in food and labor supplies and seek a dynamic volunteer staffing policy that maximizes the long run average volume of food gleaned.

3 - Economically Motivated Adulteration in Farming Supply Chains: the Role of Supply Chain Dispersion and Traceability
Somya Singhvi, MIT, 235 Albany Street, Cambridge, MA, 02139, United States, ssinghvi@mit.edu, Retsef Levi, Yanchong Zheng

We develop a game-theoretic analytical model to study the effects of quality uncertainty, supply chain dispersion, traceability, and testing accuracy on economically motivated adulteration (EMA) in a farming supply chain with a distributed network of farmers. We further analyze the manufacturer's optimal investment in traceability and testing frequency to satisfy a risk constraint while minimizing costs. We leverage the analysis of our model to derive important and new insights that can inform both policy makers and commercial entities in food supply chains to address EMA risks. We also use data from real world case studies to calibrate our model and highlight its 'predictive' power.

4 - Food Waste in Grocery Retail

Elena Belavina, University of Chicago Booth School of Business, 5807 S.Woodlawn Ave, Chicago, IL, 60637, United States, elena.belavina@chicagobooth.edu

Food waste is a major contributor to carbon emissions (as big as road transport). Identifying and influencing market conditions that can decrease food waste is thus important to combat global warming. We build and calibrate a stylized two-echelon perishable-inventory model to capture grocery purchases and expiration at competing stores and households in a market. We examine how the equilibrium waste in this model changes with store density. Our analysis shows that higher density reduces food waste up to a threshold density; it leads to higher food waste beyond this threshold. Put differently, in so far as food waste is concerned, there exists an optimal store density.

■ MB05

320B

Analytics in Medical Decision Making and Population Health

Sponsored: Health Applications

Sponsored Session

Chair: Turgay Ayer, Georgia Institute of Technology, Atlanta, GA, 30332, United States, ayer@isye.gatech.edu

Co-Chair: Anthony Bonifonte, Georgia Institute of Technology, Austell, GA, 30106, United States, ABonifon@gatech.edu

1 - Analytics in Blood Pressure Management: From Data to Decisions

Anthony Bonifonte, Georgia Institute of Technology, 5940 Water Oaks Dr, Austell, GA, 30106, United States, ABonifon@gatech.edu, Turgay Ayer, Ben A.Haaland, Ben A.Haaland

Antihypertensive drug treatment can control elevated blood pressure (BP) and reduce the risk of cardiovascular disease. We propose data-driven models that capture heterogeneity in BP progression and combine stochastic optimization and statistics to identify the optimal thresholds for initiating treatment and for increasing the treatment dosage. We analytically characterize the expected value and variance of the hazard ratio, which enables us to easily compute the optimal treatment decisions, and capture different attitudes towards risk (e.g. risk neutral or risk averse). Our findings may help guide future RCT design for hypertension treatment.

2 - Prioritizing Hepatitis C Treatment in U.S. Prisons

Turgay Ayer, Georgia Institute of Technology, School of Industrial and Systems Engineering, Groseclose 417, Atlanta, GA, 30332, United States, ayer@isye.gatech.edu, Can Zhang, Anthony Bonifonte, Jagpreet Chhatwal, Anne Spaulding

Prison systems offer a unique opportunity to control the hepatitis C virus (HCV) epidemic. New HCV treatments are very effective, but providing treatment to all inmates is prohibitively expensive. We propose a restless bandit modeling framework to support HCV treatment prioritization decisions in U.S. prisons. Parameterized by real-world data, we derive a closed-form index policy and demonstrate the improvement in our policy over current practice and benchmark policies. Our results shed light on several controversial health policy issues in HCV treatment prioritization in the prison setting and have important policy implications, such as needing to consider more than health state of inmates.

3 - Dynamically Consistent Home Health Care Routing and Scheduling

Seyma Guven-Kocak, Georgia Institute of Technology, Atlanta, GA, United States, seymaguven@gatech.edu, Pinar Keskinocak, Alejandro Toriello, Aliza R.Heching

This work addresses a real-world home health care routing and scheduling problem (HHCRSP) faced by a home care agency in the U.S. In home health care scheduling, there is a desire to retain consistency with respect to the aides servicing each patient, which is referred to as continuity of care. In order to handle continuity of care, we propose a dynamic approach and introduce the dynamically consistent home health care routing and scheduling problem (D-Con-HHCRSP). We present solution methods to address HHCRSP and D-Con-HHCRSP, where the goal is to be able to quantify and control the deviation from the existing schedule in place, so that some of the existing assignments may be retained in the new schedule.

4 - Short-term Mortality Prediction in a Cohort of Cancer Patients

Ying Zhuo, Massachusetts Institute of Technology, 70 Lincoln Street, Unit L612, Boston, MA, 02111-2670, United States, zhuo@mit.edu, Dimitris Bertsimas, Colin F. Pawlowski, John M. Silberholz, Alexander M. Weinstein, Eddy Chen, Aymen Elfiky

As cancer patients often receive aggressive and potentially unnecessary care at the end of life, there is significant need to accurately predict mortality. We obtained 11 years of electronic health records (EHR) from a large cancer center and engineered 401 features: demographics, genomics, vitals, lab tests, etc. We identified 23,983 patients who initiated 46,646 anti-cancer regimens. We fitted state-of-the-art machine learning models to predict 60-, 90- and 180-day mortality and achieved out-of-sample AUCs of 0.90, 0.89, 0.87, respectively, significantly higher than existing models.

■ MB06

320C

Health Policy Modeling, Analysis, and Insight

Sponsored: Health Applications

Sponsored Session

Chair: Pooyan Kazemian, PhD, Harvard Medical School, Boston, MA, 02114, United States, pooyan.kazemian@mgh.harvard.edu

1 - Flexible FDA Approval Policies

Taylor Corcoran, University of California-Los Angeles, 110 Westwood Plaza, Los Angeles, CA, 90024, United States, taylor.corcoran.1@anderson.ucla.edu, Elisa Frances Long, Fernanda Bravo

Current U.S. FDA approval standards require pharmaceutical companies to demonstrate drug efficacy at a 0.05 significance level using clinical trial outcomes. This policy ignores heterogeneity in disease characteristics, such as the severity and prevalence, the level of research and development taking place, and the number of alternative drug treatments available for patients. We develop a queueing framework to analyze the drug approval process that incorporates such factors. We derive optimal approval policies and conduct a numerical study for three diseases (HIV, hypertension, and breast cancer).

2 - Same-day Follow-up Appointments, Spoilage, and Continuity of Care: An Empirical Investigation

Xiaoxu Tang, University of Minnesota, Minneapolis, MN, United States, tangx238@umn.edu, Diwakar Gupta, Yichuan Ding

We use a proprietary dataset (2M+ records) to study follow-up appointments in outpatient clinics. We propose methodologies to tag episodes of care and measure continuity of care and appointment-slot spoilage (late cancellation or no-show). We find that same-day follow-up (SDFU) appointments (those booked on the day the prior appointment occurred) have greater continuity of care and higher spoilage rate while controlling for patient, physician, and clinic characteristics. Counterfactual analysis is performed to evaluate SDFU appointments as a strategy for managing follow-ups.

3 - Robust Optimization Framework to Account for Prediction Errors for Cancer Diagnosis

Selin Merdan, University of Michigan, 1640 McIntyre Street, Ann Arbor, MI, 48105, United States, smerdan@umich.edu, Brian T.Denton

In the early detection and diagnosis of disease, multiple diagnostic tests are often available in discriminating between diseased and nondiseased individuals; however, how best to use these tests to render a diagnosis is challenging because there is often a tradeoff between the benefits of an accurate diagnosis of the anticipated disease and harms and costs associated with the diagnostic tests themselves. The motivation for our work in this research is to combine multiple diagnostic tests into an optimal composite diagnostic testing, which will provide a good balance between unnecessary testing and missed cases with higher sensitivity and specificity in the context of prostate cancer detection.

4 - Optimizing Monitoring Policies under Unknown Patient Adherence

Zhenhuan Zhang, University of Minnesota, 425 13th Ave SE Apt.1001, Minneapolis, MN, 55414, United States, zhan4490@umn.edu, Diana Maria Negoescu

In most instances of disease management, adherence to treatment is crucial to treatment success. However, measurements of patient adherence are often noisy and adherence behavior is unknown to physicians prior to treatment initiation. We optimize HIV Viral Load (VL) monitoring policies in this setting, and assess the total costs and quality-adjusted life years achieved by different policies.

5 - Estimating the Economic Cost of Physician Burnout in the United States

Shasha Han, NUS.Business School, Biz 2 Building B1, 1 Business Link, PhD office, NUS.business school, Singapore, Singapore, shashahan@u.nus.edu, Tait D. Shanafelt, Christine A. Sinsky, Karim Awad, Joel Goh

Importance: Even though physician burnout is known to be associated with negative clinical and organizational outcomes, the costs of burnout are poorly understood. Consequently, leaders of healthcare institutions cannot properly assess the benefits of initiatives to remediate physician burnout.Objective: To estimate the annual cost associated with physician burnout in the United States and to develop a methodology for individual healthcare institutions to estimate their institution-level costs associated with physician burnout.

■ MB07

322A

Modeling of Pharmacy Operations

Sponsored: Health Applications

Sponsored Session

Chair: Bryan A Norman, University of Pittsburgh, Pittsburgh, PA, 15261, United States, banorman@pitt.edu

1 - Determining Optimal Policies for Medication Dispenses to In-patient Units

Anna Svirsko, University of Pittsburgh, 4200 Fifth Avenue, Pittsburgh, PA, 15260, United States, ACS167@pitt.edu, Bryan A. Norman, Seth Hostetler

While many hospital pharmacies have seen drastic improvement in their service due to technological improvements such as automated dispensing cabinets (ADCs) and pharmacy robots, these systems continue to faces challenges with how best to use these technologies. We have created a math programming model which reduces the number of missing medications and the system cost by identifying a standard pathway through which medications are dispensed to patients with considerations for the medication ordered, the dose type, the unit, and the forecasted demand for the medication. Key findings are illustrated through reviewing the results of the math program on the in-patient units of a local health system.

2 - Locating an Automated Central Filling Pharmacy for a Community Pharmacy Network

Hamdy Salman, University of Pittsburgh, Pittsburgh, PA, United States, hgs6@pitt.edu

Community pharmacies play an important role in providing patient safety by providing Medication Therapy Management (MTM). One of the strategies to provide more MTM in a community pharmacy is to use an automated Central Fill. An automated central fill offloads part of the pharmacy's prescription filling process. Our research focuses on locating a central fill that can provide relief for multiple pharmacies under stochastic demands. We provide a chance constrained capacitated facility location model when pharmacy demands are variable. The results include a comparison between using a chance constraint model and using a simpler policy to determine the central fill location.

3 - Automated Dispensing System Inventory Policy

Vera Tilson, University of Rochester, 3-343 Carol Simon Hall, W.E. Simon Graduate School of Business, Rochester, NY, 14627, United States, Vera.Tilson@simon.rochester.edu, Gregory Dobson

We discuss ILP formulation for computing inventory policy parameters for an Automated Medication Dispensing System.

4 - Modeling Clinical and Operational Workflows in Community Pharmacies

Kathryn Smith, NCSU, 2051 Trexler Court, Raleigh, NC, 27606, United States, knsmith4@ncsu.edu, Julie Simmons Ivy

As healthcare moves from fee-for-service to outcomes-based performance, community pharmacies are providing enhanced clinical services such as comprehensive medication reviews (CMRs). Through CMRs, pharmacists identify potential drug therapy problems that may interfere with patient adherence or cause adverse outcomes. This information facilitates communication between clinicians and pharmacists and can improve care. We developed a discrete event simulation of the clinical and operational workflows of multiple community pharmacies to evaluate patient wait times, prescription flow times, and staff utilization.

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■ MB08

322B

The Supply Side of Organ Transplantation Systems

Sponsored: Health Applications

Sponsored Session

Chair: Burhaneddin Sandikci, University of Chicago, Chicago, IL, 60637, United States, burhan@chicagobooth.edu

Co-Chair: Sait Tunc, University of Chicago, Chicago, IL, 60637, United States, Sait.Tunc@chicagobooth.edu

1 - Allocative Efficiency and New Supply in Kidney Exchange

Mohammad Akbarpour, Stanford University, Stanford, CA, United States, mohamwad@stanford.edu

We present a simple model of matching in stochastic networks and discuss the role of "timing" in the efficient allocation of kidneys in organ markets. We will show that, under some conditions, creating market thickness is highly valuable. Nevertheless, even the most efficient matching policies are constrained with the fundamental thickness of the market, which is the arrival of donors to the system. We will , therefore, ask a new question: What are the ways we can increase the arrival rate of donors? We will discuss two radical solutions: Creating a global exchange market, and removing the problem of double-coincidence of wants through a "token" system.

2 - Jumping the Line, Charitably: Analysis and Remedy of Donor-priority Rule

Tinglong Dai, Johns Hopkins University, 100 International Dr, Baltimore, MD, 21202, United States, dai@jhu.edu, Ronghuo Zheng, Katia P. Sycara

The ongoing shortage of organs for transplantation has generated an expanding literature on organ allocation. By contrast, organ donation has been little explored. In this paper, we develop a parsimonious model of organ donation to analyze the donor-priority rule, which grants registered organ donors priority in receiving organ. In view of the potentially undesirable social-welfare consequences, we propose a freeze-period remedy.

3 - Expanding the Donor Pool: the Use of Marginal Organs for Transplantation

Sait Tunc, University of Chicago, Chicago, IL, United States, sait.tunc@chicagobooth.edu, Burhaneddin Sandikci

Despite the efforts to increase the supply of donated organs for transplantation, organ shortage keeps increasing as the demand outpaces supply. We study the use of marginal organs for transplantation, which has been receiving increased attention in the medical community to alleviate the burden of shortages, in a queueing theoretic framework. In particular, we examine the equilibrium impact of offering marginal organs to patients who have low access to high quality organs, and conduct welfare analysis to understand the effect of individuals' decisions on social welfare. We provide policy incentives to increase the utilization of marginal organs while improving the social welfare.

4 - The Effects of Patient Portals on Kidney Allocation and Transplant Outcomes

Yeongin Kim, University of Texas-Dallas, Richardson, TX, Yeongin.Kim@utdallas.edu, Mehmet U.S. Ayvaci, Srinivasan Raghunathan, Bekir Tanriover

The recent healthcare reform promotes the use of information technology, such as patient portals, to provide patients better access to information source. Motivated by the kidney transplant decision, we empirically analyze the impact of the patient portals adoption on outcomes including time to transplant and time to drop out of the transplant waiting list. We show that the adoption of a patient portal is positively associated with the probability of receiving a deceased-donor kidney and negatively associated with the probability of receiving a living-donor kidney. The probability of drop-out from the waiting list due to worsened health conditions decreases with the adoption of a patient portal.

■ MB10

330B

Improving Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Claudia Rosales, Michigan State University, East Lansing, MI, 48824, United States, Rosales@broad.msu.edu

1 - On the Relations between Operational Focus, Operating Experience, and Operational Performance: Evidence from Patient Discharges in Cardiology Operating Units

David Zepeda, PhD, Northeastern University, 214 Hayden Hall, 360 Huntington Avenue, Boston, MA, 02115, United States, d.zepeda@northeastern.edu, Gilbert N. Nyaga, Gary J. Young

Operational focus is of much interest in health care where a long standing debate has existed over advantages/disadvantages of general vs specialty hospitals. However, there has been relatively little research in the OM literature that considers the intersection of operational focus and operating experience. Using patient discharge records from 294 California hospitals over a five-year period, we empirically evaluated the inter-relationship between operational focus and operating experience in cardiology operating units. Findings suggest that the effects of operational focus and operating experience on operational performance are complementary, but the benefits come at a cost to payers.

2 - Service Outsourcing Emphasis and Hospital Performance
Sachin B. Modi, Wayne State University, Rm 300.07, Detroit, MI, 48202, United States, ge3918@wayne.edu, Saurabh Mishra, Peter Salzarulo

Hospitals often face the decision of delivering services by relying on contracted providers versus utilizing internal resources. Such an emphasis on outsourcing to service providers can allow for better financial performance, but can also lower patient outcomes. Relying on data from US hospitals over a 14 year period, this study investigates the influence of service outsourcing emphasis of hospitals on patient length of stay and operating margins. Further, the study also highlights key boundary conditions in these relationships. The results provide important guidelines for hospital administrators, regarding their service outsourcing strategy.

3 - Managing Physician Preferred vs. General Medical Supplies – The Use of Consignment Inventory
Claudia Rosales, Michigan State University, N350 N.Business Complex, East Lansing, MI, 48824, United States, Rosales@broad.msu.edu, Anand Nair

In healthcare medical devices and materials represent the largest cost after labor. Hospitals spend significant resources purchasing and managing general as well as specialty medical supplies typically called physician preferred items. One of the ways hospitals seek to reduce the cost of medical supplies is by the use of inventory consignment. We analyze the impact of the use of consignment inventory for general and physician preferred medical supplies. Our models capture both the potential benefits that could be obtained with the use of consignment and the system conditions that can result in increased costs. Results are compared to real hospital data.

4 - The Effects of Health Information Technology and Communication Quality on Medical Malpractice Lawsuits
Luv Sharma, University of South Carolina, Columbia, SC, United States, Luv.Sharma@moore.sc.edu, Carolyn Queenan

This paper uses data from 168 acute care hospitals in Florida to study the impact of HIT and caregiver-patient communication quality on the number of medical malpractice lawsuits filed against the hospital. Results demonstrate a direct impact of communication quality and an indirect impact of HIT in influencing lawsuits.

■ MB11

332A

Empirical Research in Service Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Ruomeng Cui, Bloomington, IN, 47401-7739, United States, cuir@indiana.edu

1 - Impact of Unexpected and Expected Breaks on Worker Productivity
Pradeep Kumar Pendem, University of North Carolina-Chapel Hill, 110 Mistywood Circle, Apt S, Chapel Hill, NC, 27514, United States, pradeep.pendem@gmail.com

Using harvesting worker productivity data from a U.S based agricultural firm, we evaluate effects of two types of breaks (expected versus unexpected), and two distinct forms of unexpected breaks, and find that unexpected breaks can, under certain conditions, yield immediate post-break performance increases. We supplement our findings by a conceptual laboratory replication showing that unexpected breaks lead to increased performance when they allow people to maintain attention on the focal task. Our results have implications on design of operational systems and need for emphasis on studying the break type prior to taking any corrective action.

2 - How Local Economic Factors Affect Retail Inventory Liquidation Value
Nathan C. Craig, 630 Fisher Hall, 2100 Neil Avenue, Columbus, OH, 43210, United States, craig.186@osu.edu, Ananth Raman

Retailers close stores for many reasons, from changes in strategy to bankruptcy. When closing a store, most retailers liquidate the store's inventory in place via the process of store liquidation. We collect data from an asset disposition firm about 2,000 store liquidations involving 31 retailers and $4B of inventory. We observe that inventory liquidation values vary substantially across store closings, even for a single retailer. We combine the proprietary data with store-level economic data and identify factors that significantly affect inventory liquidation value.

3 - The Importance of Operational Efficiency for Promotional Inventory Campaigns: Empirical Evidence
Ioannis Stamatopoulos, University of Texas at Austin, McCombs School of Business, 2110 Speedway B6000, Austin, TX, 78705, United States, yannis.stamos@mccombs.utexas.edu

We use the adoption of an innovative tracking and monitoring technology by a brick and mortar retail chain in the US to causally identify the impact of operational execution on the effectiveness of promotional inventory campaigns. Our findings suggest that the potential gains from increasing operational efficiency in this setting are economically significant.

4 - Operational Transparency Increases Trust in and Engagement with Government
Ryan Buell, Harvard Business School, Morgan Hall 429, Boston, MA, 02163, United States, rbuell@hbs.edu, Ethan Porter, Michael Norton

We propose that revealing the "submerged state," by making sure that citizens can see the often-hidden work that government performs, enhances both perceptions of government and engagement with it. Three studies, comprised of original experimental and new municipal data, support this proposition.

■ MB12

332B

Robust Optimization in Operations Management

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Chaithanya Bandi, Northwestern University, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

1 - Sustainable Inventory with Robust Periodic-affine Policies
Eojin Han, Northwestern University, Evanston, IL, United States, EojinHan2020@u.northwestern.edu, Chaithanya Bandi, Omid Nohadani

We extend the work of Van Mieghem and Rudi (2002) to multi-period settings with uncertain and correlated demands. The approach leaps beyond the distributional assumption and models uncertainties via polyhedral sets. We formulate the inventory problem as a multi-stage robust optimization problem. We then develop periodic-affine policies, which require less information about past demands. We show theoretically and numerically that our framework guarantees worst-case performance, while reducing the computation. Our results are applied to the ordering policy of a pharmaceutical retailer in India.

2 - Robust Dual Sourcing Inventory Management: Optimality of Dual Index Policies
Jan Van Mieghem, Professor, Northwestern University, Evanston, IL, 60208, United States, VanMieghem@kellogg.northwestern.edu, Jiankun Sun

We provide a robust optimization model for inventory management with two supply sources with general leadtimes for which we show that a dual index, dual base-stock policy is optimal, even in a non-stationary setting. In an extensive stationary simulation study, this robust dual sourcing policy performs as well as, and can even outperform each of, the best heuristics presented in the stochastic inventory literature.

3 - Pricing the Service Level Guarantees in the Amazon AWS Spot Market
Chaithanya Bandi, 1987, 2001 Sheridan Rd, 566, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu, Siva Theja Maguluri

In this paper, we combine tools from robust queueing theory and mechanism design to design polcies for pricing spot market instances.

4 - Design of a Robust Stroke Network: Personalized Patient Transportation Policies
Amir Ardestani-Jaafari, McGill University, Montreal, QC, Canada, amir.ardestanijaafari@mail.mcgill.ca, Beste Kucukyazici

In the diagnosis and treatment of acute stroke, the timely medical intention is increasingly critical. However, transporting the patients to the closest hospital may not be the best solution. This often causes congestion in some hospitals, while the stroke beds are underutilized in others. We study the patient allocation and transportation protocols to optimize the coordination between emergency medical services and designated stroke hospitals. Specifically, we study the trade-off between minimizing transportation time to the hospital and minimizing the congestion experienced by the patient at the hospital using robust optimization.

■ MB13

332C

Health Care, Processes

Contributed Session

Chair: Alireza E. Vandi, Virginia Tech, Blacksburg, VA, United States, alvandi@vt.edu

1 - Synthesis of 12 Lead Electrocardiogram using a Single Lead and its Application in Hand-held ECG Devices

Kahkashan Afrin, Graduate Student, Texas A&M.University, 1201 Harvey Rd., Briarwood Apts,, Apt 3, College station, TX, 77840, United States, afrin@tamu.edu

Recent advancements in the sensor technology has led to the development of handheld ECG devices and facilitated remote healthcare monitoring. However, its inability to give contiguous 12 leads, essential for diagnosing cardiac disorders has made it unacceptable for the clinical use. In this work, we artificially synthesize clinically equivalent 12 lead ECG using a single channel ECG with more than 90% accuracy.

2 - Resolving Payment Denial Issues by Nursing Facilities: Role of Upper Echelon, Institutional & Market Factors

Ajit Appari, University of Texas Health Science Center at Houston, 1200 Pressler Street, RAS.W-310, School of Public Health, Houston, TX, 77030, United States, ajit.appari@uth.tmc.edu

Quality of care at nursing facilities is a major issue plaguing the US health care system. I propose and evaluate a conceptual framework reflecting deviant behavior based on institutional and upper echelon theories to understand the sluggishness of nursing facilities in resolving payment denial related deficiencies. There were 3147 denials of durations 3 to 1213days across all facilities during 2011-2016. A multilevel mixed-effects ordered logistic model with Heckman correction is used to identify what type of facilities in what institutional/market conditions take longer to resolve such denial deficiencies [Moderate (91-120days) or Laggard (>120days) Vs Early resolution (1-90days)].

3 - Comparing the use of Partial Least Squares and Covariance Based Structural Equation Modeling in an Ehealth Information Model

Anh Ta, University of North Texas, Denton, TX, 76201, United States, Anh.Ta@unt.edu, Gayle Prybutok, Victor R. Prybutok

Covariance-based Structural Equation Modeling (CB-SEM) is a common methodology used by researchers in behavioral science. Although partial least squares SEM (PLS-SEM) is sometimes considered "a silver bullet" for examining the relationships among constructs, critics claim PLS is flawed and an inappropriate methodology. This study compares the value and use of both methods in the context of eHealth information seeking behavior.

4 - Risk Factors for High Infant Mortality Rate

Alireza E. Vandi, Virginia Tech, 1311 Perry Street, Room 236, Blacksburg, VA, 26505, United States, alvandi@vt.edu, Niyousha Hosseinichimeh

Infant mortality rate (IMR) has declined over the past decade in the U.S.; however, it still has one of the highest IMR among developed countries. IMR varies substantially across states which provides the opportunity to study the state level factors associated with IMR. In 2015, IMR in MA was 4.2 per live births while it was over 9 per 1000 in MS. We gathered a state-level panel dataset for all 50 U.S. states from 2001 to 2015 and used a first differencing regression model to investigate the main factors contributing to the high infant mortality and the disparity among different states. Initial analyses show that drug abuse, and percentage of babies born low birthweight explains some of the variations in IMR.

■ MB14

332D

Predictive Analytics and Healthcare Operations

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Retsef Levi, MIT, Cambridge, MA, 02142, United States, retsef@mit.edu

1 - Predictive Models for Heart Failure Admissions

Jazmin Furtado, Massachusetts Institute of Technology, Cambridge, MA, 02140, United States, jazminf@mit.edu, Mariam Al-Meer, Retsef Levi, Ana Cecilia Zenteno Langle, Gregory Lewis, James Januzzi, Ryan Thompson

Heart failure (HF) is a chronic condition that results in the impairment of the ventricle's ability to fill with or eject blood. The American Heart Association predicts that there will be ~10 million HF patients in the US by 2037, with total hospitalization costs exceeding $70 billion. We propose a predictive model which identifies with high confidence patients at greatest risk of a first hospital admission following encounters with their primary care providers and/or cardiologists in any given year. Significant predictors include demographic characteristics, medication history, and proxies for socio-economic status.

2 - Valuing and Optimizing Non-facetime Work to Inform Physician Compensation

Michael Hu, MIT, 70 Pacific St., Apt 332, Cambridge, MA, 02139, United States, hum@mit.edu, Karen Carlson, Joseph Doyle, Stephanie Eisenstat, Annie Huppert, Retsef Levi

Primary care physicians (PCPs) have traditionally been paid according to activities-based compensation models. Health systems are now moving to patient panel-based payments. This requires methods to determine the workload associated with different patient panels. Until now, panels have been evaluated using "risk scores", which measure clinical complexity. However, risk scores do not capture non-facetime work (NFTW), such as visit documentation, which consumes a substantial amount of PCP time. We demonstrate that risk scores do not accurately measure the workload of patient panels. We then create prediction models that reliably estimate the workload required to manage different patients.

3 - Predictive Analytics to Manage Hospital Discharges

Retsef Levi, Massachusetts Institute of Technology, Cambridge, MA, United States, retsef@mit.edu, Peter Dunn, Kyan Safavi, Jonathan Zanger, Ana Cecilia Zenteno Langle

We present a surprisingly accurate predictive model to predict upcoming discharges in hospitals. The model is incorporated into a new process to drive earlier discharges and significantly improved management of the hospital bed capacity.

4 - Impacts of Staffing Patterns on Patient Length of Stay

Kimia Ghobadi, MIT, 100 Main Street, E62-459, Cambridge, MA, 02142, United States, kimiag@mit.edu, Andrew Johnston, Retsef Levi, Peter Dunn, Walter O'Donnell

Staffing pattern in resident teams of Internal General Medicine effect patients' wait-time for beds in the Emergency Department, as well as their hospital length of stay once they are on the floor. We identify a natural randomized control setting to quantify the impacts of care-team hand-offs for general medicine patients and analyze the effects for various admitting diagnosis.

■ MB15

332E

Supply Chain Risk

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Juan Serpa, McGill University, juan.serpa@mcgill.ca

1 - Inventory in Times of War

Andres F. Jola-Sanchez, Indiana University, Bloomington, IN, United States, ajolasan@indiana.edu, Alfonso J. Pedraza-Martinez, Juan Serpa

How does war affect firms' inventory? We study this question by cobbling together a unique data panel from the Colombian civil war (battled by two guerrilla groups). We glean: (i) operational-level metrics from 38,916 firms; (ii) war-level metrics from all 1,122 Colombian municipalities; and (iii) the at-fault armed group for each attack. To obtain causal estimates, we use a difference-in-difference model that hinges on the 2012-peace process between the government and one of the two guerrilla groups. We find that war leads to lower inventory. However, proximity to trade centers moderates this response: firms far from trade centers hold more inventory in times of war.

2 - Quality Control under Noisy Signals

Ahmet Colak, Northwestern University, Chicago, IL, United States, a-colak@kellogg.northwestern.edu

Combining public and private auto industry data sets, I derive novel defect variables that influence quality improvement decisions. Accounting for various product characteristics and spillover effects relating to quality, I study a panel data that span from 2004 to 2017. I examine how signal volatility impacts quality decisions. Particularly, I develop an empirical framework that assesses how much a standard deviation increase in signal variability lowers consumer and firm welfare. Finally, I consider various managerial policies to mitigate such negative effects.

3 - Strategic Inventory and Supplier Encroachment

Huiqi Guan, University of Miami, 417 Jenkins Building, School of Business Administration, Coral Gables, FL, 33146, United States, h.guan@umiami.edu, Haresh B.Gurnani, Xin Geng, Yadong Luo

We study the combined effect of strategic inventory and supplier encroachment in a two-period model. The buyer may withhold excess inventory and the supplier can introduce a direct selling channel in the second period. We find that irrespective of the buyer's unit holding cost, strategic withholding may occur and the supplier's encroachment strategy is distorted.

4 - A Quasi Experimental Study of Environmental Benefits of Craigslist

Suvrat Dhanorkar, Pennsylvania State University, 466 Business Building, University Park, PA, 16802, United States, ssd14@psu.edu

Matching platforms such as Craigslist can facilitate the creation of C2C closed loop supply chains (CLSCs) for used goods, which can enhance product reuse and limit reliance on recycling and disposal alternatives.We use a quasi-experimental setup to examine how Craigslist's entry into various U.S. geographic markets impacts environmental outcomes.

■ MB16

332F

Inventory Management

Contributed Session

Chair: Zhongjie Ma, Purdue University, West Lafayette, IN, United States, zhongjiema@purdue.edu

1 - A Reinforcement Learning Approach for Perishable Product Supply Chain with Markov-modulated Demand

Ahmet Kara, Erciyes University, Erciyes University, Department of Industrial Engineering, kayseri, 38039, Turkey, ahmet.kara@erciyes.edu.tr, brahim Do an

Inventory management of perishable products with limited shelf life is different than the classical inventory management. The inventory control of perishable products requires different ordering policies that consider both the quantity and the age of the stocks. This study analyzes a two-echelon supply chain model for perishable inventory management with Markov-Modulated Demand. We examine different ordering policies to emphasize the importance of the age information. The problem has been formulated using a reinforcement learning model.

2 - Newsvendor Problems with Demand Forecast Updating and Supply Constraints

Meimei Zheng, Shanghai Jiao Tong University, Shanghai, 200240, China, meimeizheng2009@gmail.com, Kan Wu, Yan Shu

This study investigates an extension of the newsvendor model with demand forecast updating under supply constraints. A retailer can postpone order placement to obtain a better demand forecast. However, the manufacturer would charge the retailer a higher cost for a shorter lead time and set restrictions on the ordering times and quantities. Two supply modes are investigated: supply mode A, which has a limited ordering time scale, and supply mode B, which has a decreasing maximum ordering quantity. For supply mode A, it can be proven under justifiable assumption that a retailer should order either as early or as late as possible. For supply mode B, an algorithm is proposed to simplify the ordering policy.

3 - Optimal Order and Shipment Policies on Classic Periodic-review Two-echelon Distribution Models

Youyi Feng, Professor, Business School, Sichuan University, Wangjiang Campus, Sichuan University, Wuhou District, Chengdu, Sichuan, China, Chengdu, China, yyfeng@live.com, Lei Xie

We characterize optimal dynamic inventory policies for the classic single-item periodic-review two-echelon distribution inventory models over a finite planning horizon. Consisting of a warehouse and a number of retailers, the system periodically procures inventory from an outside supplier to replenish the warehouse and delivers on-hand inventory from the warehouse to the downstream retailers. We innovate the computing procedures of linear complexity to obtain optimal order/shipment quantities respectively. Infinite-horizon models with discounted cost and long-term average cost criteria are also explored.

4 - Multi Season Production Planning under Sales Quota

Tianxiao Chen, The Chinese University of Hong Kong, ERB615, CUHK, Shatin, Shatin, Hong Kong, chentx@se.cuhk.edu.hk, Xiting Gong, Qing Li, He Xu

Motivated by the export quota in international trading, we study a periodic-review multi-season production planning problem where the total sales quantity in each season is restricted by a sales quota. By formulating the problem as a dynamic program, we characterize the structure of the optimal production policy and exam the impact of sales quota.

5 - Dynamic Coordination in a Supply Chain with Production Capacity Uncertainty

Zhongjie Ma, Purdue University, 403 W. State Street, West Lafayette, IN, 47906, United States, zhongjiema@purdue.edu, Qi Feng, J. George Shanthikumar

We study the effect of upstream supply uncertainty on the inventory decisions in a two-stage supply chain under both centralized and decentralized controls. Applying the concept of directional concave ordering and extending the notion of stochastic linearity, we develop a concave transformation of the problem for a general class of stochastic supply functions, which allows us to analyze the dynamic problem and characterize the optimal policy. Furthermore, we discuss the mechanism to dynamically coordinate the decentralized systems when the upstream and downstream make the ordering decisions based on self-interest.

■ MB17

340A

Queueing Models in Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Baris Ata, University of Chicago, Chicago, IL, 60637, United States, Baris.Ata@chicagobooth.edu

Co-Chair: Xiaoshan Peng, University of Chicago, Booth School of Business, Chicago, IL, 60637, United States, x-peng@chicagobooth.edu

1 - Managing Service Platforms with Self-scheduling Agents and Impatient Customers

Rouba Ibrahim, University College London, MS& I.department, UCL, Gower Street, London, WC1E 6BT, United Kingdom, rouba.ibrahim@ucl.ac.uk

We study the operational management of service platforms with self-scheduling agents and impatient customers. Since the customer impatience distribution plays an important role, we propose controlling it using delay announcements, and characterise the interaction between three controls at the manager's disposal: the staffing level, the compensation offered to agents, and the announcements made to customers.

2 - A Constrained Optimization Problem for a Two-Class Queueing Model

Mark E. Lewis, Cornell University, School of Ops Research & Information Engin., 221 Rhodes Hall, Ithaca, NY, 14853, United States, mark.lewis@cornell.edu, Cory Girard, Linda Vogel Green, Jingui Xie

We discuss dynamic server control in a two-class service system under a constraint on the number of high-priority customers. A class of randomized threshold policies is defined, and is proven to contain an optimal policy in the case without abandonments. The proof of optimality is then used to construct heuristic policies for the case of low-priority abandonments, which we test numerically. The experiments we run suggest that, even when abandonments are introduced, these classes of policies outperform priority policies, and, in some cases, are near-optimal.

3 - Delay Predictability Tradeoffs in Reaching a Secret Goal

Kuang Xu, Stanford Graduate School of Business, Stanford, CA, United States, kuangxu@stanford.edu, John N.Tsitsiklis

We formulate a model of dynamic decision-making to study an agent's predictability as she attempts to reach a final goal through a sequence of intermediate actions, while watched by an adversary who tries to predict the goal before it is reached. We are motivated by the increasing ubiquity of large-scale data collection infrastructures capable of predicting an agent's intentions and future actions, in juxtaposition with an agent's desire for privacy. We show the predictability of the agent's goal can be made inversely proportional to the time she spends reaching it, and that this is the best possible. This characterization does not depend on the structure of the agent's state space beyond the diameter.

4 - Managing the Callback Option under Arrival Rate Uncertainty

Xiaoshan Peng, Indiana University, Kelley School of Business, Bloomington, IN, 47405, United States, xp1@iu.edu, Baris Ata

We study how to manage the callback option effectively to mitigate congestion due to temporary surges in the arrivals to a call center. When a customer arrives, the call center manager decides whether to keep him in the online queue or to offer the callback option. Some customers may reject the callback offer. We show that a modified lookahead policy that looks into the future arrivals and service completion times for the next p/h time units and uses the current number of customers in the system who previously rejected a callback offer is pathwise optimal among the complete foresight policies.

■ MB18

340B

Asymptotic Methods in Financial Mathematics

Sponsored: Applied Probability

Sponsored Session

Chair: Jose Figueroa-Lopez, Washington University, St. Louis, MO, figueroa-lopez@wustl.edu

1 - Utility Maximization Problems in a Regime Switching Market Model

Adriana Ocejo Monge, Assistant Professor of Statistics, University of North Carolina-Charlotte, Fret 335G, 9201 University City Blvd., Charlotte, NC, 28223, United States, amonge2@uncc.edu

We present utility maximization problems where an agent builds her portfolio by investing in a bond and a risky asset whose price dynamics follow a diffusion process with regime-switching coefficients, modeled by a finite-state Markov chain. We consider the class of iso-elastic utility functions, which includes the power utility. We show how to explicitly compute the value function using Laplace transforms and present the optimal trading strategy.

2 - Optimal Thresholding of Truncated Realized Variations

Jose E.Figueroa-Lopez, Washington University-St Louis, One Brookings Drive, St Louis, MO, 63130, United States, figueroa-lopez@wustl.edu, Cecilia Mancini

We consider a univariate semimartingale model for (the logarithm of) an asset price, containing jumps having possibly infinite activity. We aim at optimally selecting the threshold of truncated realized variations by minimizing the conditional mean square error of the estimator. A parsimonious asymptotic characterization of the optimum is established, which turns out to be asymptotically proportional to the Levy's modulus of continuity of the underlying Brownian motion. Moreover, minimizing the cMSE enables us to propose a novel implementation scheme for the optimal threshold sequence. Monte Carlo simulations illustrate the superior performance of the proposed method.

3 - Short Maturity Asian Options in Local Volatility Models

Lingjiong Zhu, PhD, Florida State University, FL, United States, lz465@nyu.edu

We present a rigorous study of the short maturity asymptotics for Asian options with continuous-time averaging, under the assumption that the underlying asset follows a local volatility model. The asymptotics for out-of-the-money and at-the-money cases are derived, and explicit formulas are given in the cases of Black-Scholes model, square-root model and CEV model. We present an analytical approximation for Asian options prices, and demonstrate good numerical agreement of the asymptotic results with the results of Monte Carlo simulations and benchmark test cases. This is based on the joint work with Dan Pirjol.

4 - Price Dynamics in a Limit Order Market under Time Dependent Order Flow

Johnathan A. Chavez-Casillas, University of Calgary, Calgary, AB, Canada, jonathan.chavezcasil@ucalgary.ca

In this talk we will, briefly, introduce Limit Order Books and explain the intricate dynamics between the order flow and the price process. We will discuss some efforts to describe the price dynamics and how they have been generalized to capture some empirical properties observed in the data. We will then introduce a model that considers a time-dependent order flow and, under some assumptions, characterize the price process within this model. We will then finish by describing how this model fit some particular data under the given assumptions.

■ MB20

342B

TIMES Dissertation Award

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Zhijian Cui, IE Business School, Calle de Maria de Molina, 12, 5th Floor, Madrid, 28006, Spain, Zhijian.cui@ie.edu

1 - Stochastic Models to Optimize Biomanufacturing Operations

Tugce Martagan, Eindhoven University of Technology, Eindhoven, Netherlands, t.g.martagan@tue.nl

We develop an inter-disciplinary framework to reduce biomanufacturing costs and lead times. The proposed framework consists of several Markov decision models that dynamically control and optimize protein purification operations. We partition the state space into decision zones, and propose a novel zone-based decision making approach to quantify the business risks and costs. We develop guidelines that are easy to implement in practice. Industry implementation indicates 20% reduction in protein purification costs and timelines.

2 - Beyond Product Functionality

Tian Chan, Emory University's Goizueta Business School, 1300 Clifton Road, Atlanta, GA, 30322, United States, tian.chan@emory.edu

Products combine function and form. We focus on form. We combine clustering techniques with experimental validation to identify styles (groupings of designs of similar form) among the over 350,000 US design patents granted from 1977 to 2010. Thus we compile a dataset of styles that can serve as an empirical platform to study the role of product form in NPD. Using the data, we find that (i) style turbulence (the unpredictability of changes in a style's prevalence) follows a U-shaped relationship with respect to function turbulence and (ii) style turbulence increases over time.

3 - Corporate Predictions Markets: Evidence from Google, Ford and Firm X

Bo Cowgill, Columbia Business School, 3022 Broadway, Uris Hall 702, New York, NY, 10583, United States, bo.cowgill@gmail.com

We examine data from prediction markets run by Google, Ford Motor Company and an anonymous conglomerate (Firm X). We find these markets are relatively efficient and improve expert forecasts at all 3 firms by as much as a 25% reduction in mean squared error. The most notable inefficiency is an optimism bias in the markets at Google. The few inefficiencies that appear become smaller over time. Experienced traders and those with higher past performance trade against the identified inefficiencies.

4 - Value Creation and Capture in a World of Bottlenecks

Douglas Hannah, University of Texas at Austin, Austin, TX, United States, dph@utexas.edu

Ecosystems are settings in which firms depend on one another to provide the components that together comprise valuable products. Research has identified effective collaboration as central to firms' ability to create value in ecosystems, but a gap exists with respect to when and for whom different types of collaboration are effective. I address this gap with a game theoretic model that compares two archetypal strategies, and thus contribute to research on ecosystems and collaborative strategy.

5 - Digital Platforms and Product Innovativeness: Towards an Understanding of Innovationat the Device Layer

Hyunwoo Park, The Ohio State University, Columbus, OH, 30309, United States, park.2706@osu.edu

The infusion of digital capabilities into physical products is an increasingly pervasive phenomenon. This prolific combination of "bits" and "atoms" necessitates a deeper understanding of the association between logical capability and physical machinery innovation. This chapter frames that digital platforms represent "areas" in technology design space that enable innovative recombination of technological components. It also proposes a novel and extensible index for quantifying innovativeness.

■ MB21

342C

Predictive Analytics for Advancing Personalized and Evidence-based Medicine

Invited: InvitedHealthcare Systems and Informatics

Invited Session

Chair: Eva Lee, Georgia Tech, Atlanta, GA, 30332-0205, United States, evakylee@isye.gatech.edu

1 - Machine Learning: Multi-site Evidence-based Best Practice Discovery

Eva Lee, Georgia Tech, Industrial & Systems Engineering, Ctr for Operations Research in Medicine, Atlanta, GA, 30332-0205, United States, evakylee@isye.gatech.edu, Yuanbo Cody Wang

This work is joint wih Care Coordination Institute. We invesigate best practice characteristics among 737 clinical sites that covers 2.7 million patients. Data interoperabiity is established via non-redundancy graph mapping onto standardized medical/lab/pharma terminologies. Next, unsupervised learning is performed to uncover treatment outcome patterns. Supervised learning via a classification model ((DAMIP) is then applied to uncover discriminatory characteristics that can predict the quality of treatment outcome. We will present results for diabetic patients. The patterns identified provide clinical practice guidelines for "rapid learning" across all clinical sites.

2 - Outcome-driven Personalized Treatment Design for Managing Diabetes

Xin Wei, Georgia Institute of Technology, Atlanta, GA, United States, xwei36@gatech.edu, Eva Lee

This work is joint with Grady Memorial Hospital. The management of gestational diabetes mellitus(GDM) focuses on close monitoring of a patient's blood glucose level while the clinician experiments with dosing strategy based on some clinical guidelines and his/her own experience. We propose a drug-effect-based personalized approach to improve treatment outcome for GDM patients. Specifically, a predictive model based on pharmacokinetic and pharmacodynamic(PK/PD) analysis of drug dosage and blood glucose level is proposed to uncover personalized treatment effect and then incorporated in a planning model for optimal dosing strategy. Results for GDM patients will be presented.

3 - A Supervised Biclustering Approach for Personalized Medicine

Milad Zafar Nezhad, Wayne State University, Detroit, MI, United States, m.zafarnezhad@wayne.edu, Kai Yang

Traditional medicine typically applies one-size-fits-all treatment for the entire patient population whereas precision medicine develops tailored treatment schemes for different patient subgroups. The fact that some factors may be more significant for a specific patient subgroup motivates researchers to develop new approaches to subgroup analysis, which is an effective strategy to personalize treatment. In this study, we propose a novel patient subgroup detection method, called Supervised Biclustring (SUBIC) using convex optimization and apply our approach to detect patient subgroups in a vulnerable demographic subgroup at the high risk of cardiovascular disease.

■ MB22

342D

Mechanism Design, Networks, and New Markets II

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Santiago Balseiro, srb43@duke.edu

Co-Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States, ozan.candogan@chicagobooth.edu

1 - Strategic Dynamic Pricing with Network Externalities

Azarakhsh Malekian, University of Toronto, Toronto, ON, Canada, azarakhsh.malekian@rotman.utoronto.ca

We study the optimal pricing of a monopolist selling goods in a dynamic pricing game with multiple rounds. Customers are forward-looking and experience a (positive) network externality. The seller commits to a price sequence and strategic buyers play a perfect Bayesian equilibrium. We fully characterize the optimal pricing policy and show that it is linearly increasing in time, where the slope of the price path is described by a single network measure: sum of the entries of the inverse of network externality matrix, termed network effect. We also study the effect of price discrimination and establish that in the earlier rounds the price offered to more central buyers is lower.

2 - Facilitating the Search for Partners on Matching Platforms: Restricting Agent Actions

Yash Kanoria, Columbia Business School, New York, NY, 10027, United States, ykanoria@columbia.edu, Daniela Saban

Two-sided matching platforms, such as those for labor, accommodation, dating, and taxi hailing, control many aspects of the search for partners. We consider a dynamic model of search by strategic agents with costly discovery of pair-specific match value. We find that in many settings, the platform can mitigate wasteful competition in partner search via restricting what agents can see/do. If agents on one side have a tendency to be more selective (due to smaller screening costs or greater market power), the platform should disallow agents on the less selective side from reaching out. This forces agents on the more selective side to reach out and improves the welfare of agents on the less selective side.

3 - Temporal Microstructure of Surge Pricing

Bin Hu, UNC Chapel Hill, McColl Building CB3490, Kenan-Flagler Business School, Chapel Hill, NC, 27599, United States, bin_hu@unc.edu, Ming Hu, Han Zhu

Ride-sharing platforms such as Uber and Lyft contingently increase prices (known as Surge Pricing) to modulate surges of rider requests and attract drivers. However, in managing unpredictable demand shocks with Surge Pricing, an important feature neglected in the existing literature is that supply (drivers) reacts much slower than demand (riders) to price changes. We model this feature and the resulting rider and driver strategic behaviors, and show that neglecting this feature can lead to significantly distorted and underperforming decisions.

4 - Markov Chain Models for Controlling the Exposure Frequency Distribution of Online Advertising

Ali Hojjat, University of New Hampshire, Durham, NH, United States, ali.hojjat@unh.edu, John G.Turner

Recent trends in online advertising show that explicit reach and frequency specifications are preferred over aggregate impression or budget goals. We propose two Markov chain models for serving ads that can achieve a desired frequency distribution for an online ad campaign. We characterize the necessary and sufficient conditions on the arrival distribution that must hold for a feasible ad serving policy to exist, and characterize the publisher's impression assignment rule in closed form. Extensions of our framework to multi-advertiser and multi-audience-segment settings are also presented.

■ MB23

342E

Pricing, Information Sharing, and Other Decisions in RM Applications

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ramandeep Randhawa, University of Southern California, Los Angeles, CA, 90089, United States, ramandeep.randhawa@marshall.usc.edu

1 - Markdown Policies for Demand Learning and Strategic Customer Behavior

N. Bora Keskin, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Hongfan Chen

Consider a firm selling a product to a finite population of myopic and strategic customers with heterogeneous valuations. The firm faces uncertainty about the market size and how strategic customers are. We develop guidelines for designing asymptotically optimal markdown policies for demand learning in the presence of strategic customers.

2 - Contingent Stimulus in Crowdfunding

Longyuan Du, Rotman School of Management, University of Toronto, 105 St George St, Toronto, ON, M5S.3E6, Canada, Longyuan.Du14@Rotman.Utoronto.ca, Ming Hu, Jiahua Wu

We consider a model where backers arrive sequentially at a crowdfunding project. Upon arrival, a backer makes her pledging decision by taking into account the expected project success rate. We characterize the dynamics of a project's pledging process. To boost success, we propose and characterize three contingent stimulus policies, i.e., seeding, feature upgrade and limited-time offer. We show that the benefit of contingent policies is greatest in the middle of crowdfunding campaigns. Testing with the data set of Kickstarter, we obtain empirical evidence that the projects' success rates improve by 14.6% on average with updates in the middle of the campaign and when the pledging progress is lagging.

3 - Bayesian Persuasion on Networks

Kimon Drakopoulos, University of Southern California, drakopou@marshall.usc.edu, Ozan Candogan

In the presence of misinformation, platforms face a tradeoff between customer engagement and quality of shared information. In this paper we explore this tradeoff and discover the optimal information revelation mechanism. The amount of information provided to each agent according to this mechanism turns out to relate to a novel centrality measure that we further analyze and relate to existing notions of centrality.

4 - Information Sale in Competitive Markets

Kostas Bimpikis, Stanford University, kostasb@stanford.edu, Alireza Tahbaz-Salehi, Davide Crapis

We study the strategic interaction between a seller of information and buyers that compete in a downstream market. Our analysis illustrates that the nature and intensity of competition are key in determining the optimal strategy. In particular, we show that when the customers' action are strategic complements, it is to optimal to offer the most accurate information to all customers. In contrast, when actions are strategic substitutes, it is optimal to either (i) restrict the overall supply of the information product, or (ii) offer a product of inferior quality. We also show that the incentive to restrict the supply or quality of information intensifies in the presence of information leakage.

■ MB24

342F

Customer Choices and Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Hongmin Li, Arizona State University, Tempe, AZ, 85287, United States, hongmin.li@asu.edu

1 - Pricing under the Generalized Extreme Value Models with Homogeneous Price Sensitivities

Heng Zhang, University of Southern California, Los Angeles, CA, 90007, United States, hengz@usc.edu, Paat Rusmevichientong, Huseyin Topaloglu

We study multi-product pricing problems under generalized extreme value models and homogeneous price sensitivity parameter for all products. First, we consider the unconstrained problem, and show that the optimal prices of different products have a constant markup over costs, and give an explicit formula for optimal markups. We next study the pricing problem subject to the convex inventory constraints, the formulation of which includes the deterministic approximation for the dynamic pricing problems over a network of resources. We show the problem can be transformed into a convex problem with purchase probabilities as the decision variables, and solved efficiently.

2 - Consumer Choice and Market Expansion: Modeling, Optimization and Implementation

Ruxian Wang, The Johns Hopkins Carey Business School, 100 International Dr, Baltimore, MD, 21202, United States, ruxian.wang@jhu.edu

We incorporate market expansion effects into consumer choice models and investigate the revenue management and pricing problems.

3 - Analysis of Discrete Choice Models: A Welfare-based Framework

Xiaobo Li, University of Minnesota, 1006 27th Avenue SE,, APT.'E', Minneapolis, MN, 55414, United States, lixx3195@umn.edu, Guiyun Feng, Zizhuo Wang

In this paper, we study the relation between several well known classes of discrete choice models, namely the random utility model (RUM), the representative agent model (RAM) and the semi-parametric choice model (SCM). Using a welfare based model as an intermediate, we show that the RAM and the SCM are equivalent. Furthermore, we show that both models as well as the welfare based model strictly subsume therandom utility model when there are three or more alternatives, while the four are equivalent when there are only two alternatives. Thus, this paper presents a complete picture on the relation between these choice models. We also study substitutability and complementarity properties in choice models.

4 - Product Design under Multinomial Logit Choices: Optimization of Costly Attributes and Prices in an Evolving Product Line

Gwangjae Yu, Arizona State University, 300 E.Lemon St, BA 451G, Tempe, AZ, 85281, United States, gjyu@asu.edu

We study a product-line design problem in which customers' choice among multiple products is given by a multinomial logit (MNL) model. A firm determines product attributes and prices in an evolving product line to maximize profit. In particular, given the prices and attributes of products that already exist in a product line, the firm optimizes prices and/or attributes of the new products to be added to the same product line.

■ MB25

350A

Control and Optimization Techniques for Power Systems I

Invited: Energy Systems Management

Invited Session

Chair: Richard Y Zhang, UC Berkeley, Berkeley, CA, 94720, United States, ryz@berkeley.edu

1 - Inner Approximations of Power Flow Feasibility Sets

Konstantin Turitsyn, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, turitsyn@mit.edu, Krishnamurthy Dvijotham, Hung Nguyen

Inner approximations of power flow feasibility sets have a variety of applications for example operational security. While the outer approximations can be naturally constructed via convex relaxations, the problem of constructing inner approximations is generally hard. This talk will introduce a new strategy of constructing inner approximations for general power flow equations not restricted to any topologies and bus types. The framework is based on the adaptive bounding of nonlinearities and certification of the self-mapping of the convex set as required by the Brouwer fixed point theorem. The proposed framework is scalable to large cases and covers most of the feasible region in practice.

2 - Value of Flexible Wind Dispatch in Stochastic Unit Commitment

Georgios Patsakis, UC Berkeley, Berkeley, CA, 94720, United States, gpatsakis@berkeley.edu, Shmuel S.Oren

We explore the expected benefit on social welfare from integrating in power systems the flexibility to dispatch the wind lower than its available output. Initially, we provide motivation for instances when wind spilling could prove beneficial. We then utilize a stochastic unit commitment approach for a reduced California power system. Two decomposition techniques are used to solve the problem. The first one is based on recent literature and utilizes global cuts and Lagrangian penalties to reach an optimal solution, for a small number of scenarios. The second one is a heuristic combination of progressive hedging with scenario reduction.

3 - Pricing in Multi-interval Real-time Markets

Bowen Hua, University of Texas at Austin, 1650 West Sixth Street, Apt D, Austin, TX, 78703, United States, bowenhua90@gmail.com, Ross Baldick

A multi-interval real-time market bases itself on a look-ahead economic dispatch problem implemented in a model predictive control fashion. Under the current pricing structure in the multi-interval real-time market of CAISO and NYISO, generators may have incentive to deviate from the ISO's dispatch. We propose a pricing method that mitigates this incentive problem by explicitly considering historical loss. Numerical tests show that our method improves price signal and reduces out-of-market payments.

4 - Spurious Critical Points in Power Systems State Estimation

Richard Y Zhang, UC Berkeley, Berkeley, CA, 94720, United States, ryz@berkeley.edu, Javad Lavaei, Ross Baldick

The power systems state estimation problem computes the set of complex voltage phasors given quadratic measurements using nonlinear least squares. Even in the absence of measurement errors, local search algorithms can become "stuck" at local minima, which correspond to nonsensical estimations. In this talk, we observe that local minima cease to be an issue as redundant measurements are added. Posing state estimation as an instance of the quadratic recovery problem, we derive a bound for the distance between the true solution and the nearest spurious local minimum, in order to show that they become increasing rare and far-away from the true solution with the addition of redundant information.

■ MB26

350B

Efficiency and Productivity – YR

Invited: Data Envelopment Analysis

Invited Session

Chair: Ole Bent Olesen, University of Southern Denmark, University of Southern Denmark, Odense, 5230, Denmark, ole@sam.sdu.dk

1 - Shape Constrained Kernel-weighted Least Squares

Daisuke Yagi, Texas A&M.University, College Station, TX, United States, d.yagi@tamu.edu, Yining Chen, Andrew L. Johnson, Timo Kuosmanen

Nonparametric estimation methods avoid functional form misspecification which is caused by parametric assumptions. However, the flexibility of nonparametric methods often cause difficulties in interpreting results in many applications of productivity analysis. However, microeconomic theory provides additional structure for modeling a production or cost function which can be interpreted as shape constraints. We propose nonparametric shape constrained estimators that combine the advantage of avoiding functional misspecification with improving the interpretability of estimation results relative to unconstrained nonparametric methods.

2 - Direction Selection in Stochastic Directional Distance Functions

Kevin Layer, Texas A&M.University, College Station, TX, United States, kevin.layer@tamu.edu, Andrew L. Johnson, Robin C. Sickles

A stochastic directional distance function (SDDF) allows for noise in potentially all input and output variables; however when estimated, the direction selected will affect the functional estimates. This paper addresses the question, how should the direction be selected to improve the estimates of the underlying production behavior. From Monte Carlo simulations we find two main guidelines: picking a direction orthogonal to the region where most of the data lies and a direction that is consistent with the noise in the DGP. Finally we confirm the analysis with an application on a cost function for hospital production in the U.S.

3 - The Measurement of Revenue Inefficiency Over Time: An Additive Perspective

Samah Jradi, samah.jradi@kedgebs.com,
Tatiana Bouzdine Chameeva, Juan Aparicio

In this paper, we introduce a Luenberger-type indicator based on the weighted additive distance function defined in [Aparicio et al. 2016] to measure revenue inefficiency change over time. The weighted additive distance function endows the well-known weighted additive model in data envelopment analysis (DEA) with a structure of distance function that allows to determine values related to the performance of points located in both the interior and exterior of the reference production possibility set. We consider an application to French wine production.

■ MB27

350C

Leaders on Twitter

Invited: Social Media Analytics

Invited Session

Chair: Sung Won Kim, University of Illinois at Urbana Champaign, Champaign, IL, 61820, United States, swk@illinois.edu

1 - Leaders and Lemmings on Twitter: Examining the Role of Cognitive and Heuristic Persuasion

William Obenauer, Rensselaer Polytechnic Institute, Troy, NY, United States, Obenaw@rpi.edu

Social networking sites (SNS) are a rapidly growing global force of influence. SNS are unique in that they restrict the use of communication tools such as body language and voice inflection, while giving users unfettered access to their audience, thus allowing for new types of leaders to emerge. We examine this dynamic by collecting data during a 14-day period of the 2014 Indian Parliamentary elections using Twitter's streaming API 1.1 with a keyword filter limiting our data capture to Tweets relevant to the election. Our final data set includes 3.87 million Tweets which we analyze to identify behavioral trends that result in the emergence of leaders within SNS.

2 - Recruiting Members of Underrepresented Groups: What Women-in-Tech Meetups do Differently

Jessica Clark, University of Maryland Smith School of Business, College Park, MD, 20742, United States, jclark@stern.nyu.edu

Recruiting members of underrepresented groups into technology jobs is a major challenge for organizations. The goal of this work is to understand how various aspects of such organizations' public faces affect their ability to attract diverse membership. Using data gathered from meetup.com, we compare general technology-themed Meetups to those explicitly targeting female members. We characterize members' propensity to join and become active members of each Meetup using its textual description, events, reviews, and discussion board communications, among other aspects.

3 - The Impact of Short-term Introductory Incentives on Newmembers: Evidence from Online Health Communities

Wei Chen, University of Arizona, 1130 East Helen Street, McClelland Hall 430, Tucson, AZ, 85721, United States, weichen@email.arizona.edu, Xiaofei Zhang, Bin Gu, Xitong Guo

Many online communities deploy short-term extra incentive policy to motivate user contributions, especially for the new members. However, whether the communities can benefit from this policy is unclear. We draw on a policy change in a leading online health platform to answer this question. We find that even though the short-term extra incentives increase contribution quantity during the policy window, but decrease contribution quantity significantly after the policy window. The policy also does harm to the platform by decreasing contribution quality, but can help to increase user survival. Moreover, the impacts of the short-term extra incentives are contingent on users' professional titles.

4 - How Corporate Sponsors can Shift Donations in Philanthropic Crowdfunding Markets

Lauren Rhue, Wake Forest University, 1834 Wake Forest Rd, 212 Farrell Hall, Building 60, Winston-Salem, NC, 27106, United States, rhuela@wfu.edu

This study examines if corporate sponsorship affects donations to disadvantaged recipients and if corporate sponsorship "crowds-in" or "crowds-out" individual donations on a philanthropic crowdfunding platform. Using data from DonorsChoose and a matched sample technique, I find that corporate sponsorship can "crowd-out" individual donors but "crowd-in" local donations to the highest poverty recipients and mitigate the conflict between "home bias" and donations to highest need recipients. There are managerial implications for platforms and corporate social programs as well as societal implications based on the potential of philanthropic platforms to reduce poverty and/or inequality.

■ MB28

350D

Correlated and Interdependent Valuations in Mechanism Design

Invited: Auctions

Invited Session

Chair: Michael Albert, Duke University, Durham, NC, malbert@cs.duke.edu

1 - The Value of Side Information for Revenue Extraction

Hu Fu, University of British Columbia, Vancouver, BC, Canada, fu.hu.thu@gmail.com

Suppose we have some side information regarding a single bidder to whom we try to sell a single item, does it matter if we reveal the information to the buyer? We show that the answer is yes, and give nontrivial sufficient conditions under which the revenue loss caused by revealing the information is bounded by a small factor. We also derive implications for revenue optimal auctions with multiple correlated bidders, via a Bayesian extension of Ronen's lookahead auction.

2 - Optimal Procurement with Quality Concerns

Giuseppe Lopomo, Duke University, FSB, P.O. Box 90120, Durham, NC, 27708, United States, glopomo@duke.edu

We characterize optimal procurement mechanisms in environments where each supplier's privately known type affects both its production cost and the buyer's willingness to pay for its product. We restrict attention to mechanisms that satisfy both incentive compatibility and individual rationality ex post. We show that when the affiliation among the suppliers' types is low, it is optimal for the buyer to randomly select the winner if its willingness to pay is sufficiently large, and not trading at all otherwise. If instead the affiliation is high, a standard second-price auction, possibly with a reserve price, is optimal.

3 - Mechanism Design with Correlated Valuations: How Much Correlation is Necessary?

Michael Albert, Duke University, 308 Research Drive, Durham, NC, 27708, United States, malbert@cs.duke.edu

In a setting where bidders' values are correlated, an auction designer can extract the full social surplus as revenue. However, this result strongly relies on the assumption of a common prior distribution between the mechanism designer and the bidders. We show that if a bidder's distribution is one of a countably infinite sequence of potential distributions that converges to an independent private values distribution, then there is no mechanism that can guarantee revenue more than greater than the optimal mechanism over the independent private value mechanism, even with sampling. This suggests that a high degree of correlation is essential in the application of correlated mechanism design.

■ MB29

350E

Machine Learning in Physiological Data Analytics

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Hong Lin, linh@uhd.edu

1 - An ACT-R Model for Blog Users' Negative Emotion Generation in Crises

Jingjing Zhang, Nanjing University of Science & Technology, Jiangsu, China, zjingjing1202@163.com, Peng Wu, Yao Cai

The purpose of this paper is to study the Blog users' negative emotion generation in crises (Blog users'-NEGC). We develop an Adaptive Control of Thought Rational (ACT-R) model to represent the Blog users'-NEGC (the ACT-R-NEGC model). This model is based on two cognitive facts: memories have emotional effect restricted to the contextual part of activation, goals and confidence change over crises. An experimental study was conducted to test the efficiency of this model by using data retrieved from Sina Weibo and Twitter on food safety crises. This model strongly supported the Blog users'-NEGC, and this paper shows a way to model emotion within cognitive architecture in the context of real life crises.

2 - Understanding Reasons for Medication Nonadherence: An Exploration in Social Media using Sentiment-enriched Deep Learning Approach

Jiaheng Xie, University of Arizona, 1130 E. Helen Street, Tucson, AZ, 85721, United States, xiej@email.arizona.edu, Xiao Liu

Medication nonadherence (MNA) refers to the behavior when patients do not fill prescriptions at pharmacies. To take proactive measures, the stakeholders need to understand patients' reasons for MNA. Current studies attempt to provide one-size-fits-all solutions to the "average patients." To address this issue, we develop a semantically enhanced deep learning approach to detecting patient and drug-specific reasons for MNA using health social media data. Our model reached a precision of 86.43%, a recall of 92.53%, and an F1-score of 89.38%. This study contributes to information systems and health IT by designing a deep-learning-based framework for detecting tailored reasons for MNA.

3 - A Process Mining Framework for Analyzing Learning Clickstream Data

Kexin Yin, University of Delaware, Newark, DE, United States, yinkexin@udel.edu, Harry Wang

Learning analytics is an emerging field of research that aims to utilize a wide range of educational data to establish a deep understanding of the learning processes and learner behavior. In this paper, we propose a process mining framework for analyzing large-scale learning clickstream data collected from a major US university's learning management system. We address a number of modeling and analysis challenges from a process mining perspective and propose new concepts for process-centric learning analytics. Based on the process mining results, we conduct an experiment to see how social influence affects learning processes and results.

■ MB30

350F

Studying Social Issues with Social Media

Invited: Social Media Analytics

Invited Session

Chair: Jessica Clark, NYU Stern School of Business, Brooklyn, NY, 11217, United States, jclark@stern.nyu.edu

1 - Diffusion of Ineffectual User Innovation

Vidya Haran, University of Illinois Urbana-Champaign, 1206 South Sixth Street, 350 Wohlers Hall, Champaign, IL, 61822, United States, vharan@illinois.edu, Sung Won Kim

We examine why ineffectual user innovations diffuse and persist in online communities. We investigate the case of 'tweaking', an ineffectual yet popular user innovation, on babycenter.com. Tweaking is the use of enhancing digital pictures to determine the results of a pregnancy test earlier than using the test as instructed. Though the tweaked results are not considered valid by the scientific community, the tweaking community continues to grow. We analyze online discussion to posit that psychological safety, anxiety, desirability bias, source credibility and social proof are the important factors that keep ineffectual user innovations from getting rejected.

2 - Gender Inequalities in Online Doctor Ratings

Aishwarya Shukla, PhD, University of Maryland Smith School of Business, College Park, MD, United States, adshukla@rhsmith.umd.edu, Michelle Dugas, Gordon (Guodong) Gao, Ritu Agarwal

Despite findings that female physicians are, on average, more patient-centered and effective than male physicians, evidence that patients are more satisfied with female physicians is equivocal. We sought to further clarify the relationship between physician gender and patient satisfaction with a unique dataset of online doctor reviews from India. To this end, we examined differences in the rates of positive and negative recommendations for male and female physicians, and explored moderating factors such as gender match. We also conducted text analysis of the reviews for further insights. Implications for physician care and consumer decision-making are discussed.

3 - Can You Pay My Bills? Crowdfunding as Supplemental Income

Lauren Rhue, Wake Forest School of Business, 1834 Wake Forest Rd, 212 Farrell Hall, Building 60, NC, 27106, United States, rhuela@wfu.edu

This study examines the role of crowdfunding in supplementing individuals' income by using data from GoFundMe. Regional differences in opportunities, political leanings, and income inequality influence the crowdfunding goals and the campaigns' success rate. Areas with fewer resources may experience more campaigns per capita and lower success because there is greater need for extra income yet there are fewer affluent potential contributors. Also, because personal social connections are critical in fundraising, we investigate the use of social media as well as the linguistic and image elements of the campaigns.

■ MB31

351A

INFORMS Korea Chapter

Sponsored: INFORMS Special Sessions

Sponsored Session

Chair: Chang Won Lee, Hanyang University, School of Business, 17 Haengdang Dong, Seoul, 133-791, Korea, Republic of, leecw@hanyang.ac.kr

1 - Humanitarian Supply Chain Management: Research Opportunities and Implementation Issues

Chang Won Lee, Hanyang University, School of Business, 17 Haengdang Dong, Seoul, 133-791, Korea, Republic of, leecw@hanyang.ac.kr

This study is to explore research opportunities and Implementation issues in Humanitarian Supply Chain Management (HSCM). This study is to review some issues on social impact of HSCM consequences. Implication perspectives in SCM in non-profit sector are not reviewed well compared to those in SCM for-profit contexts so that this study provides the cases of challenges and research opportunities.

2 - Effects of Hospital Occupancy on Patient Length of Stay and Patient Outcome

Yunsik Choi, Clemson University, 100 Sirrine Hall, Clemson, SC, 29634-1305, United States, yunsikc@g.clemson.edu, Lawrence Fredendall, Aleda Roth, Babur De Los Santos, Michael Makowsky

We examine the effect of hospital occupancy on time from admission to procedure start (segment 1) and the time from procedure end to discharge (segment 2). We investigate the effect of hospital occupancy on the completion of time segment 1 and 2 and effects of the completion time on 30-days readmission.

3 - Designing Energy Supply Chains for Energy Food and Flood

Kwon Gi Mun, Fairleigh Dickinson University, Fort Lee, NJ, United States, kgmun@fdu.edu, Yao Zhao, Raza Ali Rafique

The interconnected issues of Energy, Food, and Flood are among the most formidable challenges faced by developing countries. The development of hydropower has the potential to address all these issues in the same time. We identify the unique features, economies, and trade-offs in the hydro system development. We also provide the end-to-end and dynamic perspectives.

■ MB32

351B

Forecast Aggregation

Invited: Forecasting and Prediction

Invited Session

Chair: Yael S. Grushka-Cockayne, Darden School of Business, University of Virginia, 100 Darden Boulevard, Charlottesville, VA, 22903, United States, GrushkaY@darden.virginia.edu

1 - Automating Judgement and Decision-making: Theory and Evidence from Resume Screening

Bo Cowgill, Columbia University, 11 Fox Meadow Road, Scarsdale, NY, 10583, United States, bo.cowgill@gmail.com

I develop a formal model of the comparative advantages of human judgement and machines in decision-making. I subsequently test these predictions in a field experiment in applying machine learning for hiring workers for white-collar team-production jobs. The marginal candidate picked by the machine (but not by human screeners) is +17\% more likely to pass a face-to-face interview with incumbent workers and receive a job offer, b) +15\% more likely to accept job offers when extended by the employer and c) 0.2σ-0.4σ more productive once hired as employees.

2 - Efficient Probability Forecasting using Ensembles

Eva Regnier, Naval Postgraduate School, Monterey, CA, United States, eregnier@nps.edu

We investigate the efficiency of probability forecasts derived from model ensembles—output from multiple models or multiple runs of the same model—and recommend approaches to improving ensemble probability forecasts.

■ MB33

351C

Air Traffic Flow Management

Sponsored: Aviation Applications

Sponsored Session

Chair: Guglielmo Lulli, g.lulli@lancaster.ac.uk

1 - Strong IP Models for Ground Delay Program Planning

Alexander Estes, University of Maryland-College Park, College Park, MD, United States, aestes@math.umd.edu, Michael O. Ball

The Federal Aviation Administration uses ground delay programs to manage congestion at an airport when the capacity of that airport to accept incoming flights has been impacted by some external factor. We present a multi-stage integer programming model for planning ground delay programs. This model has a strong LP relaxation, and we can show that every constraint of the formulation is facet-defining for the convex hull of integer programs. We also present computational results.

2 - A Passenger-centric Approach to Air Traffic Flow Management

Alexandre Jacquillat, Carnegie Mellon University, Heinz College, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, ajacquil@andrew.cmu.edu

Existing Air Traffic Flow Management (ATFM) approaches are based on aircraft-centric objectives. However, the ultimate impact of flight delays and cancellations on aviation stakeholders are amplified by passenger misconnections on one-stop or two-stop itineraries. We present a novel model of network-wide ATFM operations that considers simultaneously flight delay costs and passenger disruption costs. Results suggest that passenger disruptions can be greatly reduced through no, or limited, increases in flight delays, thus making the outcomes of ATFM initiatives more consistent with airline and passenger preferences. Implications for implementation are discussed.

3 - Secondary Landing Slot Allocation Mechanisms for Ground Delay Programs

Jackie W. Baek, MIT, 77 Massachusetts Ave, Bldg E40-103, Cambridge, MA, 02139, United States, baek@mit.edu, Hamsa Balakrishnan

When congestion is expected at an airport, the Federal Aviation Administration issues a Ground Delay Program (GDP) to allocate landing slots in accordance with the predicted arrival capacity. Once these slots are initially allocated, there is a Collaborative Decision Making step in which airlines can swap slots among their own flights, and also decide cancellations. There has been limited literature on secondary slot allocation mechanisms for the inter-airline trading of slots. We analyze the effectiveness of various secondary slot allocation methods with respect to cost savings, fairness, and incentive compatibility to different airlines.

4 - Mining Alternative Flight Trajectories from Data Repositories: An Application to the European Airspace

Luigi De Giovanni, University of Padua, 63 via Trieste, Dipartimento di Matemtica "Tullio Levi Civita", Padova, I-35121, Italy, luigi@math.unipd.it, Giovanni Andreatta, Lorenzo Capanna, Luca Righi

Optimization models for Air Traffic Flow Management aim at determining flight trajectories that reduce congestion of both airports and en-route sectors, and maximize the efficiency of the Air Traffic Management system. To select suitable trajectories, models should consider many factors, such as length, time, en-route charges, fuel consumption, aircraft specifications, airspace users' preferences etc.,that are not always fully known. We present a data driven approach to mine alternative 2D, 3D or 4D trajectories from the historical flight records stored in the Eurocontrol DDR2 data sources, in order to develop and feed mathematical models for the optimization of trajectory based operations.

■ MB34

351D

Analytics and Homeland Security

Sponsored: Military Applications

Sponsored Session

Chair: Andrew Oscar Hall, United States Military Academy, United States Military Academy, West Point, NY, 10996, United States, andrew.hall@usma.edu

1 - Shortest Paths for Routing Information Over Temporally Dynamic Communication Networks

Azar Sadeghnejad, University at Buffalo, Buffalo, NY, United States, azarsade@buffalo.edu, Michael Hirsch, Hector Ortiz-Pena

This research will examine the effect degraded or limited communication networks have on routing collected time-critical information during a mission. This has applications in military as well as civil situations. A mathematical model is derived, a heuristic is developed, and numerous Monte-Carlo simulations are performed to assess solution quality.

■ MB35

351E

Supply Chain Management

Contributed Session

Chair: Lorena Pradenas, Universidad de Concepcion, Concepcion, Chile, lpradena@udec.cl

1 - The Impact of Product Variety on Subassembly Inventory and Strategic Assembly Sequencing

Jeonghan Ko, Ajou University, Suwon-si, Korea, Republic of, jeonghan@umich.edu

Jeonghan Ko, University of Michigan, Ann Arbor, MI, 48105, United States, jeonghan@umich.edu, Heng Kuang

This paper identifies the impact of product variety on the safety inventory of subassemblies in serial assembly processes when limited component commonality exists among products. We derive a measure to relate the levels of the product variety and safety inventory. We show that the measure can be used to optimally sequence assembly processes to reduce subassembly inventory levels. We extend the results as a prioritized sequencing principle for more generalized cases.

2 - Field Study of Supply Chain Management Practices of Small-and-medium Enterprise (SME) Retailers

Shardul Phadnis, Malaysia Institute for Supply Chain Innovation, 2A, Persiaran Tebar Layar, Seksyen U8, Shah Alam, 40150, Malaysia, sphadnis@misi.edu.my

This study describes the nature of supply chain management practices of small-and-medium enterprise (SME) retailers in an emerging market, based on a multi-method field study. Our findings suggest that constrained supply of key resources, specifically operating cash and management skills, influences the retailers' strategies for procuring the merchandise, warehousing and transporting the goods, and operating the retail stores. We contrast the observed practices with the best practices advocated in the literature, assess the suitability of both sets of practices to the operating environment, and provide normative guidelines for improving the performance of the supply chain practices.

4 - Big Data for Integrated Supply Chain Design

Gang Wang, Assistant Professor, University of Massachusetts Dartmouth, 285 Old Westport Rd, Room 214, North Dartmouth, MA, 02747, United States, gwang1@umassd.edu

This paper considers a big-data driven, integrated supply chain design, with the focus on efficient supply chain design analytics. The supply chain is three-echelon consisting of contracted suppliers, capacitated processing centers, and demand points. It first presents a methodology for identifying potential locations for the processing centers using sales data in ERP and GIS data. Then a mixed-integer linear programming model is to determine the optimal number of processing centers, along with efficient algorithm and computational testing.

3 - Recruitment Stocking Problems

Anh Tuan Ninh, William & Mary, 1604 Queens Crossing, Williamsburg, VA, 23185, United States, ninhtuananh@gmail.com

We explore a general class of inventory control problem - the recruitment stocking problem, which can be found in clinical trials, marketing research/new product launch, as well as inventory management for end-of-life-cycle products. Both exact and approximation methods to measure key performance metrics for the system will be presented.

6 - Prediction of Consumption of Materials with Artificial Neural Networks

Lorena Pradenas, Universidad de Concepcion, Casilla 160-C Correo 3, Concepcion, 4030000, Chile, lpradena@udec.cl, Camila Flores

This study focuses on the use neural networks to effectively predict the consumption of multiple materials and spare parts of a forestry company and compare the results obtained with those achieved through traditional methods. Today, company analysts must manually assign the forecasting model that best suits the behaviors of each of the more than 100,000 materials coded.. In addition to this, there are hardware limitations, which do not allow the analysis of information in a consolidated way to make global decisions. Clustering methods and unconventional forecasting models were used to obtain predictions with better performance.

■ MB36

351F

Directions of Service Science Journal

Sponsored: Service Science

Sponsored Session

1 - Directions of Service Science Journal

Paul Maglio, University of California, Merced, 5200 N. Lake Rd, Merced, CA, 95343, United States, pmaglio@ucmerced.edu

INFORMS Service Science publishes articles about various aspects of service and service systems, highlighting customer-oriented services, service operations and management, and healthcare applications of service. In this session, you will learn more about the journal and the service science community at INFORMS from the Editor-in-Chief and Area Editors and others.

2 - Panelist

Seyed Iravani, Northwestern University, Department of Industrial Engineering, 2145 Sheridan Road/C210 Tech, Evanston, IL, 60208-3119, United States, s-iravani@northwestern.edu

3 - Panelist

Sriram Dasu, University of Southern California, Marshall School of Business Bridge Hall 401, Data Sciences and Operations, Los Angeles, CA, 90089-0809, United States, jakeiawa@marshall.usc.edu

4 - Panelist

Maria Esther Mayorga, North Carolina State University, 400 Daniels Hall, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu

■ MB37

352B

Analytics and OR for Cloud Computing and Internet of Things (IoT)

Sponsored: Service Science

Sponsored Session

Chair: Aly Megahed, IBM Research - Almaden, San Jose, CA, 95123, United States, aly@gatech.edu

1 - A Stochastic Programming Approach for Cloud Elasticity

Aly Megahed, IBM.Research - Almaden, 150 Palm Valley Blvd Apt 2066, San Jose, CA, 95123, United States, aly.megahed@us.ibm.com, Mohamed Mohamed, Sameer Tata, Chelliah Sriskandarajah, Jon Stauffer

Vertical elasticity in cloud applications is the ability of increasing or decreasing computing resources to handle incoming queries. This is commonly achieved is via increasing or decreasing deployed application instances. Determining the optimal number of instances for a given horizon is challenging, because of the random number and type of incoming queries. There is also a trade-off between deploying too many instances (paying unnecessary deployment costs) and deploying too few of them (penalties for delaying query execution). We propose a stochastic programming method for this problem.

2 - Optimizing Metric Monitoring Frequencies in Resource-constrained IoT Applications

Jennifer A. Pazour, Assistant Professor, Rensselaer Polytechnic Institute, 110 8th street, CI I.5217, Troy, NY, 12180, United States, pazouj@rpi.edu, Aly Megahed, Ahmed Nazeem, Samir Tata, Mohamed Mohamed

We formulate a mixed integer program to determine the optimal monitoring start time and interval frequency for multiple metrics in resource constrained Internet of Things (IoT) environments. The optimization model is used for adaptive monitoring and resolved when triggered based on monitored values or environmental events. Given solution time is critical, application-specific solution approaches are developed and tested, including reformulation, valid inequalities, and column generation procedures.

3 - Stabilizing Consumer Electrical Demand

Ray Strong, IBM, San Jose, CA, United States, hrstrong@us.ibm.com, Ralphael Arar, Kevin Roche, Sandeep Gopisetty

We discuss managing and stabilizing power consumption in a smartly-connected private home or office using a controlled system of IoT devices. Each IoT device is closely associated with an electrical power consuming element, a set of circuit switches, a rechargeable battery, an independent source of power, or the local connection to a public electrical power utility. Stabilizing consumption will tend to produce a win for both consumer and utility.

■ MB38

352C

Complex Multi-criteria Decision Making Problems II

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Murat Mustafa Koksalan, Middle East Technical University, Ankara, 06531, Turkey, koksalan@metu.edu.tr

Co-Chair: Banu Lokman, Middle East Technical University, Ankara, 06800, Turkey, lbanu@metu.edu.tr

1 - Interactive Approaches for Bi-objective UAV Route Planning in Continuous Space

Hannan Tureci, Middle East Technical University, çi Blokları Mah. 1427.Cad. 1508.Sok., Ankara, Turkey, hannantureci@gmail.com, Murat Mustafa Koksalan, Diclehan Tezcaner Ozturk

In this study, we consider the route planning problem of unmanned air vehicles (UAVs). We use two objectives; minimizing total distance traveled and minimizing total radar detection threat. We consider routing in a 2-D continuous terrain, in which we have infinitely many efficient trajectories between target pairs. We develop interactive algorithms that find the most preferred solution of a route planner, who has either of the underlying preference function structures: linear or quasiconvex. To implement the algorithms to problems, we use approximated nondominated frontiers of the trajectories between targets. We demonstrate the interactive algorithms on illustrative examples.

2 - An Interactive Approach for Product and Process Design Parameter Optimization under Model Uncertainty

Melis Ozates, Middle East Technical University, Industrial Engineering Dept, Office Room 318, Ankara, 06800, Turkey, mozates@metu.edu.tr, Gulser Koksal, Murat Mustafa Koksalan

We develop an interactive approach for the two-response product and process design optimization problem, considering DM's preferences under model uncertainty. We involve the problem analyst (PA) in the searching procedure to help the DM converge to his/her preferred solutions quickly. The PA systematically searches the relevant solution space at each iteration by converting DM's verbal preferences into mathematical expressions.

3 - Real Time Bicriteria Route Planning for Unmanned Air Vehicles

Murat Mustafa Koksalan, Middle East Technical University, Industrial Engineering Department, Ankara, 06531, Turkey, koksalan@metu.edu.tr
Murat Mustafa Koksalan, Georgetown University, Washington DC, DC, United States, koksalan@metu.edu.tr, Diclehan Tezcaner Ozturk, Nail Karabay

Distance and threat minimization are important criteria in the route planning of unmanned air vehicles. In this study, we consider these criteria and acknowledge that the conditions keep changing during the trip. We develop an approach that keeps modifying the route in real time. We assume that the route planner has a linear value function of the two criteria which we know partially. We demonstrate the approach on several example problems.

4 - Using Bilevel Programming to Solve Multiobjective Optimization Problems

Serpil Sayin, Koc University, College of Admin Sciences and Economics, Rumeli Feneri Yolu Sariyer, Istanbul, 34450, Turkey, ssayin@ku.edu.tr, Gokhan Kirlik

We propose a bilevel programming formulation that is capable of delivering an efficient solution of a multiobjective optimization problem that maps into a given set, provided that one exits. If the Decision Maker's preferences are known a priori, they can be used to specify the given set. Alternatively, the bilevel program can be used to obtain a representation of the nondominated set. This requires a thorough search of the outcome space. While building a discrete representation, the algorithm also generates an approximation of the nondominated set within the specified error factor. We illustrate the approach on a multiobjective linear programming problem and discuss its strengths and weaknesses.

5 - Interactive Evolutionary Approaches to Multi-objective Feature Selection

Muberra Ozmen, University College London, Level 38, 1 Canada Square, London, E14 5AA, United Kingdom, muberra.ozmen.16@ucl.ac.uk, Gulsah Karakaya, Murat Mustafa Koksalan

In feature selection problems, the aim is to select a subset of features to characterize an output of interest. In characterizing an output, we may want to consider multiple objectives such as maximizing classification performance, minimizing number of selected features or cost, etc. We develop a preference-based approach for multi-objective feature selection problems. Finding all Pareto optimal subsets may turn out to be a computationally demanding problem and we still would need to select a solution. Therefore, we develop interactive evolutionary approaches that aim to converge to a subset that is highly preferred. We test our approaches on several instances and demonstrate they work well.

■ MB39

352D

Innovative Technologies

Cluster: Analytics

Sponsored Session

1 - Crowd-Sourcing Analytics with Datasplash

Lorens Helmchen, George Washington University, Washington, DC, United States, helmchen@gwu.edu

We introduce Datasplash, a new web-based analytics application that allows anyone to load, explore, and share their data quickly, easily, and securely on any device anywhere — without downloading and installing software or learning a programming language. We show how even users with no analytics training can spot salient and significant associations, assess model fit, and compute predictions. We also show how Datasplash can be used to recognize and remedy more advanced model-fitting challenges, such as non-linearities, outliers, confounding, and collinearity. We illustrate these features by applying them to case studies from the hospitality and health care industries.

2 - Communicating with the New Machine: Human Insight at Machine Scale

Kris Hammond, Narrative Science, Chicago, IL, United States, khammond@narrativescience.com

In this talk, I will outline what we are with regard to data analytics and how the technology of automatic narrative generation from data plays the crucial role of bridging the gap between the Big Data world of numbers and symbols and our need for understandable insights. I will dive into use cases from business, education and everyday life to show how the power of automatically generated narratives can provide us all with the insights that are still trapped in the wealth of data we now control.

■ MB40

352E

Daniel H. Wagner Prize Competition I

Invited: Daniel H. Wagner Prize Competition

Invited Session

Chair: Patricia Neri, SAS Institute, Inc., 104 Grandtree Ct., Cary, NC, 27519, United States, patricia.neri@sas.com

1 - The Inmate Assignment and Scheduling Problem and its Application in the PA Department of Corrections

Tamás Terlaky, Lehigh University, 200 W. Packer Ave, Bethlehem, PA, 18015, United States, terlaky@lehigh.edu, Mohammad Shahabsafa, Chaitanya Gudapati, Anshul Sharma, Louis J. Plebani, George R. Wilson, Kristofer B. Bucklen

The inmate assignment project, in close collaboration with the PA Dept. of Corrections, took five years from start to successful implementation. Our novel Inmate Assignment Decision Support System (IADSS) is designed with the main goal of simultaneously, and system-wide optimally, assigning the inmates to the correctional institutions. IADSS includes a new hierarchical multi-objective MILO model, which accurately describes the inmate assignment problem. This is the first time that OR methodologies have been used to optimize the operations, and built into the routine business practice, of a correctional system, thus it opens a rich and untouched area for the application of OR.

2 - Forecasting and Optimization Models for Audience Targeting on Television

Wes Chaar, Turner Broadcasting System, Inc., 106 N.Denton Tap Road, # 210-273, Coppell, TX, 75019-2148, United States, wscemail2002@yahoo.com, J. Antonio Carbajal, Peter Alexander Williams

At Turner, we have developed and implemented innovative, integrated forecasting and optimization models that forecast audiences in the 24/7 programming schedule, generate media plans across all Turner's networks, and schedule commercials holistically. These methods power Turner's audience targeting solutions: TargetingNOW and AudienceNOW, which have produced significant sales and advertisement efficiencies for Turner and its clients, and moved the industry forward in the emerging audience targeting landscape.

■ MB41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Danielle Ripsman, Waterloo Ontario, ON, Canada, daripsman@uwaterloo.ca

1 - Joint Optimization of Appointment and Real-time Schedule in the Presence of Walk-ins, Waiting Time Targets and No-shows

Xingwei Pan, Shanghai Jiao Tong University, No. 800 Dongchuan Road,Minhang District, Shanghai, 200240, China, 1103951776@sjtu.edu.cn

Clinics give the highest priority to appointed patients, incurring long waiting of walk-ins. To balance the waiting between the appointed and walk-ins, this paper jointly optimizes the appointment and real-time schedule by considering appointed patients' waiting time target (WTT) and no-shows. A finite horizon Markov Decision Process model is proposed to establish structural properties of the optimal control policy. Appointment schedule is gained by combining a stochastic programming model and local search. Numerical tests show the impact of WTT and efficiency of the approach. Key words: appointment; real-time schedule; waiting time target; Markov Decision Process; Stochastic Programming

2 - Policy Design for Online Scheduling with Heterogeneous Patients and Doctors

Shan Wang, Shanghai Jiao Tong University, 1954 Huashan Road, Shanghai, 200030, China, wangshan_731@sjtu.edu.cn, Huiqiao Su, Guohua Wan

How to design the patients scheduling policy for the heterogeneous patients and doctors is a problem in health care management. We study the process of outpatient clinic service in China and find there exit problems in outpatient scheduling. In this paper, we show how to model this problem as an online scheduling problem, and demonstrate how to solve this scheduling problem by applying the Markov Decision Process. We design the numerical experiments to compare the performances of our policy and two policies employed in practice by simulating various scenarios; the numerical results show that our policy has the best performance under all scenarios, especially when the system has a heavy workload.

3 - Nurse Scheduling with Shift Preferences using Goal Programming

Esra Agca Aktunc, Kadir Has University, Kadir Has Cd. Cibali, Istanbul, 34083, Turkey, esra.agca@khas.edu.tr, Elif Tekin

Fair workload and job satisfaction should be taken into account in nurse scheduling to improve the quality of healthcare. In this study, a monthly nurse scheduling model is developed based on labor regulations, hospital management requirements, and nurse preferences. A multi-objective integer program is formulated and solved as a goal programming model to avoid disproportional shift assignment, improve job satisfaction of nurses, and reduce medical errors caused by fatigue. Resulting schedules for various shift preference scenarios are compared to show the improvement in the schedule quality in terms of performance measures such as distribution of preference violations among nurses.

4 - A Polynomial-time Approximation Scheme for Sequential Batch-testing of Series Systems

Yaron Shaposhnik, Assistant professor, University of Rochester, Simon Business School, CS.H.3-343, 500 Joseph C. Wilson Blvd., Rochester, NY, 14627, United States, yaron.shaposhnik@simon.rochester.edu, Danny Segev

We study a recently-introduced generalization of the classic sequential testing problem for series systems, consisting of multiple stochastic components. The conventional assumption in such settings is that the overall system state can be expressed as a boolean function, defined with respect to the states of individual components. However, unlike the classic setting, rather than testing components separately, we allow aggregating multiple tests to be conducted simultaneously, while incurring an additional set-up cost. We devise a PTAS for the sequential batch testing problem, thereby significantly improving on the constant-factor approximation of 6.829+eps due to Daldal et al.

5 - Personalized Fatigue-aware Scheduling of Physical Activity using Stochastic Programming

Alla Kammerdiner, New Mexico State University, 7474 Sierra Luz Dr, Las Cruces, NM, 88012, United States, alla@nmsu.edu

Sedentary people benefit from physical activity. Yet, overexertion from an activity induces fatigue, which can discourage the following physical activity and long-term adherence to exercise. In this study, we develop and formulate new stochastic programming problems for scheduling bouts of physical activity in sedentary people to maximize its health benefit while limiting overexertion. The models are formulated to maximize the time or amount of activity while constraining the chance of exercising past fatigue onset, which could have a negative impact on adhering to exercise. We present the solution algorithms and illustrate the application of the developed optimization problems on real data.

■ MB42

360A

Additive Manufacturing – Data Analytics and OR I

Invited: Invited OR and Advanced Manufacturing

Invited Session

Chair: Alaa El Wany, Texas A&M University, TAMU, College Station, TX, 77843, United States, elwany@tamu.edu

1 - Characterizing the Geometric Accuracy of Additively Manufactured Components

Mojtaba Khanzadeh, PhD Student, Mississippi State University, McCain Engineering, Starkville, MS, 39759, United States, mk1349@msstate.edu, Linkan Bian, Prahalada Rao

The objective of this work is to quantify the geometric deviations of additively manufactured parts from a large dataset of laser-scanned coordinates using a type of neural network called self-organizing map (SOM). The central hypothesis is that clusters recognized by the SOM correspond to specific types of geometric deviations, which in turn are linked to certain additive manufacturing process conditions. This hypothesis is tested on parts made using the Fused Filament Fabrication AM process. This is an important research; although AM processes can make parts with complex geometries, a major barrier preventing use of AM in mission-critical applications, is the lack of geometric accuracy of parts.

2 - Forward Uncertainty Quantification Analysis via Polynomial Chaos Expansion of an Additive Manufacturing Selective Laser Melting Thermal Model

Alaa Elwany, Texas A&M.University, College Station, TX, 77843, United States, elwany@tamu.edu, Gustavo Tapia

Thermal models of Additive Manufacturing SLM processes help gain understanding by calculating thermal histories that the material undergoes given a combination of processing parameters, and can be employed in quality assessment of the build by melt pool characterization. Nevertheless, these models normally depend in many physical inputs whose values might vary according a probability distribution. This study presents a Forward UQ approach using PCE to quantify the variation in the outputs of the model given those of the inputs. The analysis benefits users to identify specific parameters and decide if more control over them should be applied if variations of melt pool dimensions are excessive.

3 - The Impact of 3D Printing on Manufacturer Retailer Relations

Mohammad Ebrahim Arbabian, PhD Student, University of Washington, 4120 Brooklyn Ave NE unit 503, #503, Seattle, WA, 98105, United States, me.arbabian@gmail.com, Michael R.Wagner

We consider the impact of 3D printing, or additive manufacturing, on a supply chain, consisting of a manufacturer and retailer, where either the manufacturer or retailer can adopt 3D printing. The firms utilize a wholesale-price contract and serve stochastic customer demand. We also study government subsidies of the 3D printer cost.

4 - Multiple-Objective Optimization of Additive Manufacturing Processes

Linkan Bian, Mississippi State University, Industrial and Systems Engineering Department, P.O. Box 9542, Mississippi State University, MS, 39762, United States, bian@ise.msstate.edu

We propose a novel approach for improving geometry accuracy of Additive Manufacturing parts in a systematic manner. Initial experimental data show that different geometric characteristics of part may not be possible to optimize simultaneously. The developed method targeted minimizing deviations within parts major Geometric Dimensioning and Tolerancing characteristics. Efficiency of proposed method is validated using simulation studies coupled with a real world case study for geometry accuracy optimization of parts fabricated by the Fused Filament Fabrication system. The results show that optimal designs are achieved by fewer numbers of experiments compared with existing methods.

■ MB43

360B

Humanitarian and Developing Country Operations

Sponsored: Public Sector OR

Sponsored Session

Chair: Jon M. Stauffer, Texas A&M University, College Station, TX, 77843, United States, jstauffer@mays.tamu.edu

1 - The Impact of Crop Minimum-support-prices on Farmers' Sowing Decisions and Product Availability

Prashant Chintapalli, UCLA Anderson School of Management, Los Angeles, CA, 90095, United States, prashant.chintapalli.1@anderson.ucla.edu, Christopher S. Tang

We analyze the impact of crop minimum-support-price (MSP) program on the sowing decisions of farmers in emerging markets. We consider the case of 2 crops and when farmers have heterogeneous production costs. We assume that a fraction of farmers are strategic. We show that though the number of strategic farmers growing a crop can reduce with an increase in the crop's MSP, the total availability of the crop is always increasing. Due to this, improper execution of MSP can hurt the society. While the returns of farmers can be negatively affected, bad MSPs can skew product availability.

2 - Mobile Money Agent Inventory Management

Karthik Balasubramanian, Harvard Business School, Boston, MA, United States, kbalasubramanian@hbs.edu, David F. Drake, Douglas Fearing

Mobile money agents exchange cash for electronic value and vice versa, forming the backbone of an emerging electronic currency ecosystem in the developing world. We model the agent's inventory problem, develop policy recommendations, and evaluate these policies with East African data.

3 - Global Vehicle Supply Chains in Humanitarian Operations: A Network Analysis Approach

Jon M. Stauffer, Texas A&M.University, 4217 TAMU, College Station, TX, 77843, United States, jstauffer@mays.tamu.edu, Alfonso J.Pedraza-Martinez, Lu Yan, Luk N. Van Wassenhove

Using 4WD vehicle supply chains, we test the common assumption that development program supply is independent of disaster supply in humanitarian operations. We utilize Exponential Random Graph Models to empirically test hypotheses and then use simulations to study the impact of the empirical results. We find that development program supply decreases due to disaster supply, which increases the preference for centralized supply chains.

4 - Operational Drivers of Stock-outs in Reproductive Health Care Supply Chains: An Empirical Study

Amir Karimi, University of Minnesota Twin Cities, Minneapolis, MN, 55455, United States, karim100@umn.edu, Karthik Natarajan, Kingshuk K. Sinha

Despite the widespread prevalence of contraceptive stock-outs in practice, very little is known about the drivers of stock-outs and this forms the motivating context for our study. Utilizing data from service delivery points in developing countries, we investigate the relationship between the stock-outs of contraceptive products and factors such as product variety, inventory management practices, and a facility's geographic location. This study sheds light on the operational drivers of stock-outs in global humanitarian health delivery settings, thereby highlighting the potential mitigation mechanisms that can be leveraged by facilities to minimize the likelihood of stock-outs.

■ MB44

360C

Marketing

Contributed Session

Chair: Jacob Do-Hyung Cha, Seoul National University, Gwanak-gu, United States, research.dohyung@gmail.com

1 - Subscription Selling: the Role of Consumer Valuation Uncertainty and Competition

Qiaohai (Joice) Hu, University of Missouri-St. Louis, St Louis, MO, United States, joice.hu@gmail.com, Yimin Yu, Xiaobei Shen

As subscription becomes increasingly popular, it is important to understand when it is more profitable than traditional selling. The literature offers the following explanation: subscription benefits firms because it enables them to price-discriminate among heterogeneous consumers. This study reveals two new drivers of subscription: an intertemporal pooling effect in the presence of consumer valuation uncertainty and a competition softening effect.

2 - The Evil Necessity: the Role of Surge Pricing in Sharing Economy

Xinying Hao, PhD Student, The University of Texas at Austin, 3500 Greystone Dr., # 262, Austin, TX, 78731, United States, xinying.hao@mccombs.utexas.edu

Using prices as signals to equilibrate supply and demand, Uber's surge pricing fits economics theory perfectly. Yet, surge pricing still faces popular and harsh criticism. In this paper, we examine the consumer's skepticism and psychological resistance to this mandatory charge. We propose a reference price model to empirically investigate how surge pricing (in price and time dimensions) can affect consumers' behavior. We aim to provide implications for platforms in sharing economy via three natural experiments: (1) No surge pricing. (2) Optional surge pricing, which would allow riders to opt-in to surges and be expedited to the front of the queue at a premium cost. (3) Mandatory surge pricing.

3 - Characterizing Customer Choice from Sales Transaction Data for Introducing Niche Products

Elham Nosratmirshekarlou, Wayne State University, 2200 Fuller Ct, Apt 809B, Ann Arbor, MI, 48105, United States, fo7573@wayne.edu, Ratna Chinnam, Evrim Dalikran, Satyendra Rana

We exploit promising non-parametric customer choice modeling methods to identify major customer segments and subsequently rely on parametric models for identifying demand for promising niche products within segments.

4 - When Marketing Strategy Meets Capital Markets: Marketing Spending and Market Feedback from Securities Analysts

Jacob Do-Hyung Cha, Seoul National University, Room 313, 58-dong, Seoul National University, Gwanak-gu, 150-742, Korea, Republic of, research.dohyung@gmail.com, Hye-Jin Cho

This study examines the role of securities analysts in the context of marketing intensity, a largely neglected issue in the extant literature. The results of a large-scale, cross-industry research suggest that capital markets' feedback - proxied by the earnings forecasts of financial analysts - leads to reduce marketing intensity. We propose that top managers tend to cut marketing spending when they are under pressure to meet analysts' performance targets. We further argue that analyst coverage can serve as an external monitoring mechanism to help contain this agency problem. We test these hypotheses with data from a sample of U.S. manufacturing firms during the period of 1979 to 2014.

■ MB45

360D

WORMS: Female Professional Development

Sponsored: Women in OR, MS

Sponsored Session

Chair: Dorothee Honhon, University of Texas at Dallas, Richardson, TX, 75080, United States, dorothee.honhon@utdallas.edu

1 - Worms Panel Session on Professional Development for Women in OR/MS

Dorothee Honhon, University of Texas at Dallas, 800 West Campbell Road, SM30, Richardson, TX, 75080, United States, dorothee.honhon@utdallas.edu

In this panel session, successful male and female academics will discuss the topic of professional development for women in the OR/MS world. In particular they will address questions such as how women can make themselves heard in meetings, how to negotiate and apply for promotion, how to select the best service jobs and decline excessive requests, how to dress to succeed, etc. Panelists will also discuss what steps can be taken to make the OR/MS academic field more women-friendly and fair. Bring a male colleague along to attend the session and both of you get a free WORMS coffee mug!

2 - Panelist

Rachel Rong Chen, University of California-Davis, 3208 Gallagher Hall, One Shields Avenue, Davis, CA, 95616, United States, rachen@ucdavis.edu

3 - Panelist

Tava Olsen, University of Auckland, ISOM, Business School, University of Auckland, Auckland, 1142, New Zealand, t.olsen@auckland.ac.nz

4 - Panelist

Aleda Roth, Clemson University, 606 Cross Creek Drive, Seneca, SC, 29678, United States, aroth@clemson.edu

5 - Panelist

Rohit Verma, Cornell University, 338 Statler Hall, Ithaca, NY, 14853, United States, rv54@cornell.edu

6 - Panelist

Vidya Mani, Pennsylvania State University, The Smeal College of Business, The Pennsylvania State University, State College, PA, 16802, United States, vmani@psu.edu

7 - Panelist

Eric Johnson, Eric.Johnson@owen.vanderbilt.edu

8 - Panelist

Anahita Khojandi, University of Tennessee, Knoxville, TN, United States, anahitakhojandi@gmail.com

■ MB46

360E

Scheduling VII

Invited: Project Management and Scheduling

Invited Session

Chair: Alessandro Agnetis, Universita Di Siena, Siena, 53100, Italy, agnetis@dii.unisi.it

Co-Chair: Federico Della Croce, Politecnico di Torino, Torino, 10129, Italy, federico.dellacroce@polito.it

1 - Exact Algorithms for the Equitable Traveling Salesman Problem

Frits C.r. Spieksma, Catholic University of Leuven, Brussels, Belgium, frits.spieksma@kuleuven.be

Given a weighted graph G = (V, E) , the Equitable Traveling Salesman Problem (ETSP) asks for two perfect matchings in G such that (1) the two matchings together form a Hamiltonian cycle in G and (2) the absolute difference in costs between the two matchings is minimized. The problem is shown to be NP-Hard, even when the graph G is complete. We present two integer programming models to solve the ETSP problem and compare the strength of these formulations. One model is solved through branch-and-cut, whereas the other model is solved through a branch-and-price framework. We conduct computational experiments on different types of instances, often derived from the TSPLib, and we report our findings.

2 - Scheduling with Variable Time-of-use Costs

Bo Chen, University of Warwick, Coventry, United Kingdom, Bo.Chen@wbs.ac.uk

We address a class of problems of scheduling a set of independent jobs onto a single machine that charges each job for its processing under variable time-of-use (ToU) tariffs. We consider a range of regular scheduling criteria as constraints with the objective of minimizing the total ToU cost. For each of the problems in the class, we establish its computational tractability. For those tractable we provide an efficient algorithm, while for those intractable we provide a pseudo-polynomial-time algorithm or a polynomial-time approximation scheme.

3 - LPT Rule for Identical Parallel Machines Revisited

Federico Della Croce, Politecnico di Torino, Corso Duca degli Abruzzi 24, Torino, 10129, Italy, federico.dellacroce@polito.it, Rosario Scatamacchia

Consider the well known LPT rule for scheduling jobs on identical parallel machines. It requires to sort the jobs in non-ascending order and then to assign one job at a time to the machine whose load is smallest so far. We consider an alternative approach that splits the sorted jobset in tuples of m consecutive jobs (1,...,m - m+1,...,2m etc.) and sorts the tuples in nonincreasing order of the difference (slack) between the largest job and the smallest job of the tuple. Then a list scheduling is applied to the set of sorted tuples. This approach strongly outperforms LPT on benchmark literature instances. The approximation ratio of a procedure combining LPT and the proposed approach is also discussed.

4 - The Price of Fairness in a Two-agent Single-machine Scheduling Problem

Alessandro Agnetis, Universita Di Siena, Dipartimento Ingegneria, Dell'Informazione Universita Di Siena, Siena, 53100, Italy, agnetis@dii.unisi.it

In this talk we investigate the concept of price of fairness applied to scheduling problems. We consider two agents (players), each having a set of jobs to perform, that compete for using a single machine. We investigate the situation in which one agent aims at minimizing total completion time of his/her jobs, while the other is concerned with minimizing tardiness with respect to a common due date. We propose a definition of utility and discuss both max-min and proportionally fair solutions, giving bounds on the price of fairness.

■ MB47

360F

Mobile Commerce, Apps, and Services

Sponsored: EBusiness

Sponsored Session

Chair: Keum Seok Kang, PhD, Florida International University, Miami, FL, 33199, United States, kskang@fiu.edu

1 - A Net Diffusion Model of Mobile Application: Considering Self-referencing, with in-category Dependency, and Drop-out Process

Youngsok Bang, Chinese University of Hong Kong, bangyoungsok@baf.cuhk.edu.hk, Dong-Joo Lee, Kunsoo Han, Sang Won Kim

Modeling the diffusion of mobile apps is practically important, as the mobile app market has become a significant economy. Furthermore, the diffusion process of mobile application has several distinctive features, which makes the modeling work theoretically meaningful. Considering distinctive features of mobile app diffusion—assimilation gap, self-referencing, and within-category dependency—, we develop a flexible diffusion model of mobile apps. Using the large-scale data, we evaluate the model fit of competing models across multiple apps. The analysis results suggest the appropriate diffusion model for a specific app type.

2 - Consumer Search, Producer Entry, and Product Variety: Theory and Evidence from a Digital Product Market

Michael (Zhan) Shi, Arizona State University, Tempe, AZ, United States, zmshi@asu.edu, Raghu Santanam, Zhongju (John) Zhang

Many digital goods markets are characterized by large product space, functionality and design heterogeneity, and low cost of entry for producers. We examine the influence of incumbent digital products distribution on consumer search, entry of new products into different niche locations and market performance. The producers in the market strategically choose to enter different niche locations according to their capability. We analyze the entry pattern and sales distribution that emerge endogenously as part of the equilibrium market structure, and how product variety changes the equilibrium.

3 - A Dynamic Location Based Advertisement Delivery Problem

Keumseok Kang, Assistant Professor, Florida International University, 11200 S.W. 8th Street, Miami, FL, 33199, United States, kskang@fiu.edu

Location Based Advertisement (LBA) enables physical stores to attract customers more effectively than ever by sending location-aware advertisements through customers' mobile devices. In spite of increasing attention in practice, LBA has attracted little attention in the literature. We study a dynamic advertisement delivery problem in a push-based LBA from the perspective of an intermediary advertiser that is sending advertisements to prospective customers on behalf of stores.

4 - Exploring Mobile Technologies in the Hospitality Industry: The Antecedents and Differential Impacts of using Mobile Devices on Hotel Employees' Outcomes

Minwoo Lee, Assistant Professor, Conrad N. Hilton College of Hotel & Restaurant Management, University of Houston, Houston, TX, United States, mlee37@Central.uh.edu

This study attempts to identify smart-computing functions of Smartphone use at the workplace and to examine the impact of using smart-computing functions on employees' managerial roles and overall performance improvement in the hospitality industry. Findings of this study indicate that user's Smartphone dependence and perceived critical mass lead to using smart-computing functions. Using smart-computing functions is positively associated with Mintzberg's three managerial role performance, resulting in overall performance improvement. Discussions and suggestions for future research are provided.

5 - Air Matters: the Impact of Searching Air Quality Information

Sang Pil Han, Arizona State University, BA 301D, Tempe, AZ, 85287, United States, sangpil.han@asu.edu, Ki-Kwang Lee, Youngki Park, Hyuncheol Kim

More than 90% of the world's population lives in areas where air pollution exceeds safety thresholds, according to the World Health Organization. We investigate whether meaningful use of information technologies can help individuals mitigate the risk of environmental hazards such as air pollution by having immediate access to information about ambient air quality. We find that information search for air quality index such as Particulate Matter 10 (PM 10) is most helpful to individuals when the air quality condition is not evident to naked eyes without checking the exact PM10 level online.

■ MB48

361A

Managerial Judgment and Decisions

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Brent Moritz, Penn State University, University Park, PA, 16802, United States, bmoritz@psu.edu

1 - How To Benefit from Supplier-retailer Negotiations: An Example of the Buyback Contract

Michael Becker-Peth, RSM.- Rotterdam School of Management, AlbertuBurgemeester Oudlaan 50s-Magnus-Platz, Erasmus University Rotterdam, Rotterdam, 3062, Netherlands, michael.becker-peth@uni-koeln.de, Elena Katok, Ulrich Thonemann

A standard way to test newsvendor contracts in the lab is to have the supplier propose a contract and the retailer place an order to maximize the expected profit. We show that when this process is used with human decision makers, coordinating contracts do no emerge. Human retailers place sub-optimal order quantities and exhibit inequity averse behavior, i.e., reject unfair offers. We show that allowing the player to negotiate can improve the profits of both players when negotiation is successful, especially when parties negotiate over the order quantity in addition to the contract parameters.

2 - Integrating Managerial Insight and Optimal Algorithms

Blair Flicker, University of Texas-Dallas, 800 W. Campbell Road, Mailstop AD23, Richardson, TX, 75208, United States, bflicker@utdallas.edu

A nearly universal finding in behavioral operations management is that human decision-makers suffer from biases that erode firm profits. But humans can gather information that is not available to standard optimization routines (macroeconomic developments, local trends, consumer sentiment). If humans have superior information, their decisions might actually be "superoptimal." Human newsvendors endowed with superior demand information fail to improve profitability when placing orders directly due to poor decision-making. However, a novel approach to automatically convert subjects' demand forecasts into insight-informed order quantities does substantially improve profitability.

3 - Judgment Forecasting for Multiple Demand Sources

John Aloysius, University of Arkansas, Supply Chain Management Department, Wcob 204, Fayetteville, AR, 72701, United States, aloysius@uark.edu, Marat Davletshin, Siqi Ma, Enno Siemsen

Managers often forecast demand for different distribution channels (e.g., online vs in-store), geographical regions, and store formats. There may be different systematic variation between these different demand sources (e.g., growing online demand and shrinking in-store demand). We experimentally study characteristics of situations where aggregated forecasting is advantageous over disaggregated forecasting.

4 - Impact of Capacity and Fixed Costs on Routine Sourcing Decisions under Demand and Supply Uncertainty: An Experimental Investigation

Arunachalam Narayanan, University of Houston, Dept of Decision and Information Sciences, Mail Stop 6021, University of Houston, Houston, TX, 77204, United States, anarayanan@bauer.uh.edu, Nickolas K. Freeman, Brent Moritz

We consider a procurement manager who sources raw materials from two suppliers. One of the supplier is perfectly reliable and expensive, while the other is cheaper but unreliable, failing to deliver with some positive probability. The buying firm has limited capacity to process the order and may be subjected to a fixed costs, like labor and utilities, regardless of whether they produce or not in that period. We first show theoretically that the capacity is an influencing factor when making sourcing decisions, forcing the manager to choose a more reliable supplier, while the sunk cost has no effect on these decisions. We evaluate these theoretical findings in an experimental setting.

■ MB49

361B

Behavioural OR in Healthcare

Invited: InvitedBehavioral Aspects of OR

Invited Session

Chair: Sally C. Brailsford, University of Southampton, Southampton, S017 1BJ, United Kingdom, s.c.brailsford@soton.ac.uk

Co-Chair: Paul Harper, Cardiff University, United Kingdom, harper@cardiff.ac.uk

1 - Overdiagnosis Risk in Breast Cancer Screening: Incorporating Adherence Behavior and Racial Disparity

Mahboubeh Madadi, Assistant Professor, Louisiana Tech University, Ruston, LA, United States, madadi@latech.edu, Wesley Wilkes

Although known to be the primary method for early detection of breast cancer, mammography screening exposes patients to the risk of overdiagnosis, which is defined as the detection and subsequent treatment of a breast cancer that would not present clinically in a patient's lifetime. In this study, we develop a Markovian model to estimate the risk of overdiagnosis under various screening policies while incorporating patient's adherence behavior. We also provide personalized estimations for overdiagnosis risk taking into consideration different factors such as racial disparity in cancer incidence and progression as well as patient's age.

2 - Operating Theatres Scheduling Optimization by Integrating Efficiency with Patients Satisfaction

Xue Yang, Xi'an Jiaotong University, Xi'an, China, yxueyx@outlook.com, Wentian Cui, Zhen Shang, Yang Wang, Yang Zhang

We building a mixed integer programming model for the operating theatres scheduling problem in a specialized hospital in China. In this model, we use a multinomial logit choice model to characterize patients satisfaction. The efficiency of operating theatres is measured by the linear combination of the number of finished surgeries and overtime. From extensive experimental analysis, we find interesting phenomena and propose valuable suggestions to healthcare managers.

3 - Are Patients Rational Decision-makers?

Sally C.Brailsford, University of Southampton, School of Management, Southampton, S017 1BJ, United Kingdom, s.c.brailsford@soton.ac.uk

In traditional OR models, it is typically assumed that there is a single, rational decision-maker, or a group of rational decision-makers who seek a compromise solution in the absence of a solution that is optimal for all. For example, health economists seek to maximize quality adjusted life years, and public health physicians (and insurance companies) take a population-level perspective. But how does the individual patient, or their family, take decisions regarding their own health? Are patients always rational, and if not, how can we model their behavior?

■ MB50

361C

Modeling and Analysis of Emerging Mobility Services III

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Yang Liu, National University of Singapore, Singapore, 117576, Singapore, iseliuy@nus.edu.sg

Co-Chair: Yu Nie, Northwestern University, Evanston, IL, 60208, United States, y-nie@northwestern.edu

1 - Multi-cycle Optimal Taxi Routing with E-hailing

Xinlian Yu, University of Massachusetts Amherst, 130 Natural Resources Road, Amherst, MA, 01003, United States, xinlianyu@umass.edu, Song Gao, Hyoshin (John) Park, Xianbiao Hu

An optimal taxi routing problem is investigated for a single taxi that accounts for multiple cycles of pick-up and drop-off into the future. Practical implementations are proposed to solve the multi-cycle optimal taxi routing problem in a reasonable time. The solution will be compared with observed searching behaviors from GPS trajectories in a mega city to demonstrate the advantage of the multi-cycle approach.

2 - Equilibrium and Ridesharing Payment Policies for Heterogeneous Dynamic Ridesharing Travelers in Morning Commute

Rui Ma, University of California, Davis, 2041 Academic Surge, University of California, One Shields Avenue, Davis, CA, 95616, United States, drma@ucdavis.edu, Michael Zhang

We formulate a dynamic ridesharing problem for a single bottleneck in morning commute. Travelers' choices of departure-time and ridesharing modes as groups with heterogeneous values of travel time are captured at the dynamic equilibrium. An equivalent differential complementarity system is then established and solved numerically. Dynamic parking pricing strategies to achieve the system optimum at the free-flowing condition are discussed. The results suggest that the ridesharing payment policies should be properly designed to achieve the social, economic and environmental goals.

3 - Recognizing Taxi Driver Search Strategies using Sparse Subspace Clustering

Kenan Zhang, Northwestern University, Evanston, IL, United States, KenanZhang2020@u.northwestern.edu, Yu Nie

The rapid expansion of Transportation Network Companies (TNC) has revived the interest in understanding the search behaviors of traditional taxi drivers. Using a taxi GPS trajectory dataset collected in Shenzhen, China, this study explores taxi drivers' search strategies in the urban area. Customer search behaviors are represented by features including searching distance and the characteristics of origin and destinations. A sparse subspace clustering (SSC) model is applied to classify taxi driver search strategies into major groups. Compared to conventional clustering algorithms (e.g. K-means), SSC better addresses the issue of nonlinear and high-dimensional nature of human behavior.

4 - Equilibrium Analysis of Urban Road Networks with Ride-sourcing Services

Zhengtian Xu, University of Michigan, Ann Arbor, MI, 48105-2540, United States, xzt@umich.edu, Yafeng Yin

The surge of ride-sourcing services in recent years has reshaped travelers' mode choices for intra-city trips. As outcomes of the interactions between service operators and travelers, a substantial portion of vehicular trips in ride-sourcing services are spent searching and meeting travelers other than fulfilling their requested orders. These accessory trips, however, are missing ingredients in the current network equilibrium analysis methodology. Therefore, this study aims to propose a new model that describes the mixed equilibrium between the occupied vehicular trips that directly serve passenger demands and the accessory trips made by vacant ride-sourcing vehicles.

5 - Identifying Malevolent Users in Free-floating Bike Sharing Systems

Aritra Pal, USF, 2210 Fitness Club Way, Apt 202, Tampa, FL, 33612, United States, aritra1@mail.usf.edu, Yu Zhang

The purpose of this study is to extract and identify users who are deliberately mishandling or damaging bikes in a (free-floating) bike sharing system based on its historical data. We propose a four step method to solve this problem and illustrate its usage with "Share-A-Bull Bikes" free-floating bike sharing system as our case study.

■ MB51

361D

Economics of Information Goods

Sponsored: Information Systems

Sponsored Session

Chair: Zhe Zhang, University of Texas at Dallas, jameszhangzhe@utdallas.edu

1 - Towards Better Social Advertising

Shaojie Tang, UT Dallas, Richardson, TX, United States, sxt146930@utdallas.edu

Social advertising has the potential to general a significant cascade of adoption through influence in the online social networks. The goal of this work is to optimize the ad allocation such that the expected cascade can be maximized.

2 - Equilibrium Distribution of Mobile App Quality and Privacy

Jiali Zhou, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, zhoujiali90@163.com, Kai Lung Hui

Mobile APPs bring consumers great convenience but raise privacy concerns because of the collection and use of customer data. We examine the equilibrium distribution of mobile APP quality and data requests. Consumers have heterogeneous preferences for APP quality and privacy. APP developers strategically choose quality and data requests to maximize profits. Our theoretical analysis suggests that the equilibrium data requests and hence consumer privacy follow a power law distribution. APP quality decreases monotonically, with high quality APPs requesting more personal data but also earning more market share. Preliminary empirical evidence from leading APP platforms support our analysis.

3 - Organizing for Disaster Management Across Many Districts
Barrie Nault, University of Calgary, Calgary, AB, Canada, nault@ucalgary.ca, Hong Guo, Yipeng Liu

We examine districts' choice of whether to centralize in a setting with more than two districts. Districts face interoperability challenges and convex costs in deciding their investment in disaster management assets, where these assets can be shared across districts. We derive conditions for cost sharing that maximize social welfare where some, but not all, districts decide to centralize.

4 - Devising Management Response Strategies in a Competitive Market
Mingwen Yang, The University of Texas at Dallas, Richardson, TX, 75080, United States, mxy131030@utdallas.edu, Vijay Mookerjee, Eric Zheng, Hongyu Chen

We address a practical question of when a firm should respond to customer reviews in a competitive market, where consumers' purchasing decisions are influenced by the reviews of the focal and the competing firms. Factoring in competition is essential for a firm to derive an optimal response strategy to effectively manage online WOM and subsequently influence sales. Our study extends the literature by 1) designing an optimal response strategy to online reviews, 2) prescribing the relationship between firm response and sales and 3) considering competition. We develop a Stochastic Differential Equation (SDE) model that captures the data generating processes and estimate the model using real data.

■ MB52

361E

Energy

Contributed Session

Chair: Adam Ng, National University of Singapore, Singapore, isentsa@nus.edu.sg

1 - Welfare Effects of Pricing Schemes for Non-Convex Markets
Jacob Mays, Northwestern University, 2145 Sheridan Road, Room C230, Evanston, IL, 60208, United States, jacob.mays@u.northwestern.edu

A major goal of competitive electricity markets is encouraging optimal investment in generation capacity, demand response capabilities, and energy efficiency measures. For market-integrated buyers and sellers, these investments are guided by prices announced by system operators. However, the usefulness of these prices has been called into question due to the proliferation of zero-marginal-cost wind and solar resources, the influence of out-of-market supports, and the presence of non-convex technical constraints. This work investigates the influence of price formation decisions on welfare in electricity markets.

2 - Robust Design of Energy Consumption Subsidies Reform
Hossein Mirzapour, University of Montreal (HEC School of Business), 920-6275 Northcrest, Montreal, QC, H3S.2N3, Canada, hossein.mirzapour@hec.ca, Amir Ardestani-Jaafari

To raise the necessary public support for any energy subsidies reform, a prevalent recommendation is to redistribute its revenue among the most affected households/industries. However, the main challenge to design an effective redistribution mechanism is how to reach those needy entities, particularly in the presence of some uncertain side-effects such as the price inflation of non-energy goods. We study the problem of a social planner. The goal is to minimize the gap between the local subsidized price and its international level, while expecting a minimum purchasing power for the most affected entities. We show the value of a flexible distribution mechanism in such reforms.

3 - Energy and Reserve Co-optimization – Reserve Availability, Lost Opportunity and Uplift Compensation Cost
Ivan Pavic, Research Associate, University of Zagreb, Faculty of Electrical Engineering and Computing, Unska 3, Zagreb, 10000, Croatia, ivan.pavic@fer.hr, Hrvoje Pandzic, Yury Dvorkin

In a deregulated power systems, energy and reserve are often co-optimized to decrease costs payed by end-users. Generating companies can still encounter monetary losses caused by the provision of reserve. Currently, compensation of these losses is based on ex-post calculations which do not adequately factor real costs and create distortions in market prices. Proposed algorithm run energy and reserve co-optimization with an explicit consideration of two compensation mechanisms, i.e. lost opportunity and uplift payments. The problem is structured as a bi-level and converted to single level using strong duality equation. The case study shows that the proposed model increases market efficiency.

4 - A Computable General Equilibrium Model for Power Interruption Contracts
Lakshmi Palaparambil Dinesh, University of Cincinnati, 601 McAlpin Avenue, Apt 5, Cincinnati, OH, 45220-1539, United States, lakshmi603@gmail.com, Dr. Kenneth Skinner, Dr. Uday Rao

Energy demand response programs change the energy consumption behavior of consumers with changes in price and demand. Our supply demand integrated cost minimization model shows that demand response lowers overall costs for suppliers and promotes energy savings for customers. In addition to the cost savings for the supplier, we also look at the societal welfare using a Computable General Equilibrium (CGE) model that will aid the energy policy regulators. This model helps to understand the generation costs and activity levels at equilibrium, the tax rates needed to float demand response and the amount of capital that can be saved by demand response.

5 - Energy-economic Recovery Resilience with Input-output Linear Programming Models
Adam Ng, National University of Singapore, 10 Kent Ridge Crescent, Singapore, 119260, Singapore, isentsa@nus.edu.sg, Peijun He, Bin Su

We develop a novel input-output linear programming model to study the energy-economic resilience of an economy by analyzing the relationships between energy disruption, impacts on production and demands, and post-disruption recovery efforts. The model evaluates the minimum level of recovery investments required to restore production levels so that economic impacts are acceptable over the post-disruption duration. The optimization model is solved using a cutting plane method which involves computing a small sequence of mixed integer programs. A case study using China input-output data is performed to demonstrate the model's ability to uncover critical inter-sectoral dependencies.

■ MB53

361F

Advancements in Detecting and Modeling Traffic Flow

Sponsored: TSL, Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Wei-Hua Lin, University of Arizona, Tucson, AZ, 100190, United States, whlin@email.arizona.edu

1 - Transportation Network Traffic Detector Error Estimation
Han Yang, UCDavis, 1 Shield Ave, Davis, CA, 95616, United States, cnhyang@ucdavis.edu, Yudi Yang, Yueyue Fan

One of the main challenges regarding traffic sensor data is how to assess its quality, as empirical works have shown inconsistency from a large portion of road sensors even they are not labelled as "broken" by major traffic data providers. This paper aims to address the problem of identifying the malfunctioned sensors and correcting systematic error using a network modelling based statistical approach. The measurement error is defined conditionally on the true flow which is unobservable. Network flow balance is assumed to be preserved among traffic flows. We provide two different estimators based on moment matching and maximum likelihood respectively to estimate the systematic error ratio.

2 - Multi-class Support Vector Machines Based Traffic Pattern Detection
Sayyid Vaqar, King Fahd University of Petroleum and Minerals, P.O. Box 983, Dhahran, 312600, Saudi Arabia, savaqar@kfupm.edu.sa

The traffic jam detection problem is formulated as a pattern recognition problem with scarce data utilizing Principal Component Analysis and Multiclass Support Vector Machines. The collected data is viewed as a snapshot of traffic flow condition on the road. For each time step this data will provide snapshots of driving conditions for the node of interest. With proper analysis these snapshots can be used in predicting traffic jam conditions on the freeways.The model is tested under assumption of different levels of vehicles equipped with Mobile Ad hoc network communication capability. The trained MSVMs are then used to predict traffic conditions for unlabeled test data.

3 - A Generalized Theory of Mixed Traffic Flow Based on Behavioral Assumptions
Jia Li, Research Associate, University of Texas at Austin, 7630 Wood Hollow Dr, Apt 251, Austin, TX, 78731, United States, lijia.ust@gmail.com

This research proposes a generalized theory of mixed traffic flow. Most existing mixed traffic flow models are descriptive in nature and lack sound behavioral interpretations. Towards filling this gap, a theory is developed from natural behavioral assumptions and explicitly addresses factors such as lane and information access. The stationary and dynamic behaviors of mixed traffic flow in several application scenarios, including mixed connected/automated and regular traffic, will be discussed.

4 - Traffic Equilibrium in a System with Interactions Between Drivers and Traffic Control

Wei-Hua Lin, Associate Professor, University of Arizona, Systems and Industrial Engineering, Tucson, AZ, 85721, United States, whlin@email.arizona.edu

We will assess how traffic pattern would change in response to a traffic control system in which the interaction between traffic control and individual drivers is made possible. Both short-term and long-term effects will be evaluated. Properties associated with the traffic equilibrium resulting from the interaction will be examined.

■ MB54

362A

Application of Geospatial and IoT Data in Agriculture

Invited: Agricultural Analytics

Invited Session

Chair: Siyuan Lu, IBM, IBM, Yorktown Heights, NY, 10598, United States, lus@us.ibm.com

1 - Thoreau: A Fully Buried Wireless Sensor Network for Soil and Plant Science

Supratik Guha, PhD, University of Chicago, Chicago, IL, 60637, United States, guha@uchicago.edu, William Kent, Xufeng Zhang, Arseniy Andreyev, Cristina Negri, Monisha Ghosh, Jacob Gold

I will describe our research that has led to an end-to-end fully buried wireless sensor network for monitoring soil properties as a function of time on the University of Chicago campus in Hyde Park, Chicago. The network, named Thoreau, uses commercial sensors for monitoring temperature, volumetric water content, water potential and electrical conductivity as representative examples that are integrated into low power sensor packages (including the microprocessor unit, radio and antenna) that are buried 6-14 inches below the ground. A SigFox low power IoT wireless network is used for connectivity and the wireless signal path includes subterranean transmission followed by refraction into the air above ground. All data is curated on the Cloud and available via thoreau.uchicago.edu in open access mode. We will describe our experiences with Thoreau over the past 9 months, and we argue that scalable, affordable, ubiquitous subterranean sensing networks are within reach and will have significant impact on agriculture, the environment, and our understanding of soil and plant science.

2 - Advances in Agricultural Analytics

Joshua Woodard, Cornell University, Ithaca, NY, United States, jdw277@cornell.edu

By 2050, the population will approach 10 billion people, placing enormous strain on the Earth's resources, and food security is at increased risk from climate change. Meanwhile, the increased availability of high resolution geospatial, environmental, biophysical, and economic data—coupled with the expansion of computational capacity—is creating new opportunities for data-driven scientific discovery. This talk will discuss recent advances in the emerging fields of digital agriculture and agricultural analytics, including applications in policy analytics and risk assessment.

3 - Digital Agriculture and the Future of Farming

Raj Khosla, Colorado State University, Fort Collins, CO, United States, Raj.Khosla@colostate.edu

Precision Agriculture has been around for over two decades. The first decade had a strong focus on quantifying spatial variability in soils, the second decade spent significant time on science and technology of precision management of nutrients. Now with increasing adoption of Precision Ag there is interest in harnessing the power of data for making management decision based on evidence. The success of future farming practices, output, efficiency and sustainability, would rely on "farming the data" as much as "farming the ground". This presentation will empower audience with research based information on how agriculture is embracing information technologies to feed the growing population.

■ MB55

362B

Methods in Financial Engineering

Sponsored: Financial Services

Sponsored Session

Chair: Lingfei Li, Chinese University of Hong Kong, Shatin, N T, Hong Kong, lfli@se.cuhk.edu.hk

Co-Chair: Qi Wu, Chinese University of Hong Kong, Shatin, Hong Kong, qwu@se.cuhk.edu.hk

1 - Dynamic Mean CVaR Portfolio Selection and Time Consistency Induced Term Structure of CVaR

Duan Li, The Chinese University of Hong Kong, Faculty of Engineering, Dept of Systems Engineering & Engineering Mgmt. Shatin, Hong Kong, dli@se.cuhk.edu.hk

We derive in this research optimal dynamic mean-CVaR portfolio policy for general incomplete discrete-time markets. As the dynamic mean-CVaR problem formulation is time inconsistent, how to update investor's VaR level and the trade-off between the mean and CVaR measures dynamically and adaptively is an important issue to address. We provide a complete answer to this question by deriving analytically the time-consistency induced term structure of CVaR in this research.

2 - Dark Pool Trading a Hawkes Process Approach

Xuefeng Gao, Chinese University of Hong Kong, William M.W. Mong Engineering Building,, Room 606, Shatin, Hong Kong, xfgao@se.cuhk.edu.hk, Lingjiong Zhu, Xiang Zhou

Dark pools are automated trading facilities which do not display bid and ask quotes to the public. In this talk, we use the Hawkes process to model the clustered arrival of trades in a dark pool and analyze various performance metrics including time-to-first-fill, time-to-complete-fill and the expected fill rate of a resting dark order.

3 - Negative Term Structure via Density Splitting

Shingfan Chan, Chinese University of Hong Kong, William M.W. Mong Engineering Building, Rm 507, Shatin, NT, Hong Kong, qwu@se.cuhk.edu.hk, Qi Wu

Persistent low interest rate environment demands a term structure model to have high conditional probabilities near zero point. We construct a "density splitting" technique to model this "sticky" behavior of yield curves. By breaking the continuity of conditional densities of risk factors that many existing models assume, we gain control of how much probability mass is allocated at a particular level. The method is flexible in that it applies to existing models, and allows sticky behavior at both negative and positive region. We apply this approach to the Nelson-Seigel family and calibrate to ECB and JPY curves. We found that bond and swap data prefer our model over existing shadow rate models.

4 - Analysis of Markov Chain Approximation for Option Pricing and Hedging: Grid Design and Convergence Behavior

Lingfei Li, Chinese University of Hong Kong, 608 William M.W. Mong Engineering Building, Shatin, N.T, Hong Kong, lfli@se.cuhk.edu.hk, Gongqiu Zhang

Continuous time Markov chain (CTMC) approximation is an intuitive and powerful method for pricing options in general Markovian models. This paper analyzes how grid design affects the convergence behavior of barrier and European options in general diffusion models. We obtain sharp estimates for the convergence rate of option price, delta and gamma. Based on our theoretical results, we propose a novel class of non-uniform grids, which enable the CTMC approximation method to price and hedge a large number of options with different strikes fast and accurately. Applicability of our results to jump models is discussed through numerical examples.

■ MB56

362C

Fueling Station Location and Routing Decisions for Alternative Fuel Vehicles II

Sponsored: Location Analysis

Sponsored Session

Chair: Ismail Capar, xas A&M University, College Station, TX, 77843-3367, United States, capar@tamu.edu

1 - Supply Chain Planning in a Cross-Dock Environment

Manoj Vanajakumari, Texas A&M.University, 4318 Toddington Ln, College Station, TX, 77845, United States, manojuv@tamu.edu, Chelliah Sriskandarajah, Haoying Sun

We consider a supply chain planning problem via efficient cross-docking for an oil field services Company. The supply chain problem involves minimizing the total inbound and outbound transportation costs and the inventory management costs at the cross-docking facility and the plants. We analyze two problems: (i) the company ships all products bound to each plants periodically, and (ii) the company outsources the delivery of each product to a 3PL, on an individual basis, to the plants. We develop a decision support systems for the company.

2 - Evaluation Model of Traffic Network Utilizing Geographical Divergence Degree of Multiple Routes
Motoki Tajima, The University of Tokyo, Tokyo, Japan, m-tajima@iis.u-tokyo.ac.jp, Yudai Honma

In the research, we try to evaluate the traffic network in terms of geographical tolerance. Especially, we consider multiple alternate routes, and focus on divergence of them to calculate the robustness of networks. We firstly search alternate routes by adopting K shortest path routing algorithm. Next, we define several local factors which show the robustness quantitatively, then expand them to the whole network.

3 - Robust Design of Refueling Station Locations for Alternative Fuel Vehicles with Driving Range Constraint
Samuel Labi, Purdue University, 550 Stadium Mall Drive, West Lafayette, IN, 47907, United States, labi@purdue.edu, Mohammad Miralinaghi

his study develops a multi-period framework to investigate the optimal refueling locations for alternative fuel vehicles (AFVs) under travel demand uncertainty and driving range limitations. AFVs are classified by their driving range, and the uncertainty of travel demand in each AFV class is duly factored through a multi-class robust discrete optimization model. An algorithm is developed to solve the decision model for a large network.

■ MB57

362D

Parallel Simulation Optimization

Sponsored: Simulation

Sponsored Session

Chair: Jie Xu, George Mason University, Fairfax, VA, 22030, United States, jxu13@gmu.edu

1 - An Efficient Fully Sequential Selection Procedure Guaranteeing Probably Approximately Correct Selection
Sijia Ma, PhD Student, Cornell University, 292 Rhodes Hall, Cornell University, Ithaca, NY, 14853, United States, sm2462@cornell.edu, Shane Henderson

Ranking and Selection procedures are designed for selecting the best among a finite set of systems using stochastic simulation. Instead of assuming a known lower bound on the difference between the best and others, we consider the probably approximately correct selection (PAC) formulation. We present a new fully sequential selection procedure, called the Envelope Procedure (EP), which delivers PAC guarantee. A particular sampling rule that achieves good efficiency is proposed. We compare the efficiency of the EP with some existing procedures in numerical experiments, and the results show that the EP saves considerable computational effort in many problem configurations.

2 - Challenges in Parallel Ranking and Selection
Susan R. Hunter, Purdue University, School of Industrial Engineering, Grissom Hall, 315 N. Grant Street, West Lafayette, IN, 47907-2023, United States, susanhunter@purdue.edu, Barry L. Nelson

We discuss the current state of the art in R&S for large problems solved on parallel computing platforms. We provide a new stylized model for representing parallel R&S procedures, and discuss the mathematical and computational formulations of existing R&S procedures under the stylized model. We also speculate on the future of parallel R&S procedures.

3 - Simulation Based Optimization Towards High Performance Computing
Haobin Li, Institute of High Performance Computing, A*STAR.Singapore, 1 Fusionopolis Way, #16-16 Connexis, Singapore, 138632, Singapore, lihb@ihpc.a-star.edu.sg, Giulia Pedrielli, Loo Hay Lee

This talk provides a brief introduction on how to speed up the simulation based optimization towards high computational performance. Specifically, three areas are to be explored, namely 1) designing a Pareto-efficient configuration for various computational infrastructures; 2) adapting the optimization algorithms to the parallel environment, e.g., OCBA algorithm with GPU computing; and 3) developing a modelling paradigm that could systematically distribute the computational effort to parallel cores, such as the modularized O2DES framework. The motivation for the three areas of studies is to be discussed, and preliminary results will be illustrated to show the potential in each area.

4 - A Structured Approach for Parallel Simulation Optimization Implementation
Ji Xu, George Mason University, Fairfax, VA, 22205, United States, jxu13@gmu.edu, Scott Rosen

In this talk we present our framework for performing parallel simulation optimization that involves a library of simulation optimization techniques and a guidance system to assist the general analyst in using the library. We also present parallel adaptations of two simulation optimization algorithms: Industrial Strength COMPASS and Empirical Stochastic Branch and Bound. After presenting these algorithms we provide numerical performance results under a case study involving a large-scale, real-world simulation. In addition performance of these algorithms, with respect to speed and quality of the final solution, is compared to a metamodel-based optimization procedure.

■ MB58

362E

Spatial Analysis in Transportation and Logistics

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: EunSu Lee, PhD, New Jersey City University, Harborside 2, 200 Hudson Sttreet, Suite #234H, Jersey City, NJ, 07311, United States, ELee3@njcu.edu

1 - Forecasting Growth by Transit Oriented Developments using Spatial Analysis
Nimish Dharmadhikari, INCOG, 2 W. 2nd street Suite 800, Tulsa, OK, 74103, United States, ndharmadhikari@incog.org

Many cities are planning Transit Oriented Developments (TODs) in conjunction with the new transit projects. They expect the TODs to be the future growth corridors. This research proposes a methodology to forecast the growth happening with TODs. We use spatial analysis techniques to study the current land use and the future potential. This method will be useful for the cities to study the potential development. It will also generate a map of the growth centers and potential growth corridors to focus.

2 - Hyperloop Spatial Economic Analysis
Dapeng Zhang, PhD, Hyperloop One, Los Angeles, CA, United States, zhangdapeng@live.com

Hyperloop is a new way to move people and things at the airline speed with price of a bus ticket. Hyperloop can greatly contribution to spatial interaction which benefit for agglomeration benefits. This presentation will talk about what Hyperloop economic analysis is doing.

■ MB59

362F

Joint session RAS/Practice: Railroad OR Applications Showcase

Sponsored: Railway Applications

Sponsored Session

Chair: Kamalesh Somani, CSX Transportation, CSX Transportation, Jacksonville, FL, 32202, United States, kamalesh_somani@csx.com

1 - Railroad OR Applications Showcase
Kamalesh Somani, CSX Transportation, CSX Transportation, Jacksonville, FL, 32202, United States, kamalesh_somani@csx.com

Join us for an interactive look at the substantial use of advanced OR techniques in the railroad industry. Four major North American rail carriers (BNSF, CSX, NS, and Amtrak) will be onsite to give in-depth practical demonstrations of OR tools. Join us to learn how railroads implement robust solutions to complex business problems. The demonstrations will focus on the practical implementation of advanced OR models within companywide systems including the core software and technologies used, large scale data constraints, production level deployment, and business alignment.

■ MB60

370A

Publishing in INFORMS Transactions on Education

Sponsored: INFORMEd

Sponsored Session

Chair: Jeroen Belien, KU Leuven, KU Leuven, Brussel, 1000, Belgium, jeroen.belien@kuleuven.be

1 - Informs Transactions on Education (ITE): A General Overview
Jeroen Belien, KU. Leuven, Warmoesberg 26, Brussel, 1000, Belgium, jeroen.belien@kuleuven.be

The panelists include ITE editors and authors who have published recently in ITE. The authors will discuss their experiences with submitting articles to ITE. The editors will provide suggestions to authors who wish to submit their work to ITE; in particular, articles about case studies and about educational games.

2 - Panelist
Stefan Creemers, IESEG France, Lille, France, sc@cromso.com

3 - Panelist
Jill Hardin Wilson, Northwestern University, Industrial Engineering & Mgmt Sciences, 2140 Sheridan Road, Evanston, IL, 60208, United States, jill.wilson@northwestern.edu

4 - Panelist
Ashlea Bennet Milburn, University of Arkansas, AR, United States, ashlea@uark.edu

■ MB61

370B

Hidden Figures Panel Discussion

Sponsored: Minority Issues

Sponsored Session

Chair: Karen T Hicklin, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599, United States, khicklin@email.unc.edu

Co-Chair: Julie Simmons Ivy, North Carolina State University, Raleigh, NC, 27695-7906, United States, jsivy@ncsu.edu

1 - Hidden Figures Panel Discussion
Karen T.Hicklin, University of North Carolina at Chapel Hill, B-24 Hanes Hall, Chapel Hill, NC, 27599-3260, United States, khicklin@email.unc.edu

The movie Hidden Figures (2016), based on the book by Margot Lee Shetterly, is a depiction of the untold story of black women mathematicians at NASA whose integral roles played a major part in some of America's historical space achievements. In this session, we celebrate the achievements of black women and their contributions to advancements in operations research. The panel features women at different points in their careers and will highlight their work as operations researchers with the goal of encouraging diversity.

2 - Panelist
Lauren Berrings Davis, North Carolina A&T.State University, 1601 E.Market Street, 404 McNair Hall, Greensboro, NC, 27411, United States, lbdavis@ncat.edu

3 - Panelist
Tasha Inniss, INFORMS, Catonsville, MD, United States, TInniss@informs.org

4 - Panelist
Harriet Nembhard, Oregon State University, Corvallis, OR, United States, harriet.nembhard@oregonstate.edu

■ MB62

370C

Quality Monitoring and Analysis in Complex Manufacturing Processes

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Weihong Guo, Rutgers, The State University of New Jersey, Piscataway, NJ, 08854, United States, wg152@rutgers.edu

1 - Software Reliability Modeling with Considering Randomness of Environmental Factors
Mengmeng Zhu, Rutgers University, 1920 Aspen Court, Piscataway, NJ, 08854, United States, mengmeng.zhu@rutgers.edu, Hoang Pham

Software reliability gains more attention from the researchers and practitioners in the past few decades. Lots of environmental factors defined by many studies can affect software reliability during the development process. However, most existing software reliability models have not incorporated these environmental factors. We propose a theoretic software reliability model with considering the fault detection rate is a stochastic process due to the randomness of the environmental factors. Examples are included to demonstrate the effectiveness and predictive power of the proposed model.

2 - Ensemble Modeling of in Situ Variables for Printed Electronics Manufacturing with in Situ Process Control Potential
Hongyue Sun, University at Buffalo, Buffalo, NY, United States, hongyues@buffalo.edu, Yifu Li, Ran Jin

Aerosol jet® printing is a printed electronics process that is capable to print various materials with fine features. In this paper, an ensemble model strategy is proposed to quantify the effect of the process setting variables on the in situ variables, and the effect of the in situ variables on the product quality in a two-level hierarchical way. By identifying significant in situ variables as responses for the process setting variables, as well as significant predictors for the product quality in a joint model estimation problem, the proposed model has a hierarchical variable relationship to enable in situ process control. A case study is used to demonstrate the advantages of the proposed method.

3 - Optimize Wind Farm Development with Hybrid Wind Biorefinery Renewable Energy System in Micro Grid Community
Qing Li, Rutgers University, Piscataway, NJ, United States, ql78@scarletmail.rutgers.edu, Honggang Wang

As one of the most promising renewable energy sources, wind power has been widely applied to meet the ever growth of energy consumption. Energy production varies due to wind fluctuation, thus constantly meeting community's demand while maintaining cost efficiency is not always the case. In this study, the food waste from local community serves as energy recovery source in biorefinery to produce baseline energy. Computational models and optimization methods are developed for optimal development of wind farm in hybrid wind-biorefinery energy system to meet community demand. Two-stage optimization framework is proposed to search and improve the optimal number and placement of turbines.

4 - Nonparametric Change-point Detection for Process Monitoring and Prognostics in Advanced Manufacturing
Weihong Guo, Rutgers, The State University of New Jersey, 96 Frelinghuysen Rd, CoRE Rm 220, Piscataway, NJ, 08854, United States, wg152@rutgers.edu, Shenghan Guo

It is essential to detect significant changes to the production processes. In this study, we develop a monitoring and prognostics method that implements non-parametric change-point detection methods on non-stationary time series data collected from a real automobile manufacturing system. For offline change-point detection, we integrate three non-parametric methods: LASSO, threshold TLASSO, and wild binary segmentation (WBS); for online change-point detection, we implement the modified sequential change-point detection and multivariate adaptive regression splines. These nonparametric methods are compared in case studies with real manufacturing data.

■ MB63

370D

Energy and Climate VI

Invited: Energy and Climate

Invited Session

Chair: Murat Erkoc, University of Miami, Hialeah, FL, 33015, United States, merkoc@miami.edu

1 - A Multi-objective Energy Management Model for Operation Planning in Smart Grids

Haluk Damgacioglu, PhD Candidate, University of Miami, 1251 Memorial Drive McArthur Engr. Bldg. Room 280, Coral Gables, FL, 33156, United States, haluk.damgacioglu@miami.edu, Nurcin Celik

The efficient utilization of distributed generation resources and demand side management (DSM) play a crucial role in satisfying and controlling electricity demand in smart grids. DSM programs make the operation planning problem more difficult with the additional objective of customer stakeholder. Here, we model the operation planning problem considering three conflicting objectives, minimizing the total operation cost and GHG emission, and maximizing the customers' satisfaction. The multi-objective model is implemented on a generic smart grid and solved using augmented epsilon contraint method.

2 - A Multi-objective Mathematical Model for Integrated Electricity and Natural Gas Pipeline Network Problems

Ahmet Akgun, Wichita State University, Wichita, KS, United States, axakgun@shockers.wichita.edu, Mehmet Bayram Yildirim

A multi-period multi-objective mathematical model for integration of electricity expansion planning and natural gas pipeline network problem is proposed. The proposed model is formulated as MINLP and it optimizes the costs, greenhouse gas emissions and foreign dependency for both electricity and natural gas pipeline networks simultaneously. This paper aims to determine what kind of generation units to be built, where and when to build generation units. The proposed model is tested on a 22-node electricity and 24-node Belgium natural gas network to determine the optimum investment strategy.

3 - A Zero Carbon Multi-site Production Model under Stochastic Demand and Intermittent Power

An Pham, Graduate Research Assistant, Texas State University, San Marcos, TX, United States, a_p276@txstate.edu, Tongdan Jin, Jin Qin, Fei Sun

We investigate whether is it economically viable and technically feasible to operate zero carbon manufacturing, transportation and warehouse using onsite wind and solar power. A big data analytics method is developed to characterize the renewables yield based on 11-year meteorological data. We show that zero carbon is achievable if the wind capacity factor is 0.3 or the photovoltaic capacity factor reaches 0.4. Our study facilitates manufacturing industries to become a "prosumser" who actively participate in demand responses as a green energy producer under smart grid paradigm.

4 - Load Shifting and Energy Storage in the Smart Grid

Murat Erkoc, Associate Professor, University of Miami, 1251 Memorial Drive, Coral Gables, FL, 33146, United States, merkoc@miami.edu, Eyad M.Al-Ahmadi

We study load-shifting and energy storage in an electricity market composed of a single energy provider and multiple customers via a Stackelberg game setting. The provider acts as the leader and decides on price discounts across a finite time horizon. The consumers follow and decide if and how they shift their consumption from their nominal demand. In terms of energy storage, we consider and compare two cases. In the first case, the consumers make the energy storage decisions. In the second, the energy provider manages the client storage devices at consumer sites. We investigate the joint impact of price discounts and storage option on player incentives and peak-to-average ratios.

■ MB64

370E

Big Data Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Wenjun Zhou, University of Tennessee Knoxville, 916 Volunteer Boulevard, Knoxville, TN, 37996, United States, wzhou4@utk.edu

1 - Crowdsourcing

Xi Zhang, jackyzhang@tju.edu.cn

Abstract not Avialable

2 - B2B Marketing Campaign Recommendation: A Social and Temporal Perspective

Jingyuan Yang, Rutgers University, Newark, NJ, United States, jingyyan@rutgers.edu

The buying processes of Business to Business (B2B) customers involve series of various marketing campaigns providing multi-faceted product/service information. To better guide B2B customers through dynamic and complex buying processes, we propose a unified view of social and temporal modeling for B2B marketing campaign recommendation. Specifically, we first construct temporal graph as the knowledge representation of each B2B customer's buying process. The recommender system is then built in a low-rank graph reconstruction framework using probabilistic graphical models. We also incorporate the business community relationship as the social factor to further improve overall performance.

3 - Diagnostics and Treatment of Chronic Disease with Artificial Intelligence

Bo Jin, Dalian University of Technology, Dailian, China, jinbo.dlut@gmail.com

Parkinson's disease (PD) is a chronic disease that develops over years and varies dramatically in its clinical manifestations and overall prognosis. It is challenging to compute similarity due to patient data collected from longitudinal clinical trials often consists of multiple modalities and presents temporal dynamics. To provide scalable solutions that can accurately identify similarity from the complex patient data, we propose a deep model that directly learns patient similarity from longitudinal and multi-modal patient data with an RNN architecture that can encode the similarity between two sequences and dynamically match temporal patterns inpatient data.

■ MB65

370F

Green Vehicle Routing

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Mesut Yavuz, University of Alabama, myavuz@cba.ua.edu

1 - Managing Electric Vehicle Charging Station Congestion under Uncertainty

MD Abdul Quddus, Mississippi State University, 319 North Jackson Street, Apt 3E, Starkville, MS, 39759, United States, mq90@msstate.edu, Mohammad Marufuzzaman, John Usher, Mesut Yavuz

This study incorporates a non-linear cost term in the objective function to capture the congestion effect at charging stations. We propose a hybrid decomposition algorithm that combines Constraint Generation algorithm with a Sample Average Approximation with an enhanced Progressive Hedging algorithm. A case study is conducted by considering road network of Washington, D.C. area. The results of the analysis indicate that incorporating congestion factor encourage larger capacity charging stations opening decisions, increase the number of batteries storing decisions, and higher congestion cost decreases the number of charging stations opening decisions.

2 - Green Location-routing Problem

Okan Dukkanci, Bilkent University, Ankara, Turkey, okan.dukkanci@bilkent.edu.tr, Bahar Kara, Tolga Bektas

This talk will introduce the Green Location-Routing Problem, an extension of the classical Location-Routing Problem that explicitly accounts for fuel consumption and emissions, the amount of which is measured by a widely used comprehensive modal emission model. The objective is to minimize a total cost function comprising depot, fuel and emission costs. The talk will present a mixed integer programming formulation of the problem with a set of valid inequalities, and describe solution approaches. Computational results on realistic data sets will be presented.

3 - An Integrated Fleet Management Model Introducing Alternative Fuel Trucks into Existing Diesel Long-haul Fleets

Ilke Bakir, Georgia Institute of Technology, H. Milton Stewart School of ISyE, Atlanta, GA, 30332, United States, ilkebakir@gatech.edu, Alan Erera

We address the challenge of smoothly introducing alternative fuel trucks (AFTs) into an existing long-haul trucking fleet while making necessary structural changes and maintaining feasible operations during the transition. We develop an integrated fleet management model, which incorporates the decisions for (i) opening new maintenance/fueling facilities, and (ii) assigning trucks to travel routes for ensuring demand satisfaction, into a fleet replacement framework. Additionally, in order to obtain optimal (or good feasible) solutions for realistically sized problem instances, we propose a Benders' decomposition framework and a local search based heuristic.

4 - An Iterated Beam Search & Column Generation Hybrid Solution to the Green Vehicle Routing Problem

Mesut Yavuz, The University of Alabama, Alston Hall Box 870226, Tuscaloosa, AL, 35487, United States, myavuz@cba.ua.edu, Isil Koyuncu

This talk addresses the routing problem of a homogeneous fleet of green vehicles, where each vehicle has a finite driving range before it must visit a refueling station, and all vehicles must return to the depot by end-of-day. We develop a column generation algorithm based on optimally routed customer sets. An iterated beam search algorithm is developed to generate the customer sets. The talk discusses static and dynamic strategies to integrate the two algorithms. Computational evaluation of the proposed algorithm is also presented.

■ MB66

371A

School Bus Routing and Scheduling

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Dimitris Bertsimas, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-147, Cambridge, MA, 02139, United States, dbertsim@mit.edu

1 - Solving Multi-school Bus Routing and Scheduling Problem

Zhongxiang Wang, Graduate Student, University of Maryland, 406 Ridge Rd, Apt 7, Greenbelt, MD, 20770, United States, zxwang25@umd.edu, Ali Shafahi, Ali Haghani

School bus routing and scheduling is usually treated as two separated problems. Such separation will lead to a worse solution than solving them together with respect to the number of buses and travel time. The key point connecting routing and scheduling problem - trip compatibility - is thus deeply studied. A Mixed Integer Programming model is proposed along with a School Decomposition Algorithm. The model and algorithm are tested on eight sets of randomly-generated mid-size problems in comparison to the existing models. The results show that the proposed model and algorithm can find a better solution using up to 30% fewer buses than the best traditional models in a reasonable amount of time.

2 - Dynamic Electric Buses Scheduling under Stochastic Traffic Conditions

Xindi Tang, Tsinghua, Beijing, China, txd16@mails.tsinghua.edu.cn, Fang He, Xi Lin

Our research proposes a dynamic electric bus scheduling model under pre-determined timetable which effectively handles the subsistent stochasticity of traffic conditions and range limitation of electric vehicles. To expeditiously solve the problem which suffers from exponential expansion of variables, we embed it into a branch and price framework. We conduct numerical experiments based on real data in Beijing, simulate potential scenarios with delay propagation considered, and do sensitivity analyses, proving effectiveness of our models and performances of our algorithms.

4 - To School and Back Again an Optimization Approach to Large Scale School Bus Routing

Dimitris Bertsimas, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-147, Cambridge, MA, 02139, United States, dbertsim@mit.edu, Arthur J. Delarue, Sebastien Martin

We present a novel optimization-based methodology for the School Bus Routing Problem (SBRP) that maximizes bus re-use between schools, in order to minimize overall costs to the city. Our method is tractable at the scale of a large city, simultaneously optimizing routes for 200 schools and 25,000 students, in a network with tens of thousands of edges. In the real-world setting of the Boston Public Schools (BPS) district, we show that our method reduces the overall number of buses needed each day by 18%, the total daily driving distance by 40%, and the total daily driving time by 37%.

■ MB67

371B

Computer Experiments and Uncertainty Quantification

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ying Hung, Rutgers State University of New Jersey, Piscataway, NJ, 08854-8019, United States, yhung@stat.rutgers.edu

1 - A Generalized Gaussian Process Model for Computer Experiments with Binary Time Series

Chih-li Sung, Georgia Institute of Technology, Atlanta, GA, United States, csung33@gatech.edu, Jeff Wu

Conventional analysis for computer experiments is based on Gaussian process (GP) models. Non-Gaussian observations such as binary responses are common in some computer experiments, but the extensions of GP models to these cases have received scant attention in the literature. Motivated by the analysis of a class of cell adhesion experiments, we introduce a generalized Gaussian process model for binary responses. The methodology is applied to study two different cell adhesion mechanisms, which were conducted by computer simulations. The fitted models reveal important biological differences between the two mechanisms in repeated bindings, which cannot be directly observed experimentally.

2 - Sequential Learning of Deformation Models in Additive Manufacturing through Calibration of Simulation Models.

Tirthankar Dasgupta, Rutgers, Piscataway, NJ, United States, tirthankar.dasgupta@rutgers.edu

Successful prevention of geometric shape deformation of products manufactured by additive manufacturing depends on building predictive deformation models. However, resource constraints impose restrictions on the number of test shapes of a particular type, making the use of meta models inevitable. To build meta models of deformation with good predictive power, calibration of existing models with data from physical experiments is necessary. We propose a sequential procedure for designing physical experiments and calibrating an ensemble of existing simulation models with data obtained from such experiments.

3 - Active Subspaces: Emerging Ideas for Dimension Reduction in Computational Science and Engineering Models

Paul Constantine, Colorado School of Mines, Golden, CO, 80401, United States, paul.constantine@colorado.edu

Engineers use simulations to study relationships between a model's inputs and outputs. However, thorough parameter studies (e.g., UQ) are challenging when the simulation is expensive and the model has several inputs. The engineer may try to reduce the dimension of the model's input parameter space. Active subspaces identify important directions in the input parameter space. I will (i) describe computational methods for discovering active subspaces, (ii) propose strategies for exploiting the reduced dimension, and (iii) review results from engineering applications. Visit activesubspaces.org

■ MB68

371C

Functional Data, Image and Shape Analysis: Methodology and Applications

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Hao Yan, Atlanta, GA, 30319, United States, yanhao@gatech.edu

Co-Chair: Kamran Paynabar, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, kamip@umich.edu

1 - An Image Data Based Manifold Learning Approach for Online Diagnosis of Additive Manufacturing Processes

Chenang Liu, Virginia Tech, Blacksburg, VA, 24060, United States, lchenang@vt.edu, Zhenyu Kong

Online quality monitoring and control is one of the major challenges in additive manufacturing (AM). A potential effective approach for online quality control of AM is based on image analysis. This work proposes an online manifold learning based classification method for analyzing real-time image data collected by digital microscopes embedded in the AM machine. The resulting system can diagnose the surface quality status, i.e., to identify the type and severity of the printing defects, in a real-time manner. The case study shows that the proposed method is very effective and it can also be integrated into an online closed-loop control system.

2 - Sparse Subspace Learning of Dynamic Multivariate Functions

Hao Yan, Georgia Institute of Technology, 3525 Highgrove Way

NE, Atlanta, GA, 30319, United States, yanhao@gatech.edu, Chen Zhang, Jianjun Shi

This paper presents a dynamic subspace learning method for multivariate functional data modeling. We assume different functions come from different disjoint subspaces, and only functions of the same subspace have cross-correlations with each other. These subspaces can be learnt as a sparse regression problem. By allowing but regularizing the regression change over time, we can further describe cross-correlation dynamics. The model can be efficiently estimated by the fast iterative shrinkage-thresholding algorithm, and the features of every subspace can be extracted using the smooth multi-channel functional PCA. Numerical studies demonstrate the efficiency of the proposed methodology.

3 - Minimizing Negative Transfer of Knowledge Through Scalable and Regularized Cokriging Models

Raed Al Kontar, University of Wisconsin-Madison, 1513 University Avenue, Room 3255, Madison, WI, 53706, United States, alkontar@wisc.edu, Shiyu Zhou

Multivariate Metamodeling and the estimation of functional data is specifically challenging due to the large number of parameters to be estimated, high computational complexity and the negative transfer of knowledge which may occur if different functional output have no commonalities. In this paper, we present a scalable approach to simultaneous estimation of functional data based on the multivariate Gaussian process. Specially, we introduce a regularized process which allows sequential estimation of parameters and minimizes the negative transfer of knowledge between uncorrelated outputs.

4 - Point Cloud Data Analysis for Process Modeling and Optimization

Hao Yan, 3525 Highgrove Way NE, Atlanta, GA, 30319, United States, yanhao@gatech.edu, Kamran Paynabar, Massimo Pacella

Advanced 3D metrology technologies such as Coordinate Measuring Machine (CMM) and laser 3D scanners have facilitated the collection of massive point cloud data, beneficial for process monitoring, control and optimization. However, due to their high dimensionality and structure complexity, modeling and analysis of point clouds is a challenge. In this paper, we utilize techniques developed in multilinear algebra and propose a set of tensor regression approaches to model the variational patterns of point clouds and link them to process variables. The performance of the proposed methods is evaluated through simulation and a real case study of turning process optimization.

■ MB69

371D

11:00 - 11:45 Simio/11:45 - 12:30 AMPL

Invited: Vendor Tutorial

Invited Session

1 - 11-11:45 Simio

Renee Thiesing, Simio LLC, Louisville, KY, United States, rthiesing@simio.com

Simio is a premier simulation and scheduling software that allows you to expand traditional benefits of simulation to improve daily operations. In this tutorial, we will demonstrate Simio's 3D rapid modeling capability to effectively solve real problems. Explore how a single tool can be used to not only optimize your system design, but also provide effective planning and scheduling. Come explore the Simio difference and see why so many professional and novice simulationists are changing to Simio.

2 - Developing Optimization Applications Quickly and Effectively through Algebraic Modeling in AMPL

Robert Fourer, AMPL.Optimization Inc., 2521 Asbury Ave, Evanston, IL, 60201, United States, 4er@ampl.com

Can you negotiate the complexities of the optimization modeling lifecycle, to deliver a working application before the funding runs out or the problem owner loses interest? Algebraic languages streamline the key steps of model formulation, testing, and revision, while offering powerful facilities for incorporating models into larger systems and deploying them to users. This presentation introduces algebraic modeling for optimization by carrying a single illustrative example through multiple contexts, from interactively evolved formulations to scripted iterative schemes to embedded applications. We feature the new Python API for AMPL, and the QuanDec system for creating web-based collaborative applications from AMPL models.

■ MB70

371E

Data Mining

Contributed Session

Chair: Safak Yakti, Binghamton University, Binghamton, NY, United States, syakti1@binghamton.edu

1 - A Classification Based Method to Detect Epilepsy using EEG Signals

Eda Karacaoglan, Erciyes University, Kayseri, Turkey, edakaracaoglan@erciyes.edu.tr, Mahmut Tokmakci, Fatma Uysal

It is important to diagnosis epilepsy correctly. Because EEG signals are dynamic and nonstationary, it is very hard to diagnosis epilepsy exactly. In literature there are some studies to detect epilepsy with the help of data mining methods. In this study, it has been tried to detect epilepsy by classifying Electroencephalogram (EEG) signals. For this purpose a new method is developed and applied on test data. The results are presented.

2 - A Classification Based Method to Detect Stress using ECG Signals

Fatma Uysal, Research Assistant, Erciyes University, Engineering Faculty, Biomedical Engineering Department, Kayseri, 38039, Turkey, fatmauysal@erciyes.edu.tr, Mahmut Tokmakçı, Eda Karacao lan

Stress is one of the serious factors for inducing many physical illnesses such as heart attacks, cognitive dysfunctions and depression. Electrocardiogram signal (ECG) which reflects the electrical activity of the heart ensures useful information in detection human stress. This work consists of five steps including stress-inducing test, data collection, signal preprocessing, feature extraction and classification. The aim of this study is to classify the stress using feature extraction algorithms and machine learning algorithms.

3 - Could Wellness Programs Help Decrease the Health Costs?

M. Gabriela Sava, Clemson University, College of Business, 145 Sirrine Hall, Clemson, SC, 29634, United States, msava@clemson.edu, Lawrence Fredendall, Kristin Scott

To reduce their total healthcare costs, private companies are starting to invest more in preventive care. Wellness programs are one strategy to try to minimize the total healthcare costs. We use data from one wellness program to analyze how employees' life style characteristics could predict future healthcare costs faced by the employer.

4 - Can Analytics Help Improve the Implementation of Preventive Care Programs?

M. Gabriela Sava, Clemson University, College of Business, 145 Sirrine Hall, Clemson, SC, 29634, United States, msava@clemson.edu, Luis G. Vargas, Jerrold H. May, James G. Dolan

In order to improve public health and to reduce healthcare costs, the U.S. Preventive Task Force has developed preventive programs for chronic diseases, such as colorectal cancer. We suggest how analytical methods might be used to help increase the level of implementation of preventive screening for colorectal cancer, by improving healthcare providers' understanding of patients' preferences with respect to the set of screening options available. Improved understanding enables healthcare providers to propose "personalized" medical paths that should increase the likelihood of patients' compliance.

5 - Data-driven Patient Scheduling on Asthma Intervention Considering Air Pollution

Luo Li, Professor, Sichuan University, Business School, Chengdu, 610064, China, luolicc@163.com, Fengyi Zhang, Wei Zhang

The aim of this study is to provide a framework of data-driven asthma patient scheduling on intervention with minimized readmissions . We first identified corresponding factors (especially on air pollution) that affect readmission and discharge process by accessing health insurance database; then we figured out the Markov transition process of readmission and discharge under each circumstance; finally, we constructed a MDP (Markov decision process) model, in which the penalties of Markov states are non-monotonic.Due to the fact that the optimality only exits under certain conditions, we proposed heuristics to achieve near-optimal and analyzed their performance.

6 - Mortality Risk Prediction for Atrial Fibrillation Patients

Safak Yakti, PhD Candidate, Binghamton University, Binghamton, NY, United States, syakti1@binghamton.edu, Mohammad T.Khasawneh, Serkan Saygi

Atrial Fibrillation (AF) is the most common heart rhythm disorder worldwide according to CDC. AF affects more than 3 million Americans and causes 130,000 death per year. Aim of this research is to identify the factors that influence mortality caused by AF and to compare between the prediction models namely Logistic Regression, Decision Trees, and Alternating Decision Tree methods. Performance measures are used to evaluate performances of the models. These models are utilized by using two different datasets; first one imbalanced dataset (7,796 patients), and second under-sampled dataset (2,350 patients) with AF diagnosis who were referred between 2012 and 2014.

■ MB71

371F

MINLP Methods and Applications

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Christos Maravelias, PhD, University of Wisconsin - Madison, Madison, WI, United States, christos.maravelias@wisc.edu

1 - Integer Programming Approaches for Appointment Scheduling with Random No-shows and Service Durations

Ruiwei Jiang, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48109, United States, ruiwei@umich.edu, Siqian Shen, Yiling Zhang

We consider an appointment scheduling problem with random no-show and service duration. We propose a distributionally robust optimization model and derive computationally tractable reformulations based on integer programming approaches. Numerical results demonstrate that the proposed approach yields better out -of-sample performance, especially when the randomness is misspecified.

2 - Closing the Gap NNAC Optimal Power Flow by Strengthening the Convex QC Relaxation using Parallel Computing

Gabriel Hackebeil, hackebeg@umich.edu

An important problem in power systems is finding optimal operating conditions for transmission systems, which are governed by the non-convex AC power flow equations (AC-OPF). In this work, we apply global optimization strategies, such as optimality-based range reduction and spatial branch-and-bound, in an HPC setting to close the optimality gap on many of the AC-OPF test cases from NESTA. We use the convex QC relaxation as a subproblem and employ linearization techniques to avoid numerical issues with solving this SOCP in practice, allowing for faster and more robust subproblem solves. Our implementation is built on the open-source AML Pyomo.

3 - An MINLP Model and Solution Methods for Blend Scheduling Problems

Christos T. Maravelias, University of Wisconsin-Madison, 1415 Engineering Drive, Engineering Hall 2024, Madison, WI, 53706, United States, maravelias@wisc.edu, Yifu Chen

We propose a new mixed integer nonlinear programming (MINLP) model for integrated blending and scheduling problems in oil refineries. Unlike existing approaches, the model considers crude oil operations, intermediate processing and final product blending simultaneously. To solve the proposed model efficiently, we develop preprocessing techniques based on propagation of product demands and property specifications, and propose three families of tightening constrains. We present computational results showing the effectiveness of these methods.

4 - Exploiting Integrality in the Global Optimization of Mixed-integer Nonlinear Programming Problems with Baron

Nikolaos Sahinidis, Swearingen Professor, Carnegie Mellon University, Department of Chemical Engineering, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, sahinidis@cmu.edu, Mustafa Kilinc

We present recent developments in the global optimization software BARON to address problems with integer variables. A primary development was the addition of mixed-integer linear programming relaxations to BARON's portfolio of linear and nonlinear programming relaxations. We describe BARON's dynamic strategy for deciding under what conditions to activate integer programming relaxations in the course of branch-and-bound. We also describe primal heuristics for finding good solutions of mixed-integer nonlinear programs. Finally, we report extensive computational results to analyze the impact of each technique in the solution process.

■ MB72

372A

Network Optimization VI

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Foad Mahdavi Pajouh, University of Massachusetts Boston, Boston, MA, 02125-3393, United States, mahdavi@okstate.edu

1 - Finding Central Clique Clusters in Graphs

Foad Mahdavi Pajouh, University of Massachusetts Boston, Boston, MA, Foad.Mahdavi@umb.edu, Maciej Rysz

We propose a solution algorithm for identifying the most central cliques in graphs and examine its effectiveness when the centrality measure is defined by betweenness. Numerical experiments demonstrating the computational performance of the proposed method are conducted and compared with results obtained from solving an equivalent mixed integer programming representation.

2 - Extreme-point Search Methods for Solving Fixed-charge Generalized Networks

Angelika Leskovskaya, Southern Methodist University, Caruth Hall 3145 Dyer Street, Suite 372, Dallas, TX, 75275, United States, aleskovs@lyle.smu.edu, Richard Barr

While researchers have studied generalized networks flow problems extensively, the powerful addition of fixed charges on arcs has received scant attention. This work describes network-simplex-based algorithms that efficiently exploit the quasi-tree basis structure of the problem relaxations and presents computational comparisons with commercial solution alternatives.

3 - Finding Groups with Maximum Betweenness Centrality

Oleg Prokopyev, University of Pittsburgh, Pittsburgh, PA, 15261, United States, droleg@pitt.edu, Alexander Veremyev

In this talk we consider the problem of identifying the most influential (or central) group of nodes (of some predefined size) in a network. Such a group has the largest value of betweenness centrality or one of its variants, for example, the length-scaled or the bounded-distance betweenness centralities. We demonstrate that this problem can be modelled as a mixed integer program (MIP) that can be solved for reasonably sized network instances using off-the-shelf MIP solvers. We also present extensive computational experiments with different types of real-life and synthetic network instances to illustrate the effectiveness and flexibility of the proposed framework.

■ MB73

372B

Tutorial on Meta-algorithms

Sponsored: Computing

Sponsored Session

Chair: Meinolf Sellmann, IBM, 1101 Kitchawan Rd, Yorktown Heights, NY, 10, United States, meinolf@us.ibm.com

1 - Meta-Algorithms

Meinolf Sellmann, IBM, 1101 Kitchawan Rd, Yorktown Heights, NY, United States, meinolf@us.ibm.com

Meta-algorithmics is a subject on the intersection of learning and optimization whose objective is the development of effective automatic tools that tune algorithm parameters and, at runtime, choose the approach that is best suited for the given input. In this tutorial, we summarize the core lessons learned when devising such meta-algorithmic tools.

■ MB74

372C

Combinatorial Optimization and Applications

Sponsored: Computing

Sponsored Session

Chair: Illya V. Hicks, Rice University, Rice University, Houston, TX, 77005-1892, United States, ivhicks@rice.edu

Co-Chair: Derek J. Mikesell, Rice University, P.O. Box 1892, Houston, TX, 77005, United States, djm13@rice.edu

1 - The Traveling Salesman Problem with Road Distances

William J. Cook, University of Waterloo, Combinatorics and Optimization, Waterloo, ON, N2L.3G1, Canada, bico@uwaterloo.ca

Following Dantzig, Fulkerson, and Johnson, we show that a certain tour of 49,603 sites in the US is shortest possible, measuring distance with point-to-point routes obtained from Google Maps. We highlight a cost-refinement technique that allows the cutting-plane method to generate lower bounds on the tour length without explicit knowledge of the full distance matrix. The talk is based on joint work with Daniel Espinoza, Marcos Goycoolea, and Keld Helsgaun.

2 - Redistricting with Optimal Minority Representation

Boris Brimkov, PhD, Rice University, Houston, TX, United States, bb19@rice.edu

Redistricting is the process of partitioning geographic regions and population groups into electorates for municipal and state legislatures. In states with diverse populations, districts in which minority demographic groups comprise voting majorities can help prevent minority vote dilution. While other aspects of the redistricting problem have been thoroughly investigated by the combinatorial optimization community, the formation of minority-majority districts has not yet received an adequate treatment. This talk will discuss several theoretical and computational investigations aimed at producing redistricting plans that are optimal with respect to minority representation.

3 - A Hybrid Metaheuristic for Finding Near Optimal Target Sets in Consensus Models

Derek J.Mikesell, Rice University, P.O. Box 1892, MS-134, Houston, TX, 77005, United States, djm13@rice.edu

Given a network, we consider the problem of selecting a subset of nodes A of a fixed size K such that the average hitting time to A is minimized. This study is motivated by modeling communication models as a random walk on a weighted loopless directed graph, where the desired information is observed when a random walk reaches the chosen set. In general, this problem is NP-hard. In this paper we observe near-optimal solutions to this problem by considering a hybrid metaheuristic. This hybrid metaheuristic is formed from a discrete version of a simplified Cuckoo Optimization Algorithm and a Greedy Randomized Adaptive Search Procedure (\textit{GRASP}). Additionally, the restricted candidates for this method are chosen based on a spectral decomposition of the network - taking advantage of a random walks likelihood of staying within a cluster. Results show that better-than-greedy solutions can be obtained in a small number of iterations.

4 - Regression-Style Learning by Column Generation

Ai Kagawa, Rutgers University, 100 Rockafeller Road, Building A, Piscataway, NJ, 08854, United States, ai.kagawa@gmail.com

REPR (Rule-Enhanced Penalized Regression) is a column generation method to predict a scalar response from numerical observations. It enhances a penalized L1 or L2 regression model with new variables indicating whether observations lie inside certain multidimensional boxes. The column generation subproblem is the NP-hard RMA (Rectangular Maximum Agreement) problem, which we solve by parallel branch and bound. We empirically compare REPR to various alternatives and discuss accompanying data discretization techniques and tactics for reducing the computational load of the subproblems.

■ MB75

372D

Interactions of Optimization and Statistical Learning I

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Ethan Xingyuan Fang, Pennsylvania State University, University Park, PA, 16802, United States, xxf13@psu.edu

1 - Sample Complexity Analysis for Low-order Optimization Algorithms

Shuzhong Zhang, University of Minnesota, 111 Church Street, Department of Industrial and Systems Engineer, Minneapolis, MN, 55455, United States, zhangs@umn.edu

In this talk we study sample complexities for various zeroth-order algorithms for (stochastic) convex optimization. Essentially, the analysis is meant to understand how many times one will need to call the (stochastic) zeroth-order oracle in order to get an ϵ optimal solution in expectation. Such algorithms and analysis are important for various Bayesian optimization models and applications arising from revenue management. We shall also extend our discussions to include certain non-convex models.

2 - Dynamic Factorization and Partition of Complex Networks

Mengdi Wang, Princeton University, 226 Sherrerd Hall, Princeton, NJ, 08544, United States, mengdiw@princeton.edu

Finding the reduced-order structure is critical to understanding complex networks. Existing approaches are applicable only when the full network is explicitly observed. We focus on online factorization and partition of implicit large-scale networks based on observations from an associated random walk. We propose an efficient nonconvex stochastic gradient algorithm that processes dependent data dynamically generated by the underlying network and learn a low-dimensional representation. Using a diffusion approximation analysis, we show that the algorithm achieves nearly optimal performance in both sample and space complexity. The proposed approach is experimented on Manhattan taxi data.

3 - Tuning-free Heterogeneity Pursuit in Massive Networks

Jinchi Lv, University of Southern California, IOM.Department, Marshall School of Business, Los Angeles, CA, 90089, United States, jinchilv@marshall.usc.edu, Yingying Fan

Heterogeneity is often natural in many contemporary applications involving massive data. While posing new challenges to effective learning, it can play a crucial role in powering meaningful scientific discoveries through the understanding of important differences among subpopulations of interest. In this paper, we exploit multiple networks with Gaussian graphs to encode the connectivity patterns of a large number of features on the subpopulations. To uncover the heterogeneity of these structures across subpopulations, we suggest a new framework of tuning-free heterogeneity pursuit (THP) via large-scale inference, where the number of networks is allowed to diverge. In particular, two new tests, the chi-based test and the linear functional-based test, are introduced and their asymptotic null distributions are established. Under mild regularity conditions, we establish that both tests are optimal in achieving the testable region boundary and the sample size requirement for the latter test is minimal. Both theoretical guarantees and the tuning-free feature stem from efficient multiple-network estimation by our newly suggested approach of heterogeneous group square-root Lasso (HGSL) for high-dimensional multi-response regression with heterogeneous noises. To solve this convex program, we further introduce a tuning-free algorithm that is scalable and enjoys provable convergence to the global optimum. Both computational and theoretical advantages of our procedure are elucidated through simulation and real data examples.

4 - Understanding Best Subset Selection and Relatives

Rahul Mazumder, Massachusetts Institute of Technology, Sloan School of Management, 100 Main Street, Cambridge, MA, 02139, United States, rahulmaz@mit.edu

Sparsity plays a key role in linear statistical modeling and beyond. In this talk I will discuss the best subset selection problem and recent computational techniques relying on integer optimization and first order optimization methods, that enable us to obtain high-quality, near-optimal solutions for best-subsets regression, for sizes well beyond what was considered possible. This sheds interesting new insights into the statistical behavior of subset selection problems vis-a-vis popular, computationally friendlier methods thereby motivating the design of new statistical estimators with better statistical and computational properties.

■ MB76

372E

Discrete and Combinatorial Optimization

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Gerdus Benade, Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, jbenade@andrew.cmu.edu

1 - A Matrix Selection Problem

Zeyang Wu, University of Minnesota, 609 Southeast Oak St Apt 2-12, Minneapolis, MN, 55414-2922, United States, wuxx1164@umn.edu, Qie He

Consider a discrete-time dynamic system xk+1 = Mk xk among time horizon k = 0,1,2,...,T. The matrix Mk can be chosen as one of the given two matrices A or B. The matrix selection problem is defined as follows: given an initial vector x0, select matrices M1, M2, M3, ... MT, such that a linear function over the states x1, x2, x3, ... xT is minimized. This problem is motivated by various applications, e.g. cancer treatment planning, antibiotics design. We formulate this problem as a mixed-integer linear program and derive several families of facet-defining inequalities for the resulting formulation.

2 - Preference Elicitation for Participatory Budgeting
Gerdus Benade, Carnegie Mellon University, 6235 Fifth Avenue, Apt B17, Pittsburgh, PA, 15232, United States, gerdusbenade@gmail.com, Swaprava Nath, Ariel Procacci a, Nisarg Shah

Participatory budgeting is a practical variant of the knapsack problem which enables the allocation of public funds by collecting and aggregating individual preferences; it has already had a sizable real-world impact. Making the most of this new paradigm requires a rethinking of some of the basics of computational social choice, including the very way in which individuals express their preferences. We analytically compare four preference elicitation methods through the lens of implicit utilitarian voting, and find that threshold approval votes are qualitatively superior. This conclusion is supported by experiments using data from real participatory budgeting elections.

3 - The Replenishment Schedule to Minimize Peak Storage Problem
Dorit Simona Hochbaum, University of California-Berkeley, Dept of IEOR, 4135 Etcheverry Hall MC 177, Berkeley, CA, 94720-1777, United States, hochbaum@ieor.berkeley.edu, Xu Rao

The replenishment storage problem is to determine the integer timing of orders of items, each of given size, and each order is depleted within a given number of days (cycle time), so that the peak storage capacity is minimized. The problem is known to be NP-hard. We demonstrate here that RSP is weakly NP-hard for constant joint cycle length (the least common multiple of all individual cycles) and strongly NP-hard for non-constant joint cycle length. For constant joint cycle discrete-RSP, we present a pseudo-polynomial optimization algorithm and the first FPTAS for identical cycles.

4 - Ranking Students using Noisy Self-generated Questions
Nam Ho-Nguyen, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, hnh@andrew.cmu.edu, Gerdus Benade, Wolfgang Gatterbauer, R. Ravi

We consider the question of evaluating students based on student-generated questions. Unlike teacher-generated questions, student-generated questions are more unreliable and can misleading, i.e., unable to distinguish between strong and weak students. We explore several novel methods for this problem which are scalable, robust to misleading questions and missing responses, and capable of identifying ill-posed questions. We perform a comprehensive computational study to compare our methods against traditional parametric frameworks.

■ MB77

372F

Joint session OPT/Practice: Recent Progress in Optimization Software II

Sponsored: Optimization, Computational Optimization and Software

Sponsored Session

Chair: Hans Mittelmann, Arizona State University, Tempe, AZ, 85287-1804, United States, mittelmann@asu.edu

1 - The SAS MILP Solver: Current Status and Future Developments
Philipp M. Christophel, SAS.Institute Inc., Maria-Sibylla-Merian-Str. 36, Mainz, 55122, Germany, Philipp.Christophel@sas.com, Imre Polik, Menal Guzelsoy, Amar Kumar Narisetty

We give an overview of the current status of the SAS mixed integer linear programming (MILP) solver. The focus will be on describing recent implementation efforts for the MILP solver as well as future development directions.

2 - Recent Progress in the Xpress Solvers
Michael Perregaard, Xpress Developer, FICO, Birmingham, United Kingdom, MichaelPerregaard@fico.com

We will present some of the recent advances in the FICO Xpress solvers. The emphasis will be on how we can bring in different technologies, such as interior point solvers, in order to improve MILP performance.

3 - Matlab Optimization Update
Mary Fenelon, MathWorks, 3 Apple Hill Drive, Natick, MA, 01760, United States, Mary.Fenelon@mathworks.com, Steve Grikschat

The MATLAB Optimization Toolbox has solvers for linear, quadratic, mixed-integer linear and nonlinear optimization problems. Recent improvements to these solvers will be presented along with their application to building prescriptive analytics applications with MATLAB.

4 - Recent Improvements in SCIP 4
Robert Lion Gottwald, Zuse Institute Berlin, Rubensstr. 102, Berlin, 12157, Germany, robert.gottwald@zib.de

SCIP is a branch-and-cut based solver for mixed-integer-nonlinear programming (MINLP) problems. Its extensible design makes it particularly well suited for research and it is currently one of the fastest solvers available in source code. We will present improvements in the latest release of SCIP and give a prospect of new features such as presolving methods for the sparsification of the constraint matrix and enhancements in the cutting plane separation.

■ MB78

381A

Deterministic and Stochastic Optimization for Electric Power Systems

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Andy Sun, Georgia Institute of Technology, Atlanta, GA, 30312, United States, andy.sun@isye.gatech.edu

1 - Market-based Transmission Expansion Planning using an Area and Unit Decomposition Approach
Philipp Hartel, Fraunhofer IWES, Konigstor 59, Kassel, 34119, Germany, philipp.haertel@iwes.fraunhofer.de

Motivated by future offshore grid connections in the North Sea region, a market-based TEP model with a particular focus on long-term operational flexibility in multiple market areas of the energy system in Europe is presented. While accounting for interactions of power, heat, and transport sectors in the future, aggregated formulations of hydro-thermal units are used to capture short- to long-term power market dynamics. To solve the problem with a planning horizon of a full consecutive year, a solution strategy involving an area and unit decomposition for the resulting large-scale convex linearly-constrained non-smooth problem is pursued using a doubly stabilized proximal bundle algorithm.

2 - Valid Inequalities for Hydro Genco Self-scheduling Optimization
Minseok Ryu, University of Michigan, msryu@umich.edu, Antonio J. Conejo, Ruiwei Jiang

We focus on a self-scheduling optimization problem for a hydro generation company that manages a set of interconnected hydro reservoirs. We consider a class of key physical and operating characteristics of hydro reservoirs and generators in practical settings, including the prohibited operating zones and the nonlinear and nonconvex performance curves. We employ a mixed-integer linear programming (MILP) approach to approximate these characteristics. The MILP approach facilitates the use of many efficient computational tools, e.g., optimization solvers and valid inequalities. Finally, numerical experiments are conducted based on a real-world case study.

3 - Leveraging Predictive Analytics to Control and Coordinate Operations Scheduling and Maintenance
Murat Yildirim, Georgia Institute of Technology, Atlanta, GA, United States, murat@gatech.edu, Andy Sun, Nagi Gebraeel

Penetration of the renewable sources, distributed generation, and market dynamics increase the congestion and volatility in modern power grids, leading to frequent on-off cycles and stringent production requirements on power plants that significantly affect their lifetime. This presentation proposes a unified analytics framework that integrates i) a stochastic degradation model to provide accurate sensor-driven predictions of the remaining life distribution for power plants operating under varying loading conditions, with ii) an adaptive optimization model that finetunes the loading on the power plants by determining the optimal maintenance and operational decisions.

4 - Multistage Stochastic Unit Commitment with SDDIP
Andy Sun, Georgia Institute of Technology, 755 Ferst Drive, Atlanta, GA, 30312, United States, andy.sun@isye.gatech.edu

Unit commitment is one of the key operational problems in power systems. We propose a new type of decomposition algorithm based on Stochastic Dual Dynamic Integer Programming (SDDiP) to solve a dynamic programming formulation of a multistage stochastic unit commitment (MSUC) problem. We propose a variety of computational enhancements to adapt SDDiP to MSUC, and conduct extensive computational experiments to demonstrate that the proposed method is able to handle elaborate stochastic processes and can solve MSUCs with a huge number of scenarios that are impossible to handle byexisting methods.

5 - Techniques to Assess Performance of Electricity System Operation in the Presence of Ex Post Pricing
Tuong Nguyen, The New Zealand Electricity Authority, Level 7 - 2 Hunter Street, Wellington, 5024, New Zealand, manhtuong@yahoo.com

This paper examines an approach for the analysis of the system operator's real-time dispatch performance. In the New Zealand electricity system, generators are economically dispatched every five minutes in real time based on a real-time dispatch schedule. Computation of this schedule takes account of offers to supply, network topology, and demand forecasts. Market settlement prices are determined for each 30-minute trading period the following day using the final pricing schedule. The paper discusses the major causes of the differences between the real-time dispatch schedule and the final pricing schedule, and describes various options to measure system operation performance.

■ MB78B

380B

Humanitarian Logistics

Contributed Session

Chair: Yi Chu, Industrial Engineering, Beijing, China, chuy14@mails.tsinghua.edu.cn

1 - Research on Diabetes Screening Strategies in China using Agent Based Simulation Model

Bowen Pang, Tsinghua University, Tsinghua Univ. Zijing 14#, Beijing, 100084, China, pzkaixin@foxmail.com, Xiaolei Xie, Yan Li, José A. Pagán

Diabetes is one of the major chronic diseases in China with a prevalence rate of more than 10%. Screening is an effective way to recognize diabetes at early stage in order to control and reduce relative costs. However, considering the large population with high variety, screening without sound strategy often incurs considerable amount of costs. Therefore, it is significant and challenging to make policies on diabetes screening. An agent based model (ABM) is developed and validated to simulate the status quo in order to provide policy implications for nation-wide screening strategy, which is currently lacking.

2 - Determinants of Older Patient Choice of Medical Service Provider in China

Yi Chu, PhD Student, Industrial Engineering, Beijing, China, chuy14@mails.tsinghua.edu.cn, Xie Xiaolei, Zuojun Shen

It is crucial to understand factors influencing health service choice to manage patient flow on a national level. We aim at finding the determinations of medical service provider choice between older patients in China. We use conditional logit model to analyze nationwide data from China Health and Retirement Longitudinal Study and local yearbooks in 2013. Outpatient and inpatient choice patterns in different regions are also compared. Our research shows that policy makers should design a flexible policy and pay attention to important factors, such as regional effect.

3 - Impact of Affordable Care Act (ACA) on Patient Choices and Care

Sarah Berkin, California State University, Hayward, CA, United States, sberkin@horizon.csueastbay.edu, Philip Cole-Regis, Kimberly Reyes, Balaraman Rajan, Surendra Sarnikar

We analyze the impact of the Affordable Care Act (ACA) on healthcare coverage in the United States. Rollout of the plans, protections, and mandates began in 2010, progressing until full implementation in 2015. There has since been a notable decrease in uninsured citizens. To assess the quality of healthcare, we focus on: number of, type, and cost of emergency room visits including wait times and appointment availability. We also look at the impact on preventive care through different indicators.

■ MB79

381B

Operational Modeling for Energy Storage

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Ramteen Sioshansi, The Ohio State University, 240 Baker Systems Engineering Building, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, sioshansi.1@osu.edu

Co-Chair: Antonio J. Conejo, The Ohio State University, 286 Baker Systems Engineering Building, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, conejonavarro.1@osu.edu

1 - Reducing Degradation in Batteries used for Frequency Regulation via Nonlinear Control

Johanna Mathieu, University of Michigan, 1301 Beal Avenue, EECS.Building, Ann Arbor, MI, 48109, United States, jlmath@umich.edu, Joshua Adam Taylor

Batteries can be used to provide frequency regulation to electric power systems; however, a battery's energy storage capacity degrades as it consumes and produces power. We extend an existing nonlinear battery model, pose the battery control/management problem as a tracking control problem, and develop several nonlinear controllers. In simulation, we show how the controllers enable us to easily tradeoff tracking accuracy and battery life, and how explicitly considering nonlinear battery dynamics in the controllers improves performance.

2 - Task-based End-to-end Model Learning in Stochastic Optimization

Priya L. Donti, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, pdonti@cs.cmu.edu, Brandon Amos, J. Zico Kolter

While prediction algorithms commonly operate within some larger process, the criteria by which we train these algorithms often differ from the criteria on which we actually evaluate them: the performance of the full "closed-loop" system on the ultimate task at hand. For instance, instead of merely predicting electricity demand in a standalone setting, one may want to use these predictions within planning and control tasks such as power generator allocation in the presence of energy storage. We propose an end-to-end approach for learning probabilistic machine learning models in stochastic programming that directly capture the objective of the task for which they will be used.

3 - Collaborative Demand-response Planner for Smart Buildings with Storage

Juan A. Gomez, Polytechnique Montréal, 3190 Boul. Edouard Montpetit 104, Montreal, QC, QC H3T.1K2, Canada, juan.gomez@polymtl.ca, Miguel F.Anjos

We present a collaborative scheme for the end-users in a smart building with multiple housing units. This approach determines a day-ahead operational plan that provides demand-response services by taking into account the amount of energy consumed per household, the use of storage and solar panels, and the amount of shifted load. We use a biobjective optimization model to trade off total user satisfaction versus total cost of energy consumption. Experimental results and a sensitivity analysis validate the performance of the proposed approach and help to clarify its strengths, its limits, and the requirements for ensuring the desired outcome.

■ MB80

381C

Interdependent System Modeling – The Nexus of Power, Natural Gas, and Water Systems

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Andrew Lu Liu, Purdue University, West Lafayette, IN, 47907, United States, andrewliu@purdue.edu

1 - Quantifying the Effect of Natural Gas Price Uncertainty on Economic Dispatch Cost Uncertainty

Dan Hu, Iowa State University, 422 Stonehaven Dr. Unit 17, Ames, IA, 50010, United States, danhu@iastate.edu, Sarah M. Ryan

In competitive electricity markets, vulnerability in gas supply to electricity generators creates a risk of high electricity prices. We propose an hourly economic dispatch model that accounts for natural gas availability and cost from both contracts and the spot market. With probabilistic inputs estimated from historical data, we use Monte Carlo simulation to generate the resulting distributions of electricity dispatch cost both with and without gas price uncertainty. The effect of gas price uncertainty is assessed in terms of distance between the distributions.

2 - An Economic Equilibrium Model for the Integrated Electricity Market

Lihui Bai, University of Louisville, Dept. of Industrial Engineering, J.B. Speed School Of Engineering, Louisville, KY, 40292, United States, lihui.bai@louisville.edu, Andrew Lu Liu, Qipeng Zheng

We consider an equilibrium model for an integrated electricity market system consisting of electricity consumers, power generators, grid owners, coal producers, natural gas producers, marketers and pipeline owners. In the equilibrium model, each individual player optimizes its own subsystem while market-clearance conditions are satisfied wherever players interact with each other. Numerical results will be reported including validation with the EIA's published data.

3 - Joint Optimization of Power and Water Systems through Distributed Algorithms

Andrew Lu Liu, Purdue University, 315 North Grant Street, School of Industrial Engineering, West Lafayette, IN, 47907, United States, andrewliu@purdue.edu

There has been an increasing interdependence between the power and water sector. Meeting growing electricity demand would require more fresh water for power plants' cooling, causing tension on water systems. While co-optimization of all the inter-linked systems may reach the most efficient solutions, it is impossible to do so with regulatory and computational constraints. We propose a provably-convergent distributed algorithm so that through each sector's individual optimization and information sharing, the joint-systems-wide optimal solution can be reached.

4 - Robust Defense Strategy for Gas-electric Systems Against Malicious Attacks

Feng Qiu, Argonne National Laboratory, Lemont, IL, United States, fqiu@anl.gov, Cheng Wang, Jianhui Wang

This talk proposes a methodology to identify and protect vulnerable components of connected gas and electric infrastructures from malicious attacks, and to guarantee a resilient operation by deploying valid corrective actions, while accounting for the interdependency of gas pipeline network and power transmission network. The proposed mathematical formulation gives rise to to a tri-level optimization problem. Case studies on two test systems demonstrate the effectiveness and efficiency of the proposed methodology.

■ MB81

382A

Distributionally Robust Stochastic Programming

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Hamed Rahimian, Ohio State University, Columbus, OH, 43210, United States, rahimian.1@osu.edu

1 - Wasserstein Distributional Robustness and Regularization in Statistical Learning

Rui Gao, Georgia Institute of Technology, Atlanta, GA, 30332, United States, rgao32@gatech.edu, Xi Chen, Anton J.Kleywegt

A central question in statistical learning is to design algorithms that generalize to new data. We tackle this problem by formulating a Wassestein distributionally robust stochastic optimization (DRSO), and establish its connection with gradient-norm regularization. Such connection has several important implications. (i) It provides new interpretations for problems involving regularization, including many machine learning problems and discrete choice models. (ii) It enables a new way to derive generalization error bounds for statistical learning problems using tools from DRSO. (iii) It suggests a systematic approach to regularize problems in deep learning (e.g. training of GANs).

2 - Decomposition Algorithms for Distributionally Robust Optimization using Wasserstein Metric

Sanjay Mehrotra, Northwestern University, Dept of I.E./M.S.C246 Tech Inst, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States, mehrotra@iems.northwestern.edu, Fenqiao Luo

We study distributionally robust optimization (DRO) problems where the ambiguity set is defined using the Wasserstein metric. We show that this class of DRO problems can be reformulated as semi-infinite programs. We give a central cutting-surface method for the convex objective, assuming that we have a separation oracle. We used a distributionally robust generalization of the logistic regression model (DRLR) to test our algorithm. Numerical experiments on the DRLR models show that the number of oracle calls are typically $20\sim 50$ to achieve 5-digit precision. The solution found by the model is generally better in its ability to predict with a smaller standard error.

3 - Data-driven Distributionally Robust Chance-constrained Programming with Wasserstein Metric

Ran Ji, Assistant Professor, George Mason University, 4400 University Dr. MS.4A6, Fairfax, VA, 22031, United States, rji2@gmu.edu, Miguel A.Lejeune

We investigate a class of distributionally robust chance-constrained (DRCC) optimization problems with Wasserstein metric. We develop a reformulation and algorithmic framework to solve the problem. We formulate a series of new DRCC models for portfolio optimization problems, including some widely used reward-risk ratios in finance. The computational study shows the applicability and scalability of the proposed framework.

4 - Distributionally Robust Newsvendor Problems with Variation Distance

Hamed Rahimian, The Ohio State University, 1971 Neil Avenue, 210 Baker Systems Building, Columbus, OH, 43210, United States, rahimian.1@osu.edu, Guzin Bayraksan, Tito Homem-de-Mello

We use distributionally robust stochastic optimization to model a general class of newsvendor problems. We form the ambiguity set by all demand distributions that their variation distances are bounded by a level of robustness-from a nominal distribution. For this problem: (1) we derive closed-form expressions of the optimal solution as a function of the level of robustness, (2) we determine the regions of demand that are critical to the optimal cost, and (3) we establish quantitative relationships between the distributionally robust model and the corresponding risk-neutral and classical robust optimization models. Our study can guide decision makers to choose an appropriate level of robustness.

■ MB82

382B

Optimization in the Presence of Network Uncertainties

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Anna Timonina-Farkas, EPFL, RAO, Anna.farkas@epfl.ch

1 - Distributionally Robust Location-routing Problem

Dimitri Papadimitriou, Nokia Bell Labs, Rue du Charme 24, Brussels, 1190, Belgium, dimitri.papadimitriou@nokia-bell-labs.com

In Distributionally Robust Optimization (DRO), model data is represented as random variable over a family of probability distributions. The motivation of using this technique for the solving location-routing problems stems from the ambiguity characterizing the probability distribution of demands in space (origin) and size driving location and allocation-dependent routing decisions. For this propose, we propose a data-driven DRO model which produces decisions that are robust with respect to the ambiguity set of all demand distributions that satisfy prescribed statistical hypothesis tests.

2 - Optimizing Crashing Decisions in Project Management Problem with Disruptions

Haoxiang Yang, Northwestern University, 2145 Sheridan Road, Room C151, Evanston, IL, 60208, United States, haoxiangyang2019@u.northwestern.edu, David Morton

We consider the problem of crashing a PERT network to accelerate project completion under a small number of disruptions. When a disruption occurs, the duration of an activity, which has not started, can change. The magnitude of that change, and the timing of the disruption, can both be random. We formulate this problem as a stochastic mixed integer program (SMIP). We propose a branch-and-bound algorithm to solve the SMIP and evaluate the computational performance of our approach.

3 - Information Theoretic Learning in MDPs with Hierarchical Parametric Uncertainty in Transition Probabilities

Peeyush Kumar, B14, Industrian and Systems Engineering, MEB, University of Washington Seattle, Seattle, WA, 98195-2650, United States, agaron@uw.edu, Archis Ghate

This research extends the recent work on Information Directed Policy Sampling (IDPS) to hierarchical MDPs. IDPS provides a way for decision maker to simultaneously balance the effect of exploration and exploitation. We consider MDPs where uncertainty in transition probabilities comes from two levels. The top level uncertainty corresponds to the decision-maker's uncertainty about the system model. The bottom-level uncertainty is rooted in the decision-maker's knowledge about the model parameters. This research extends IDPS to hierarchical MDPs and provides analytical performance bounds as well as numerical analysis on Response Guided Dosing.

4 - Robust PageRank: Stationary Distribution on a Growing Network Structure

Anna Timonina-Farkas, EPFL, RAO, Rue Saint-Laurent 33, Lausanne, Switzerland, anna.farkas@epfl.ch

PageRank is a challenging and important network ranking algorithm, which plays a crucial role in information technologies and numerical analysis due to its huge dimension and wide range of possible applications. Recently, a robust formulation of the PageRank model has been proposed for the case, when links in the network structure may vary influencing the transportation matrix defined by the network structure. In this work, we make a further step forward, allowing the network to vary not only in links, but also in the number of nodes. We propose a new robust formulation of the PageRank problem for uncertain networks with fixed growth rate.

■ MB83

382C

Stochastic Mixed-Integer Programming and Applications

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Semih Atakan, University of Southern California, Los Angeles, CA, 90089-0193, United States, atakan@usc.edu

1 - Error Bounds for Inexact Cutting Plane Techniques for Stochastic Mixed-integer Programming Problems

Ward Romeijnders, University of Groningen, Nettelbosje 2, Groningen, 9747 AE, Netherlands, w.romeijnders@rug.nl

We derive error bounds for a class of inexact cutting plane techniques for stochastic mixed-integer programming problems. These error bounds converge to zero if the total variations of the probability density functions of the random variables in the model converge to zero. Moreover, we show several numerical experiments, illustrating the actual error of using these inexact methods.

2 - Solving Stochastic Mixed-Integer Programs using a Generalized Value Function

Onur Tavaslioglu, University of Pittsburgh, 7171 Buffalo Speedway, Apt 1934, Houston, TX, 77025, United States, ont1@pitt.edu, Oleg A.Prokopyev, Andrew J. Schaefer

We introduce the generalized value function of a mixed-integer program, which is simultaneously parameterized by its objective and right-hand side. We describe its fundamental properties, which we exploit through three algorithms to calculate it. We then show how this generalized value function can be used to reformulate two classes of very difficult mixed-integer optimization problems: two-stage stochastic mixed-integer programming and multi-follower bilevel mixed-integer programming. For both of these problem classes, the generalized value function approach allows the solution of instances that are significantly larger than those solved in the literature.

3 - Subgradient Methods for Stochastic Mixed-Integer Programs

Cong Han Lim, University of Wisconsin-Madison, Madison, WI, United States, clim9@wisc.edu, Jeff T.Linderoth, James Luedtke, Stephen J.Wright

We present our work on improving the subgradient method for solving the Langrangian dual of a stochastic mixed-integer program (SMIP). Our techniques include subsampling and asynchronicity, and leads to methods that have similar guarantees as the full subgradient method. The algorithms run effectively on both large-scale distributed platforms and multi-core servers. We present computational results on some classic SMIP problems.

4 - PH-BAB Applications in Power Systems Planning

Semih Atakan, University of Southern California, 3715 McClintock Ave, GER.240, Los Angeles, CA, 90089-0193, United States, atakan@usc.edu, Suvrajeet Sen

Progressive Hedging (PH) has been used as a heuristic optimization method for many SMIP problems. In this talk, we briefly describe our framework (PH-BAB) for using PH to compute optimal solutions to stochastic mixed-integer convex programs (SMICPs). We, then, present an algorithm within this framework for specially-structured SMICPs. The performance of the algorithm will be demonstrated on academic benchmark instances and stochastic Unit Commitment problems.

Monday, 12:30 - 2:30PM

■ Monday Poster

Monday Poster Session

Poster Session

1 - Weighted Networks: Edge-splitting Procedure in Centrality Computations

Ivan Belik, Dr., Norwegian School of Economics, Helleveien 30, Bergen, 5045, Norway, ivan.belik@nhh.no

The analysis of social network's centralities has a high-level significance for many real-world applications. The variety of game and graph theoretical approaches has a paramount purpose to formalize a relative importance of nodes in social networks. In the given research, we present a formalized symbiotic graph theoretical and game theoretical algorithm for the centrality computation in the domain of weighted networks. The given algorithm calculates network centralities for weighted graphs based on the proposed edge-splitting procedure. The approach is tested and illustrated based on different types of network topologies.

2 - Managing Volunteer Convergence at Disaster Relief Centers

Hussain Abualkhair, North Carolina A&T.State University, 614 Eagle Road, Apt 2C, Greensboro, NC, 27407, United States, hfabualk@aggies.ncat.edu

Disaster Relief center managers face uncertainty in both the timing and quantity of donations, as well as the number of spontaneous volunteers. Volunteer convergence is one of the biggest challenges for relief center managers. To better understand this phenomenon and find effective management strategies, we develop an agent-based simulation model consisting of donors providing relief items, beneficiaries in need of relief items and random arrivals and departures of volunteers. We investigate volunteer assignment policies that reduce donor beneficiary waiting time under given changes in volunteer capacity, available inventory, and beneficiary's arrival rates.

3 - Budgeting Dredging Projects to Improve Resilience of the Inland Waterway Network

Khatereh Ahadi, PhD Candidate, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States, kahadi@uark.edu

We consider the problem of selecting a budget-limited subset of maintenance actions to maximize the expected tonnage of commodities that can be transported through the inland waterway system. Uncertainty in our model is the budget required at each district for emergency dredging arises from unpredictable conditions. Thus, our main decision is allocating budget to each district to cover the cost of reactive dredging. We model this problem as a stochastic programming model, develop solution approaches, and analyze computational results.

4 - Robust Synthetic Control

Muhammad J. Amjad, Massachusetts Institute of Technology, 235 Albany Street, Suite 3121A, Cambridge, MA, 02139, United States, mamjad@mit.edu, Devavrat Shah, Dennis Shen

Abadie et al introduced the idea of using "synthetic control" for comparative case studies, where the control unit is a convex combination of unaffected (donor) units. We present "robust" synthetic control where we propose a generic latent variable model which subsumes the classical method. Algorithmically, we first "de-noise" the observations and then learn the linear synthetic control allowing us to do away with needing preprocessing "expert" knowledge or covariate information to identify a good subset of donor units. Additionally, our algorithm is asymptotically consistent in MSE and robust to missing and/or noisy observations.

5 - Predicting Power Price Profile in the Electricity Market by Solving a Bi-level Optimization Problem

Maliheh Aramon, Applied Researcher, 1QBit, Unit 403, 1461 Harwood Street, Vancouver, BC, V6G 1X7, Canada, maliheh.aramon@1qbit.com

In this project we address a practical bi-level optimization model in the electricity market. By considering market data for a particular operating horizon, our goal is to find an hourly price profile incentivizing global production levels that closely match the market demand. To solve the problem, a two-stage heuristic algorithm is developed. An initial price profile is first found and a sequence of steps then iteratively perturbs the price profile closer to an optimal price profile. The designed heuristic algorithm can also be solved using disruptive hardware such as a quantum annealer. Our numerical results on a real data set illustrate a close match between supply and demand for 95% of the hours.

6 - Interdicting Layered Physical and Information Flow Networks

Nail Orkun Baycik, Rensselaer Polytechnic Institute, 110 8th Street Center for Industrial Innovation, Suite 5015, Troy, NY, 12180, United States, baycin@rpi.edu

We study the interdiction of layered networks that involve a physical flow and an information flow network. The objective of the defender is to maximize the physical flow and the objective of the attacker is to minimize this maximum amount. There exist interdependencies between the networks which leads to a network interdiction problem with a discrete inner problem. By using duality, we reformulate the problem and obtain a single-level model. We apply this technique to the application of combating illegal drug trafficking and protecting cyber infrastructures, and present computational results.

7 - Optimal Operation of Large Scale Flexible Hydrogen Production in Constrained Transmission Grids with Stochastic Wind Power

Espen Flo Bødal, PhD Candidate, Norwegian University of Science and Technology, O.S.Bragstads Plass 2E, Trondheim, 7030, Norway, espen.bodal@ntnu.no

The focus of this work is on developing and assessing the value of using a stochastic model when planning the operation of the flexible hydrogen production in a region with large wind power potential and constrained transmission grids, and how it affects storage strategies. Specific situations when the stochastic model is superior to a deterministic model based on the expected value is identified and analyzed in detail. The effects from stochastic wind power production on the optimal size of storage is also investigated by conducting an analysis of the dual variables of the storage constraints.

8 - Best Subset Selection of Factors Affecting Influenza Spread using Multi Objective Optimization

Aigerim Bogyrbayeva, graduate Student, University of South Florida, 4202 E. Fowler Avenue, Tampa, FL, 33620, United States, aigerimb@mail.usf.edu, Hanisha Tatapudi, Walter Silva, Hadi Charkhgard

Influenza ranks among the most common viral infections. It is extremely contagious and fatal for senior adults and children. Influenza is treated by pharmaceutical interventions (i.e. vaccines) and non-pharmaceutical interventions (i.e. quarantines). Due to the nature of the disease and its viral mutations, creating vaccines for every Influenza strain is time consuming. Hence, Non-Pharmaceutical Interventions (NPIs) have been successfully used in the past. We study the impact of NPIs on the spread of the disease and recommend the best subset selection of NPIs. We used a bi-objective optimization approach for accurately predicting the infection attack rate and minimizing the number of NPIs.

9 - Will the High-speed Passenger Railway Line Operation Affects on Regional Logistics System

Mi Gan, Southwest Jiaotong University, Jinniu District, 111 N.1st Erhuan Road, Chengdu, 610031, China, migan@swjtu.cn, Xi Huang

An applied STIRPAT model has been applied to estimate the impacts of high speed passenger railway line operation on regional logistics system. The regional freight volume from 2014-2016 has been selected to represent the status of logistics system, the number of passenger of each stations of high speed passenger railway line has been selected as the independent variable. The analysis result shows high-speed rail operation has positive effects on regional logistics system.

10 - An Optimization Model for Resilient Service Systems

Jing Gong, Jinan University, School of Public Administration, Guangzhou, China, tgongjing@jnu.edu.cn

A service system in our research has two-fold meaning: 1)to meet the demand; 2)to be delivered by a directed graph. Recent catastrophic events precipitate a wide range of impacts so that public awareness continues to grow of resilience as an important means of characterizing the ability to deal with them. Taking resilience into account will raise the following questions: How can we represent the resilience of a service system? How can managers tradeoff between a cost minimum system and a resilience maximum system? This paper proposes a linear piecewise recovery function and applies it to the decision-making processes of improving a service system's resilience to disasters.

11 - Educational Efficiency Distance in Secondary Schools of SãO Paulo Municipalities

Maria Cristina Gramani, Professor, INSPER.Institute of Education and Research, Rua Quatá 300, Sao Paulo, 04546-042, Brazil, mariacng@insper.edu.br

This study analyzes the performance of secondary schools in Brazil according to two indicators: (i) "gap of the school", which measures the real distance of performance between schools in national ranking and, (ii) "discipline bias", which investigates whether schools with better educational performance are those with a higher tendency to score better in certain fields. We found that, high level of students in Mathematics consists on the determinant of efficiency of schools with a higher socioeconomic level, and the lower number of students with low level in Human science is the efficiency determinant of schools with lower socioeconomic status.

12 - Determining Decoupling Points in a Supply Chain Associated with Different Design Preferences

Lin Guo, University of Oklahoma, Norman, OK, United States, lin.guo@ou.edu, reza alizadeh, Janet Katherine Allen, Farrokh Mistree

In this research, we propose an approach using exploration of the solution space of a multi-goal compromise Decision Support Problems model to determine the decoupling points of a three-echelon supply chain. Facing different design preferences of the supply chain, the goals should be satisfied in different degree, and the change of the design preference may take place rapidly, which requires the decoupling points flexible enough to be moved through the supply chain.

13 - Bus Ranking Method for Robust Optimization

Amandeep Gupta, Cornell University, 316 Highland Road, Ithaca, NY, 14850, United States, ag729@cornell.edu, Lindsay Anderson

Interest in efficient and flexible stochastic methods for unit commitment has been growing steadily in answer to increasing renewable energy resources on the grid. This work describes a statistical bus ranking methodology that identifies the most critical buses based on criteria such as economic dispatch cost, or ramping needs to provide a robust unit commitment solution. The method is illustrated via a case study on the IEEE 30-bus system and compared to other established approaches to demonstrate the efficacy of obtained solutions. Results show that the bus ranking method performs as well as the best of these methods, with the provision of additional flexibility and potential for parallelization.

14 - Optimal Step-stress ALT under Interval Monitoring and Progressive Type-I Censoring

David Han, University of Texas at San Antonio, Management Science & Statistics, College of Business, San Antonio, TX, 78249-0632, United States, david.han@utsa.edu

A step-stress ALT under progressive Type-I censoring was considered when a continuous monitoring of failures is infeasible but inspections at certain time points is possible. In addition to the accelerated failure time model, a general scale family of distributions was considered for flexible modeling. The MLE of scale parameters and their conditional densities could be derived explicitly. Using the exact distributions of the estimators, confidence intervals for the parameters were obtained and numerically assessed.

15 - Views and Subscriptions: Which One Matters to a Youtuber's Monetization Success?

Bo Han, Texas A&M.University-Commerce, 2600 S.Neal, Commerce, TX, 75428, United States, bo.han@tamuc.edu

The critical factors to a monetization success have gained a tremendous interest from YouTubers and social media entrepreneurs. However, there has not been a rigorous study testing the effects of the view factors and subscription factors on a YouTuber's revenues. We introduce a new empirical model to address this knowledge gap. Validating our model by a panel data of 116 most viewed YouTuber channels, we find that the new daily views, the daily view growth rate, and the existing total views of a YouTuber's videos are significantly positively associated with her daily revenue. The subscription variables do not directly contribute to a YouTuber's daily revenue.

16 - Server Behaviours in Queueing Systems

Paul Harper, Cardiff University, School of Mathematics, Cardiff, CF24 4AG, United Kingdom, harper@cardiff.ac.uk

In the classical queueing theory literature, a server is commonly assumed to work at a constant speed. Motivated by observations from healthcare applications, in particular within Emergency Departments, a study is made to explore the nature of the relationship between service times and workload in order to assess and quantify any workforce (server) behaviours. An analytical model is presented in which service time depends on queue length. The research helps to demonstrate the importance of more accurately capturing server behaviours in workload-dependent environments, and the impact this has on the overall system performance.

17 - Optimization of Emergency Evacuations Through Exit Allocation and Risk Analysis

Elizabeth Hooper, Texas A&M.University-Kingsville, Kingsville, TX, United States, elizabeth@alumni.purdue.edu

Exit locations and evacuation procedures facilitate occupant safety during emergencies. This research aims to optimize building exit locations and analyze risk during building evacuations. Nonlinear programming and queueing theory are used to optimize exit locations and determine egress times. A risk analysis with risk matrix and flow chart for emergency evacuation are also created. Lastly, this paper discusses an application of smart building technology for building evacuations during emergencies. The results show that the use of optimization techniques and risk analysis allow better planning and response during emergencies.

18 - Decision Pattern Mining in Chronic Disease

Praowpan Tansitpong, Mahidol University International College, 999 Bhuddamonthn 4 Rd., Nakon Pathom, 73170, Thailand, praowpan.tan@mahidol.ac.th

This study utilizes electronic medical records (EMRs) to evaluate diversity in standard of care from prescription decision in multiple clusters and identify "high cost" segment by using health benefit differentiation, brick-and-mortar Pareto classification, and Hierarchical clustering.

19 - Natural Language Processing Techniques for Patent Analysis in Management Research

Mike Horia Teodorescu, Doctoral Candidate, Harvard Business School, Wyss House, Boston, MA, 02163, United States, miketeod@hbs.edu

As legal instruments, patents do not follow the linguistical assumptions expected in a natural language. Direct application of standard linguistic tools does not capture the intricacies of the patent corpus. I present a novel corpus model, modified measures of textual similarity, and applications of patent text processing to knowledge flows within and across firms.

20 - Optimization of Scheduling Malleable Tasks on Single-stage Non-identical Machines

Qing Wang, Northeastern University, Heping District, 3-11 Wenhua Road, Liaoning, 110819, China, qwang@mail.neu.edu.cn

This paper considers a special manufacturing environment of make-to-order quartz processing enterprise. The tasks for scheduling are malleable and each has a due date with penalty for tardiness. The considered production stage is the bottleneck factor of order tardiness in the whole manufacturing process, and there are several equipments or machines in common function at the stage. Each equipment or machine has distinctive processing efficiency and processing costs. The study aims to minimize the total costs in two aspects of the processing costs and the tardiness penalties to find the optimal schedule solution.

21 - An Artificial Neural Network Based Decision Framework for VRPTW

Bochen Wang, Shanghai University, Shanghai, China, websterchen@163.com

This paper proposes an improved technique for VRPTW decision framework by using the Cplex solution to train the BP neural network. Through tunning parameters, the trained network can get the near optimal solution of VRPTW. The numerical result shows the improved method can reduce computing time efficiently.

22 - Cranes Scheduling in Frame Bridges Based Automated Container Terminals

Wencheng Wang, Shanghai University, Shanghai, China, 194716297@qq.com

This paper investigates crane scheduling problems for a new type of automated container terminal system, which is based on multi-storey frame bridges. For this new design concept, this paper studies how to schedule two types of cranes, i.e., quay cranes and bridge cranes that transfer containers between different storeys. The schedules of these two types of cranes impact the operation efficiency of the terminal system. Mathematical models are proposed for the two scheduling problems. Meta-heuristics are developed to solve them. Numerical experiments are conducted to validate the effectiveness of the proposed models and the efficiency of the proposed solution method.

23 - Forecasting Environmental Life Cycle Impacts (FELCI) for U.S. Army Material Selection

Matthew D. Wood, U.S. Army Engineer Research and Development Center, ERDC - US.Army Corps of Engineers New England, 696 Virginia Road, Concord, MA, 01742, United States, matthew.d.wood@usace.army.mil, Taylor E.Rycroft, Jeffrey Cegan, Igor Linkov

Managers of military training ranges require approval from environmental regulators and other interests when proposing changes to training activities (e.g., new materials, operating procedures). Regulators bias toward requiring all possible environmental tests, however, information gained tends to decrease logarithmically as time/dollar cost increases. We introduce the FELCI tool, a portfolio model built on top of UNEP/SETAC's USEtox 2.0 model. It recommends the optimal portfolio(s) of fate, exposure, and effects tests that minimize uncertainty in predicted ecotoxicological impacts while adhering to program cost and time constraints.

24 - Multi-parametric Sensitivity Analysis of Integer Programming: A Comparison of Two Optimization Algorithms

Hsin Pin Wu, National Tsing Hua University, No. 101, Section 2, Kuang-Fu Road, Hsinchu, Taiwan 30013, R.O.C., Hsinchu, 30013, Taiwan, newstephanie90404@gmail.com, Yu Ching Lee, Chor Yiu Sin

This study develops multi-parametric sensitivity analysis theorems for integer programs from two different algorithms: column generation and the iterative dual method proposed by Shapiro (1977). We develop post-optimality analysis theorems which indicate that the optimal solution will remain optimal if the sum of the negative reduced cost is not less than a threshold. Then, we carry out numerical experiments with multi-parameter costs perturbation problem using two proposed theorems separately and compare the results and computational tractability.

25 - Store Brand Introduction Strategy under Retailer Stackelberg Leadership Supply Chain

Hongming Xu, Doctoral Candidate, Tongji University, School of Economics and Management, 1239 Siping Road, Shanghai, China, shyiming2013@gmail.com, Yongrui Duan, Jiazhen Huo

We study store brand introduction strategies in a market channel composed of one national brand manufacturer and two retailers which, each, carry a national brand product and may sell its own brand product. We use a game theoretic model to analyze interactions between retailers' store brand decision and channel leadership structures which contained both vertical level (between manufacturer and retailers) and horizontal level (between retailers) with retailers as leader . As a result, retailers will be easier to introduce a store brand in a retailer stackelberg leadership structure.

26 - Measuring Nursing Home Efficiency using PCA-DEA Approach

Fangzheng Yuan, Upper Great Plains Transportation Institute, 1340 Administration Ave, Fargo, ND, 58108, United States, Fangzheng.yuan@ndsu.edu, Yongshin Park

This study employs a robust approach to measure the efficiency of the nursing homes in Fargo-Moorhead Metropolitan area using two stage analysis consisting of principal component analysis (PCA) and data envelopment analysis (DEA). The objective is to improve discriminatory power of the DEA by reducing the dimensionality of data set when there is an excessive number of inputs and outputs compared to the number of decision-making units (DMUs). The performance of each DMUs is ranked and a benchmarking target is provided to improve the efficiency score in this study. The result demonstrates that using PCA can noticeably improve the discrimination of DEA models.

27 - Multimodal Emergency Medical Transportation Network Design for Trauma Patients

Nasibeh Zanjirani Farahani, University of Missouri, E3437 Thomas and Nell Lafferre Hall, Columbia, MO, 65211, United States, nzqpc@mail.missouri.edu, James Noble, Moein Enayati

Parallel usage of different modes of transportation in the design of healthcare transportation network provides the chance of full demand coverage for trauma patients' services. Ambulances and helicopters should work together to achieve the highest rate of survival. This paper presents a mathematical model to reach the minimum commuting time.

28 - Liner Ship Deployment Considering Transshipment, Fuel Cost and Port Capacity

Lu Zhen, Shanghai University, Room 469, 599 Shangda Road, Shanghai, 200444, China, mmshan@shu.edu.cn, Hu-Chen Liu, Jianxin You, Jianxin You, Mengmeng Shan

This paper investigates a liner ship deployment problem, which can help a liner shipping company to decide the suitable number of ships deployed on each route as well as the suitable arrival time at each port of call on each route in the company's shipping network. Different from the related literature, this paper considers some more comprehensive and realistic factors such as the container transshipment in the network, ships' fuel consumption cost affected by their sailing speed, capacity limitations at ports with respect to the resources of berths

29 - Flexible Design under Uncertainties

K.Jo Min, Iowa State University, 3004 Black Engineering, Department of Industrial &, Ames, IA, 50011-2164, United States, jomin@iastate.edu, John Jackman, Chung-Hsiao Wang, Joe Eilers

In this poster, we examine the economic value of various flexibilities in the design of products, processes, and systems based on simple principles of stochastic optimal control. We show how such a value determines strategic decisions relevant to design, and discuss the economic implications and managerial insights.

30 - Applying a Pythagorean Model for NFL Playoff Analytics

Tung Cu, Bloomsburg University of Pennsylvania, 400 E. Second Street, Bloomsburg, PA, 17815, United States, tcu@bloomu.edu, Carolyn Lamacchia, Ty Rohrbach

Sport analytic topics have been received a large attention by both professional and academic communities. However, previous research on predictive modeling of National Football League (NFL) games only focuses on one-for-all models for an entire season. Since competitions in regular season much differ from that in playoffs, previous models are not robust. Strategic moves in a regular season are for the best conference position while playoffs present a win-at-all-cost situation. The result of the playoffs is much more uncertain than regular season games. The current study proposes a Pythagorean model to predict the NFL playoffs since playoff games lead to the coveted championship.

31 - New Data for Representing Irrigated Agriculture in Economy-wide Models

Kirby Ledvina, MIT.Joint Program on the Science and Policy of Global Change, 77 Massachusetts Avenue, Building E19-411, Cambridge, MA, 02139, United States, kledvina@mit.edu, Niven Winchester, Kenneth Strzepek, John Reilly

The paper develops a framework to represent irrigated land's crop production value and expansion potential within economy-wide models. Production values are calculated at a high spatial resolution, and a global dataset of evaluation metrics identifies the regions and crops where there are large differences in irrigated production value shares based on direct calculation and approximated by output volumes. Separately, the paper quantifies irrigated land's expansion potential through regional supply curves based on water availability and the costs of irrigation infrastructure. Altogether, the paper enables a deeper exploration of the impacts of water availability on economic activity.

32 - Measuring Climate Resilience of Hong Kong's Transportation System

Xinying Huang, University of Hong Kong, Pokfulam Road, Haking Wong Building, Hong Kong, Hong Kong, xinying@hku.hk

Transportation plays an important role in a society's daily operation. Under the background of global warming, there are more extreme weather events, such as tropical cyclone, rainstorm, etc. Almost all modes of Hong Kong's transportation will be affected by these events. The impact reflects on the decrease in road capacity, the increase in transportation time, etc. Resilience is the ability of a system to maintain its main function when disaster or emergency happens. This research uses stochastic programming to model a multi-modal transportation network under adverse weather condition for Hong Kong and does analysis on network resilience.

33 - Cloud-based Inventory Optimization Solution for Retail

Dmitry Pechyony, Microsoft, Cambridge, MA, United States, dmpechyo@microsoft.com, Chenhui Hu, Hong Lu, Praneet Singh Solanki, Ilan Reiter

We present a cloud-based inventory optimization solution. It can be deployed in Azure cloud from https://aka.ms/invopt and customized to business goals and constraints of retailers. Our solution has a flexible, scalable and extensible architecture. Operations researchers and developers can use it to define optimization problems of new inventory management policies, operationalize them and track their performance. We use Azure Data Lake to store unlimited data volumes and Azure Batch to solve optimization problems in parallel. Furthermore, many free and commercial solvers can be plugged into our solution using Pyomo interface. The source code and documentation are at https://aka.ms/invdoc .

34 - Information Overload's Hidden Impact – the Response to a Rising Tide of Information.

William D. Senn, Dr., Texas Woman's University, 8808 Cassidy Lane, Aubrey, TX, 76227, United States, wsenn1@twu.edu

As information load increases, decision accuracy also increases up to an undefined point after which decision accuracy decreases. This turning point is where information overload begins, according to (Eppler & Mengis, 2004). This study looks at how knowledge managers perceive information overload. It investigates the impact of fake news and big data on these perceptions. In a world of ever increasing information flow people are bombarded with information. This research provides insight into the information overload response function.

35 - Ranked Constraint Reconciliation for Price Optimization

Jagdish Ramakrishnan, Data Scientist, Walmart Labs, 1000 National Ave, Unit 214, San Bruno, CA, 94066, United States, jagdish.ram@gmail.com, Matyas Sustik

Given a set of ranked infeasible constraints, generate a new feasible set of constraints. In the context of price constraint reconciliation, merchants provide local constraint information (e.g., item price bounds, pack sizes) that together are impossible to meet. We would like to avoid violations on high priority constraints and allow some violations on low priority constraints. The proposed method processes constraints by rank and repeatedly solves optimization subproblems using slack variables. We implemented a python module that takes in ranked linear constraints and outputs a set of feasible constraints. It enables maintainability and flexibility compared to lengthy logic-based code.

36 - Biological Restoration of Fragmented Landscapes for Connectivity and Intactness

Denys Yemshanov, Research Scientist, Natural Resources Canada, 1219 Queen street East, Sault Ste. Marie, ON, P6A2E5, Canada, denys.yemshanov@canada.ca, Robert G. Haight, Frank H. Koch, Marc-André Parisien, Tom Swystun, Quinn Barber, Salimur Choudhury, Fabio Campioni, Cole Burton

Maintaining habitat connectivity for endangered wildlife is critical for successful restoration of fragmented landscapes. We propose a maximum flow, multigraph connectivity formulation with connected area requirements and budget constraint to address landscape restoration. The MIP model is scenario-based, with an objective of determining restoration strategies that maximize habitat area accessible to wildlife in a fragmented landscape. We apply the model to habitat restoration for woodland caribou in boreal forest in Cold Lake area, Alberta, Canada.

37 - Investigating the Effect of Prescription Sequence on Developing Adverse Drug Reactions

Behrooz Davazdahemami, Oklahoma State University, 4599 N. Washington St, Apt 40A, Stillwater, OK, 74075, United States, davazda@okstate.edu, Dursun Delen

Adverse Drug Reactions (ADR) is a pharmacovigillance term that refers to any injury caused by taking drugs in the way prescribed by physicians. In this study applying an emergent pattern mining approach to electronic health records of more than 370,000 diabetic patients, we examine the potential effect of drug prescription sequence on the development of ADRs. Specifically we focus on Acute Renal Failure as a condition that frequently occurs in diabetic patients. We first investigate whether common diabetic drugs play any confounding role in developing renal failure; afterwards, the effect of prescription sequence on this ADR is examined. The results verify that such role exists.

38- Analysis on the Coordinated Development Between Logistics Industry and the Other Industries in Sichuan Based on Grey Relativity Analysis

Si Chen, Dr., Southwest Jiaotong University, #111 North of Erhuan Road, ChengDu, 610031, China, chensi@swjtu.edu.cn, Xinyuan Li, Yinying Tang, Mi Gan

Logistics industry plays an important role in the development of Sichuan economy. We research into the relationship between the logistics industry and the agriculture,manufactory and business, which are the main economic development departments in Sichuan. And we analysis the gray correlation and the coupling degree of logistics industry and the other industries based on the logistics related data of Sichuan province from 2011 to 2016. Therefore, the development of logistic industry is a strong influence to the other industries, and it can provide adaptive supporting environment forthe other industries.

39 - Pricing and Service Strategies in E-retailing: the Effects of Safety Stock

Yi Ding, Southeast University, Sipailou 2, Nanjing, 210096, China, drdingyi@outlook.com

This study aims to examine service and price competition in an online retailing system comprised of two suppliers and one e-retailer. A Stackelberg game is formulated with the suppliers as the leaders who determine wholesale prices and service times and the e-retailer as the follower who sets the retail prices. Changes of service time affect safety stock which is characterized by the guaranteed service model. We find that the "service first" strategy should be pursued when suppliers face increasing safety stock cost, and the influence of one supplier's service can be spilled over to the competing product's wholesale and retail prices, depending on the difference between consumer transfer ratios.

40 - Forecasting Strategies for Predicting the Peak Load Demands of a University Campus: A Case Study on Rochester Institute of Technology

Harshit Saxena, Master of Science, Rochester Institute of Technology, 1 Lomb memorial drive, Rochester, NY, 14623, United States, hs3185@rit.edu, Katie McConky

Academic institutions spend thousands of dollars every month on their electric power consumption. A large percentage of these institutions follow a demand charges pricing structure; here the amount a customer pays to the utility not just depends upon the energy consumed during the month but also on the maximum load required by the customer over a moving window of time as decided by the utility. This research is a case study conducted on Rochester Institute of Technology which aims at developing a forecasting strategy to predict the occurrence of peak load periods and hence run a demand response plan to maximize the financial savings for the institution.

41 - Signal Effect of XBRL Filing: An Investor's Perspective

Soohyun Cho, Assistant Professor, Rutgers University, Newark, NJ, United States, scho@business.rutgers.edu

The SEC requires companies to provide financial data in the XBRL format as well as traditional financial statements. Despite XBRL disclosures containing information identical to the statements, and belying corporate sector doubt of the disclosures' benefits, most capital market investors tend to respond positively to the filing. For market reaction analysis, we develop a stylized model using two investor groups - market leaders and market followers, depending on their respective information sets. Applying this model, we find that the level of the XBRL filing's capital market impact is associated with the number of market followers.

42 - An Analysis of One Version of the Tracking Signal

Peruvemba Sundaram Ravi, Associate Professor, Wilfrid Laurier University, Operations & Decision Sciences, Waterloo, ON, N2L.3C5, Canada, pravi@wlu.ca

Tracking signals are used to determine whether a sequence of forecasts is unbiased. We analyse a version of the CUSUM tracking signal that is used in standard Operations Management texts. We show that this version of the tracking signal can indicate that the sequence is not unbiased even when it is unbiased. We suggest a simple modification that serves to eliminate this flaw.

43 - Data-driven Decision Making for Re-timing and Optimization of Signalized Intersections

Nabaruna Karmakar, PhD Candidate, North Carolina State University, 3609 Research Building IV, Raleigh, NC, 27695, United States, nkarmak@ncsu.edu, Thomas Chase, Billy M. Williams

This research is aimed at using a variety of data sets to enable intelligent decision-making regarding signal re-timing and maintenance. The final product of this research is building a data-driven optimization technique, using mathematical programming to identify corridors that need re-timing and suggesting different time of day signal timing plans for such corridors. With continuous data like high resolution controller data and Vehicle Probe Data, enhanced performance metrics can be calculated to strategically prioritize and select systems for re-timing that have a higher potential of improvement solely based on optimization benefits.

44 - Content Discovery and User Engagement in Digital Platforms: A Field Experiment in Music Platforms

Shadi Janansefat, PhD Candidate, University of Pittsburgh, 229 Mervis Hall, Pittsburgh, PA, 15260, United States, shj35@pitt.edu

Digital content provider platforms focus on improving success metrics such as engaged time and content discovery, which create continuous usage and engagement. We draw from information foraging theory and social foraging model to investigate how platforms can use social design to improve users' engagement and content discovery. We employ a randomized field experiment on a social music platform mobile application to study how availability of two information signals, popularity on platform and popularity among peers, can enhance user engagement and content discovery. We enumerate the experiment design to test our hypotheses.

45 - Challenges with Data Collection in Methods to Reduce Clinic Wait Times

Rachel Moeckel, Graduate Student, University of Michigan, 504 1/2 N.5th Avenue, Ann Arbor, MI, 48104-1110, United States, rachwold@umich.edu, Amy Cohn, Paula Anne Newman-Casey

A chief complaint received at an Ann Arbor clinic concerns long wait times during appointments. A team assembled with goals of reducing wait times and introducing patient education in irreducible periods, thereby enabling the clinic to see patients with better efficiency and effectiveness, increase adherence through education, and ultimately improve the patient experience. To do so, we implemented passive RFID technology, the data from which enables exact and automatic calculation of wait times. However, challenges arose with clinic staff, collaboration of engineering and medicine, and conversion of RFID signals to wait times. Here we explore such matters and provide insight into solutions.

46 - Method of Update Forecast Sales Data for DDMRP Respecting Product Similarity

Shuto Tsuchiya, Master, The University of Tokyo, 4-6-1, Komaba, Meguro-ku, Tokyo, 1530041, Japan, shuto555@iis.u-tokyo.ac.jp, Mondo Sygiyama, Motoki Tajima, Tsuyoshi Nobata, Miyuki Wakasugi, Yudai Honma, Masayuki Soneda

Demand Driven Material Requirements Planning (DDMRP) is one of production methods that can flexibly respond to a variety of factors such as supply, operation, and demand in supply chains. Although it has established a short-term strategy policy to decide inventory volume for actual demand in DDMRP, it has not been established on how to make a long-term strategy using demand forecast. Thus, it can be said to be a developing method. In this paper, we devise a method of updating demand forecast by an actual demand that can deal with cases of demand change, seasonal variation, new products, and discontinued products in adopting DDMRP. We also show examples of simulations utilizing actual sales performance data.

47 - Optimal Design of Multi-tiered Drug Formularies in Canada: Multiple Criteria Decision Making

Vusal Babashov, Doctoral Student, University of Ottawa, 55 Laurier Ave East, DMS.6115, Ottawa, ON, K1N.6N5, Canada, vusal.babashov@uottawa.ca, Sarah Ben Amor, Gilles Reinhardt

We focus on the downstream relationships between pharmacy benefit management and consumers. In this phase, we assume that the set of products and the formulary structure (number of tiers and copay schedule) are fixed. We develop drug-to-tier allocation model that uses multi-criteria decision methods to maximize the expected return of the plan, its coverage, and other objective criteria that take into account operational factors (demand, capacity, inventory, and service level), clinical factors (drug effectiveness, interactions, and indications), and economic factors (cost, utility, and preference).

48 - Night Team Scheduling for Pediatric Inpatient Residents

Bassel Salka, Center for Healthcare Engineering and Patient Safety, 1075 Beal Avenue, Ann Arbor, MI, 48109, United States, bsalka@umich.edu

We present our development of a decision-support tool that uses linear programming to automate the construction of team assignments for residents rotating on the inpatient ward night team each month in a pediatric hospital.

49 - MAP Estimation in Bayesian Variable Selection Models via MINLP

Michael Lindon, PhD Student, Duke University, Durham, NC, 27710, United States, michael.lindon@duke.edu

A Bayesian approach to variable selection in regression models formulates a prior over the coefficients as a mixture of a continuous distribution and a point mass at zero. Full Bayesian inference, even with moderate numbers of predictors, is computationally prohibitive due to the combinatorial explosion in the number of models. I demonstrate that MAP estimation in many models can be formulated as a mixed integer nonlinear programming problem for a variety of popular priors over the model space. I also provide strategies for developing heuristic algorithms that are able to quickly find good incumbent solutions, which, when used to warm start the MINLP solver, can enhance performance greatly.

50 - A Dynamic Approach to Improve Chemotherapy Pre-mix Policies

Hwon Tak, University of Michigan, 500 S.State St, Ann Arbor, MI, 48109, United States, hwontak@umich.edu

The key goal of our project is to reduce patient waiting time by mixing chemotherapy drugs before patients arrive in the system or at earlier stages in the process (i.e. pre-mix). In collaboration with the University of Michigan Comprehensive Cancer Center (UMCCC) pharmacy, we have developed an improved template model based on their current pre-mix policy efforts. We present a data driven pre-mix template generator to customize the pre-mix list that the UMCCC currently uses by day of week. We show that full utilization of our dynamic template reduces waste costs, pharmacy workload and patient waiting time.

51 - Dynamic Inventory and Price Controls Involving Unknown Demand

Tingting Zhou, Rutgers University, Newark, NJ, United States, tingzhou@rutgers.edu, Michael N.Katehakis, Jian Yang

We study adaptive policies that handle dynamic inventory and price controls when the random demand for discrete nonperishable items is unknown. Pure inventory control is achieved by targeting newsvendor ordering quantities that correspond to empirical demand distributions learned over time. On the basis of it, we conduct the more complex joint inventory-price control, where demand-affecting prices are chosen. We identify policies that strive to balance between exploration and exploitation and measure their performances by regrets.

52 - Lifted Polymatroid Inequalities for Mean-risk Optimization with Indicator Variables

Hyemin Jeon, University of California Berkeley, Sutardja Dai Hall, 450, Berkeley, CA, 94720, United States, hyemin.jeon@gmail.com, Alper Atamturk

We investigate a conic quadratic minimization problem with 0-1 indicator variables that arises in mean-risk optimization. Observing that the problem reduces to a submodular function minimization under the binary restriction on the continuous variables, we derive three classes of strong convex valid inequalities by lifting the polymatroid inequalities on the binary variables. We report the result of computational experiments on mean-risk problems with fixed charges and cardinality constraints, which demonstrate the effectiveness of the inequalities in strengthening the convex relaxations and improving the solution times.

53 - Optimal Decentralized Network Formation using a Continuous-time Actor-oriented Model

Abhinav Perla, University at Buffalo, Buffalo, NY, 14260, United States, aperla@buffalo.edu, Alexander Nikolaev, Eduardo Pasiliao

We address a network formation problem in a decentralized context. The network actors (nodes) are assumed to be independent decision-makers that pursue the same objective - to build a network whose global structure has desirable properties, based on connectivity and closeness. Each actor has partial information about the network structure: the structure of its connections with peers and an estimate of its centrality. We present a continuous-time actor-oriented model as a form of solution and analyze the steady state distribution over the networks formed under this model. Then, we present an approach to infer the model parameters to achieve network outcomes enabling robust global communication.

54 - Research on Logistics Efficiency of the E-commerce with the Influence of the Storage Information Visualization Online

Si Chen, Assistant Professor, Southwest Jiaotong University, #111 North of Erhuan Road, ChengDu, 610031, China, chensi@swjtu.edu.cn, Yu Cai, Gang Wu, Mi Gan

The effective operation of E-commerce logistics system is the key guarantee for the operation. The efficiency of logistics system can be influenced by many factors. Among all the influences, the improvement of logistics information can be significantly improved with low investment. To study the impact of E-commerce logistics system efficiency from the product storage information visualization. An empirical analysis with DEA model has been used to analyze the influence on the JingDong platform from 2009 to 2016. The results show that relatively low product warehousing information visualization investment can bring preferable logistics operational efficiency improvement.

55 - Analysis on the Coordinated Development Between Logistics Industry and the Other Industries in Sichuan Based on Grey Relativity Analysis

Xinyuan Li, Southwest Jiaotong university, ChengDu, China, lixinyuan331@qq.com, Si Chen, Yinying Tang, Mi Gan

Logistics industry plays an important role in the development of Sichuan economy. We research into the relationship between the logistics industry and the agriculture,manufactory and business, which are the main economic development departments in Sichuan. And we analysis the gray correlation and the coupling degree of logistics industry and the other industries based on the logistics related data of Sichuan province from 2011 to 2016. Therefore, the development of logistic industry is a strong influence to the other industries, and it can provide adaptive supporting environment forthe other industries.

56 - Does Firm Innovation Improve Organization's Resilience? A Literature Review

Sima Sabahi, PhD Student, North Carolina A&T State University, 119 D.Village Lane, Greensboro, NC, 27409, United States, sima.sabahi@gmail.com

This research investigates whether firms that are more innovative are also more resilient to supply chain disruptions, and if so, what capabilities of innovative firms support the firms' resilience. Our findings indicate that a firm with a more innovative environment would be more resilient to disruptions, because innovation helps them fortify capabilities that are also antecedents of resilience. More specifically, we found that the practices of collaboration, leadership, and information sharing, which are all considered as antecedents of both resilience and innovation, would aid innovative firms to be more resilient.

57 - Signal Control Strategy to Improve Person Mobility and Air Quality

Farnoush Khalighi, PhD Student, University of Massachusetts, Amherst, 99 wildflower dr, amherst, MA, 01002, United States, fkhalighi@engin.umass.edu, Eleni Christofa

This study develops an analytical model to estimate emissions produced by cars and buses at signalized intersections. Then, a real-time signal control system to minimize person delay and vehicular emissions is developed. The objective of the optimization problem presents different weighted combinations of person delay and vehicular emissions. A Pareto frontier of optimal solutions is generated to demonstrate the trade-off between person delay and emission levels and provide policy makers with a tool to choose between different signal control systems based on traffic conditions and air pollutant levels. This system provides priority to buses due to the higher weight given to them in the model.

58 - The Case for Nearliers

Jeffry N. Savitz, SavitzConsulting, LLC, 1500 Locust St. #2120, Philadelphia, PA, 19102, United States, jsavitz@savitzresearch.com

Nearliers are data points within a random sample whose values are closer to the sample mean than the average data point. In an empirical study, 719 respondents' average ratings were computed for 30 popular brands. The average ratings of the Nearliers was within an absolute percentage difference of only 2.5% with the variance of the Nearliers being 17.4% less than the random sample. Thus, accurate and reliable predictions of population means can be made using Nearliers with a sample size 17.4% less than a random sample at an annual cost savings to the U.S. survey research community of $1.7 billion dollars based on information from CASRO and ESOMAR.

■ Monday Poster Competition

Exhibit Hall

Monday Poster Competition

Competition Poster Session

Chair: Jeffrey W. Herrmann, University of Maryland-College Park, Department of Mechanical Engineering, College Park, MD, 20742, United States, jwh2@umd.edu

Co-Chair: Sergiy Butenko, Texas A&M University, 4037 Emerging Technologies Building, Mail Stop 3131, College Station, TX, 77843-3131, United States, butenko@tamu.edu

1 - Maximizing the Probability of Reaching a Set of States While Avoiding a Forbidden Set

Daniel Felipe Ávila, Universidad de los Andes, Bogotá, Colombia, df.avila353@gmail.com, Mauricio Junca

Using average cost functions we present a solution to the problem of finding a control policy that maximize the probability of reaching a set A while avoiding a set B. We show discounted cost functions provide an approximation to the solution. Both approaches can be solved using a linear program, the discounted case happens to admit an easier linear program than the average. We present simulations for the control of a plane under stochastic wind.

2 - Airline and Passenger Incentive Optimization Models for Airport Congestion Mitigation

John Park, Assistant Professor, North Carolina A&T.State University, 800 revolution mill drive, apt 232, greensboro, NC, 27405, United States, hpark1@ncat.edu

Bilevel Optimization Extended to Anticipatory Stochastic to Accommodate the Uncertainty. Passenger accessing based on airport with check in and security scheduling multiple airports with incentives.

3 - Estimating an Inverse Mean Subspace

Jiaying Weng, University of Kentucky, 300 Alumni Drive, Apt 179, Lexington, KY, 40503, United States, jiaying.weng@uky.edu, Yin Xiangrong

Estimating an inverse regression space is specially important in sufficient dimension reduction, and it typically requires a tuning parameter such as a number of slices in slicing method or bandwidth selection in kernel estimation approach, which then increases difficulties for multivariate responses. In this paper, we use Fourier transform idea to avoid such difficulties while easily incorporates with multivariate responses. We further develop Fourier transform method to deal with a sparse issue, categorical predictor variables and large p, small n data. Asymptotic as well as the sparse eigen-decomposition method for dimensionality tests are obtained.

4 - A Semantic Text Mining Technique for Classification of Manufacturing Suppliers Based on Their Capabilities

Ramin Sabbagh, Graduate Research Assistant, Texas State University, 601 University Dr., San Marcos, TX, 78666, United States, r_s343@txstate.edu

This work proposes a novel framework for capability-based supplier classification that relies on the unstructured capability narratives available on the suppliers' websites. Naïve Bayes is used as the text classifier technique. One of the innovative aspects of this work is incorporating a thesaurus that contains the informal vocabulary used in the contract manufacturing industry for advertising manufacturing capabilities. An Entity Extractor tool is developed for the generation of the vector model associated with each capability narrative. The proposed framework is validated experimentally through forming two capability classes (heavy & complex machining) based on real capability data.

5 - Data Enabled Planning of Transcatheter Aortic Valve Replacement Procedure using Logistic Regression Model and 3d-printing

Geet Lahoti, Graduate Research Assistant, ISyE, Georgia Institute of Technology, 1038 Mcmillan St. NW, Atlanta, GA, 30318, United States, glahoti6@gatech.edu, Zih Huei Wang, Kan Wang, Zhen Qian, Mani Vannan, Chuck Zhang, Ben Wang

Paravalvular leak (PVL) is a defect around the valve replacement, through which blood can leak. Prior assessment of PVL is preferable as it helps in procedural planning of TAVR. Patient-specific features can help predict PVL. We develop a logistic regression model for predicting PVL using computed tomography heart valve data. Five significant features including annulus diameter, none calcium, patients' basic information (e.g. age and valve size) and the ratio of annulus diameter and valve size are used as predictors. Considering 178 patients, the accuracy of the developed model for training data is found to be 75.16% and that for testing data is 69.22% after performing 10-fold cross validation.

6 - Flexcct: A Methodological Framework and Software for Ratings Analysis and Wisdom of the Crowd Applications

Stephen L. France, Assistant Professor, Mississippi State University, 324 McCool Hall, 40 Old Main, Mississippi State, MS, 39762, United States, sfrance@business.msstate.edu, Mahyar Sharif Vaghefi, William H. Batchelder

FlexCCT provides an integrated framework and tool-set for analyzing and aggregating ratings. It utilizes a likelihood based statistical model to create aggregate ratings weighted for rater competencies and rater biases. It has features for the analysis of multiple rating cultures and for consensus adjusted reliability. Multiple optimization algorithms are implemented, along with a range of identifiability options to restrict certain subsets of the model parameters. Bootstrapping and jackknifing based methods are implemented to give confidence intervals for parameters. A holdout validation method is developed to allow for the testing of solution reliability and stability.

7 - Reducing Discarded Organs and Improving Physician-patient Decision-making via Decision-support Tools and Systems Optimization

Ethan Mark, Georgia Institute of Technology, Atlanta, GA, United States, emark3@gatech.edu, David Goldsman, Pinar Keskinocak, Hannah Smalley, Joel Sokol

Organ supply is not sufficient to meet demand for transplant. Organs with increased risk for Hepatitis B, Hepatitis C, HIV, and infectious Encephalitis could help fill the gap. We developed decision-support tools which estimate infection risks for donor organs and personalized post-transplant and waitlist survival curves for potential transplant recipients. In some cases, a potentially infected organ provides higher survival probability versus remaining on the waitlist. The decision support tools encourage shared and informed decision making between physicians and patients and may decrease the number of discarded organs by quantifying the tradeoffs of using a potentially infected organ.

8 - Improving the Resilience of Service System by a Network Flow Approach

Jing Gong, Jinan University, School of Public Administration, Guangzhou, China, tgongjing@jnu.edu.cn

Recent catastrophic events precipitate a wide range of impacts so that public awareness continues to grow of resilience as an important means of characterizing the ability to deal with them. The best service systems aren't just cost-effective. They also respond quickly, handle smoothly and recover promptly from disruptions. This paper proposes a linear piecewise recovery function and applies it to the decision-making processes of improving a service system's resilience to disasters. A numeric example is developed to demonstrate the proposed model enables tradeoff between a cost minimum system and a resilient system.

9 - Causal Analyses for the Impact of Homecare Services on Patient Discharge Disposition

Biplab Bhattacharya, University at Buffalo, 80 Sterling Ave, Upper, Buffalo, NY, 14216, United States, biplabsu@buffalo.edu, Sabrina Casucci, Yuan Zhou, Li Lin, Alexander Nikolaev

Improving health outcomes for low-income adult Medicaid beneficiaries is challenging due to high rates of chronic disease comorbidities, limited mobility, and inconsistent access to care. We demonstrate how causal inference modeling can derive actionable insights from a home healthcare claims dataset. This innovative understanding of the impact of chronic disease comorbidities and service utilization on patient health outcomes can inform healthcare policies that improve the effectivity of home health care services.

10 - Using Nash Equilibrium Mathematical Model to Explore the Impact of Slots Competition on Profitability of Airlines

Yuan Feng, National Tsing Hua University, Dept of Industrial Engineering and Management, Hsinchu, 30073, Taiwan, erinfeng830624@gmail.com, Yu-Ching Lee

Having the data of known number of airlines, passenger capacity, load factor, operating cost and average fare income, we use Nash equilibrium model to find an solution, which could be used to analyze the profitability of the airlines. We derive the Nash equilibrium formulation from the KKT condition of the profit maximizing problems for every airline. We assume that the airline will not withdraw from any market. The analysis under two conditions for satisfying the market demand and the total number of flights shows that the routes will concentrate on the higher lucrative routes. Furthermore, by reducing the total slots in a certain range will enhance the average passenger load factor and the profits.

11 - Developing a Location Model to the Planning of Sustainable Perinatal Care Network in Korea

Hoon Jang, Science and Technology Policy Institute, 370 Sicheng-daero, Sejong, 30147, Korea, Republic of, hoonjang@stepi.re.kr, Kyosang Hwang, Taeho Lee, Taesik Lee

The reformation of rural perinatal service systems is an important public health task in Korea. For this, the government set up a support program; locating hospitals is one of key strategies to cover populations. Motivated this, we proposed the location model addressing how to design a rollout plan to maximally serve the demand. The novelty of our model lies in the incorporation of the uncertainty of future demand and individuals' hospital choice behavior. To build this model, we combine a discrete choice model with a location model, and the model is formulated by using the robust optimization framework. With the case study using a real dataset, we provide insights on how to design a better rollout plan.

12 - Statistical Modeling and Analysis of Chronic Disease Progression using Electronic Health Record (EHR) Data

Rema Padman, Professor of Management Science & Healthcare IS, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, rpadman@cmu.edu, Vijaya Priya Rama Vijayasarathy

Improved risk stratification of chronic disease patients may enable early identification of disease progression and allow appropriate interventions to mitigate preventable adverse outcomes and improve care delivery. Leveraging 22-years of EHR data and two clinical markers of chronic kidney disease, we develop and compare data-driven, statistical models to identify and profile groups of patients following four distinct trajectories of disease progression and their statistically significant covariates, potentially enabling better management of the patients.

13 - Supporting the Definition and Analysis of Cervical Cancer Public Health Policies

Ivan Mura, Visiting Professor, Universidad de Los Andes, Carrera 1 Este #19A-40, Bogota, 111711, Colombia, i.mura@uniandes.edu.co, Karen Daniela Angulo, Maria F. Cortés, Daniel Felipe Otero, Raha Akhavan-Tabatabaei

Cervical cancer is a global health issue, and developing countries bear the highest death rates. Though, cervical cancer etiology is well understood and prevention is possible. Both vaccines and effective screening tests exist, which can significantly reduce incidence. While designing cost-effective public health policies is of paramount importance in countries with limited resource availability, it requires an ability to generate reliable long-term predictions about the dynamics of a population health state, a task that entails significant complexity. This poster presents a simulation-based computational tool that can assist decision-makers in shaping national public health policies.

Monday, 1:30 - 3:00PM

■ MC01

310A

Decision Analysis, Game Theory, Homeland Security, and Disaster Management, Part I

Sponsored: Decision Analysis

Sponsored Session

Chair: Jun Zhuang, University at Buffalo, SUNY, Buffalo, NY, 14260, United States, jzhuang@buffalo.edu

1 - System Defensibility in Reality

Alexander Gutfraind, Uptake Technologies, 600 W. Chicago St, Suite 775, Chicago, IL, 60654, United States, agutfraind.research@gmail.com, Vicki Bier

A system is termed defensible if modest investment of resources can significantly improve the outcome to the defender. Defensibility in reality is made quite complex when e.g. the more valuable assets are also more costly to defend. We report on how these realities affect defensibility and optimal defense strategies.

2 - Individual Terrorism Risk Assessment: A Signal Detection Theory Framework

Richard S.John, University of Southern California, Dept of Psychology MC 1061, Los Angeles, CA, 90089-1061, United States, richardj@usc.edu

Increasingly analytics are utilized to assess individual terrorism threat. Such "risk-based" approaches are designed to bin individuals in order to apply differential levels of scrutiny based on individual characteristics related to terrorism threat. A Signal Detection Theory framework is proposed, and sensitivity analysis is conducted to determine conditions in which such threat assessments are useful. The viability of risk-based approaches depends heavily on priors, indicator diagnosticity, and the relative cost of false-positives and false negatives. Risk-based approaches are severely limited for highly adaptive adversaries who can effectively diminish indicator diagnosticity.

3 - An Overview of Uncertainty-tolerant Decision Support for Cybersecurity

Samrat Chatterjee, Pacific Northwest National Laboratory, Richland, WA, United States, samrat.chatterjee@pnnl.gov

Cyber system defenders face the challenging task of continually protecting critical assets and information from a variety of malicious attackers. Defenders typically function within resource constraints, while attackers operate at relatively low costs. Thus, design and development of resilient cyber systems that support mission goals under attack, while accounting for the dynamics between attackers and defenders, is an important research problem. This talk will highlight decision support challenges under uncertainty within non-cooperative cybersecurity settings.

4 - Robust Resource Allocation to Interdependent Networks under Multiple Disruption Scenarios

Hannah Lobban, University of Oklahoma, 202 W. Boyd St, Room 124, Norman, OK, 73069, United States, hannahrose@ou.edu

In recent years, the threat of intentional attacks on infrastructure networks, such as water, electrical, communication, and transportation, has grown. Due to interdependency in the networks, a disruption could have far-reaching effects on the networks' ability to meet demand. Common disruption scenarios include degree- and capacity-based attacks; however, attackers targeting a network may give additional weight to components with less quantitative (e.g., religious, governmental) significance. This work attempts to determine the allocation of defensive resources that accounts for all these factors while minimizing both costs and the unmet demand in the disrupted network.

5 - Estimating Effectiveness of Investment, Optimal Resource Allocation, and Predictive Risk Analytics for Fire Protection

Vineet Madasseri Payyappalli, University at Buffalo, SUNY, Buffalo, NY, United States, vineetma@buffalo.edu, Adam Behrendt, Jun Zhuang

Fire hazards are an everyday phenomenon, and the estimated total cost of fire was $329 billion in 2011. Using the large amount of data available from National Fire Protection Association (NFPA) and National Fire Incident Response System (NFIRS), we create empirical and theoretical models to estimate the effectiveness of investment and to formulate optimal resource allocation strategies. Our results show that fire losses have decreased exponentially in investment with high R2 values (~0.8) and also show potential under- and overspending in fire protection for certain years/regions. The research will be of use to policymakers and analysts in fire protection, and will help in mitigating fire losses.

■ MC02

310B

Healthcare Decision Analysis I

Sponsored: Decision Analysis

Sponsored Session

Chair: L Robin Keller, University of California-Irvine, Irvine, CA, 92697-3125, United States, LRKeller@uci.edu

1 - A Preliminary Decision Model for Brest Cancer Screening

Cristina del Campo, PhD, Universidad Complutense de Madrid, Madrid, Spain, campocc@ccee.ucm.es, Manuel Luque, Cristina Antón Rodríguez, Manuela Parras, Francisco Javier Diez

Breast cancer is one of the leading causes of cancer-related deaths in women all over the world. It is therefore imperative to determine an optimal screening pattern for breast cancer that trades off between early cancer detection and avoiding unnecessary procedures for healthy women. We present a preliminary decision model, implemented as a Markov influence diagram, for evaluating the cost-effectiveness of the optimal breast screening policy for an individual patient. The model takes into account major risk factors such as a positive family history or age and uses clinical data to recommend the best screening policy.

2 - Markov Cost-effectiveness Analysis for Cancer Treatment

Jiaru Bai, Binghamton University, School of Management, Binghamton, NY, 13902, United States, jiarub@uci.edu, L. Robin Keller

We present a way to build a Markov decision tree to model cancer progression and cost-effectiveness analysis for two or more cancer treatments. We propose several problems researchers can encounter in this kind of research and provide possible solutions.

3 - The Effects of Assigning Buddies in Online Health Communities

Ali Esmaeeli, University of California, Irvine, 1914 Verano Place, Irvine, CA, 92617, United States, esmaeeli@uci.edu, Cornelia Pechmann

We look at the effects of assigning buddies on the relationships between them and its result on abstinence in online smoking cessation groups. We show that directed links to active buddies are stronger than directed links to active non-buddies. We also show that for inactive buddies, the directed relations to them is not looser than the directed relations to inactive non-buddies. Then we show that those participants who have stronger directed relations with their pairs have better performance in quitting smoking.

■ MC03

310C

Optimization Methods for Supervised Machine Learning: From Linear Models to Deep Learning

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, 77204, United States, jopeng@Central.uh.edu

Co-Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Optimization Methods for Supervised Machine Learning: From Linear Models to Deep Learning

Katya Scheinberg, Lehigh University, Bethlehem, PA, United States, katyas@lehigh.edu, Frank E.Curtis

The goal of this tutorial is to introduce key models, algorithms, and open questions related to the use of optimization methods for solving problems arising in machine learning. It is written with an INFORMS audience in mind, specifically those readers who are familiar with the basics of optimization algorithms, but less familiar with machine learning. We begin by deriving a formulation of a supervised learning problem and show how it leads to various optimization problems, depending on the context and underlying assumptions. We then discuss some of the distinctive features of these optimization problems, focusing on the examples of logistic regression and the training of deep neural networks. The latter half of the tutorial focuses on optimization algorithms, first for convex logistic regression, for which we discuss the use of first-order methods, the stochastic gradient method, variance reducing stochastic methods, and second-order methods. Finally, we discuss how these approaches can be employed to the training of deep neural networks, emphasizing the difficulties that arise from the complex, nonconvex structure of these models.

■ MC03A

Grand Ballroom A

Data-Driven Revenue Management

Sponsored: Applied Probability

Sponsored Session

Chair: Gah-Yi Ban, London Business School, London Business School, London, NW1 4SA, United Kingdom, gban@london.edu

1 - A Nonparametric Self-adjusting Control for Multi-product Pricing with Unknown Demand Function and Finite Resource Capacity

George Chen, University of Texas at Dallas, Richardson, TX, United States, georgeqc@umich.edu, Stefanus Jasin, Izak Duenyas

We study a multi-period network revenue management problem where the underlying demand function is unknown (in the nonparametric sense) to the seller who uses dynamic pricing to minimize expected revenue loss. It is known that the asymptotic revenue loss of any feasible pricing policy is O(k^{1/2}) (k indicates the size of the problem), but there is a considerable gap between this theoretical lower bound and the performance bound of all existing heuristics. We propose a Nonparametric Self-adjusting Control and show that it guarantees a revenue loss of O(k^{1/2+epsilon} log k) for any arbitrarily small epsilon>0, provided that the underlying demand function is sufficiently smooth.

2 - Assortment Optimization of Vertically Differentiated Products for Quality-conscious Customers

Arnoud Victor den Boer, University of Amsterdam, Postbus 94248, Room number F3.33, Amsterdam, 1090 GE, Netherlands, boer@uva.nl, N. Bora Keskin

A product is available in a continuum of different quality levels. Potential customers are differentiated according to their minimum required quality level, which is random and unknown to the seller. We discuss the full-information assortment optimization problem of determining which subset of products maximize the seller's expected revenue. This is an optimization problem over measurable subsets of the positive real line. In addition we discuss a version of the problem with incomplete information, where the distribution of required quality is learned from data.

3 - Personalized Dynamic Pricing with Machine Learning

N. Bora Keskin, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Gah-Yi Ban

Motivated by online retail applications, we consider a seller who offers personalized prices to individual customers. The seller initially does not know the impact of individual customer characteristics on demand, but can learn about this relationship via sales observations. We construct and analyze near-optimal policies that balance the learn-and-earn tradeoff in this setting.

4 - Statistics for Cross-sectional Surveys: Inferring Total Eventual Time in Current State using Only Elapsed Time-to-Date

Richard C.Larson, Massachusetts Institute of Technology, E40-233, Cambridge, MA, 02139, United States, rclarson@mit.edu, Louis Cammarata

A recent paper by the 2nd author focused on cross-sectional surveys in which a question asked is, "How long have you been in this temporary state?" The result is a derivation of distribution of total duration in the temporary state based only on answers to that question. The method utilizes properties of longevity bias. Here, using nonparametric estimation methods we investigate the statistical accuracy of the method as a function of survey sample size and properties of underlying distributions. We report Monte Carlo simulations using discrete and continuous distributions and provide confidence interval results.

■ MC03B

Grand Ballroom B

Static and Dynamic Optimization in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Huseyin Topaloglu, Cornell University, Ithaca, NY, 14853, United States, topaloglu@orie.cornell.edu

1 - Dynamic Resource Allocation with Reusable Resources and Customer Choice

Mika Sumida, Cornell University, Ithaca, NY, 14850, United States, ms3268@cornell.edu, Paat Rusmevichientong, Huseyin Topaloglu

We consider a resource allocation model with reusable resources. Customers arrive in an online fashion and are offered an assortment of products. When a customer selects a product, it becomes unavailable for a fixed service time. After the service time, the resource is returned to the system for reallocation. The goal is to pick assortments that maximize the total expected revenue. This problem has a number of applications in the hotel and rental car industries, cloud computing, and the sharing economy. We present a computationally efficient policy with provable performance guarantees.

2 - Single-leg Revenue Management with Fare-locking

Huseyin Topaloglu, Cornell University, 223 Rhodes Hall, Ithaca, NY, 14853, United States, topaloglu@orie.cornell.edu, Mika Sumida

We study a revenue management model over a single flight leg, where the customers are allowed to lock an available fare. Each customer arrives into the system to purchase a ticket for a particular fare class. If this fare class is available, the customer either immediately purchases the ticket by paying the fare or locks the fare by paying a fee. If the customer locks the fare, then the airline reserves the capacity for the customer for a certain duration of time. At the end of this duration of time, the customer makes her ultimate purchase decision. We give a 2-approximation algorithm.

3 - Dynamic Assortment Optimization with Inventory Cost

Venus Lo, Cornell University, 206 Rhodes Hall, Ithaca, NY, 14853, United States, vhl8@cornell.edu, Huseyin Topaloglu

We consider a dynamic assortment optimization problem of selecting an assortment of products and their inventory level to offer to a stream of customers. Unlike traditional revenue management problem where the seller controls the products available to each arriving customer, the seller only makes initial inventory decisions. There is a cost of stocking the inventory, with no salvage value. The assortment available to each customer depends on the initial stock and the purchases of preceding customers, who are willing to substitute. We present a dynamic program for deterministic customer arrivals with nested preferences and develop related heuristics for the case of stochastic customer arrivals.

4 - Pricing Discounts in an Electric Vehicle Share System

Bobby Nyotta, UCLA Anderson School of Management, Los Angeles, CA, United States, bobby.nyotta.1@anderson.ucla.edu, Fernanda Bravo, Jacob Feldman

We study the use of pricing discounts in an electric vehicle share-system with free-floating parking. Specifically, we examine the optimal policy for the operator to offer free rides to the charging stations. Free rides can help to keep vehicles charged and to rebalance the system, however a revenue loss is experienced. Based on the optimal policy structure, we decompose and approximate the problem with an algorithm that performs well on real problem instances.

■ MC03C

Grand Ballroom C

Empirical Studies with a Behavioral Element

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Robert Batt, Wisconsin School of Business, UW-Madison, Wisconsin School of Business, UW-Madison, Madison, WI, 53706, United States, rbatt@bus.wisc.edu

1 - Managing Capacity in an Outbound Contact Center with Crowdsourced Servers

Marcelo Olivares, Universidad de Chile, Beaucheff 851, Santiago, Chile, molivares@u.uchile.cl, Andres I.Musalem

Customer contact centers are increasingly using crowd-sourcing strategies to hire agents that provide service remotely, providing more flexibility and lower the cost of operating at low utilization levels. Lower system utilization reduces customer waiting times but can also affect productivity and churn of the agents. In this work we conduct an empirical study to measure time-sensitivity of customers and agent's behavior in this type of service system, using data from an outbound call center. We show how the empirical results can be used to conduct a cost-benefit analysis to plan service capacity.

2 - Manager Incentives, Outcomes, and Operational Decisions

Saravanan Kesavan, University of North Carolina-Chapel Hill, Kenan-Flagler Business School, Cb 3490 McColl Building, Chapel Hill, NC, 27599-3490, United States, skesavan@unc.edu

As customers increasingly shopping through their desktops, laptops and mobile devices, retailers across the industry are looking to ramp up their investments in omnichannel retailing to offer them a seamless shopping experience. These new workflows can create serious challenges to store management. So, retailers are figuring out ways to restructure the compensation plan for store managers to enhance cooperation. In this study, we explore data from a retailer that changed it compensation plan to emphasize greater coordination among store managers.

3 - Oversight and Efficiency in Public Projects: A Regression Discontinuity Analysis

Ruomeng Cui, Goizueta Business School, Emory University, Atlanta, GA, United States, ruomeng.cui@gmail.com, Eduard Calvo, Juan Serpa

During the execution of a public project, should regulators continually scrutinize the contractor's operations? In this paper we explore the causal impact of government oversight on a project's delay time and cost overrun. We glean a detailed procurement database of public projects spanning 173 U.S. federal agencies. We exploit a regulatory bylaw in federal procurement: if a project's budget exceeds a cutoff, the project's operations are surveilled. Using a regression discontinuity design, we find that decreasing the intensity of oversight significantly decreases a project's delay time and cost overrun. Further, the result depends on contract type and the contractor's experience.

4 - The Effects of Searching and Learning on Pick-worker Performance

Robert Batt, Wisconsin School of Business, UW-Madison, 5279 Grainger Hall, 975 University Ave., Madison, WI, 53706, United States, rbatt@bus.wisc.edu, Santiago Gallino

We study "chaotic storage" order-fulfillment systems in which dissimilar items are stored together in a single location. This necessitates a searching task as part of the item picking process. We show that pick times increase by as much as 16% as the searching task becomes more difficult. However, the deleterious effect of searching decreases with pick worker experience. Using simulation, we show that pick times can be improved by approximately 5% by incorporating distance, complexity, and picker experience into pick assignments and pick routing.

■ MC04

320A

Selected Topics in Sustainable Operations

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Li Chen, Cornell University, Ithaca, NY, 14853, United States, li.chen@cornell.edu

Co-Chair: Shiqing Yao, The Chinese University of Hong Kong, Room 938 9/F, Cheng Yu Tung Building No.12 Chak Cheung Street, Shatin, N.T., Hong Kong, Hong Kong, yaoshiqing@gmail.com

1 - Testing by Competitors in Enforcement of Product Standards

Erica Plambeck, Stanford University, Graduate School of Business, 518 Memorial Way, Stanford, CA, 94305-5015, United States, elp@stanford.edu

This paper explores a potentially efficient mechanism to encourage compliance with and identify violations of safety and environmental standards: Firms testing competitors' products.

2 - Cooperative Approaches to Managing Social Responsibility in Supply Chains

Xin Fang, Singapore Management University, 50 Stamford Road, #05-01, Singapore, 178899, Singapore, xfang2015@gmail.com, Soo-Haeng Cho

This paper investigates two cooperative approaches of firms' managing social responsibility violations of suppliers: auditing a common supplier jointly or sharing independent audit results with other firms. We develop a model based on a cooperative game in partition function form, and show that: (1) competing firms have incentives to cooperate when the negative externality of one firm's social responsibility violation on other firms is high; and (2) neither cooperative approach necessarily improves social responsibility, especially when one firm can benefit from others' social responsibility violations (i.e., the positive externality is high).

3 - Joint Carbon Abatement Efforts in Supply Chains
Tarkan Tan, Eindhoven University of Technology, School of Industrial Engineering, Den Dolech 2 Paviljoen F-07, Eindhoven, 5612AZ, Netherlands, t.tan@tue.nl, Mohsen Reisi, Behnam Fahimnia

We consider carbon emission abatement decisions taking manufacturer-supplier interactions into account. We present a set of models to identify the situations where cooperation can help invest in joint emissions abatement projects. Various approaches are used to allocate project costs based on the role and bargaining power of each project participant.

4 - Supplier Centrality and Auditing Priority in Socially-responsible Supply Chains
Jiayu Chen, The University of Texas at Dallas, 800 W. Campbell Road, Richardson, TX, 75080, United States, jxc144030@utdallas.edu, Anyan Qi, Milind Dawande

In a supply network with multiple buyers and multiple suppliers, we explore how the degree centralities of the suppliers (i.e., the number of buyers they supply to) affect the social-responsibility decisions of both the buyers and the suppliers, and offer several novel and useful insights. For instance, while prioritizing the compliance audit of suppliers with a high degree centrality is better for the aggregate profit of the firms, downstream competition between the firms conspires to make them audit only their respective independent suppliers. This inefficiency can be corrected if the firms cooperate to jointly audit the suppliers.

5 - Should Brands Tighten Certification Standards? the Effect of Supplier-certifier Collusion
Shiqing Yao, Chinese Univ of Hong Kong, Flat C.8th floor, Sunning Building, Shatin Ce, N.T., Hong Kong, yaoshiqing@gmail.com, Kaijie Zhu, Li Chen

While enjoying low costs in sourcing from emerging economies, buyers also face serious quality risks in the form of supplier noncompliance. Supplier certification has been used widely to tackle such challenge in practice. In this paper, we study how supplier-certifier collusion can affect the buyer's optimal contracting and certification strategy.

■ MC05

320B

Applied Operations in Health Services: Research by Bonder Scholars

Sponsored: Health Applications

Sponsored Session

Chair: Pooyan Kazemian, Harvard Medical School, 50 Staniford St, 930B, Boston, MA, 02114, United States, pooyan.kazemian@mgh.harvard.edu

Co-Chair: Alba Rojas-Cordova, Virginia Tech, Blacksburg, VA, 24060, United States, albarc@vt.edu

1 - Modeling Joint Inpatient and Outpatient Decisions to Reduce Hospital Readmissions
Xiang Liu, University of Michigan, 322 Village Green Boulevard, Apt 204, Ann Arbor, MI, 48105, United States, liuxiang@umich.edu, Jonathan Helm, Mariel Sofia Lavieri, Ted Skolarus

Hospital readmissions affect hundreds of thousands of patients, placing a tremendous burden on the healthcare system. We develop a two-stage stochastic dynamic programming framework that spans the inpatient stay and the post-discharge outpatient monitoring to reduce readmissions. By reducing readmission risk in the 1st stage, and monitoring the patient's condition in the 2nd stage, our goal is to jointly guide discharge and post-discharge decisions. This could lead to reduced readmissions.

2 - Efficient and Fair Allocation Rules for Heart Transplantation
Amin Khademi, Clemson University, 1267 Madden Bridge Rd Apt B, Central, SC, 29630, United States, khademi@clemson.edu, Farhad Hasankhani

The optimal allocation of limited donated hearts to patients on the waiting list is one of the top priorities inheart transplantation management. In order to design an efficient and fair system for allocating donor heartsto patients waiting for transplantation, we model the problem as a constrained stochastic dynamic programto maximize total quality-adjusted life years (QALYs) of the population.

3 - Resource Allocation Decision-making in Sequential Adaptive Clinical Trials
Alba Rojas-Cordova, Assistant Professor, Southern Methodist University, Caruth Hall 339. Southern Methodist University., Dallas, TX, 75205, United States, alba@smu.edu, Ebru Korular Bish, Niyousha Hosseinichimeh

Adaptive clinical trials promise significant savings to the pharmaceutical industry and an expedited access to new drugs and therapies. Certain designs allow decision makers to alter the course of a trial based on interim results on a new drug's performance. We develop: 1) a simulation model to study and quantify the risk of false negatives, and the amplification thereof as a result of a behavioral phenomenon, and 2) a stochastic dynamic programming model to derive an optimal resource allocation strategy, based on Bayesian updates on the estimate of a drug's efficacy. We propose an augmented methodology for optimal stopping and optimal resource allocation in sequential adaptive clinical trials.

4 - Ambulance Emergency Response Optimization in Developing Urban Centres
Justin James Boutilier, University of Toronto, 532 Palmerston Boulevard, Apartment 6, Toronto, ON, M6G 2P5, Canada, j.boutilier@mail.utoronto.ca, Timothy Chan

Time sensitive medical emergencies are a major health concern comprising one third of all deaths in low and middle income countries (LMICs). Despite evidence that ambulance services can save lives, poor access and availability of emergency medical care in LMICs continues to be a widespread problem. In this paper, we develop a novel ambulance location-routing model, tailored to address the challenges faced by urban areas in LMICs. We use extensive field data from Dhaka, the capital of Bangladesh and one of the most densely populated cities on earth, to apply our modelling framework.

■ MC06

320C

Hospital Operations Management I

Sponsored: Health Applications

Sponsored Session

Chair: Hui Zhang, University of Chicago, Chicago, IL, 60637, United States, corinnaz@uchicago.edu

Co-Chair: Thomas Best, tbest3@bsd.uchicago.edu

1 - Improving Hospital Operations using a Real-time Locating System
Hyojung Kang, University of Virginia, 1557 Montessori Terrace, Charlottesville, VA, 22911, United States, hkang@virginia.edu, Ethan Haswell

Long waiting times indicate costly inefficiencies for healthcare facilities and influence patient satisfaction and outcomes. Hospitals have adopted a Real-Time Locating System (RTLS) technology to identify bottlenecks in a system and improve its operations by tracking entities at all times throughout a facility. However, limited studies have shown how the RTLS data has been utilized to support operational decision-makings. This study demonstrates how the RTLS data combined with electronic health records and scheduling data can be used to provide hospitals insights into patient flow, patient-provider interactions, and scheduling.

2 - Predicting if New Patients in the Comprehensive Care Physician Program will Attend Most of their Appointments with their Comprehensive Care Physician
Thomas J. Best, University of Chicago, Chicago, IL, United States, tbest3@bsd.uchicago.edu, Arnab Bose, Devdeep Banerji, Reelina Sircar, David O.Meltzer

The Comprehensive Care Physician (CCP) program at the University of Chicago strives to provide more cost-effective healthcare for patients at high risk of hospitalization by enrolling them with a CCP who manages all their hospitalizations and outpatient care. Initial data suggests that the program can be especially cost-effective when enrollees attend most of their clinic appointments with their CCP. We describe our application of machine learning techniques to improve predictions of whether a new enrollee will attend most of their clinic appointments with their CCP in the first six months of enrollment. We also describe how we use the predictions to target efforts to improve attendance.

3 - Distance, Quality or Relationship? Interhospital Transfer of Heart Attack Patients
Susan F. Lu, Purdue University, Krannert 441, West Lafayette, IN, 47907, United States, lu428@purdue.edu, Lauren Xiaoyuan Lu

We empirically investigate the pattern of where heart attack patients are transferred between hospitals. Using 2011 Florida State Emergency Department and Inpatient Databases, we demonstrate the relative importance of three key factors in determining transfer destinations: (1) the distance between sending and receiving hospitals, (2) publicly-reported quality measures of receiving hospitals, and (3) the relationship between sending and receiving hospitals as indicated by whether they are affiliated with the same multihospital system.

4 - Hospitalist Service Mix and Patient Length of Stay
Masoud Kamalahmadi, Indiana University, 1309 E. 10th Street Room HH 4100, Bloomington, IN, 47405, United States, maskamal@iu.edu, Jonathan Helm, Alex Mills, Kurt M. Bretthauer

Hospitalists are physicians that specialize in caring for hospital inpatients, replacing a primary care physician who may only make rounds once per day and thereby reducing delays. Given a limited number of hospitalists in a hospital, we seek to determine their optimal service mix (workload and patient types).

■ MC07

322A

Real-time Models for Epidemiological Risk Assessment

Sponsored: Health Applications

Sponsored Session

Chair: Lauren Gardner, University of New South Wales, l.gardner@unsw.edu.au

1 - Influenza Phylogeography for Public Health Surveillance
Matthew Scotch, Arizona State University, Tempe, AZ, United States, Matthew.Scotch@asu.edu

Next-generated sequencing has resulted in a tremendous growth in the amount of virus sequences such as influenza. Phylogeography, which estimates the evolutionary diffusion of viruses, is potentially a valuable technique for utilizing this influx of sequence data. Unfortunately, most health agencies lack the bioinformatics expertise to implement these techniques. Here, we will highlight ZooPhy, a bioinformatics resource for virus phylogeography, via case studies of seasonal and avian influenza. We will also address potential issues with providing a "black box" model for informing policy decisions at the agency level as part of critical analyses of the system.

2 - Modeling HIV Transmissions Across At-risk Populations
Lu Zhong, City University of Hong Kong, Kowloon, Hong Kong, luzhong2-c@my.cityu.edu.hk, Qingpeng Zhang

We proposed a 2-layer social network framework to model the HIV transmissions across two at-risk populations, and evaluated the effectiveness of a set of structural intervention strategies. Experiments demonstrated the important role played by bridge individuals across layers. Isolating such nodes could segregate at-risk populations for a better prevention outcome.

3 - A Generalized Inverse Infection Model for Inferring the Spread of the 2015-16 Zika Outbreak
Lauren Gardner, University of New South Wales, Sydney, Australia, l.gardner@unsw.edu.au, Andras Bota

Most network-based infection spreading and diffusion models require a real value or (transmission) probability on the edges of the network as an input, which is often unknown in real-life applications. This work presents a general framework to estimate the value of these probabilities on a network exposed to an infection process, where spatiotemporal information on the outbreak pattern is known. The model is applied to the 2015-16 Zika outbreak in the Americas. This general model works with a range of infection models, and is able to handle an arbitrary number of observations on such processes.

■ MC08

322B

Stochastic Models in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Oguzhan Alagoz, University of Wisconsin-Madison, Madison, WI, 53706, United States, alagoz@engr.wisc.edu

Co-Chair: Ali Hajjar, University of Wisconsin-Madison, Madison, WI, 53706, United States, hjaar@wisc.edu

1 - An Explicit Stochastic Model of ICU Length of Stay
Mehmet Yasin Ulukus, University of Pittsburgh, 3700 O'Hara Street, 1048 Benedum Hall, Pittsburgh, PA, 15261, United States, myu1@pitt.edu, Andrew J.Schaefer, Guodong Pang, Gilles Clermont

There have been numerous attempts to predict ICU LOS. Statistical models, are commonly used to make predictions of the LOS but almost none consider time progression of the health status of patients. In this study, we present an explicit stochastic ICU LOS model by (1) considering the health progression of the patients via a novel score process, (2) modeling the transfer decision via a threshold policy, and (3) considering the downstream bed availability and transfer delay dynamics. We characterize LOS for different stochastic score processes, and test the estimation power with empirical data.

2 - Stochastic Optimization Models for the Active Surveillance of the Prostate Cancer
Zheng Zhang, University of Michigan, 2361 Lancashire Drive, Apt 1B, Ann Arbor, MI, 48105, United States, zzhang0409@gmail.com, Brian T.Denton, Christine Barnett, Todd Morgan

Active surveillance (AS) has become a popular management option among favorable-risk prostate cancer patients to avoid unnecessary surgeries or radiations. We describe a stochastic programming model for optimization of AS strategies that allow for personalized patient feathers, unobservable health states, and stochastic cancer progression. The results show our model solutions outperformed the benchmark strategies in terms of maximizing the quality-adjust life years.

3 - Optimal Decision Making in Risk Reduction for Women at High Risk of Breast Cancer
Mehmet Ali Ergun, University of Wisconsin-Madison, Madison, WI, United States, mergun@wisc.edu, Murtuza Rampurwala, Oguzhan Alagoz

Breast cancer (BC) is the most common non-skin cancer and a leading cause of death among U.S. female population. Studies provide estimates on the individual risk of a woman as well as finding interventions to reduce it for the high-risk patients. On the other hand, the guidelines tying individual risk assessments to risk reduction interventions are not as rigorously studied and not as detailed. To fill this gap, we have developed finite-horizon Markov Decision Process (MDP) model that finds optimal preventative actions given the individual risk when the objective is to maximize quality-adjusted life years of the patients.

■ MC09

330A

Multi-faceted Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Rodney P. Parker, Indiana University, Bloomington, IN, 47405, United States, rodp@indiana.edu

1 - Negative Shocks and Innovation Incentives: Evidence from Medical Device Recalls
George Ball, Indiana University, Kelley School of Business, 1309 E. 10th St, Bloomington, IN, 47405, United States, gpball@indiana.edu, Jeffrey Macher, Ariel Stern

Medical device firms seek to operate at the frontiers of innovation. When functioning properly, innovative medical devices can prolong and improve lives; when malfunctioning, the same devices may harm patients and lead to product recalls. Consequently, medical device firms' innovation efforts may be influenced by innovation failures. Using 13 years of FDA product recall and new product submission data, we explore the impact of recalls on subsequent innovation. We utilize a recurrent-event hazard model to examine how recalls of varying severity influence the hazard of different types of new product submissions by firms. The results identify a relationship between recalls and future innovation.

2 - Social Responsibility Auditing of Supply Chain Networks
Han Zhang, Indiana University, Bloomington, IN, 47404, United States, hz8@indiana.edu, Goker Aydin, Rodney P.Parker

We study a buyer's problem of auditing its supply network for social responsibility concerns, when the suppliers' identities and relations further upstream are initially invisible, and only discernible via costly auditing. The buyer may suffer economic damages if an upstream supplier, even if unknown to the buyer, is exposed as unethical. We characterize the equilibrium in the production stage, and study the buyer's auditing strategies before the production stage.

3 - Supply Chain Strategy: Beyond Fisher's Framework
Tava Olsen, University of Auckland, ISOM, Business School, University of Auckland, Auckland, 1142, New Zealand, t.olsen@auckland.ac.nz, Quan Spring Zhou

Devising an effective supply chain strategy is essential for exporters. Fisher's framework provides exporters some guidance on this and has also been extended in a number of ways. In this talk we first discuss what is known (mathematically, empirically, and qualitatively) about applying Fisher's framework in practice. Then we discuss our own empirical analysis based on New Zealand data, where we investigate the practice of using efficient, responsive, and, potentially, ambidextrous supply chain strategies and their associated impacts.

4 - The Role of the Regulator in Product Recalls

Rodney P. Parker, Indiana University, Kelley School of Business, 1309 E.10th Street, HH4129, Bloomington, IN, 47405, United States, rodp@indiana.edu, George Ball, Ruth Beer

A firm selling products faces the prospect of failures in the market. However, the firm is uncertain whether these product failures are the result of a systemic cause (for which they are responsible) or purely random (for which they are not). As failure reports arrive (while sales continue), the firm updates their belief whether the failures are "recall-worthy" or not. Similarly, the relevant regulator (NHTSA or FDA) will possibly intervene if they have sufficient evidence. We investigate how the firm's optimal recall-behavior changes under the gaze of the regulator.

■ MC10

330B

Operations in Sharing Economies

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Yi Xu, University of Maryland, College Park, MD, 20742, United States, yxu@rhsmith.umd.edu

1 - Referral and Learning on Social Network: Implications for Newsvendor

Guangwen Kong, gkong@umn.edu, Guangwen Kong, Ankur Mani, Yuanchen Su

We consider a firm selling differentiated products to customers in a social network . We study how the network structure and learning influence the demand distributions and thus have an impact on the firm's inventory decision and the optimal design of referral programs.

2 - Strategically Giving Service: the Effect of Real-time Information on Service Efficiency

Nil Karacaoglu, Kellogg School of Management, 531 Grove Street, Evanston, IL, 60201, United States, n-karacaoglu@kellogg.northwestern.edu, Antonio Moreno-Garcia, Can Ozkan

Using data from a on-demand taxi service, we study the impact of information on driver behavior.

3 - Managing and Designing Online Platform Networks

Hongfan Chen, University of Chicago, International House, 1414 East 59th Street, 657, Chicago, IL, 60637, United States, hongfan.chen@chicagobooth.edu, John R.Birge, Ozan Candogan, Daniela Saban

In this paper we provided a model of a platform which matches buyers with suppliers. The transaction prices are determined endogenously, and the platform tries to improve its revenues through admission control and display control. We characterize the platform's optimal policies, and relate it to the underlying compatibility network structure.

4 - An Empirical Analysis of Price Formation, Utilization, and Value Generation in Ride Sharing Services

Weiming Zhu, IESE Business School, Avenida Pearson 21, Barcelona, 08034, Spain, zhuwm923@gmail.com, Liu Ming, Tunay Tunca, Yi Xu

Using data obtained from a leading company, we construct a structural model to estimate price formation in ride-sharing services based on operational characteristics such as the number of consumers and the utilization of drivers. Further, we conduct counterfactual analysis to examine efficiency and welfare implications.

■ MC11

332A

The Employee Role in Retail Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Santiago Gallino, Dartmouth College, Hanover, NH, 03755, United States, santiago.gallino@tuck.dartmouth.edu

1 - Does Online Learning Work in Retail?

Santiago Gallino, Dartmouth College, 100 Tuck Hall, Hanover, NH, 03755, United States, santiago.gallino@tuck.dartmouth.edu, Marshall L.Fisher, Serguei Netessine

A knowledgeable retail sales associate (SA) can explain the features of the available product variants and give the customer sufficient confidence in her choice that she becomes willing to purchase. It is thus plausible that increasing SA knowledge will increase sales. Given that training is not costless, an important question is whether training increases SA productivity, and if so, whether the increase is enough to justify the cost of training. We found that as SAs engaged in training over time, their sales rate increased by 1.8 percent for every module taken.

2 - Structural Estimation of Traffic at Retail Store to Achieve Better Conversion

Anup Hanamant Walvekar, INSEAD, 1 Ayer Rajah Avenue, PhD Office, Singapore, 138676, Singapore, anup.walvekar@insead.edu, Nils Rudi, Serguei Netessine

Conversion rate is an important KPI used by retail chains to compare the performance of stores across different locations and times intervals. Using the traffic data coded using video footage obtained from multiple retail stores from Europe and UAE, we observe that a group of customers seldom have multiple transactions. Hence it is better to use #groups as a measure of traffic instead of #individuals to estimate conversion rate. We model the customer arrival process and structurally estimate the #groups from a stream of customers. We compare the performances of different methods using the real and simulated traffic data.

3 - Ration Gaming and the Bullwhip Effect

Robert Louis Bray, 830 Hinman Ave., 2s, Evanston, IL, 60202, United States, robertlbray@gmail.com

We model a single-supplier, 73-store supply chain as a dynamic discrete choice problem. We estimate the model with transaction-level data, spanning 3,251 products and 1,370 days. We find two phenomena: ration gaming (strategic inventory hoarding) and the bullwhip effect (the amplification of demand variability along the supply chain). We estimate that the bullwhip effect would be 12% smaller in the counterfactual scenario without ration gaming incentives, confirming the long-standing hypothesis that ration gaming causes the bullwhip effect.

4 - Field Evidence on Employee Training and Customer Performance

Ryan Buell, Harvard Business School, Morgan Hall 429, Boston, MA, 02163, United States, rbuell@hbs.edu, Tatiana Sandino

Using data from a randomized field experiment conducted in collaboration with a global consulting firm, we examine the effects of a training program that broadens the front line's perspective on the firm's service offerings. We examine whether the program affects job engagement, the types (and consistency) of services offered by the consultants, sales, profitability, and the trajectory of service relationships.

■ MC12

332B

Service Networks: Empirics and Theory

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Gad Allon, I, The Wharton School, gadallon@wharton.upenn.edu

Co-Chair: Qiuping Yu, Kelley School of Business, Indiana University, Bloomington, IN, 47405-1701, United States, qiupyu@indiana.edu

1 - A Quality Value Chain Network: Linking Supply Chain Quality to Customer Lifetime Value

Qiuping Yu, Kelley School of Business, Indiana University, 1309 E. Tenth Street, Bloomington, IN, 47405-1701, United States, qiupyu@indiana.edu, Shawn Mankad, Masha Shunko

We create a quality value chain network concept to analyze the impact of supply chain quality (SCQ) on the customer lifetime value (CLV). We apply our framework to a rich dataset from a major restaurant chain utilizing text analysis of the complaints to measure SCQ, a two-stage least squares (2SLS) model with instruments to assess the impact of SCQ on customer experience, and a structural model of consumer purchasing behavior to eventually link customer experience to CLV. We identify the profile of the most valuable customers and provide insights on which SCQ issues the supply chain should focus on, and which restaurants should be prioritized for supply chain improvements.

2 - The Impact of Delay Announcements on Hospital Network Coordination

Jing Dong, Northwestern University, 2145 Sheridan Road, Room C210, Evanston, IL, 60208, United States, jing.dong@northwestern.edu, Elad Yom-Tov, Galit Bracha Yom-Tov

We investigate the impact of delay announcements on the coordination within hospital networks using a combination of empirical observations and numerical experiments. We offer empirical evidence which suggests that patients take delay information into account when choosing emergency service providers and that such information can help increase coordination in the network, leading to improvements in performance of the network, as measured by Emergency Department waiting times.

3 - Growth and Customer Loyalty: Evidence from the App Economy

Ken Moon, The Wharton School, Philadelphia, PA, 19104, United States, kenmoon@wharton.upenn.edu, Haim Mendelson

We study a dataset encompassing apps' daily, weekly, and monthly usership time series and show how its nested-echelon structure allows researchers to reliably infer how and when an app's customers adopt, use, and leave its services. Thereby gaining novel visibility into these services' customer flows, we study how developers should prioritize the acquisition of customers and market share via viral effects against cultivating customer loyalty. In particular, evidence suggests that a potent experience curve rewards developers' experience with loyal customers.

4 - Managing Service Systems in Presence of Social Networks

Gad Allon, The Wharton School, Philadelphia, PA, United States, gadallon@wharton.upenn.edu, Dennis Zhang

We study a service system with the presence of a social network. In our model, firms can differentiate resource allocations among customers, and customers learn the service qualities from the social network. We study the interplay among network structure, customer characteristics, and information structure, and characterize the optimal policy. We further calibrate our model with data from Yelp.com and quantify the value of social network knowledge empirically.

■ MC13

332C

Health Care, Processes

Contributed Session

Chair: Alaa Alazzam, Binghamton University, Binghamton, NY, United States, aalazza2@binghamton.edu

1 - Healthcare Analytics

Isabel Smith-Nino, London Business School, 26 Sussex Place, London, NW1 4SA, United Kingdom, ismithnino@london.edu, Nicos Savva, Sandra Sulz

We investigate two questions regarding hospital operations. First, we study the impact of staffing mix in the emergency department on patient outcomes by exploiting a natural experiment where junior doctors went on strike. Second, we investigate whether an additional physician dedicated to discharging patients during some weekends improves the discharge rate as compared to other weekends where no such physician was deployed. Our results show the importance of empirical work in the healthcare context, not only for patient safety and quality, but also for efficiency.

2 - Measurement Variability of Postoperative Nausea and Vomiting in the Postanesthesia Care Unit

Elnaz Torkamani, PhD Student, Wayne State University, 4815 Fourth Street, Detroit, MI, 48202, United States, fj6985@wayne.edu

Postoperative nausea and vomiting (PONV) is common and distressing to the patient. The incidence and severity of PONV has been found to depend on patient specific factors, the type of surgery performed, prophylaxis, the type of anesthetic and the treatment if symptoms occur. Post anesthesia care unit (PACU) nurses routinely document the presence of any PONV into the patients' medical record. In this study, we will study the variation attributable different PACU nurses in the assessment of PONV.

3 - Disease Phenotype Search Algorithm Application Improves Surgical Outcomes of Diabetic Patients

Danny Whipple, Health Systems Engineer, Mayo Clinic, 200 First Street SW, Rochester, MN, 55905, United States, whipple.daniel@mayo.edu

Poor management of diabetes mellitus in surgical patients is shown to increase their hospital length of stay (LOS) and 30 day readmission rate. The study determined proper management begins with accurate identification and communication of the diabetes condition to the surgical team and proposed the development of a disease phenotype search algorithm application that systematically identifies the presence of diabetes based on medical history, medications, and lab results and utilizes the indication for proper disease management. This resulted in a 1.5% increase in diabetes identification of surgical patients which led to a 7% decrease in LOS as well as a 4% decrease in the 30 day readmission rate.

4 - Efficient Transition to Post-acute Care

Alex Mills, Assistant Professor, Indiana University Bloomington, 1309 E. Tenth St, Bloomington, IN, 47405, United States, millsaf@indiana.edu, Xiaoyang Yu, Jonathan Helm

Many hospital patients are discharged to a skilled nursing facility (SNF) for post-acute care. A shortage of SNF beds can lead to expensive discharge delays. Using a queueing control model, we show that the system can be coordinated through a capacity reservation contract. When the hospital is a monopolist, both the hospital and SNF benefit from this arrangement. However, when two hospitals form a duopoly, coordination leads to a prisoners' dilemma, where each hospital has an incentive to coordinate with its preferred SNF but all parties are worse off when both hospitals coordinate. The results of our model lead to insights for urban and rural hospital systems.

5 - An Empirical Analysis on Stroke Care Process: Changes in EMS Field Triage Decisions and Their Effect on Stroke Patient Care Outcomes

Brandon Lee, Clemson University, 100 Sirrine Hall, Clemson, SC, 29634, United States, woohyel@clemson.edu, Bernardo F. Quiroga, Lawrence Fredendall, Aleda Roth

This study examines how some of the recent methodological and structural changes for the stroke patient care (e.g., formation of telestroke network, stroke center certification with endovascular neurological services, and the use of a stroke severity scale, etc.) have affected the field triage decision-making behavior of the EMS providers and the consequent clinical outcomes (i.e., disability, mortality, etc.).

6 - A Process Mining Based Approach to Study Patient Flow in Emergency Departments

Alaa Alazzam, PhD Student, Binghamton University, Binghamton, NY, 13902, United States, aalazza2@binghamton.edu

Due to the Affordable Care Act (ACA) guidelines and the rapidly rising healthcare costs, hospitals are in an urgent need to reform their processes to provide better quality at lower costs. To do so, clinical pathways need to be discovered and analyzed to help manage the variation among physicians. Therefore, this paper aims at applying a process mining-based approach to build process models for care flows in two different emergency departments (EDs) based on knowledge extracted from event logs. The generated models are analyzed in terms of cost reduction, capacity gains, and resource utilization, which can lead to a long-term success in process optimization in a wider variety of healthcare settings.

■ MC14

332D

New Approaches to Value in Health Care

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Noah Gans, University of Pennsylvania, Philadelphia, PA, 19104-6340, United States, gans@wharton.upenn.edu

Co-Chair: Ozge Yapar, University of Pennsylvania, Philadelphia, PA, 19103, United States, yapar@wharton.upenn.edu

1 - Bayesian Bandits for Sequential Clinical Trials of Multiple Technologies

Ozge Yapar, University of Pennsylvania, Wharton School of Business, 3730 Walnut Street, Philadelphia, PA, 19103, United States, yapar@wharton.upenn.edu, Stephen E.Chick, Noah Gans

We focus on the design of multiarm multistage (MAMS) clinical trials. We build on two trends, on the one hand allowing for more than two arms in a trial and on the other using information accumulated during a trial to modify its experimental design as the trial progresses. We frame the problem as a stoppable bandit problem with multiple correlated arms, and we allow for arbitrarily many stages of sampling by using a diffusion approximation that allows for adaptive stopping rules. We develop new allocation and stopping rules that can be used in fully sequential sampling algorithms.

2 - Accelerated Approval: Gatekeeper or Roadblock?

Liang Xu, The Pennsylvania State University, 419A Business Building, Penn State University, State College, PA, 16801, United States, lzx103@psu.edu, Hui Zhao

In 1992, FDA enacted the accelerated approval pathway which allows fast approval of drugs but requires further post-market study to verify the true clinical benefit. Unfortunately, most of these post-market studies are delayed or never completed. Indeed, managing such post-market studies are very challenging due to moral hazard and asymmetric information. We propose mechanisms to assure compliance on post-market study and use realistic data to show the results.

3 - Outcomes-based Reimbursement Policies for Chronic Care Pathways

Sasa Zorc, INSEAD, Singapore, Singapore, sasa.zorc@insead.edu, Stephen E.Chick, Sameer Hasija

We develop an outcomes-based model of contracting in care of chronic patients, using data from United Kingdom's NHS. The government contracts with healthcare providers in effort to maximise population health minus the cost. We consider the decision of whether to contract with individual healthcare providers or groups of such providers, as well as which contract type to use. Individual contracts fail to provide the desired incentives if providers under such contracts cooperate (collusion), however so do group contracts if group members fail to coordinate (free-riding). We demonstrate that individual outcomes-adjusted capitation contracts are the most resistant to these adverse effects.

4 - An Instrumental Variable Tree Approach for Detecting Heterogeneous Treatment Effects in Observational Studies

Guihua Wang, Ross School of Business, University of Michigan, 1209 McIntyre Drive, Ann Arbor, MI, 48105, United States, guihuaw@umich.edu, Jun Li, Wallace J. Hopp

We develop a new Instrumental Variable (IV) tree approach for detecting heterogeneous treatment effects in observational studies. We show that the IV tree approach effectively corrects for endogeneity issues and partitions subjects into groups such that those in the same group have similar treatment effects and those in different groups have different treatment effects. We demonstrate the practical application of the IV tree approach by using colectomy as the clinical setting to compare teaching (treatment) and non-teaching (control) hospitals and find that the outcome differences between teaching and non-teaching hospitals are heterogeneous across patient types.

■ MC15

332E

Sustainable Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Suresh Muthulingam, Pennsylvania State University, University Park, PA, 16803, United States, suresh@psu.edu

1 - Diversity vs. Efficiency: A Policy to Service and Survive

Mahyar Eftekhar, Arizona State University, BA 433, Main Campus, P.O. Box 874706, Tempe, AZ, 85287, United States, eftekhar@asu.edu, Iman Parsa, Charles J.Corbett

Nonprofit firms are resource-dependent entities whose existence relies on donations they collect. This research empirically examines which factors impact nonprofits' income, and discusses whether nonprofits can develop a sustainable policy to fulfill their mandates efficiently while maximizing their income. Our data contains information of 120 organizations over 15 years.

2 - Recycling as a Strategic Supply Source

Gilvan Souza, Indiana University, Kelley School of Business, 1309 E.10th St, Bloomington, IN, 47405, United States, gsouza@indiana.edu, Gal Raz

We investigate how recycling can be used as a strategic source of supply in the presence of competition and a powerful material supplier. We examine the economic and environmental impact of a manufacturer's decision to recycle its products and the implications for its customers, supplier, and society. We show that the result depends on the type of recycling the manufacturer does as well as on the market dynamics and price of recycling.

3 - The Impact of Spill and Pollution Controversies on Firm Environmental Activity

Rick Hardcopf, University of Minnesota, 321-19th Avenue S, Suite 3-150, Minneapolis, MN, 55455, United States, hardc001@umn.edu, Rachna Shah, Suvrat Dhanorkar

The adoption of environmental management practices (EMPs) intended to reduce a firm's environmental footprint has increased steadily over the years. EMPs are also positively related to superior environmental, financial, and operational performance. Yet, no empirical research has evaluated how a negative environmental event, such as an environmental spill or pollution controversy, impacts a firm's on-going pattern of EMP adoption. Does the controversy accelerate, decelerate or have no impact on adoption? We evaluate this relationship using a novel secondary dataset derived from 10k filings, sustainability reports, and other public sources.

4 - Predicting Outcomes of Carbon Abatement Opportunities using Textual Analysis

Christian Blanco, Ohio State University, Columbus, OH, United States, blanco.58@osu.edu

Managers need to predict the outcome of carbon abatement opportunities before they can decide to implement them. Are there features of a project that can predict the monetary savings and carbon emissions reduction outcome of these opportunities? We explore this question using textual analysis on 45,554 carbon abatement opportunities reported to CDP (formerly the Carbon Disclosure Project) from 2011-2016.

■ MC16

332F

Inventory Management

Contributed Session

Chair: Yossiri Adulyasak, HEC Montreal, Montreal, QC, Canada, yossiri.adulyasak@hec.ca

1 - A Statistical Analysis Study to Optimize Working Capital from Product Inventories in a Steel Manufacturing Company

Mohammed Almethen, Alfaisal University, Riyadh, Saudi Arabia, methenma@gmail.com

The success of a product in today's global marketplace depends on capabilities of firms in the product's supply chain. Among these capabilities, effective working capital management is a capability necessary to lead in the global marketplace. The purpose of this research is to investigate the working capital reduction opportunities by analyzing the safety stock of product inventories in the Arabian Gulf Steel Industry. A history of high profit margins had created a culture where relatively little attention was paid to cash, benchmark shows that SMC (Steel Manufacturing Company) to be less efficient than its peers with a huge working capital value of around $1 billion against sales of $0.365 billion. That is nearly twice as much working capital investment for every $1 billion as the top Steel Industry performers. Experiential learning was applied in an MBA course to find opportunities in the Gulf environment for innovative working capital management approaches with particular focus on inventory management. A Bottom-up approach is taken to Identify opportunities of reducing inventories per SKU (Stock Keeping Unit) i.e. +1000 SKU by calculating the SS (safety stock) and CS (cycle stock) by using a mathematical model. Data to be analyzed includes historical sales/inventory/supply/consumption to calculate variabilities. The findings were inventory reduction opportunity by $22.1MM from FP, $107MM from LP and $103MM from row materials. A total of $232.1MM. The DIOH (Days Inventory on Hand) will be reduced by 25 Days. Working capital optimization techniques from product inventories vary between industries. This research can significantly ease the optimization using scientific methods with agreed bases. This analysis can reduce working capital in this SMC if top management endorsed these opportunities and execute it.

2 - Joint Pricing and Inventory Optimization under Min-max Regret

Chengzhang Li, Purdue University, 403 W. State Street, west lafayette, IN, 47906, United States, li1392@purdue.edu, Mengshi Lu

We study a robust pricing newsvendor problem under the min-max regret framework where the firm only knows the interval in which the random factor lies with high confidence in the demand model. We characterize the optimal decisions with a general demand model and further study the impact of inventory risk by comparing the optimal price and the risk-free price. We also study comparative statics of the optimal price with different unit cost and degree of demand ambiguity. Finally, our approach outperforms the traditional one in a data-driven setting with small sample sizes, high demand variability, or demand model misspecification.

3 - Ordering Policy with Demand Learning for a New Product

Yanzhi Li, City University of Hong Kong, Department of Management Sciences, Tat Chee Avenue Kowloon, Hong Kong, Hong Kong, yanzhili@gmail.com

Consider a retailer that needs to prepare inventory for a new product. Due to the inherent demand uncertainty, the firm needs to learn the demand over time in the meanwhile of achieving an economy of scale in ordering. This paper attempts to address the trade-off faced by the retailer between business efficiency and prediction accuracy.

4 - Inventory Policies in Dual Sourcing Systems with Uncertain Yield

Andrei Sleptchenko, Assistant Professor, Qatar University, Dep. of Mechanical & Industrial Engineering, P.O. Box 2713, Doha, Qatar, andrei.sleptchenko@qu.edu.qa, Adriana Gabor

We study an inventory system with uncertain demand and two supply sources, one using Traditional Manufacturing processes (TM) and the other Additive Manufacturing (AM), aka 3D printing. Traditional manufacturing has lower costs, guaranteed quality, but longer lead time. Additive manufacturing has shorter lead time, but higher costs and uncertain yield due to unstable production quality. For this problem, we propose close to optimal inventory policies and study the conditions at which Additive Manufacturing can help to reduce the total costs.

5 - Optimal Buffer Capacity of Steel Strips in Continuous Steel Pipe Manufacturing

Md Shahriar J.Hossain, Graduate Research Assistant, Louisiana State University, 4141 Burbank Dr. Apt. 3, Baton Rouge, LA, 70808, United States, msjhossain1@gmail.com, Bhaba R.Sarker

The steel strip joining process in a seam welded pipe manufacturing line, is followed by a coil accumulator that facilitates buffer inventory. Size of the buffer determines the allowable time for strip joining. High buffer inventory increases cost for the accumulator but reduces the occurrence of line stoppage due to additional joining time. The problem is to find an appropriate buffer capacity that minimizes the total cost. Considering the issues of line stoppage, buffer storage and strip joining parameters, a total cost function is formulated and solved optimally in this research.

6 - Multi-item Inventory Optimization Approach under Multiple Target Levels

Yossiri Adulyasak, Assistant Professor, HEC Montreal, 3000 Cote-Sainte-Catherine, GOL.department, Montreal, QC, H3T.2A7, Canada, yossiri.adulyasak@hec.ca, Eric Prescott Gagnon, Thierry Moisan

This research focuses on a development of a multi-item inventory optimization approach under group target levels which is represented as a coupled Markov decision process (MDP). This problem is solved in a decomposition framework where a master problem will select a policy for each item that minimize overall costs while satisfying a set of targets such as a minimum cycle service level. A set of subproblems, one for each item, generates new inventory policies using an MDP approach. We discuss the practical considerations and extensions of the framework.

■ MC17

340A

Queueing Systems

Sponsored: Applied Probability

Sponsored Session

Chair: Yunan Liu, North Carolina State University, Raleigh, NC, 27695-7906, United States, yliu48@ncsu.edu

1 - Optimal Controls for Double-ended Queues with Time-varying Demand

Ling Zhang, North Carolina State University, Raleigh, NC, United States, lzhang42@ncsu.edu, Chihoon Lee, Xin Liu, Yunan Liu

Continuous manufacturing has received much of recent attention both in academia and industry. We consider production systems with a time-varying demand, perishable inventory, and abandonment of backorders. The system incurs inventory-related costs of holding and perishment, and demand-related costs of waiting and abandonment. We study the finite-time production planning to minimize the sum of the demand and production related costs. We use fluid models to derive time-dependent production rates that are asymptotically optimal as the system scale increases; specifically, we prove a limit theorem to verify the asymptotic effectiveness of the optimal solution.

2 - Delay-based Service Differentiation in a Time-varying Environment

Xu Sun, Columbia University, New York, NY, 10027, United States, xs2235@columbia.edu, Ward Whitt

We study service differentiation in the presence of diverse customer needs and time-varying arrivals. We propose a new control family that exploits the head-of-line delay information. We refer to this family as the head-of-line-delay-ratio (HLDR) rule and show that it achieves desired differentiated service in a multi-class multi-server queue with non-stationary arrivals.

3 - Data-driven Inpatient Bed Assignment: Balancing Boarding and Overflowing using the P-model

Shasha Han, NUS.Business School, Singapore, Singapore, shashahan@u.nus.edu, Shuangchi He, Hongchoon Oh

Balancing boarding and overflowing are a chanllenge to most public hospitals. To tackle with it, we provide a practical P-model approach, which is able to capture critical features of patient flow management, while keep the resulting optimization problem tractable. Based on a set of patient flow data from a hospital, our simulation study shows that the proposed approach can greatly reduce patients' transfer delays and mitigate the time-of-day effect on boarding. Through the study with real data, we demonstrate that the P-model could be a useful tool for the control of queueing systems with time-sensitive service requirements.

4 - Queueing Models in Interactive Random Environments

Guodong Pang, Penn State University, 310 Leonhard Bldg., Industrial and Manufacturing Engineering, University Park, PA, 16802, United States, gup3@psu.edu

We study queueing models in interactive random environments. The arrival and/or service parameters are driven by a Markov process whose generators depend on the state of the queueing system. The underlying Markov process can be a Markov chain with a finite/countable state space, or a (reflected) diffusion process. We study the ergodicity properties and characterize the joint stationary distributions of the queueing processes and underlying Markov processes under certain conditions.

■ MC18

340B

Limit Order Book

Sponsored: Applied Probability

Sponsored Session

Chair: Raghu Pasupathy, Purdue University, pasupath@purdue.edu

1 - Optimal Placement of a Small Order under a Diffusive Limit Order Book Model

Jose E. Figueroa-Lopez, Washington University-St Louis, One Brookings Drive, St Louis, MO, 63130, United States, figueroa@math.wustl.edu, Hyoeun Lee, Raghu Pasupathy

We present a framework to study the optimal placement problem of a stock trader who wishes to clear his/her inventory by a predetermined time horizon by using a limit order or a market order. Building on diffusion approximations for LOB models, we consider the analogous problem in a diffusive market and characterize the optimal limit order placement under different market conditions. In particular, we propose a simple method to determine the optimal order placement and show its performance.

■ MC19

342A

OM-Finance Interface

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Jie Ning, Case Western Reserve University, Cleveland, OH, 44106, United States, jie.ning@case.edu

Co-Chair: Qi Wu, Case Western Reserve University, Cleveland, OH, 44122, United States, qxw132@case.edu

1 - Financing and Supply Chain Network Structure

John R.Birge, University of Chicago, Booth School of Business, 5807 South Woodlawn Avenue, Chicago, IL, 60637, United States, John.Birge@ChicagoBooth.edu

Firms have differing incentives to form specific supply chain relationships depending on their relative positions downstream or upstream in the chain. These incentives including reliability of physical fulfillment and flexibility in financing. This talk will discuss a model that captures these dual roles of supply chain relationships and its implications for observed supply chain network configurations.

2 - Production and Capacity Management with Internal Financing

Matthew J. Sobel, Case Western Reserve University - Retired, Department of Operations, 10900 Euclid Avenue, Cleveland, OH, 44106-7235, United States, matthew.sobel@case.edu, Jie Ning

We analyze a price-taking firm that manages production and capacity, uses only internal financing, and faces stochastic market environments. The firm has two operationally independent production facilities, each of which makes two products, and a cash reserve which finances all operations and dividend issuance. We completely characterize the optimal policy and the endogenous values of the capacities and cash reserve, and show that they invite a real-option interpretation. We find that internal financing creates a spillover between the endogenous values of the two operationally independent facilities and we specify how this leads to interdependence of their optimal policies.

3 - Managing Inventory for a Multi-divisional Firm with Cash Pooling

Kevin Shang, Duke University, Fuqua School of Business, Duke University, Durham, NC, 27708, United States, khshang@duke.edu, Jianan Wang, Yi Yang

We consider a firm with N divisions, each replenishing inventory from an external supplier to satisfy a random, nonstationary demand in a finite horizon. The headquarter consolidates cash in a master account for external investments and purchasing inventory. The objective is to optimize the expected working capital at the end of the horizon. We derive near-optimal heuristics for the joint inventory and cash retention policy. We also investigate the value of cash pooling and the impact of cash on the order variability with correlated demands.

■ MC20

342B

Managing New Product Development Uncertainties

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

1 - To Better Manage Risks in Multi-Period New Product Development — Select Riskier Projects

Janne Kettunen, Assistant Professor, George Washington University, Department of Decision Sciences, 2201 G. Street NW, Washington, DC, 20052, United States, jkettune@gwu.edu, Shivraj Kanungo

We consider multi-period new product development (NPD) where the decision maker chooses, periodically, which development projects to fund from the pool of available projects. We show that the availability of new development projects in future periods, which the initiated projects can be switched for, has major implications for what projects are optimal to select and thereby for the portfolio value and risk. Furthermore, we show that a risk-averse NPD portfolio selection approach implies higher risk than a risk-neutral selection approach. We name this phenomenon the risk aversion paradox and develop an approach to overcome it.

2 - A Theoretical Analysis of the Lean Start-up's Agile Product Development Process

Onesun Yoo, University College London, London, United Kingdom, o.yoo@ucl.ac.uk, Tingliang Huang, Kenan Arifoglu

Lean startup paradigm is emerging as a best practice for early product development for entrepreneurs and is widely adopted by entrepreneurship curricula in business schools. Despite its influence, there is no theoretical underpinning, leading to lack of clarity in its generalizability and explanation of implementation challenges in practice. We present a stylized model of the lean startup implementation problem. We show how the (vertical) quality of minimum viable product impacts learning about consumer's (horizontal) taste, and also how product-market characteristics impact its effectiveness.

3 - Learning Strategies to Deal with Market Disruptions and Turbulences in a Finite Time Horizon

Leonardo Santiago, Copenhagen Business School, Copenhagen Business School, Solbjerg Plads 3, Blok B.5. sal, Frederiksberg, 2000, Denmark, leonardo.p.santiago@gmail.com, Julia Couto, Nitin Joglekar

The ability to continuously innovate is a key asset to maintain a competitive advantage. However, very often, market turbulences or disruptions force firms to shift gears in their new product development strategies. This work considers the question of how firms should react to such disruptions when pursuing a finite time initiative. In particular, we focus on the role of pivoting strategies and cognitive maps to manage efforts to explore and exploit.

4 - Firm Clockspeeds: Toward a Theory of Relativity

Sina Moghadas Khorasani, Doctoral Student, David Eccles School of Business, Salt Lake City, UT, 84112, United States, sina.moghadas@eccles.utah.edu, Glen M.Schmidt

Fast clockspeeds imply short product lifespans. However, we find that two firms running at the same internal clockspeed may, to an outside observer, have quite different external clockspeeds, depending on product "type," market competitiveness, and whether product innovation or process innovation prevails.

5 - When is Necessity the Mother of Invention?

Sezer Ulku, McDonough School of Business, Georgetown University, DC, United States, Sezer.Ulku@georgetown.edu

We conduct several experiments to investigate how time, resource and performance constraints influence the search behavior and the performance achieved in problem solving tasks. We find that solution quality attained under a moderate constraint is superior to that attained when no such constraint is present. This is explained by differences in search effectiveness. We also find that in the presence of a challenging performance goal, participants exert more effort on average, they are more attentive to the tasks and as a result they achieve better results. As expected, when the resource constraint becomes very tight, performance suffers.

■ MC22

342D

Data-driven Studies in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ken Moon, The Wharton School, Philadelphia, PA, 19104, United States, kenmoon@wharton.upenn.edu

Co-Chair: Kostas Bimpikis, Stanford University, 655 Knight Way, Stanford, CA, 94305, United States, kostasb@stanford.edu

1 - Leveraging Comparables for New Product Sales Forecasting

Georgia Perakis, Massachusetts Institute of Technology, Sloan School of Management, MIT, 100 Main Street Rm E62-565, Cambridge, MA, 02142-1347, United States, georgiap@mit.edu, Lennart Baardman, Divya Singhvi

We introduce a simple and intuitive approach for forecasting demand for new products. We identify comparable products that allow us to make accurate predictions. The approach we propose is both simple and intuitive and mimics the current operational practice of retailers. We show that our approach is fast and scalable. In collaboration with two big industry partners, we provide prediction improvements of the order of 40%-50% (WMAPE) that are robust across various product categories.

2 - Predicting with Proxies: Pitfalls and Solutions

Hamsa Sridhar Bastani, IBM Thomas J. Watson Research Center, Yorktown Heights, NY, United States, hamsab@wharton.upenn.edu

An increasingly common problem with machine learning is that true outcomes of interest are costly to measure. Instead, practitioners use proxy outcomes for prediction and subsequent decision-making. For example, a content recommender may make critical decisions based on predicted click-through rates (easily available) rather than user experience (costly to measure). However, the proxy outcome may be biased and result in poor decisions. We introduce a novel estimator that leverages many proxy outcomes and a few true outcomes to provably detect and reduce bias. Simulations on real datasets demonstrate significant improvements in prediction accuracy.

3 - Welfare Implications of Congestion Pricing: Evidence from SF Park

Hsin-Tien Tsai, UC Berkeley, 1822 Francisco St., Apt 4, Berkeley, CA, 94703, United States, hsintien@berkeley.edu, Pnina Feldman, Jun Li

Using data from San Francisco both before and after the implementation of a congestion pricing policy, we estimate the welfare implications of the policy. We find that congestion pricing increases consumer welfare in popular areas, but when implemented in less-congested areas, it may actually hurt consumers. In less congested areas, a simpler pricing policy may actually achieve higher welfare than a complex one.

4 - Optimal Retail Location: Empirical Methodology and Application to Practice

Chloe Kim Glaeser, University of Pennsylvania, 3730 Walnut St. Suite 500, Philadelphia, PA, 19104, United States, chloekim@wharton.upenn.edu, Marshall L.Fisher, Xuanming Su

We empirically study the spatio-temporal location problem motivated by an online grocery retailer. Customer demand is influenced by the convenience of pick-up locations and days. We combine demographic and economic data, business location data, and the retailer's historical sales and operations data to predict demand at potential locations. We introduce a novel procedure that combines machine learning and econometric techniques. Based on the predicted demand, we solve the spatio-temporal integer program using quadratic program relaxation to find the optimal pick-up location configuration and schedule.

■ MC23

342E

Recent Development on Revenue Management and Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ruxian Wang, The Johns Hopkins Carey Business School, Baltimore, MD, 21202, United States, ruxian.wang@jhu.edu

1 - New Bounds for Assortment Optimization under the Nested Logit Model

Sumit Kunnumkal, Queen's University, Kingston, ON, 500032, Canada, sk162@queensu.ca, Huseyin Topaloglu

We consider the assortment optimization problem under the nested logit choice model. We establish new bounds on the quality of revenue ordered assortments.

2 - Is Ignorance Bliss? Demand Learning in Dynamic Pricing with Limited Inventory

Chengyu Wu, Duke University, 877 Louise Circle, Durham, NC, 27705, United States, chengyu.wu@duke.edu, Li Chen

We examine the value of Bayesian demand learning in the context of a dynamic pricing problem with inventory scarcity. An interesting and counter-intuitive numerical result is discovered where a no-learning system may outperform the corresponding Bayesian learning system. We perform analytical analysis to shed light on this observation.

3 - Omni Channel Assortment Pricing

Shivaram Subramanian, IBM.Research, Yorktown Heights, NY, United States, subshiva@us.ibm.com, Pavithra Harsha, Markus Ettl

We analyze certain large-scale constrained optimization problems that arise in the retail industry in the context of pricing product assortments sold across multiple sales channels and locations. The problem becomes challenging when we consider cross-product and cross-channel demand interactions. We derive an effective global optimization approach and present computational results.

4 - Pricing Ancillary Service Subscriptions

Ruxian Wang, The Johns Hopkins Carey Business School, 100 International Dr, Baltimore, MD, 21202, United States, ruxian.wang@jhu.edu, Maqbool Dada, Ozge Sahin

We investigate customer choice behavior in the presence of main products, ancillary services with options of pay-per-use and subscription, as well as the outside option with heterogeneous customers.

■ MC24

342F

Spatial Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: Valentina Ferretti, London School of Economics and Political Science, London, United Kingdom, v.ferretti@lse.ac.uk

1 - Preferences in Spatial Decision Making

Jay Simon, American University, 4400 Massachusetts Avenue, NW, Washington, DC, 20016, United States, jaysimon@american.edu, L. Robin Keller

Decision maker preferences for spatial decisions can be challenging both to model and to assess. When outcomes occur over a geographic space, the decision maker must consider not only uncertainty, risk, relative preferences for different levels of an attribute, and tradeoffs between attributes, but also the geographic areas in which each attribute level is realized. We provide several representation theorems ensuring the existence of value and utility functions for spatial decisions, explore a range of viable elicitation techniques, and demonstrate the concepts with simple examples.

2 - Sustainability of Potential Areas for Deep Geothermal Energy Systems: A Preliminary Application to Switzerland

Matteo Spada, Paul Scherrer Institut, OHSA/D19, Villigen PSI, 5232, Switzerland, matteo.spada@psi.ch, Marco Cinelli, Peter Burgherr

Deep geothermal energy (DGE) is a renewable technology with a secure base-load, which is gaining interest among stakeholders due to its theoretically large resource potential. However, as for other geoenergy systems, the feasibility of DGE is strongly dependent on local conditions such as, for example, geological/geophysical ones. This study presents a methodology to assess the sustainability of potential areas of interest for DGE. The proposed method is based on outranking approaches combining explicit (e.g., heat flux) and calculated (e.g., risk indicators) criteria for specific a priori defined capacity plants. The results will be presented for a case study of Switzerland.

3 - Multi Criteria Decision Analysis for Contingency Base Siting

Jeffrey Cegan, USACE, 676 Virgiia Road, Concord, MA, 01742, United States, jeffrey.c.cegan@usace.army.edu, Matthew Bates

The US Army is in need of the ability to rapidly plan and site base camps in order to maximize the combat effectiveness of deployed forces. By defining mission specific requirements prior to the deployment of base camps, commanders are able to optimize base camp site selection. Currently, existing doctrine and guidance for contingency basing (CB) are not developed to support deployment in dense urban environments. Preliminary research reveals the inadequacy of current doctrine for conducting operations in such environments (Chief of Staff of the Army, 2013). The CB-SITE project seeks to address these problems by utilizing multi-criteria decision analysis for base camp site suitability assessment.

4 - Any Cognitive Bias in Spatial Decision Analysis Processes?

Valentina Ferretti, London School of Economics and Political Science, Houghton Streetl London l WC2A 2AE, London, United Kingdom, V.Ferretti@lse.ac.uk

The need and interest to consider cognitive and motivational biases has been recognized in different disciplines (e.g. economics, decision theory, finance, risk analysis, to name the most relevant ones) and has recently reached environmental decision making. Within this domain, the intrinsic presence of a spatial dimension of both alternatives and criteria calls for the use of maps throughout decision analysis processes. This talk presents insights from a literature review on cognitive biases in spatial decisions, as well as some preliminary results from a behavioural experiment on the spatial dimension of biases.

■ MC25

350A

Control and Optimization Techniques for Power Systems II

Invited: Energy Systems Management

Invited Session

Chair: Javad Lavaei, University of California-Berkeley, United States, lavaei@berkeley.edu

1 - Promises of Conic Relaxations in Optimal Transmission Switching of Power Systems

Salar Fattahi, University of California-Berkeley, Berkeley, CA, United States, fattahi@berkeley.edu, Javad Lavaei, Alper Atamturk

In this talk, we consider the problem of optimal transmission switching (OTS) in power systems. The goal is to identify a topology of the power grid that minimizes the cost of the system operation while satisfying the operational constraints. In the first part of the talk, we study the difficulty of finding a strong MILP formulation of the OTS problem. Then, we propose a convex conic relaxation of the problem based on a semidefinite program (SDP). Strong valid inequalities are proposed to strengthen the SDP relaxation by multiplying different linear constraints and then convexifying them in a lifted space. We extensively evaluate the performance of the proposed method on IEEE benchmarks systems.

2 - Opportunity for Strategic Behavior in Electricity Distribution Network Marginal Cost Based Markets

Fatma Selin Yanikara, Boston University, 15 St. Mary's Street, Room 140, Boston, MA, 02215, United States, yanikara@bu.edu, Michael C. Caramanis

Transmission & Distribution (T&D) network day-ahead market co-clearing of energy and reserves must rely on Distributed Algorithms that discover Nash Equilibria of participating Distributed Energy Resources (DERs).Given the required individual DER self-scheduling - with or without the involvement of aggregators — strategic behavior may be possible under certain network information availability conditions available to DER market participants and the Network Operator. We examine the theoretical possibility for strategic behavior and quantify possible deviations from social welfare on a small T&D network.

3 - Error Bounds on Power Flow Linearizations: A Convex Relaxation Approach

Daniel K. Molzahn, Argonne National Laboratory, 1111 S. Wabash Ave., Apt 1507, Chicago, IL, 60605, United States, dan.molzahn@gmail.com, Krishnamurthy Dvijotham

The power flow equations relate the voltages and power injections in an electric power system. The nonlinearity of these equations results in algorithmic and theoretical challenges, including non-convex feasible spaces. Accordingly, many practical approaches for solving power system optimization and control problems employ linearizations of the power flow equations. By leveraging developments in convex relaxation techniques, this presentation describes a method for bounding the worst-case errors resulting from power flow linearizations over a specified range of operational conditions.

4 - Robustness Analysis of Power Grid under False Data Attacks Against AC State Estimation

Ming Jin, jinming@berkeley.edu, Javad Lavaei

The integration of sensing and information technology renders the power grid vulnerable to cyber-attacks. To understand how robust state estimators are, we study their behavior under worst attacks possible. Three types of data injection attacks are formulated in an optimization with "unobservability" and "sparse attack" constraints. A novel treatment of the continuous nonconvexity and discrete nonlinearity of the problem is proposed based on semidefinite programming (SDP) relaxation with a sparsity penalty, where a rank-1 and sparse solution exists under mild conditions. In light of the analysis, measures to improve the robustness of power grid are discussed.

■ MC26

350B

Innovative Methods in Productivity and Efficiency Measurement

Invited: Data Envelopment Analysis

Invited Session

Chair: Abolfazl Keshvari, Aalto University School of Business, Helsinki, 00100, Finland, abolfazl.keshvari@aalto.fi

1 - A Comparative Study of Alternative Approaches to Estimate Productivity

Joseph Atwood, Montana State University, Bozeman, MT, United States, jatwood@montana.edu, Saleem Shaik

The main objective of the paper is to estimate & compare productivity measures between & within three approaches for single output-input technology. The following models are considered - index (Tornqvist and Fisher), programming (Malmquist Input, Output & Graph; Malmquist total factor productivity) and parametric (Input & Output; total factor productivity). Results support differences in productivity growth rate across approaches due to the composition of the frontier and the underlying assumptions. However, within nonparametric (parametric) approach, differences are due to the use of distance functions (residuals) or ratio of conditional distance functions (conditional residuals).

2 - Estimating Parameter Uncertainty in the Stoned Model

Endre Bjørndal, Norwegian School of Economics, Bergen, Norway, Endre.Bjorndal@nhh.no, Ørjan Mydland, Jonas Andersson

We investigate the performance of estimators for parameter uncertainty in the StoNED model (Kuosmanen and Kortelainen, 2012). More specifically, we study the performance of the bootstrap for making inference on the estimation of model coefficients. The estimators, based on different versions of the bootstrap, are investigated by means of a Monte Carlo study. We apply the method to a dataset for Finnish electricity distribution companies, and we discuss the relevance and importance of measuring the uncertainty in cost function coefficient estimates in a regulatory context.

3 - A Data Mining Approach to Hedonic Pricing Model via Nonparametric Piecewise Linear Regression

Abolfazl Keshvari, Abolfazl, Helsinki, Finland, abolfazl.keshvari@aalto.fi

This paper first reviews the main developments in nonparametric piecewise linear regressions. The statistical properties and applications of a family of such models are discussed. Numerical techniques to solve the related problems are also explained. Next, nonparametric concave regression is used to build a hedonic pricing model, which determines similar pricing strategies and categorizes observations accordingly. Advantages of this model are demonstrated and it is compared with similar approaches.

■ MC27

350C

Marketing Insights from Social Media

Invited: Social Media Analytics

Invited Session

Chair: Ali Hojjat, University of New Hampshire, 10 Garrison Ave., Durham, NH, 03824, United States, ali.hojjat@unh.edu

1 - The Impact of Product Placement on Brand-related Social Media Conversations and Website Traffic

Beth Fossen, Indiana University, 3013 E.Daniel St, Bloomington, IN, 47401, United States, bfossen@indiana.edu, David Schweidel

Despite the popularity of product placement, there is limited research that empirically explores the impact of placement activities in television programs. We examine the effect of television product placements on the volume of social media activity and web traffic for the placed brand. Using data on 2,800 product placements, we find that placements contribute to both more online conversations and web traffic for the brand, with audiovisual placements yielding the largest increases. We also find that television advertising can enhance the impact of product placement on social media activity.

2 - Exit, Voice, and Response in Digital Platforms: An Empirical Investigation of Online Management Response Strategies

Naveen Kumar, University of Memphis, Memhis, TN, United States, nkumar7@memphis.edu, Liangfei Qiu, Subodha Kumar

In the past decade, we have witnessed the growing importance of management responses to online reviews in digital platforms. In this study, we examine the impact of such responses on business performance. We also uncover the spillover effect of such responses on the nearby businesses and identify conditions under which business owners are more likely to respond to consumer comments. Our findings have direct implications for both the business owners and digital platforms that can help businesses develop the right engagement strategies by taking the online response strategies into account.

3 - Influence of Flavors on the Propagation of Electronic Cigarettes Related Information

Jiaqi Zhou, City University of Hong Kong, 83 Tat Chee Avenue, 6/F, Academic 1, Kowloon, 12180, Hong Kong, jiaqi.zhou@my.cityu.edu.hk, Qingpeng Zhang, Daniel Dajun Zeng, Kwok-Leung Tsui

Depicting the influence of e-cigarette flavors on information propagation is critical for understanding the use of e-cigarettes and the reception of flavors. Modeling such influence could provide quantitative policy decision support concerning smoking initiation and contagion, and e-cigarettes regulations. This study aims to characterize the influence of flavors on the propagation of e-cigarette related information on social media. The occurrence of three flavors (coffee, fruits, and herbs&spices) did not enhance the popularity of information, indicating users' lack of interests in flavors.

■ MC28

350D

Matching and Assignment

Invited: Auctions

Invited Session

Chair: Thayer Morrill, North Carolina State University, Raleigh, NC, 27695, United States, thayermorrill@gmail.com

1 - The Simple Structure of Top Trading Cycles in School Choice

Irene Yuan Lo, Columbia University, New York, NY, 10025, United States, iyl2104@columbia.edu, Jacob Leshno

Top Trading Cycles (TTC) is attractive for school choice, as it is strategy-proof, Pareto efficient, and allows school boards to guide the allocation via priorities. However, the combinatorial description of TTC makes it non-transparent to parents and designers. We give a simple characterization of TTC for school choice: the TTC assignment is given by n2 admission thresholds, where n is the number of schools, and these thresholds can be easily observed after running the mechanism. To calculate these thresholds, we define TTC through trade balance equations, which correspond in a continuum model to a differential equation. The model allows us to compute comparative statics and evaluate welfare.

2 - Communication Requirements and Informative Signaling in Matching Markets

Peng Shi, Assistant Professor, USC Marshall School of Business, 3670 Trousdale Pkwy, Los Angeles, CA, 90089, United States, pengshi46@gmail.com, Itai Ashlagi, Mark Braverman, Yash Kanoria

We study how much communication is needed to find a stable matching. Previous results show that any protocol must incur a high communication cost per agent, which scales linearly in the number of agents. On the other hand, we show that when the distribution of preferences satisfy natural restrictions, the amount of communication needed is much less. We give efficient protocols based on giving agents an estimate of whom they have realistic chances of matching, and recommending that agents reach out to easier-to-match partners while waiting for harder-to-match partners to reach out to them. Our protocols have good incentive properties and give insights on how to reduce congestion in matching markets.

3 - Competitive Equilibria in School Assignment

Thayer Morrill, North Carolina State University, Campus Box 8110, Raleigh, NC, 27695, United States, thayermorrill@gmail.com, Umut Dur

Top Trading Cycles was originally developed as an elegant method for finding a competitive equilibrium of Shapley and Scarf's housing market. We extend the definition of a competitive equilibrium to the school assignment problem and show that there remains a profound relationship between Top Trading Cycles and a competitive equilibrium. Specifically, in every competitive equilibrium with weakly decreasing prices, the equilibrium assignment is unique and exactly corresponds to the Top Trading Cycles assignment. This provides a new way of interpreting the worth of a student's priority at a given school. It also provides a new way of explaining Top Trading Cycles to a school board.

4 - The Effects of Thickness and Competition in Ride-sharing Markets

Afshin Nikzad, Stanford University, 741A Homer Ave, Stanford, CA, 94301, United States, afshin.nikzad@gmail.com

We study the effects of thickness and competition in ride-sharing markets. We vary thickness by varying the size of labor supply while holding the customer side fixed. When the market is sufficiently thick, wage and workers' average welfare decrease with labor supply. Otherwise, wage and workers' average welfare increase with labor supply, countering the prediction by the law of demand. Intuitively, workers are "complements" in a thin market -for example, their hourly wage and average employment time goes up with the labor supply- whereas they become "substitutes" and compete with each other in a thick market.

■ MC29

350E

Robust Optimization and Machine Learning

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Marek Petrik, University of New Hampshire, 33 Academic Way, Kingsbury W233, Durham, NH, 03861, United States, mpetrik@cs.unh.edu

1 - Efficient Algorithms for Robust Markov Decision Processes with State Rectangularity

Clint Chin Pang Ho, Imperial College Business School, London, United Kingdom, c.ho12@imperial.ac.uk, Marek Petrik, Wolfram Wiesemann

Robust Markov decision processes (MDPs) seek for optimal policies in view of the worst transition kernel from within an ambiguity set that specifies the knowledge about the unknown true Markov process. Although robust MDPs have emerged as powerful modeling tools, robust MDPs have typically been considered to be intractable, except for special cases where the ambiguity sets are rectangular in both the states and the actions. In this talk, we develop tractable solution techniques for robust MDPs whose ambiguity sets are only required to be rectangular in the states.

2 - Information Collection Optimization in Designing Marketing Campaigns for Market Entry

Somayeh Moazeni, Assistant Professor, Stevens Institute of Technology, Babbio Center, 1 Castle Point Terrace on Hudson, Hoboken, NJ, 07030, United States, smoazeni@stevens.edu

Developing marketing strategies for market entry is challenging due to the scarcity of relevant data. A sequential information collection optimization assists in creating new data points, given a finite learning budget to identify effective features maximizing the final outcome. We model the marketing campaign performance by a multiplicative advertising exposure model with Poisson jumps whose intensity depends on the marketing features. We develop an optimal learning policy and propose a computationally efficient algorithm to handle the large number of features. The performance of the optimal learning policy is compared to commonly used benchmark policies.

3 - Robust Reinforcement Learning with a Baseline

Yinlam Chow, IBM.Research, 1101 Kitchawan Rd, Yorktown, NY, 10598, United States, na, Marek Petrik, Marek Petrik, Marek Ghavamzadeh

A fundamental problem in sequential decision-making under uncertainty is to compute a safe policy, i.e., a policy that is guaranteed to have a better performance than a baseline strategy, given a batch of data. In this talk, We describe a model-based approach to this problem, in which the goal is to compute a safe policy, given an inaccurate model of the system with known accuracy guarantees. The inaccurate model and error bound may be constructed using the batch of data and prior knowledge about the system.

■ MC30

350F

Supporting Personal Decisions with Social Media Analytics

Invited: Social Media Analytics

Invited Session

Chair: Xue Tan, University of Washington, University of Washington, Seattle, WA, 98105, United States, xuetan@uw.edu

1 - Assessing the Impact of Disclosure Policy on Investment Pattern: Evidence from a Natural Experiment in Supply Chain Finance Market

Zhijin.Zhou, University of Washington, Foster School of Business, Seattle, WA, 98195, United States, zjzhou@uw.edu

We examine the effect of exogenous information disclosure policy change on projects' fundraising performances in an online supply chain finance market. Regression Discontinuity analysis was conducted to verify a discontinuous jump in fundraising performances around the shock. Panel model was then used to assess the inside mechanism of the jumps. Results show that the policy change has a positive effect on projects' fundraising speed and investment rate, while has a negative influence on projects' average investment amount. Moreover, the influence will be attenuated by the fundraising target and debtors' ex experience, and strengthen by creditors' ex experience.

2 - Value of Information in Online Dating: An Empirical Study

Kyungmin Park, University of Washington, Seattle, WA, United States, parkk30@uw.edu

Online dating service has become a popular source to meet new people. A typical challenge to a firm in this market is matching people who are likely to be attractive to each other. In this regard, improving matching efficiency is important to enhance a firm's competence in the market. An user wants to find a person not only whom he like, but also who would like him. In this setting, a firm should also consider dyad-level characteristics of each pair of users in addition to individual-level characteristic of each user. This research explore this point by analyzing a rich data from a Korean major online dating application.

3 - Uber Introduction and Spillover Effects on Transportation System: Empirical Study

Kyungsun Rhee, University of Washington, 4725 24th Avenue NE, # 405, Seattle, WA, 98105, United States, ksr22@uw.edu, Jinyang Zheng, Yong Tan, Youwei Wang

This study aims to investigate whether the entry of Uber influences on the demand patterns in overall transportation system. Using a national panel data set constructed from four sources, we examine the longitudinal relationship between Uber entry and Taxi efficiency, along with its horizontal and vertical spillover effects. To identify the entry effects on shift of transportation demands to other transportation, we rely on a natural experiment setup inherent in city Shanghai in China, as the policy is applied at same time everyday. Our empirical analyses reveal that the demand on taxi is reduced whereas demand for other alternative transportation increased.

4 - Competition in Mobile Operating Systems: the Strategy of Facebook

Tongxin Zhou, University of Washington, 3927 Adams Lane NE, Seattle, WA, 98105, United States, txzhou5@uw.edu, Xue Tan

React Native is a JavaScript-based cross-platform mobile development language that has attracted a lot of attention among mobile development teams. Much of the code used to develop an iOS app in React Native will work on Android and vice versa. It reduces the dependency on this very limited pool of iOS and Android platform developers and repurposes the large community of web JavaScript developers to mobile development.

■ MC31

351A

INFORMS Internal Activities & 2018 INFORMS International Conference Overview

Panel Session

1 - Moderator
Grace Lin, Institute for Information Industry, 1F, No. 133, Sec. 4, Minsheng E. Rd., Taipei, Taiwan, gracelin.ny@gmail.com

We will present our effort in integrating big data information including market trend, industry talent needs, and recruiting website information with the institution internal information to guide university course and program design and to support students' Major selection. The corresponding big data lake, natural language processing and multi-source algorithms will also be discussed.

2 - Panel: INFORMS Internal Activities & 2018 INFORMS International Conference Overview
Grace Lin, Institute for Information Industry, 1F, No. 133, Sec. 4, Minsheng E. Rd., Taipei, Taiwan, gracelin.ny@gmail.com

3 - Panelist
Kathryn Stecke, University of Texas at Dallas, Richardson, TX, United States, kstecke@utdallas.edu

4 - Panelist
Mary Magrogan, INFORMS, Catonsville, MD, United States, mary.magrogan@informs.org

■ MC32

351B

Simplicity Versus Complexity in Forecasting and Prediction

Invited: Forecasting and Prediction

Invited Session

Chair: Nathaniel Phillips, University of Basel, Basel, 4001, Switzerland, nathaniel.phillips@unibas.ch

1 - FFTrees: How to Easily Create and Visualise Fast-and-frugal Decision Trees to Make Accurate Decisions Based on Minimal Information
Nathaniel Phillips, Basel, 4053, Switzerland, Nathaniel.D. Phillips.is@gmail.com, Hansjoerg Neth, Wolfgang Gaissmaier, Jan Woike

Fast and frugal decision trees (FFTs) are simple decision algorithms that allow people to make efficient and effective decisions based on limited information. We introduce an R package called FFTrees that allows anyone to create, visualize, and use FFTs from data with minimal programming. We explain how FFTs work and provide a 5 step tutorial for using the FFTrees package to create them. We then present a simulation across a 10 datasets that show how FFTs created by FFTrees can predict data as well as complex machine learning algorithms while remaining simple enough for anyone to understand and use.

2 - Recency: Predicting with Smart Data
Florian Artinger, Max Planck Institute for Human Development, Berlin, Germany, artinger@mpib-berlin.mpg.de

Since the early 1910s, managers have been using a simple recency-based decision strategy, the hiatus heuristic, to identify valuable customers. This study analyzes the role of recency using a library of 60 data sets from business and other areas including weather, sports, and medicine. We find that the hiatus heuristic can perform on par with complex algorithms such as from machine learning and taking into account further variables apart from recency does not improve performance. We show that the results are not so much driven by limited sample size than by the dominant role that recency plays in most of these environments.

3 - Simple Rules for Complex Decisions
Daniel G.Goldstein, Microsoft Research, New York, NY, United States, dan@dangoldstein.com, Jongbin Jung, Connor Concannon, Ravi Shroff, Sharad Goel

We present a new method, select-regress-and-round, for constructing simple rules that perform well for complex decisions. These rules take the form of a weighted checklist and can be applied mentally. Importantly, our method for creating these rules is itself simple, and can be carried out by practitioners with basic statistics knowledge. Across 22 domain, including a key example of bail decision making, we find that these simple rules are nearly as good as state of the art models trained on all available features.

4 - Social Learning Strategies for Matters of Taste
Pantelis Pipergias-Analytis, Cornell University, Ithaca, NY, United States, pantelispa@gmail.com, Daniel Barkoczi, Stefan Herzog

Most choices people make are about "matters of taste", where no universal, objective truth about the options' quality exists. Still, people can learn from the experiences of individuals who have already evaluated available options. We mapped recommender system algorithms to social learning strategies for "matters of taste". Using computer simulations, we studied how people can leverage the opinions of (similar) others to make better decisions. We show that experienced individuals can benefit from relying more on the opinions of seemingly similar people, whereas inexperienced individuals are better off picking the mainstream option despite inter-individual differences in taste.

■ MC33

351C

AAS Special Presentation

Sponsored: Aviation Applications

Sponsored Session

Chair: Virginie Lurkin, Ecole Polytechnique Fédérale de Lausanne, Route Cantonale, Lausanne, 1015, Switzerland, vlurkin@ulg.ac.be

1 - Probabilistic Decision Making and Airline Operations: Why it Pays to Play Games of Chance
Tim Niznik, Director, Operations Systems and Decision Support, American Airlines

Decisions made in the absence of probability-based analytics will not just usually be wrong, they will consistently be wrong, especially when those decisions involve weather and ATC. One of the objectives of the Decision Support Vision for the Operations Control Center at American Airlines is to improve how we respond to weather events, specifically in terms of the determining the timing, level of risk, and specific actions to take. We need to move away from deterministic decision making that is primarily ad-hoc and experience-based to a more data-driven process that is built on predictive analytics and accounts for uncertainty. This talk looks at some examples where probabilistic decision making could be applied, some examples in the industry of where these techniques are already being applied, and finally, our current efforts to develop this capability internally.

■ MC34

351D

Applications of Cyber Defense

Sponsored: Military Applications

Sponsored Session

Chair: Natalie M Scala, Towson University, Towson, MD, 21252, United States, natalie.scala@gmail.com

1 - Reinforcement Learning for Autonomous Cyber Defense
Ahmad Ridley, Department of Defense, Washington, DC, United States, adridle@tycho.ncsc.mil

Our research goal is to build an autonomous cyber defense system that will make an enterprise network, and its associated missions/services, more resilient to cyber-attack. Such a cyber defense system should make decisions and implement appropriate responses to anticipate, withstand, recover from and/or evolve in the presence of cyber-attacks. Since attack methods are constantly evolving, this defense system must be adaptive, and also operate in real-time and at network scale. Therefore, in our research, we apply reinforcement learning to train the system to perform sequential decision making under uncertainty to defend the network.

2 - Performance Benchmarking of Cyber Streaming Analytics
Caleb Baechtold, Janine Bainger, BAH, Baltimore, MD, baechtold_caleb@bah.com

This research effort explores streaming platform behaviors to build models predicting performance metrics of concern as they relate to combinations of system environments and analytic configurations. The research focuses on WaterSlide, an open-source streaming analytic technology commonly used to perform Cyber operations by processing metadata using its event-at-a-time architecture.

3 - Risk Implications in Cybersecurity Applications

Natalie M.Scala, Towson University, Dept. of e-Business and Technology Management, 8000 York Road, Towson, MD, 21252, United States, nscala@towson.edu, Michel Cukier, Allison C. Reilly, Paul L.Goethals

This research addresses risk in cyber defense and identifies opportunities to incorporate risk modeling and decision analysis into current initiatives. Specifically, the Science of Security Five Hard Problems approach frames cybersecurity from a computer science perspective. We identify the problems/attributes that are collectively exhaustive from a risk perspective as well as the overlap with the hard problems framework. Finally, we discuss approaches to take to address risk, including predictive analytics, value modeling, and developing metrics to score performance and measure risk.

■ MC35

351E

Supply Chain Management

Contributed Session

Chair: Xingxing Chen, Washington University-St. Louis, Saint Louis, MO, United States, xingxing.chen@wustl.edu

1 - Customer Order Value Evaluation Model for Customer Classification in Multi-class Production Systems

Hyun-jung Kim, Professor, Seoul School of Integrated Sciences & Technologies, Seoul, Korea, Republic of, charitas@empal.com, Eungab Kim

We consider a manufacturer that produces make-to-order products in retail industry. While inventory rationing has extensively been covered in the literature, how to classify customer orders practically has not been studied yet. We develop a sophisticated modeling scheme that quantifies the value of customer orders. This model is based on statistical and machine learning algorithms. Using data collected from financial statements of retail companies in Korea, we show that our model can be very effective in customer classification for multi-class production systems in practice.

2 - Developing a Continuous Location Routing Model and Solving it by using Benders Decomposition

Ali Sarabi, Arizona State University,Tempe, AZ 85287, United States, asarabi1@asu.edu

One of the most important measures, in order to reduce the costs of logistic and distribution, is to integrate the location of distribution centers and the routing paths of the goods. In this study, we try to develop a model for the decision-making in a continuous situation. The proposed model is actually a model to determine the locations of the facilities and routing in order to deliver products to the customers in a bi-level distributed system. Although the proposed approach and locating in the continues space may be associated with complications, the time and money spent to collect the information about the potential locations for solving the problem will be reduced.

3 - Cooperative Supply Chain Coordination using Sustainability-focused Joint Economic Lot-sizing

Kurt A.Masten, Assistant Professor of Supply Chain Management, Fairleigh Dickinson University, 285 Madison Ave., Unit E, Madison, NJ, 07940, United States, masten@fdu.edu

Considerable efforts have been spent on how to best define and explain "sustainability" from multiple perspectives. Most research in the area concludes that significant savings should be possible with proper application of sustainability principles. However, little attention has been given to the practical logistics and methods required to help shift the discussion from "what" to "how". An updated cooperative solution based on an established joint economic lot-sizing model is proposed to offer a quantitative aid to practitioners and researchers.

4 - Project-based Supply Chain: Role of Operational Hedging

Xingxing Chen, Washington University-St. Louis, Campus Box 1156, One Brookings Drive, Saint Louis, MO, 63130, United States, xingxing.chen@wustl.edu, Panos Kouvelis, Yu Xia

We analyze a two stage supply chain where a Manufacturer sources a key component from suppliers in order to complete a project. The consumption level of the component can't be perfectly predicted due to various reason. Therefore, planning for the component inventory can be critical. We formulates a newsvendor model which includes a linear penalty when delay materializes. We find that 1) optimal operational hedges is contingent on time buffer in an integrated supply chain 2) under a decentralized supply chain, optimal operational hedges occur at different level of the supply chain and may vary with time buffers; 3) supply chain coordination can be achieved.

5 - Consignment Contract with Revenue Sharing in Online Retailing under Strategic Information Sharing

Tatyana Chernonog, Bar-Ilan University, Ramat Gan, Israel. Tatyana.Chernonog@biu.ac.il

This work suggests a general model of a two-echelon supply chain where a dominant retailer and a manufacturer interact via a consignment contract with revenue sharing. The manufacturer's cost function is known only to him, whereas the retailer has to evaluate this function. We formulate the problem as a Retailer-Stackelberg game in which the less-informed party moves first. We investigate a strategic information-sharing policy of the manufacturer when the revenue and cost functions are general as well as the set of his decisions.

■ MC36

351F

Socially Responsible Operations

Sponsored: Service Science

Sponsored Session

Chair: Muge Yayla Kullu, University of Central Florida, Orlando, FL, 32816, United States, muge@ucf.edu

1 - Examining the Impact of Employees with Disabilities on Productivity

Sriram Narayanan, Michigan State University, 632 Bogue Street, Room N357 North Business College Complex, East Lansing, MI, 48824, United States, narayanan@broad.msu.edu, Tharo Soun, Kalyanmoy Deb

In this study, we examine the role of team diversity on employee productivity using real-life time study data. In particular, we examine how diversity of different forms of disability in a garment manufacturing unit.

2 - Diversities in Supply Chain Network an Empirical Study on Supply Chain Governance Strategies in Reducing Carbon Emissions

Baiyang 'Herbie' Huang, Kenan-Flagler Business School, 123B S. Roberson St, None, chapel hill, NC, 27516, United States, herbie_huang@kenan-flagler.unc.edu, Jayashankar M.Swaminathan, Sriram Narayanan

Suppliers are an important aspect of firms in reducing greenhouse gas emissions. Firms use multiple strategies to facilitate this reduction. We empirically examine this question using a novel secondary dataset of 1400 global companies' supply chain carbon emissions mitigation strategies with their supply base. We theorize and empirically test the impact of supplier base diversity in both industry and geographic locations, supply chain's network properties and regulatory environment on the strategies they pursued.

3 - Collaboration Among Supply Chain Partners: Better Outcomes or More Conflict?

Muge Yayla Kullu, University of Central Florida, 4000 Central Florida Blvd., Orlando, FL, 32816, United States, muge@ucf.edu

In this paper, we are interested to find out how acceptable or fragile collaborative sourcing partnership models would be under various supply chain configurations. We account for the heterogeneity of the customer base and differentiation of the products in the market which has not been done before in this context. Our findings indicate that if the end products have independent demand structures, all parties benefit from the end results. However, when there is a quality differentiated product structure with heterogeneous customer base, collaborative sourcing would be lethal for the national brand manufacturer.

■ MC37

352B

Applications in Supply Chain Management

Sponsored: Service Science

Sponsored Session

Chair: Sara Saberi, Worcester Polytechnic Institute (WPI), Worcester, MA, 01609, United States, ssaberi@wpi.edu

1 - Regulation Compliance in the Multilevel Supply Chain

KiHyung Kim, Purdue University, School of Industrial Engineering, 315 N.Grant Street, West Lafayette, IN, 47907-2023, United States, kim1151@purdue.edu

As the supply chain is more globalized, imposing regulation along the supply chain is an issue. In our model, there are three participants in the supply chain, the brand owner, the manufacturer, and the supplier. The supplier is located overseas, and it is a critical issue for the brand owner to let participants comply the domestic regulation. We study three cases: the stick only case, the carrot only case, and the stick and carrot case. Equilibrium is investigated, and our analysis indicates that the stick and carrot strategy can prevent collusion and let participants comply the regulation.

2 - Coordinating a Dual-channel Supply Chain with a Risk-averse Retailer under Deferred Payment

Bo Li, College of Management and Economics at Tianjin University, No.92 Weijin Road, Nankai District, Tianjin, 300072, China, libo0410@tju.edu.cn

The study considers a dual-channel supply chain with a risk-averse retailer under a deferred payment contract. We design a benchmark without deferred payment to compare the equilibrium solutions. We find that if the retailer is moderately risk-averse and the unit production cost is large, the profits of the manufacturer and the entire supply chain will decrease as she tends to be risk-neutral, and vice versa. In addition, whether the two agents benefit from the deferred payment depends on two key parameters (unit production cost and risk-averse attitude). Finally, a mixed contract that combines revenue sharing and deferred payment is introduced to coordinate the dual-channel supply chain.

3 - A Responsive Pricing Retailer Sourcing from Competing Suppliers Facing Disruption

Tao Li, Santa Clara University, 2730 Park Ave Apt 3, Santa Clara, CA, 95050, United States, tli1@scu.edu, Suresh P.Sethi, Xi Shan

We study a problem of a retailer who orders from two competing strategic suppliers subject to independent or correlated disruptions and responds by setting the retail price upon delivery. We model it as a Stackelberg-Nash game with the suppliers as the leaders and the retailer as the follower. We identify a scenario in which an increase in the reliability of a supplier may, counter to our intuition, hurt him. In the literature without responsive-pricing, the retailer's profit increases and a supplier's profit decreases in the disruption correlation, whereas with responsive-pricing, the retailer's profit increases and a supplier's profit may not decrease in the disruption correlation.

4 - Pricing of New Product Technologies in Supply Chains and Technology Markets

Ayhan Aydin, George Mason University, 4400 University Drive, Enterprise Hall, Fairfax, VA, 22030, United States, aaydin2@gmu.edu

Upstream firms can market their technology to downstream tiers either by licensing the use of the technology or through a product carrying the advanced technology. We compare the levels of technology transfer under three different price tariffs - only fixed tariff, only variable tariff, and two-part tariff - and under two methods of marketing on the level of technology transferred.

■ MC38

352C

Parametric LCP and Multiobjective Optimization

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Margaret M Wiecek, Clemson University, Clemson, SC, 29634-1907, United States, wmalgor@clemson.edu

1 - A Two-Phase Algorithmfor the Multi-Parametric Linear Complementarity Problem with Sufficient Matrices and Parameters in General Locations

Nathan Adelgren, Edinboro University of PA, 159 Ross Hall, Edinboro, PA, 16444, United States, nadelgren@edinboro.edu

In this talk we present a new two-phase procedure for solving the multiparametric Linear Complementarity Problem (mpLCP) with sufficient matrices. As the variant of mpLCP considered in this talk was previously unsolved, we first consider the theoretical properties of this problem which allow it to be solved. We then present the solution procedure and explore its use on an example. Finally, we present the results of some preliminary computational experiments.

2 - Multiobjective Quadratic Programming: State of the Art and Application to Portfolio Optimization

Pubudu Jayasekara Merenchige, Clemson University, Clemson, SC, 29634, United States, pwijesi@clemson.edu, Margaret M. Wiecek, Nathan Adelgren

We review algorithms for computing efficient solutions to multiobjective quadratic programs (MOQPs) and analyze their applicability to the portfolio selection problem. We compare the algorithms with respect to the type of MOQPs they can handle. The type is determined by the number of quadratic criteria and the properties of the feasible set.

3 - On the Robustness Gap in Uncertain Multiobjective Optimization

Margaret M.Wiecek, Clemson University, Mathematical Sciences Dept, Clemson, SC, 29634-1907, United States, wmalgor@clemson.edu, Corinna Krüger, Anita Schöbel

We propose a definition of robustness gap in uncertain multiobjective optimization. Under convexity assumptions and using of the weighted-sum scalarization, we derive upper and lower bounds for the gap that are easier to calculate than the gap itself. We also specify conditions under which the gap is zero.

4 - A Cost to Coverage Ratio Based Heuristic Algorithm for the Multiobjective Set Covering Problem

Lakmali Weerasena, University of Tennessee Chattanooga, 9629 Shooting Star Circle, Chattanooga, TN, 37379, United States, lakmali-weerasena@utc.edu

The multiobjective set covering problem (MOSCP), a NP-hard combinatorial optimization problem, has received limited attention in the literature from the perspective of approximating its Pareto set. We present a two-phase heuristic algorithm to approximate the Pareto set of the MOSCP. Computational experiments on instances with two, three and four-objective set covering problems are conducted to analyze the performance of the algorithm.

■ MC39

352D

Smart Services and Service Systems

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Pennsylvania State University, Malvern, PA, 19355, United States, robinqiu@psu.edu

1 - Research on the Quality Promotion System of Logistics Service

Zuqing Huang, PhD, China Jiliang University, Hangzhou, 310018, China, hzq1210@163.com

With the rapid development of e-commerce, the logistics industry has been got the rapid development. But the quality of logistics service is unsatisfied. From the perspective of the quality of logistics service, this paper constructed the index system of logistics service and provided a method to evaluate the quality of logistics service.

2 - A Patient-centric Approach to Mitigating Alzheimer's Disease Progression

Robin Qiu, Pennsylvania State University, 30 E. Swedesford Road, Malvern, PA, 19355, United States, robinqiu@psu.edu

In 2016, about 5.4 million Americans were diagnosed with Alzheimer's disease (AD). The project was to develop a predictive model to classify a patient into normal, mild, and moderate, and severe AD stages. Based on the patient's cognition evaluation, we aim to develop a cheap, convenient, and accurate self-diagnostic tool. More importantly, actionable factors that could slow down the disease's progression are determined. Hence, this study would be able to facilitate developing a platform to guide an individual in making the necessary lifestyle choices, ultimately resulting in retaining or rejuvenating the brain's cognitive ability of the individual.

3 - Identification of Critical Quality Dimensions for Continuance Intention in mHealth Services: A Case Study of Onecare Service

Ki-Hun Kim, Pohang University of Science and Technology, 77 Cheongam-Ro Nam-Gu, Engineering Building 4-316, Pohang, Gyeongbuk, 790-784, Korea, Republic of, kh_kim@postech.ac.kr, Kwang-Jae Kim, Dae-Ho Lee, Min-Geun Kim

Mobile health (mHealth) services provide health-related support through mobile devices. Onecare is an mHealth service to support health behavior monitoring of college students by utilizing daily behavior data collected through activity trackers and smartphones. This study aims to identify the quality dimensions that are crucial for users' intention to continue the use of Onecare based on the survey responses of 191 Onecare users. This study would serve as a basis for planning mHealth service improvement to enhance users' continuance intention.

4 - Directed Disease Networks in Support of Multiple-disease Risk Prediction Modeling

Tingyan Wang, Ph.D candidate, Tsinghua University, Beijing, 100084, China, wangty14@mails.tsinghua.edu.cn, Robin Qiu, Ming Yu

In this study, we propose a novel framework that combines directed disease network and collaborative filtering techniques for multiple disease risk prediction modeling. Firstly, a directed disease network considering temporal information was built on grouped diseases. Then based on this network, we explore different disease risk score computing approaches. We validate the proposed methods with real-world datasets. The results demonstrate the potential value of the proposed modeling framework, e.g. a reference for medical experts to provide patients healthcare guidance, or a tool helps individuals design a better healthcare plan over time.

■ MC40

352E

Daniel H. Wagner Prize Competition II

Invited: Daniel H. Wagner Prize Competition

Invited Session

Chair: Patricia Neri, SAS Institute, Inc., 104 Grandtree Ct., Cary, NC, 27519, United States, patricia.neri@sas.com

1 - Crew Decision Assist: Optimizing Crew Deployment for Freight Trains

Dasaradh Mallampati, BNSF, Ft. Worth, TX, United States, dasaradh.mallampati@bnsf.com, Brian Roth, Anant Balakrishnan, Pooja Dewan, April Kuo, Juan Morales

Crew costs account for a significant portion of train operating expenses, and so effective crew deployment is an important priority for railroad companies. Motivated by BNSF Railway's desire to replace the current manual crew planning process with a systematic and efficient approach, we developed an optimization model and solution methodology, and implemented a system called Crew Decision Assist (CDA) to support crew scheduling for single-ended districts at BNSF. Our approach is novel because it incorporates many practical details in train crew scheduling and accounts for uncertainty in train schedules. CDA interfaces with existing systems to quickly generate effective crew deployment plans, and is expected to yield cost savings of several million dollars per year.

2 - Optimized Scoring Systems: Towards Trust in Machine Learning for Healthcare and Criminal Justice

Cynthia Rudin, Duke University, 737 E. Franklin St, Chapel Hill, NC, 27514, United States, cynthia@cs.duke.edu, Berk Ustun

Questions of trust in machine learning models are becoming increasingly important, as these models are starting to be used widely for high-stakes decisions in medicine and criminal justice. Transparency of models is a key issue affecting trust. The topic of transparency in modeling is being heavily debated in the media, and there are conflicting laws on the use of black box models between the European Union and the United States. This paper reveals that: (1) There is new technology to build transparent machine learning models that are often as accurate as black-box machine learning models. (2) These methods have had impact already in medicine and criminal justice. This work calls into question the overall need for black box models in these applications.

■ MC41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Anders Gullhav, Norwegian University of Science & Technology, Trondheim, Norway, anders.gullhav@iot.ntnu.no

1 - Impact of Budget Uncertainty in a Coordinated Vaccine Market

Nicholas Morris, Rochester Institute of Technology, Rochester, NY, 14623, United States, njm2868@rit.edu, Jose Batista, Ruben Proano

This study evaluates the impact on total welfare in a coordinated vaccine market when countries' procuring budgets are uncertain. This uncertainty is represented through two approaches. A simulation is used to evaluate each procurement approach on randomly generated scenarios. Each experimental instance is solved via a mixed integer nonlinear program model that generates a procurement schedule. An example is discussed on how uncertainty in the US Federal budget for vaccine procurement could impact the global vaccine market.

2 - An Approximate Dynamic Programming Approach for Patient and Process Prioritization in a Hospital Environment

Lida A. Apergi, University of Maryland, 8223 Paint Branch Drive, 2243 AV. Williams, ISR, College Park, MD, 20742, United States, lapergi@rhsmith.umd.edu, John Baras, Bruce L. Golden, Kenneth Wood

This research tackles the problem of patient and process prioritization in a healthcare environment with limited resources. Considering the medical cardiology department of a large medical center, a holistic model is designed and developed towards optimizing the decisions of allocating the available resources to the patients in order to minimize patients' waiting costs. Approximate Dynamic Programming techniques are applied to optimize the aforementioned decisions over time, as well as capture the heterogeneity of the patients.

3 - Optimizing the Appointment Scheduling at MRI Labs

Anders N. Gullhav, Norwegian University of Science & Technology, Department of Industrial Ec & Tech Man, Trondheim, 7491, Norway, anders.gullhav@iot.ntnu.no, Marielle Christiansen, Anders R. Eilertsen, Bjorn Nygreen, Hanna M. Selvaag

We study the appointment scheduling problem, where randomly arriving examination requests are to be allocated to an MRI machine at a specific time and day in the future. Due to the different urgency levels of the requests, ranging from hours to weeks and months, the MRI planners must ensure that there is enough available time at any given day to schedule urgent patients, while maintaining a high utilization. We develop an optimization model that schedules non-urgent patients and facilitates the scheduling of urgent patients. The model is run in a rolling horizon framework, and is tested on real data from a Norwegian hospital. We show how the model can be used as decision support in the scheduling process.

■ MC42

360A

1:30 - 2:15 Lindo Systems, Inc/ 2:15 - 3:00 Artelys Corp

Invited: Vendor Tutorial

Invited Session

1 - Optimization Modeling Tools from LINDO Systems

Mark A.Wiley, LINDO.Systems Inc, 1415 No. Dayton Street, Chicago, IL, 60622, United States, mwiley@lindo.com

Exceptional ease of use, widest range of capabilities, and flexibility have made LINDO software the tool of choice for thousands of Operations Research professionals across nearly every industry for over 30 years. LINDO offers a full range of solvers to cover all your optimization needs. The Linear Programming solvers handle million variable/constraint problems fast and reliably. The Quadratic/SOCP/Barrier solver efficiently handles quadratically constrained problems. The Integer solver works fast and reliably with LP, QP and NLP models. The Global NLP solver finds the guaranteed global optimum of nonconvex models. The Stochastic Programming solver has a full range of capabilities for planning under uncertainty. Get all the tools you need to get up and running quickly. LINDO provides a set of versatile intuitive interfaces to suit your modeling preference. What's Best is an add-in to Excel that you can use to quickly build spreadsheet models that managers can use and understand. LINDO has a full featured modeling language for expressing complex models clearly and concisely, and it has links to Excel and databases that make data handling easy.LINDO API is a callable library that allows you to seamlessly embed the solvers into your own applications. You can pick the best tool for the job based upon who will build the application, who will use it, and where the data reside. Technical support at LINDO is responsive and thorough - whether you have questions about the software or need some guidance on handling a particular application. Get started today. Visit our booth or www.lindo.com to get more information and pick up full capacity evaluation licenses to try them out on your toughest models.

2 - Discover Artelys Knitro, the Leading Solver for Nonlinear Optimization

Richard Waltz, Artelys, 150 N.Michigan Avenue, Suite 800, Chicago, IL, 60601, United States, Richard.waltz@artelys.com

Artelys Knitro is the premier solver for nonlinear optimization problems. This software demonstration will highlight the latest Knitro 10.3 developments, including a new preconditioner option, advancements in solving large nonlinear least-squares models and enhancements to the R interface. In addition, we will summarize some of new features coming in Knitro 11.0. The demo will also provide an overview of how to effectively use Knitro in a variety of environments.

■ MC43

360B

Humanitarian and Disaster Relief Logistics

Sponsored: Public Sector OR

Sponsored Session

Chair: Christopher Zobel, Virginia Tech, Blacksburg, VA, 24061-0235, United States, czobel@vt.edu

Co-Chair: Andrew N. Arnette, University of Wyoming, Laramie, WY, 82071-2000, United States, aarnette@uwyo.edu

1 - An Optimization Model for Disaster Relief Asset Pre-positioning

Andrew Arnette, University of Wyoming, aarnette@uwyo.edu, Christopher Zobel

This research extends previous work on improving the pre-positioning of assets used for disaster relief. It is founded on an evidence-based analytical model that utilizes multiple factors for analytically characterizing risk. This, in turn, is used to determine the potential need for the sheltering of impacted populations in the face of multiple possible natural disasters. By explicitly considering risk, the model is able to consider overall effectiveness at the same time that it ensures equity in the resource allocations.

2 - Resiliency: How Perception Informs Action
Michelle Seref, Virginia Instiitute of Technology, Blacksburg, VA, United States, mmhseref@vt.edu

This research uses text mining to analyze how the perception of a community's resilience stance, as reflected in newspaper accounts of disaster events, affects subsequent actions taken by the community, both businesses and public policy. Preliminary results show a correlation between resilience stance and type of action, as well as resilience stance and type of disaster.

3 - Optimal Allocation of Reserved Inventories in a Supply Network with Demand Surge
Liu Fang, Nanyang Technological University, Singapore, Singapore, Liu_Fang@ntu.edu.sg, Pengfei Guo, Yulan Wang

We study the optimal pre-positioning of reserved emergency inventories in a supply network that faces random demand surge, with the aim of minimizing the expected total unmet demand. The demand surge follows a time-dependent stochastic process, and the post-surge transshipments of the reserved inventories are scenario-driven uncertain. We characterize the matching processbetween the post-surge delivery of the reserved inventories and the corresponding demand surge process and derive the expected total unmet demand.

4 - Routing for Post-disaster Needs Assessment to Improve Information Accuracy
Duygu Pamukcu, Middle East Technical University, Ankara, 06400, Turkey, duygupamukcu@gmail.com, Melih Celik, Burcu Balcik

In the aftermath of the disaster, the accuracy of the estimates on disaster effects depends on how much time is spent for statistical sampling to collect information. In this study, we consider the problem of routing needs assessment teams, where there exists an inherent trade-off between information collection and travel time. Mathematical models and solutions approaches are presented to analyze this trade-off and support sample size and site selection decisions.

■ MC44

360C

Marketing

Contributed Session

Chair: Omid Javidbakht, Lehigh University, Bethlehem, PA, United States, omj212@lehigh.edu

1 - When Does Price Matching Mitigate Showrooming
Yilong Luo, Illinois Institute of Technology, 565 West Adams Street, Chicago, IL, 60661, United States, yluo4@hawk.iit.edu, Jiong Sun

Consumers' "showrooming" behavior poses a threat to brick-and-mortar stores. In our paper, we study when the price matching policy is effective in mitigating this behavior and enhancing stores' profits. First, we show that price matching may hurt stores when the mis-match risk is relatively high and only a few consumers are aware of this policy. Second, we show that under some cost conditions, the manufacturer can benefit from price matching and, therefore, has incentives to support this policy without intensifying the downstream market competition.

2 - Tie-in with Downstream Competition
Sreya Kolay, Assistant Professor, University of California, Irvine, 8 Vega Court, Irvine, CA, 92617, United States, skolay@uci.edu

Sellers often use tie-in contracts, offering a product only as a part of a bundle of two or more products and not by itself. Such contracts have been accused of being used for exclusionary purposes, i.e., a dominant firm in a primary product market can use such contracts to force buyers to purchase a secondary product from it to exclude a more efficient rival in the latter market. This paper examines a dominant firm's incentives to offer exclusionary tie-in contracts when it sells its products through downstream competing retailers. The profitability of exclusionary tying is shown to be related to two key factors: the ability to commit to prices by the upstream firms, and the nature of downstream competition.

3 - Strategic Choice of Quality for Entrants in the Presence of Anchoring Effect
Keita Nire, Keio University, Yokohama, Japan, k.nire1030@gmail.com, Nobuo Matsubayashi

In this study, using a two-stage duopoly model of vertical product differentiation, we investigate how the anchoring effect, where consumers' perceived quality is affected by a predetermined quality position, influences an entrant's quality choice when it competes with an incumbent firm. We show the optimal quality choice for the entrant, along with its resulting profitability, with varying degrees of anchoring effect.

4 - The Implications of Market Characteristics for Vertical Strategic Interactions in Supply Chains
Shahryar Gheibi, Siena College, The School of Business, Siena College, 515 Loudon Rd, Loudonville, NY, 13204, United States, sgheibi@siena.edu, Eunkyu Lee

Our analysis on the relationship between market characteristics and the type of vertical strategic interactions in supply chains fully identifies the linkage, and demonstrates that a single aggregate-level demand property, demand's decay rate, holds the key. We show the generality of our results and their practicality for managers. Our results indicate that an empirical distribution of consumers' willingness to pay provides insights into the type of strategic interactions in a decentralized distribution channel. Our findings also lead us to propose some interesting strategic implications of the product type (broadly targeted vs. niche) for price leadership in supply chains.

5 - Information Provision in a Vertical Channel
Chenchen Di, UIUC, Champaign, IL, 61820, United States, cdi2@illinois.edu, Yunchuan Liu, Jiong Sun

This paper investigates how manufacturers and retailers play different roles in revealing product quality information and facilitating consumers' learning their appreciation for quality, respectively, when consumers face uncertainties for both. We find that firms' incentives of information provision may or may not be aligned, and it depends on the flexibility of information provision. Both the retailer and the manufacturer can benefit from flexible information provision.

6 - Coupon Targeting Competition in Privacy Sensitive Market
Omid Javidbakht, Lehigh University, 19 Memorial Dr, Room 304, Bethlehem, PA, 18015, United States, omj212@lehigh.edu, Alberto J.Lamadrid, Parv Venkitasubramaniam

The problem of coupon targeting competition between two retailers which sell the same product with the same price and marginal cost is studied. The competition is modeled by a set of non-zero sum stochastic games over consumers located on a specific segment of Hoteling line. Equilibrium and optimal stationary policies of retailers on each segment is derived. Moreover, It is demonstrated that a retailer will have lower defensive strategy on the consumers with weak preference on him whilst the rival retailer will have higher offensive strategy on the same consumers as discounting factor increases.

■ MC45

360D

WORMS: Managing the Work/Life Balance

Sponsored: Women in OR, MS

Sponsored Session

Chair: Xiajun Amy Pan, University of Florida, Gainesville, FL, 32611-7169, United States, amy.pan@warrington.ufl.edu

1 - Moderator
Xiajun Amy Pan, University of Florida, P.O. Box 117169, 364 Stz, Gainesville, FL, 32611-7169, United States, amy.pan@warrington.ufl.edu

In this panel session, successful male and female academics will discuss the topic of achieving work/life balance. In particular, they will address questions such as how to manage dual career households, how to balance the constraints of work with the care of kids and elderly parents, how to best organize one's time and maximize productivity, etc. Bring a male colleague along to attend the session and both of you get a free WORMS coffee mug!

2 - Panelist
Haoying Sun, Texas A.& M.University, Mays Business School, Info Department, 320 Wehner Building, College Station, TX, 77843-4217, United States, hsun@mays.tamu.edu

3 - Panelist
Burcu B.Keskin, University of Alabama, 4138 Meretta Lane, Tuscaloosa, AL, 35406, United States, bkeskin@cba.ua.edu

4 - Panelist
Kyle D.Cattani, Indiana University, Kelley School of Business, 1309 E.Tenth Street, Bloomington, IN, 47405, United States, kcattani@indiana.edu

5 - Panelist
Gokce Esenduran, Ohio State University, 2100 Neil Avenue, 656 Fisher Hall, Columbus, OH, 43210, United States, esenduran_1@fisher.osu.edu

6 - Panelist
Karen L.Donohue, University of Minnesota, SCO.Department, 321 19th Street Avenue S, Minneapolis, MN, 55455, United States, donoh008@umn.edu

7 - Panelist
Irina Dolinskaya, National Science Foundation, 101 Gracie Park Dr, Herndon, VA, 20170, United States, irina.s.dolinskaya@gmail.com

■ MC46

360E

Scheduling and Logistics

Invited: Project Management and Scheduling

Invited Session

Chair: Xiangtong Qi, Hong Kong University of Science & Technology (HKUST), Kowloon, Hong Kong, ieemqi@ust.hk

1 - Approximation Algorithms for Capacitated Vehicle Routing Problems with a Fixed Number of Depots

Liang Xu, Associate Professor, Southwestern University of Finance & Economics, 555 Liutai Avenue, Tongbo Tower A.202, Chengdu, China, arecxuliang1112@gmail.com, Zhou Xu

We study problems of routing capacitated vehicles to serve customers with an objective to minimize the total travel distance. In this talk, we present several novel constant ratio approximation algorithms, which run in polynomial time when vehicles are located at a constant number of depots.

2 - Scheduling Service Package with Acclimation and Non-homogeneous Memory Decay

Yifu Li, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, 999077, Hong Kong, ylick@connect.ust.hk, Tinglong Dai, Xiangtong Qi

Sequence decision of an experiential service is intensively studied by researchers from various disciplines. While empirical research shows that the ideal schedule is usually with the peak activity early in the interior, behavior study suggests that a sequence with the peak activity by the side is optimal. To address this inconsistency, we introduce a modification of the acclimation and memory decay model. We examine the condition of the interior peak optimal schedule, and we find the optimal position of the peak activity may change non-monotonically as its memory decay rate increases. Furthermore, we explore the shape property and propose an optimal algorithm for the service scheduling problem.

3 - Due Date Assignment and Scheduling on a Single Machine with Limited Information of Job Processing Times

Guohua Wan, Shanghai Jiao Tong University, 535 Fahua Zhen Road, Antai College of Economics and Management, Shanghai, 200052, China, ghwan@sjtu.edu.cn, Qing Yue, Shenghai Zhao

We study a single machine scheduling problem with due date assignment and stochastic job processing times, where only the mean and support of job processing times are known but not the distribution. The objective is to minimize the total costs of earliness, tardiness and due date assignment. We develop an approximation for the problem and propose both branch and bound and heuristic algorithms to find the optimal solution. We also conduct computational experiments to evaluate the efficiency of approximation and the performance of proposed heuristic algorithms.

4 - Stabilizing Unbalanced Cooperative Scheduling Games

Xiangtong Qi, Hong Kong Univ. of Science & Technology (HKUST), Dept of IELM, HKUST, Kowloon, Hong Kong, ieemqi@ust.hk

We consider cooperative parallel machine scheduling games. In many cases such games are unbalanced, i.e., having an empty core. Hence the grand coalition of the game is not stable. We study how an outsider can take some action to stabilize the game so that the grand coalition can be sustained. We will discuss different schemes and show how each of them works.

■ MC47

360F

Managing Service Delivery and Software Processes in an ebusiness Environment

Sponsored: EBusiness

Sponsored Session

Chair: Yonghua Ji, University of Alberta, Edmonton, AB, T6G 2R6, Canada, yji@ualberta.ca

1 - Does Online Real Estate Information Affect Property Price? Evidence from Zillow

Zhengrui Jiang, Iowa State University, Iowa CIty, IA, United States, zjiang@iastate.edu, Yuheng Hu, Arun Rai, Hua Sun

Using data collected from Zillow.com, this study examines how online property information affects offline property price. Our results reveal that property information has a larger influence on the sale price of uncommon properties, i.e., those valued significantly lower or higher than neighborhood averages, than on the price of common properties, i.e., those valued close to neighborhood averages. Furthermore, we find that Zestimate, property value assessed by Zillow, influences the price of all properties. Finally, sellers tend to provide more property information when a property is more expensive, less comparable to surrounding ones, or priced higher than its estimated property value.

2 - Optimal Pricing and Workforce Composition for Service Delivery using a Hybrid Workforce

Monica Johar, University of North Carolina, 9201 University City Blvd, Friday 352 C, Charlotte, NC, 28223, United States, msjohar@uncc.edu

Organizations are increasingly able to use an on-demand workforce to complement in-house workers to perform sophisticated workflows in a Hybrid Service environment. Such sophisticated workflows include simple as well as more complex integration tasks. We present an optimization model that integrates pricing, workforce composition and task allocation decisions for such a hybrid service environment.

3 - How Much to Open, How Fast to Fix and Develop? Impacts of Openness on Software Development and Maintenance

Rakesh Mallipeddi, TX, United States, mallipeddi@tamu.edu, Emre Muzaffer Demirezen, Subodha Kumar, Ram Gopal

Proprietary software vendors have recently begun to emulate the open source software community in opening up part of their software. We analyze the impact of software openness in the context of resource allocation between bug fixing and new version development, an important operations issue that many software vendors face in light of prevalence of software defects. We first empirically analyze the impact of openness on time it takes to fix a defect. Using the findings from the empirical study, we formulate optimal control models to examine the effects of making the software code open (fully or partially) on the overall quality of the software and the development efforts of its next version.

4 - Dynamic Optimization of Software Maintenance Requests with Duplications

Yonghua Ji, University of Alberta, Business School, Edmonton, AB, T6G 2R6, Canada, yji@ualberta.ca, Said Samiedaluie

We study the problem of software request maintenance by using a dynamic optimization approach. We consider both duplication of and prioritization of requests. Duplicated requests can arrive independently and are grouped before being worked on. Also requests are classified into different priority classes. Our work explores various characteristics of an optimal policy.

■ MC48

361A

Opportunities and New Directions for Behavioral OM

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Robert Batt, Wisconsin School of Business, UW-Madison, Madison, WI, 53706, United States, rbatt@bus.wisc.edu

Co-Chair: Jordan Tong, University of Wisconsin-Madison, Madison, WI, United States, jordan.tong@wisc.edu

1 - Humans are not Machines: Queueing with Human Servers

Amy R.Ward, University of Southern California, Marshall School of Business, Bridge Hall BR.I.401H, Los Angeles, CA, 90089-0809, United States, amyward@marshall.usc.edu

There is a long history of using queueing models for system design purposes. This is because there is a well-developed framework that provides insightful analytic expressions for many performance measures of interest, such as expected customer wait time. The issue is that traditional queueing models assume processing rates are fixed. However, in many systems that arise both in manufacturing and service applications, people rather than machines are doing the processing, and people may change their processing rates. In this talk, we discuss how to incorporate behavioral elements in queueing models. We highlight some surprising results, and propose some open questions.

2 - Beyond the Lab: Next Frontiers in Behavioural Research

Serguei Netessine, University of Pennsylvania, Philadelphia, PA, United States, netessin@wharton.upenn.edu

While vast majority of behavioural research in our field uses lab experiments, there are important complementary approaches that we need to utilise going forward to make stronger practical impact. I will discuss these approaches using recent papers as examples.

■ MC49

361B

Influence of Human Behaviour on Project Success: Theories, Models and Practices

Invited: InvitedBehavioral Aspects of OR

Invited Session

Chair: Sijun Bai, Management School, Northwestern Polytechnical University, Xi'an, China, baisj@nwpu.edu.cn

Co-Chair: Lin Wang, Management School, Northwestern Polytechnical University, Xi'an, China, linwang.nwpu@gmail.com

1 - Research on Emergency Decision Management of Chemical Accidents Based on Game Theory

He Zhai, Northwestern Polytechnical University, Xi'an, China, zhaihe0218@163.com, Mengna Guo, Yuntao Guo

With the arrival of China's economic and social transition period,the complexity and dynamics of various projects are gradually increasing, which makes the project management more difficult. In recent years, the safety accidents and unexpected events in Shaanxi province emerge in endlessly,and the "conspiracy of optimism" is the main factor leading to the failure of decision-making. Based on the game theory, this paper analyzes the reasons of the "conspiracy of optimism" phenomenon in the process of emergency decision making and a model will be constructed based on this problem, which may provide a reference for the improvement of the emergency decision-making management.

2 - Project Portfolio Implementation under Uncertainty: A Behavioral Perspective

Lin Wang, Northwestern Polytechnical University, Xi'an, China, linwang.nwpu@gmail.com

Lin Wang, Institutes of science and development, Chinese Academy of Sciences, Beijing, China, linwang.nwpu@gmail.com, Sijun Bai

As a social system highly influenced by decision makers' behaviors, the management of project portfolios should highlight behavioral factors instead of adhering to rational and normative plans. This paper investigates the uncertainties generated by behavioral biases (e.g. planning fallacy, strategic misrepresentation and optimism bias), how should decision makers respond to these uncertainties, and the impact of individual and interactive biases (e.g. lies and delays) on the monitoring and control process. System dynamics is applied to model the complex system and provide the foresight of each decision, and an example is illustrated to validate the model.

■ MC50

361C

Privacy in Urban Transportation

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Christian Claudel, University of Texas-Austin, Austin, TX, United States, christian.claudel@utexas.edu

1 - Privacy Aware Traffic Monitoring in Work Zones

Daniel Work, University of Illinois, Urbana, IL, United States, dbwork@illinois.edu, Yanning Li

Despite the increasing popularity of Lagrangian sensors, fixed location traffic sensors are still irreplaceable in certain safety-critical applications, such as monitoring traffic in work zones. However, the high cost and privacy concerns of conventional fixed video-based monitoring systems create economic and policy challenges for dense sensor deployments. This talk advocates the use of a low-resolution passive infrared camera to reduce both energy demands and privacy challenges. To extract vehicle counts and speeds from the sensor, an unsupervised machine learning algorithm is proposed. Results from recent field experiments will be discussed.

2 - Differentially Private Road Traffic Estimation

Jerome Le Ny, Polytechnique Montreal, Montreal, QC, H3T1J4, Canada, jerome.le-ny@polymtl.ca

Urban transportation systems rely on an increasing number and variety of sensors capturing our activities in order to optimize their operations, which raises important privacy concerns. Naive data sanitization techniques such as removing names from location traces are known to provide insufficient protection. This talk gives an introduction to differential privacy, a state-of-the-art formal tool for privacy preserving data analysis, and illustrates its application to real-time traffic estimation with static sensors and floating car data.

3 - A Dual Machine Learning-model Based Framework for Privacy Analysis of Traffic

Christian Claudel, University of Texas-Austin, TX, 78750, United States, christian.claudel@utexas.edu

In this talk, we consider the problem of tracking vehicles generating anonymous GPS tracks. Using an Hamilton Jacobi formulation of traffic flow, we pose the problem of reidentifying anonymous tracks as a Mixed Integer Linear program (MILP). This MILP results is used as an input to an Artificial Neural Network (ANN) classifier that reidentifies vehicles from anonymous tracks. This framework is validated using experimental location data, and shows that 94% reidentification is possible, considerably above random reidentification (50%) or naive reidentification based on the kinematics of vehicles (88%).

4 - An Algorithm for Preserving the Privacy of Sharing Transport Service Route Data

Yueshuai He, New York University, New York, NY, United States, yh1995@nyu.edu, Joseph Y j Chow

Despite the increasing relevance of private transport operators as Mobility-as-a-Service in the success of smart cities, desire for privacy in data sharing limits collaborations with public agencies. We propose an original model and algorithm that circumvents this limitation, by designing a diffusion of the data—in this case, service tour data—such that passenger travel times remain reliable to the recipient agency. The Tour Sharing Privacy Design Problem is formulated as a nonlinear programming problem that maximizes entropy. An algorithm based on formulation of an equivalent kth best traveling salesman problem is evaluated using several network instances.

■ MC51

361D

Field Experiment in Online Marketplace and Social Network

Sponsored: Information Systems

Sponsored Session

Chair: Tianshu Sun, University of Southern California, Los Angeles, CA, 90089, United States, tianshus@marshall.usc.edu

1 - Learning from Inventory Information: Field Evidence from Amazon

Ruomeng Cui, Goizueta Business School, Emory University, 1300 Clifton Rd, Atlanta, GA, 30322, United States, ruomeng.cui@gmail.com, Dennis Zhang, Achal Bassamboo

Many online retailers provide real-time inventory availability information. Customers can learn from the inventory level and update their beliefs about product quality. Based on a unique setting from Amazon lightning deals, which displays the percentage of inventory consumed in real time, we explore whether and how consumers learn from inventory availability information. We run randomized field experiments on Amazon and run a panel data analysis. We find evidence of consumer learning from inventory information: a decrease in product availability causally attracts more sales in the future; in particular, a 10% increase in past sales leads to a 2.08% increase in cart add-ins in the next hour.

2 - Dynamic Personalized Targeting with Hidden Use Engagement Stages: Mobile Tapstream Data and Field Experiment

Yingjie Zhang, Carnegie Mellon University, Pittsburgh, PA, United States, yingjie2@andrew.cmu.edu, Beibei Li, Xueming Luo, Xiaoyi Wang

Low engagement rate and high attrition rate have been major challenges for the success of mobile apps. To date, little is known towards how companies can improve user engagement and business revenues through designing effective in-app pricing strategies. We propose a structural model by accounting for time-varying nature of engagement and consumer forward-looking behavior. We analyze mobile tapstream data from a popular mobile reading app. Our results enable us to tailor optimal pricing strategy to each consumer based on their engagement status. Interestingly, we found such engagement-specific pricing strategy leads to lower average price for consumers and higher overall business revenues.

3 - Social Influence Across Products: A Large-Scale Randomized Experiment in Social Advertising

Shan Huang, Massachusetts Institute of Technology, 100 Main Street, # 427, Cambridge, MA, 02142, United States, shanh@mit.edu, Sinan Aral, Jeffrey (Yu) Hu, Erik Brynjolfsson

Spending on social advertising is increasingly dramatically. Unfortunately, large-scale experimental evidence of the lift from social ads almost always focuses on a single product at a time. As a result, we know little about how social influence and the effectiveness of social advertising vary across product categories. We, therefore conducted a randomized field experiment measuring social influence and social ad effectiveness across 71 products in 25 product categories among a random sample of more than 37 million users of WeChat Moments Ads.

4 - Social Media Integration and E-commerce Platform Performance: A Randomized Field Experiment

Ni Huang, Arizona State University, Tempe, AZ, United States, ni.huang@asu.edu, Tianshu Sun, Pei-yu Chen, Joseph Golden

E-commerce platforms can integrate with social media to let users directly comment on product pages. Such integration can convey credible information but may also hinder product sales due to less control over user comments. Thus, it is not clear whether an ecommerce platform should embrace such integration. We conduct a randomized experiment with a large ecommerce platform to examine the impact of social media integration on users' shopping behaviors. We find customers in the treatment, who see product pages with Facebook comment integration, are significantly more likely to place an order. We further explore heterogeneous treatment effects and find them aligned with social learning mechanism.

■ MC52

361E

Energy

Contributed Session

Chair: Zhi Zhou, Argonne National Laboratory, 9700 South Cass Avenue, Bldg 221, Argonne, IL, 60439, United States, zzhou@anl.gov

1 - Efficient Pricing Methodologies for Integration of Distributed Technology.

J.M.Omar Khaiam, PhD Candidate, University of Auckland, Auckland, New Zealand, jkha088@aucklanduni.ac.nz, Anthony Downward

With the rapid development of solar PV and holdhouse and grid-scale battery technology, the distribution network facing a number of challenges. In this presentation we discuss a model that determines how batteries should be installed in the distribution network (either by households, or by the distribution network owner), and how changes to the distribution tariff structure may induce efficient investment choices. We examine whether the economic 'death-spiral' for distribution assets can be avoids using efficient market signals.

2 - A Mixed Complementarity Problem Extension to Find Near Equilibrium Electricity Prices for Non-convex Unit Commitment Models

Mehrdad Pirnia, University of Waterloo, 200 University Ave, West, Waterloo, ON, N2L3G1, Canada, mpirnia@uwaterloo.ca, Hassan Shavandi, John David Fuller

We propose a realistic unit commitment model, based on an extension of the mixed complementarity problem method, to approximate the minimization of the opportunity cost of electricity market players, including generators, consumers and transmission line operators. The opportunity costs arise due to the nonconvexities of binary variables for the on/off status of generators. The solution of the proposed model reduces the opportunity cost of generators, compared to the standard maximum social welfare calculation for unit commitment, and it provides near equilibrium electricity market prices and generation dispatch quantities.

3 - Investments in Power Generation and Transmission: The Effect of Capacity Procurement

Kazuya Ito, Tokyo University of Science, 2641 Yamazaki, Noda-shi, Chiba, 278-8510, Japan, 7416605@ed.tus.ac.jp, Ryuta Takashima, Makoto Tanaka

The penetration of renewable energy has induced a decrease in capacity factors and a decommissioning for existing generations, and a reduction in new investments. This problem implies a fear for the shortage of capacity in the electricity market. Thus, in order to meet the capacity in the market, policymakers implement various policies for capacity procurements. In this work, we analyze investments in power generation and transmission by means of real options theory. The ISO decides the investment timing by maximizing social welfare whereas a generation firm invests by maximizing the own profit. Especially, we examine the effect of capacity procurement for the ISO on the investment decisions.

4 - Energy-water Nexus Modeling and Analysis: From Cooling Water Efficiency and Electric Grid Operation Perspectives

Zhi Zhou, Argonne National Laboratory, 9700 South Cass Avenue, Bldg 362, Argonne, IL, 60439, United States, zzhou@anl.gov, Ying Wang, Getnet Betrie, Eugene Yan

Most electricity generation needs large amounts of cooling water, which is extensively demanding in hot and arid areas. We propose a model to estimate the water usage (including water withdraw and consumption) in the power plants operation based on practical operation data. The water usage model reflects the impacts of environment temperature, electricity generation and cooling technologies, et. al. The cooling efficiency and water availability constraints are integrated into the power system operation model. Results show that water availability and temperature have significant impact on power grid economics.

■ MC53

361F

Opportunities and Issues of Shared Mobility Services

Sponsored: TSL, Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Mohammad Abdollahi, Wayne State University, 4815 Fourth Street, Room 1067, Detroit, MI, 48202, United States, abdollahi@wayne.edu

1 - Dynamic Ride Pooling. Benefiting from Last Mile Opportunity

Mohammad Abdollahi, PhD Student, Wayne State University, 4815 Fourth Street, Room 1067, Detroit, MI, 48202, United States, abdollahi@wayne.edu, Kai Yang

This paper is addressing the design of DRT system where real-world practical constraints are considered in providing customized vehicle routing and scheduling. Designing this system allows for dispatch operators to quickly explore tradeoffs between level-of-service and operating costs. We have developed a constraint programming based benders decomposition algorithms for this system. Using the methodology developed in this paper we expect not to have just cost benefits, but also improved quality of service and the reduction in total vehicle-kilometers traveled which leads to environmental benefits.

2 - The Effect of New Shared Mobility Services on the Transportation Network

Mona Asudegi, Lead Technologist, Booz Allen Hamilton, 20 M St. SE, #1000, DC, 20003, United States, asudegi_mona@bah.com, Sara Sarkhili

Mobility market is rapidly changing due to changes in technology, information availability, and social trends. More people are using these new forms of mobility services for their day-to-day transportation. It is of interest to see how these new forms of services are affecting the transportation networks; are they taking more customers away from transit or are they reducing the single occupant vehicles on the road? This study models, simulates, and investigates difference scenarios of shared used mobility services, for a specific region, to determine their effects on traffic network performance measures.

3 - A Date-driven Analysis of the Impact Exerted on Government Regulations in Taxi Industry by E-hailing Service

Ziyang Guo, Sparkzone Research Group, Room6, Yard 7, Fenzi Hutong, Xidan North, Street, Xicheng District, Beijing, China, Beijing, China, 1872371084@qq.com, Yide Zhao, Yinghao Jia

Government has mainly regulated the traditional taxi market from four perspectives: taxi number, price and quality of service, as well as standard working time of drivers. However, the emergence of E-hailing service has posed a great challenge for the traditional industry. This study, emphasizing on the four aspects above, aims to capture the impact of E-hailing service on traditional market based on data-driven approaches. Primarily focusing on the flexibility and elasticity of the E-hailing service, we propose a model that takes into account the influence exerted on the equilibrium position of the taxi market, thereby optimizing regulation policies for administration.

■ MC54

362A

Syngenta Crop Challenge in Analytics

Invited: Agricultural Analytics

Invited Session

Chair: Robin Lougee, IBM Research, Yorktown Heights, NY, 10598, United States, rlougee@us.ibm.com

1 - A Hierarchical-ensemble of Machineries to Optimize the Choice of Soybean Varieties

Durai Sundaramoorthi, Washington University in Saint Louis, 10352 Conway Road, Saint Louis, MO, 63131, United States, dsundaramoorthi@gmail.com, Lingxiu Dong, Iva Petrova Rashkova, Piruthiviraj Sivaraj

Selecting soybean varieties for planting is an important decision that has significant implications for the yield of a farm. With many soybean varieties available along with data on yield performance collected over several years at various farm locations, the seed-mix selection is a highly intriguing decision to modern day farmers and seed retailers. To aid soybean-mix selection, this work describes and evaluates a hierarchical-ensemble of machine learning and optimization methods which chooses soybean varieties to obtain optimal yield.

2 - A Decision Making Approach for Crop Seed Variety Selection via Hedging Against Weather Risk

Leyuan Shi, Peking University, Room 512 Founder Building, 298 Chengfu Road, Beijing, 10080, China, leyuan.shi@wisc.edu
Leyuan Shi, University of Wisconsin, Madison, WI, United States, leyuan.shi@wisc.edu, Zhongshun Shi, Yu Zhao, Xi Zhang

This paper develops an efficient decision making approach for the seed retailer to determine the seed varieties selection in appropriate proportions for the next season. The proposed approach integrates the customized portfolio selection theory and effective machine learning technique. We formulate this decision making problem as the mean-covariance model to balancing the weather risk and crop yield. A hybrid coefficients evaluation method is designed to produce the expected yield of each seed variety under different weather type. We develop a MIQP-based decomposition algorithm to solve the decision making problem efficiently and effectively.

3 - A Machine Learning Approach to the Syngenta Crop Challenge 2017

Wenjun Zhou, University of Tennessee, Knoxville, TN, 37996, United States, wzhou4@utk.edu, Yunhe Feng

Seed companies need to plan for the variety and quantity of seeds to stock at least a year in advance. There are a large number of seed varieties, each can perform best under different growing conditions. Since next year's weather is unpredictable, it is hard to foresee which seed varieties work the best in each field. We propose using multi-task learning for estimating the yield and risk of each variety as if they were planted at each location. The best mix of seeds for each location was then determined by seeking a trade-off between yield and risk.

■ MC55

362B

Topics in Finance: Systemic Risk Management

Sponsored: Financial Services

Sponsored Session

Chair: Xuedong He, xdhe@se.cuhk.edu.hk

Co-Chair: Nan Chen, nchen@se.cuhk.edu.hk

1 - Submodular Risk Allocation

Paul Glasserman, Columbia University, 403 Uris Hall, Columbia Business School, New York, NY, 10027, United States, pg20@columbia.edu, Samim Ghamami

Changes in the over-the-counter derivatives markets leave dealers some flexibility in whether to trade bilaterally or through central counterparties (CCP) and which CCP to choose. We analyze the problem of optimal allocation of trades to portfolios to minimize risk-based margin and capital requirements. With submodular margin requirements, the problem becomes a submodular intersection problem; the dual provides per-trade margin attributions. We derive conditions under which standard deviation and other risk measures are submodular functions of sets of trades. We compare systemwide optimality with individually optimal allocations.

2 - On Default Probabilities in Financial Networks

Dohyun Ahn, PhD Candidate, KAIST, #2111, E2-2, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon, Korea, Republic of, dohyun.ahn@kaist.ac.kr, Nan Chen, Kyoung-Kuk Kim

We consider the Eisenberg-Noe network model for systemic risk, focusing on random shocks to financial institutions. Using duality, we characterize shock amplification caused by the network structure and find when a specific bank fails. These results enable us to improve our understanding of default probabilities in financial networks. Specifically, we establish general upper and lower bounds of firm-specific default probabilities. We also discuss the impact of network structure on default probabilities. In addition, as default events become rare, asymptotic behaviors of corresponding probabilities can be derived.

3 - Financial Contagion in a Multilayer Network

Zachary Feinstein, Washington University-St. Louis, St. Louis, MO, United States, zfeinstein@wustl.edu

This talk provides a general framework for modeling financial contagion in a system with obligations in multiple illiquid assets. In so doing, we develop a multi-layered financial network that extends the single network of Eisenberg and Noe (2001). In particular, we develop a financial contagion model with fire sales that allows institutions to both buy and sell assets to cover their liabilities and act as utility maximizers. We prove that, under standard assumptions, equilibrium portfolio holdings and market prices exist which clear the multi-layered financial system. We demonstrate the value of our model through illustrative numerical case studies.

4 - Leverage Constraint, Market Illiquidity, and Financial Fragility

Nan Chen, Chinese University of Hong Kong, William M.W. Mong Engineering Bldg, Rm 609, Shatin N.T, Hong Kong, nchen@se.cuhk.edu.hk, Jing Chen, Xuedong He

We establish a full equilibrium model to show how systemic fragility is built up in the presence of leverage constraints and market illiquidity. The model can generate two distinct regimes: normal and crisis. Due to highly nonlinear amplification effects caused by both illiquidity, the economy is prone to instability and occasionally enters into the volatile crisis regime. The equilibrium risky asset price demonstrates heteroscedasticity in different regimes. Our model shows that margin requirement, a common practice in risk management at the micro level, may yield an undesirable pro-cyclic effect in a systemic context.

■ MC56

362C

Joint Session SOLA/PSOR: Public Sector Location Analysis

Sponsored: Location Analysis

Sponsored Session

Chair: Kayse Lee Maass, Mayo Clinic, Rochester, MN, 7, United States, maass.kayse@mayo.edu

1 - A Robust Model for Pre-positioning Relief Items for a Typhoon

Joline Uichanco, University of Michigan, Ross School of Business, 701 Tappan St, Room 4418, Ann Arbor, MI, 48109-1234, United States, jolineu@umich.edu

We consider the problem faced by a humanitarian agency in pre-positioning relief items to prepare for an oncoming typhoon whose future outcome (trajectory and wind speed) is uncertain. We develop probabilistic models of municipality-level demand and of damage to pre-positioned supply that are dependent on the typhoon outcome. The dependence of demand on the typhoon outcome is determined by a hierarchical linear model estimated from a dataset that includes typhoon effects from five West Pacific typhoons affecting the Philippines. We propose to solve the pre-positioning problem using a bi-objective two-stage stochastic optimization model.

2 - Anticipation Effects in Post-disaster Supply Chain Modeling

Diana Gineth Ramirez-Rios, Rensselaer Polytechnic Institute, 134 25th Street, Troy, NY, 12180, United States, ramird2@rpi.edu, Jose Holguin-Veras, Luk N. Van Wassenhove, Victor Cantillo, Shaligram Pokharel, Johanna Amaya-Leal, Trilce Encarnacion

This research focuses on disaster relief modeling, particularly in the period of time starting at the moment a disaster strikes and when the initial response takes place. This research introduces the anticipation function, which assesses both the deprivation and psychological cost or anxiety of the deprived individual. The results of an exploratory analysis of this anticipation function is empirically derived through SP surveys. Some management implications and its possible incorporation to the supply chain model formulation were also considered.

3 - Bike Sharing using Toggle Locations and Portable Stations

Rahul Swamy, University of Illinois at Urbana-Champaign, 205 E. Clark St, Apt 303, Champaign, IL, 61820, United States, rahulswamy91@gmail.com, Jose Luis Walteros

We explore an alternative approach to fixed station locations in a bike sharing system by turning on/off (toggle) certain locations for certain periods of time. A Mixed Integer Program is presented that decides which of the candidate locations to choose to serve as bike stations at what time, with the objective of minimizing the bike redistribution load. The MIP has a rich structure that is exploited using Bender's Decomposition. The second part of the talk focuses on how portable stations can be used to serve in the toggle station locations. This routing problem is solved using implicit enumeration followed by a variant of set covering problem. Computational results are presented with a Case Study in NYC.

4 - Selecting Locations of Rehabilitative Shelters for Human Trafficking Survivors among States in the U.S.: A Decision Analytic Approach

Kayse Lee Maass, Mayo Clinic, Rochester, MN, United States, maass.kayse@mayo.edu, Renata Alexandra Konrad, Andrew C. Trapp

Rehabilitative shelters are an important component of anti-human trafficking efforts and entail a large investment. While survivors of human trafficking exist in every U.S. state, roughly only 2/3 of states provide dedicated shelters. Even in states with shelters, demand exceeds the current capacity. Furthermore significant disparity exists between states with regard to the legislative environment and provision of auxiliary services for survivors. This project develops a decision analytic approach to evaluate the impact of a dedicated shelter at the state level. Using concepts from health and social welfare economics, we develop a budget allocation problem that maximizes societal value.

■ MC57

362D

Simulation in Healthcare

Sponsored: Simulation

Sponsored Session

Chair: Tahir Ekin, Texas State University, t_e18@txstate.edu

1 - Minimizing Patient Waiting Time at a Pure Walk-in Clinic

Eduardo Perez, Texas State University, Roy F. Mitte Complex, 749 N. Comanche St., San Marcos, TX, 78666, United States, eduardopr@txstate.edu, Vivekanand Anandhan

Walk-in clinics have grown in popularity in the United States as a substitute for traditional medical care delivered in primary care clinics and emergency rooms. The open access nature and lack of patient scheduling can lead to long wait times for patients or long periods of idle time for providers. In this talk, we derive a discrete event simulation model to study pure walk-in clinics where patients are served without appointments. A case study is discussed that consider a walk-in clinic located in central Texas. The computational study provides useful insights that are applicable to any walk-in health care facility.

2 - A JaamSim Model of Medical Evacuation and Treatment in Combat

Lawrence Fulton, Texas Tech University, 911 Stoney Ridge Road, Bulverde, TX, 78163, United States, lfulton159@gmail.com, Nathaniel D. Bastian

A JaamSim discrete event simulation (DES) of medical treatment and hospitalization requirements for a simulated, large-scale combat operation is presented. Simulation excursions illustrate the inherent trade-offs among the number of ground / air evacuation assets, the location of treatment / evacuation assets, and the type of treatment provided by location. The DES model is compared to a simpler Monte Carlo simulation of the same scenario. Results of these models are being used to support military force structure decisions.

3 - Multivariate Spatial Models for Substance Abuse Related Incidences

Rasim M.Musal, Texas State University, School of Business, 601 University Drive, San Marcos, TX, 78666, United States, mmusal@gmail.com

We investigate the relationship between correlated substance abuse incidences and socio-economic covariates within the counties of New York State.

4 - Medical Fraud and Abuse Assessment using Prescriber-level Medicare Data

Babak Zafari, Babson College, Babson Hall 218C, Babson Park, MA, 02457, United States, bzafari@babson.edu, Tahir Ekin

The existence and magnitude of fraud in health insurance programs, requires the utilization of fraud prevention and detection procedures. Data Mining methods are used to uncover odd billing patterns in large databases of health care claims history. In this work, we propose data-driven methods to find the anomalies in the medical claims data using publicly available CMS Part D Prescriber dataset. In so doing, we introduce a set of new indicators that can better separate providers with unusual billing patterns.

■ MC58

362E

Route Optimization for Vehicle Fleet

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Sebastien Martin, Massachusetts Institute of Technology, 70 Pacific Street, Apt 462A, Cambridge, MA, 02139, United States, semartin@mit.edu

1 - Clustering Algorithms for Vehicle Routing Problems

Castaing Jeremy, Applied Research Scientist, LLamasoft, Ann Arbor, MI, United States, jeremy.castaing@llamasoft.com

As the typical size of vehicle routing problems (VRP) solved in the industry keeps increasing, we need to develop ways to partition the data into smaller sub-problems. We describe several variants of clustering algorithms adapted to VRP that are used in the Transportation Optimization engine of Supply Chain Guru, developed by LLamasoft. These clustering methods allow to reduce the size of the problem with minimal loss of solution quality. We consider several VRP features such as different asset types, time windows or continuous pick-ups and deliveries.

2 - Dispatching Strategy for Autonomous Taxi Fleets

Barry R. Cobb, Associate Professor, Missouri State University, Department of Marketing, 216 Glass Hall, Springfield, MO, 65897, United States, barrycobb@missouristate.edu, Linda Li

We build a real time dispactching model for taxi fleets, assuming total backlogging if the customers not immediately served. We show if the assignment and repositioning costs are equivalent and proportional to the distance, then the optimal policy is non-repositioning and quasi-myopic. The strategies suggested are aimed at a centralized taxi dispatching system. For instance, an autonomous taxi system.

3 - Package Delivery with Trucks and UAVS

Siyuan Song, University of Southern California, 11657 Kerwwod Pl, El Monte, CA, 91732, United States, siyuanso@usc.edu

We determine the efficiency of a delivery system in which an unmanned aerial vehicle (UAV), or a fleet of UAVs, provides service to customers while making return trips to a truck that is itself moving. Although the hardware for such systems already exists, it is not yet understood to what extent such an approach can actually provide a significantly improved quality of service. In this paper, a mathematical formulation of this problem is given and followed by an asymptotic result based on probabilistic analysis. We then put forward a heuristic algorithm and give some numerical experiments based on it. In addition to that, some variants of this problem that may happen in practice are also discussed.

4 - Rich Trailer Routing Optimization for Chemicals and Liquid Bulk

Ashesh Kumar Sinha, Assistant Professor, Kansas State University, Manhatan, KS, 66502, United States, ashesh.sinha24@gmail.com

We consider a rich trailer routing problem with stochastic transit times for chemicals and liquid bulk shipments. A route of a trailer comprises of pickup and delivery of restricted sequence of shipments while undergoing specialized tank wash operations. Using stochastic models and efficient parallel computing, we determine optimal trailer, shipments, and washes combinations while meeting the expected service level and cost.

5 - Joint Electric Vehicle Sharing and Vehicle2grid Service System Operations

Dongfang Zhao, Doctor, University of South Florida, 4202 E. Fowler Avenue ENG 216, TAMPA, FL, 33617, United States, dongfangzhao@mail.usf.edu, Xiaopeng Li

This study proposes a new model for designing a new (electric vehicle) EV sharing and V2G service system. This model considers the operations of a fleet of EVs that may opt to serve a transportation system when transportation demand is high or return electricity to the grid when the power price shoots high. An integer programming model is proposed to determine the optimal allocation of the fleet's time over these two markets. This model is solved with an efficient dynamic programming algorithm. Real-world data about the configurations of these two markets are used to build numerical examples. Sensitivity studies are constructed to draw insights into the feasibility of this joint service system.

6 - Online Vehicle Routing the Edge of Optimization at Scale

Sebastien Martin, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, MA, 02139, United States, semartin@mit.edu, Dimitris Bertsimas, Patrick Jaillet

Developing vehicle routing optimization algorithms that are capable of solving very large real-time problems involving tens of thousands of customers per hour is becoming more and more important and impactful. We introduce generalizable algorithms to scale mixed integer optimization to these practical problem sizes. A novel backbone algorithm allows us to dispatch in real time thousands of taxis serving more than 25,000 customers per hour in New York City. Historical simulations shows that our algorithms improve upon the performance of existing heuristics in real-world settings.

■ MC59

362F

Joint Session RAS/Practice: Roundtable A: State of Driverless Technology – Trucking and Railways

Sponsored: Railway Applications

Sponsored Session

Chair: Dharma Acharya, GE Transportation, GE Transportation, Ponte Vedra, FL, 32081, United States, dharma.acharya@ge.com

1 - The Road to an Automated Transportation Industry

Douglas Mattenburg, J.B. Hunt, Lowell, AZ, United States, Douglas.Mettenburg@jbhunt.com

Adaptation is a key part of business success, and the transportation industry is set for a big shake-up. How will autonomous vehicles affect the transportation industry? Adjusting to this change will make-or-break many of the trucking companies out there today. Come hear how J.B. Hunt is preparing for this modernization of the industry. J.B. Hunt is a Fortune 500 supply chain management company that provides technology-driven solutions through a variety of services, including intermodal, dedicated, refrigerated, truckload, less-than-truckload, flatbed, single source, final mile, and more.

2 - State of the Driverless/Smart Driving Technologies
Carl D. Van Dyke, TransNetOpt, 6 Snowbird Court, West Windsor, NJ, 08550, United States, carl@cvdzone.com

In this round table session, we will examine the state of the driverless/smart driving trucking and railway technologies. We will also discuss how viable it is and how likely it is going to be accepted by the businesses.

3 - Benefits of Driverless Technology when used by Trucking Companies
Bruce Patty, Veritec Solutions, San Rafael, CA, United States, bpatty@veritecsolutions.com

This paper will provide an overview of the areas where there are benefits expected from a transition to Driverless Technology. Estimates of potential benefits for various recipients will be reviewed.

■ MC60

370A

A Spectrum of Business Analytics Curricula

Sponsored: INFORMEd

Sponsored Session

Chair: Susan Wright Palocsay, James Madison University, Harrisonburg, VA, 22807, United States, palocssw@jmu.edu

1 - Implementing an Interdisciplinary Business Analytics and Data Science Program at an Urban University
J.D Jayaraman, Associate Professor, New Jersey City University, Jersey City, NJ, United States, jjayaraman@njcu.edu, EunSu Lee

One of the challenges in today's data driven world is educating students in being adept at working with large amounts of data and extracting meaning out of it. This study describes an attempt at meeting this educational challenge with the creation of an interdisciplinary business analytics and data science program at an urban university in New Jersey. Curricular challenges and needs for such a program are detailed. Tools, teaching techniques, industry involvement, marketing and administrative support required for successful implementation are outlined. Challenges and hurdles encountered are also presented.

2 - The Story of Operational Analytics Program at the University of South Dakota
Ali Dag, Assistant Professor, University of South Dakota, 414 E. Clark Street, Beacom Hall, Office : 217, Vermillion, SD, 57069, United States, ali.dag@usd.edu, Thomas Tiahrt

University of South Dakota's Beacom School of Business was established in 1927 and has been accredited by AACSB since 1949. The leading business school in the region, Beacom has recently started its new Operational Analytics major at the undergraduate level and Business Analytics focus at the MBA level. In this talk, we will present the structure of the curriculum of these newly created programs and the story behind it.

3 - Experiences with Business Analytics Curriculum Implementation
Susan Wright Palocsay, Professor, James Madison University, Msc 0202, Computer Info Sys & Bus Analytics Dept, Harrisonburg, VA, 22807, United States, palocssw@jmu.edu, Ina Samanta Markham, Scott Stevens

Advanced analytics is a key technology trend providing a plethora of new opportunities to create business value. Consequently, it has given business schools an opening to introduce extended coverage of statistical analysis, data mining, and OR/MS modeling skills in business education. We will describe our experiences in creating an undergraduate minor in business analytics, including how we have addressed challenges with student capabilities, faculty expertise, recruiters, and limited resources.

4 - Connecting OR/MS to General Studies
Michael J.Racer, University of Memphis, 302 Fogelman College of Business, Memphis, TN, 38152, United States, mracer@memphis.edu, Orrin Cooper

There's a huge part of what's going on in the "real" world that students aren't grasping or connecting to OR. Interdisciplinary content in OR classrooms is crucial to helping students value OR. Core courses like psychology, political science, and English, suffer from similar stereotypes but can be integrated into OR. One solution is requiring students to bring articles to class.

■ MC61

370B

Joint Session MIF/PSOR: Nonprofit Operations and Humanitarian Logistics

Sponsored: Minority Issues

Sponsored Session

Chair: Irem Sengul Orgut, Lenovo, Raleigh, NC, 27612, United States, isengul@ncsu.edu

1 - Supply Chain Management in Limited Data Environments: Application to Community Health Workers
Kezban Yagci Sokat, Northwestern University, IEMS, 2145 Sheridan Rd, Evanston, IL, 60208, United States, kezban.yagcisokat@u.northwestern.edu, Karen Smilowitz, Irina Dolinskaya

Limited historical data and limited on hand inventory bring up additional difficulty to supply chain management. In collaboration with Last Mile Health, we develop an inventory optimization model for different levels of the supply chain where we link health outcomes to inventory optimization under limited data.

2 - Dynamic Allocation of NGO Funds among Program, Fundraising, and Administration
Telesilla Olympia Kotsi, 3400 S Sare Rd, Apt 917, Bloomington, IN, 47401, United States, tkotsi@indiana.edu, Goker Aydin, Alfonso J. Pedraza-Martinez

US NGOs report three types of spending: program spending to deliver services directly to beneficiaries; fundraising spending; and administrative spending. Watchdog organizations give higher ratings to NGOs that allocate more of their budget to the program. However, fundraising and administrative spending are also beneficial. Fundraising helps increase the NGO's future budget, while administrative spending helps make future program spending more impactful. We model this trade-off in a dynamic program. We use financial data from human services NGOs to conduct a case study. Our results show that prioritization of fundraising and administration spending is necessary under certain conditions.

3 - Assessment Routing with Uncertain Travel Times
Burcu Balcik, Ozyegin University, Industrial Engineering Department, Nisantepe Mah Orman Sok No 34-36, Cekmekoy, 34794, Turkey, burcu.balcik@ozyegin.edu.tr, Ihsan Yanikoglu

This study focuses on rapid needs assessment operations conducted immediately after a disaster occurs. We consider a stochastic selective assessment routing problem, which determines the sites to be visited within a limited amount of time to ensure coverage of different community groups affected by the disaster. We use ambiguous chance constraints to model random travel times and apply a safe approximation technique using robust optimization to obtain a tractable formulation. We present an efficient tabu search algorithm, which obtains high quality solutions for the problem.

4 - Modeling for the Equitable and Effective Distribution of Food Donations under Stochastic Capacities
Irem Sengul Orgut, Lenovo, 4944 Summit Arbor Dr, Apt 205, Raleigh, NC, 27612, United States, isengul@ncsu.edu

Motivated by our partnership with a local food bank, we present a robust optimization model to support the equitable and effective food distribution over the food bank's service area. Our model addresses uncertainty in the counties' capacities which depend on factors such as budget and workforce. Assuming the capacity of each county varies within a range, the model seeks to maximize total food distribution while enforcing a user-specified level of robustness. We derive structural properties of the model and develop an efficient exact solution algorithm. We illustrate our model using historical data, summarize the policy implications of our results and examine the impact of uncertainty on outcomes.

■ MC62

370C

Smart Manufacturing

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ran Jin, Virginia Tech, Blacksburg, VA, 24061, United States, jran5@vt.edu

1 - 3D Freeze Assembling Printing of Graphene Aerogel

Dong Lin, Assistant Professor, Kansas State University, 2080 Rathbone Hall, 1701 D Platt St., Manhattan, KS, 66506, United States, dongl@ksu.edu

The surging field of graphene aerogels (GA) provides a promising methodology for transferring inherent properties of graphene into macroscopic applications for composite materials, energy storage, stress sensor, thermal insulator, and shock damping. However, fabrication of GA with tailored macrostructures by scalable and controllable methods remains a significant challenge. The vision of tailoring macroarchitecture of GA for specific applications, including separation, all-solid-state batteries, micro pressure sensors, flexible electrodes, and electrochemical catalyst templates, has stimulated the research on 3D printing of GA. Here, we propose a printing methodology that contines multinozzle drop-on-demand inkjet printing of pure graphene oxide (GO) suspension with freeze casting for rapid printing of 3D GA architectures to achieve several key qualities, namely, pure, continuous, boundary free, controlled microstructure, and truly 3D architectures (e.g., 3D truss with overhang structures). To date, we have successfully printed world's lightest material via 3D printing through the proposed technique.

2 - Manufacturing Quality Modeling with Smooth Variable Selection Based on Spatial Predictors

Yifu Li, Virginia Tech, Blacksburg, VA, 24060, United States, liyifu@vt.edu

Spatial data are widely collected in manufacturing to reflect the product quality information. It is challenging to transform these spatial data into useful information for product quality improvements due to the increasing spatial resolution and defect complexity. Motivated by an aerosol jet® printing process, we propose a smooth variable selection estimator using spatial predictors from high-resolution microscopic images to model printed electronics' resistances as responses. We demonstrated the effectiveness of the proposed method for prediction and variable selection with simulation studies and a case study.

3 - Data Challenges from Modern Manufacturing System

Shan Ba, The Procter & Gamble Company, Cincinnati, OH, United States, ba.s@pg.com

Modern manufacturing systems are often equipped with numerous sensors and high-speed cameras, which constantly measure hundreds or thousands of quality and process variables throughout the production process. The high volume and velocity of the incoming sensor/image data streams pose major challenges in data storage, data transfer, and data analysis. Bigger data should bring bigger insights. In this talk, we will discuss several challenges in handling and analyzing manufacturing big data in order to boost quality, minimize waste and gain process insight in a timely manner.

4 - A Statistical Model for Computer Experiments in Smart Additive Manufacturing

Xinwei Deng, Department of Statistics, Virginia Tech, 406 Hutcheson Hall, Blacksburg, VA, 24061, United States, xdeng@vt.edu, Jingran Li, Ran Jin

For computer experiments in the additive manufacturing, the scanning path in the process often contains valuable information that links the time and space domains. A novel Gaussian process (GP) model is proposed to quantify the surface characteristics, which integrates the distinct effects of the time evolution and spatial distance at the printing process. This proposed GP model is examined on several geometrical designs to evaluate the performance of model prediction and model interpretation.

5 - Smart Manufacturing

Ran Jin, Virginia Tech, 1145 Perry Street, Durham Hall, Room 250 (0118), Blacksburg, VA, 24061, United States, jran5@vt.edu

Modern manufacturing needs to optimize the entire product lifecycle to satisfy the highly diverse customer needs. With the deployment of Internet of Things, data-driven decision making is expected to enable smart manufacturing to achieve high level of adaptability and flexibility. This talk discusses the recent advancement of methodologies, and the corresponding sensing, analysis and decision making to enable smart manufacturing.

■ MC63

370D

Biophysical and Economic Modeling – Assumptions, Metrics, and Decisions

Invited: Energy and Climate

Invited Session

Chair: Carey King, The University of Texas at Austin, careyking@energy.utexas.edu

1 - A Long-term Macroscale Model Linking Biophysical and Economic States

Carey King, Energy Institute at The University of Texas at Austin, 2304 Whitis Ave., C2400, Austin, TX, 78712, United States, careyking@mail.utexas.edu

New macroeconomic frameworks are needed to properly interpret the post-2008 macroeconomic situation of high debt, low interest rates, and aging populations (primarily in advanced economies). Monetary models of finance and debt often assume that natural resources (energy, food, materials) and technology are not constraints on the economy. Energy scenario models often assume that economic growth, finance and debt will not be constraints on investment in resources. This presentation discusses a new modeling framework that eliminates aforementioned assumptions by integrating states of resources, economy (employment, debt, wages, capital), and population at a fundamental level.

2 - Changing Resource Productivity under Resource Constraints

Eric Kemp-Benedict, Senior Scientist, Stockholm Environment Institute, 11 Curtis Avenue, Somerville, MA, 02144, United States, eric.kemp-benedict@sei-international.org

Resource constraints are of growing economic importance. Nonrenewable resources have historically been so abundant that productive capacity has mattered more than the total stock, but now that the most accessible resources have been exhausted, extraction is increasingly resource-intensive. Renewable resources, if treated well, can produce indefinitely into the future, but productive potential, once it has been reached, can only expand slowly. Future economic prospects thus increasingly depend on the pace of resource productivity growth. This presentation shows how productivity and output might evolve under resource constraints in a model of cost share-driven technological change.

3 - Beyond GDP: National Accounting in the Age of Resource Depletion

Michael Carbajales-Dale, Clemson University, madale@clemson.edu

Energy-economy-environment systems analysis (E3SA) is becoming increasingly important in the drive for sustainable development and to better understand the imminent future energy transition. E3SA necessarily spans a multitude of scales and disciplines. This talk will give an overview of the work being done by the E3SA group at Clemson University at three different scales: life cycle assessment of electricity generation technologies, network analysis of the infrastructure and industries, and a physical input-output framework for national or global economies.

4 - How Should we Learn from Models of Complex, Open Systems?

Michael Gerst, University of Maryland, 1337 Meridian Place NW, Washington, DC, 20010, United States, mgerst@umd.edu

Biophysical and economic models represent complex, open systems. Such systems are difficult to understand; consequently models built to learn about them are necessarily incomplete. We introduce a novel framework to gauge model incompleteness using expert elicitation that links learning about model behavior to expert judgment on target system behavior.

■ MC64

370E

Big Data II

Sponsored: Data Mining

Sponsored Session

Chair: Subhashish Samaddar, Georgia State University, s-samaddar@gsu.edu

Co-Chair: Milton Soto-Ferrari, miltonrene.sotoferrari@wmich.edu

1 - Methodology for Systematic Monitoring of Radiotherapy Administration to Breast Cancer Patients

Milton Soto-Ferrari, Indiana State University, 30 N.7th St, Terre Haute, IN, 47809, United States, miltonrene.sotoferrari@wmich.edu

The proposed methodology presents a Bayesian based quality control framework for the monitoring of patients to predict radiation receipt based on the associations among clinical and non-clinical variables. The framework was developed using information from a cancer center with a sample of 1922 patients from years 2009-2014. As result of the implementation, a total of 48 patients were flagged. The quality control framework flagged patients with a metastatic disease as condition for an aggressive treatment in the center. Physicians from the review panel denoted that radiation treatment is offered as a palliative treatment for patients in a metastatic phase to mitigate side effects and pain.

2 - Assessing the Accuracy of Influenza Incidence Characterization During an Emergency

Diana Prieto, Western Michigan University, Industrial and Manufacturing Engineering, 4601 Campus Dr. (Office E-213), Kalamazoo, MI, 49008-5336, United States, diana.prieto@wmich.edu, Yuwen Gu

In the United States, emergent influenza outbreaks pose challenges in public health operation. One of such challenges is in the process of collection and testing of specimens to characterize the incidence trend. It is currently unknown whether this process is capable of retrieving accurate and timely incidence trends for response planning. In this talk, we will discuss the results from a simulation based evaluation of the operational features that allow the specimen collection and testing in the state of Michigan.

3 - Forecasting for Hotel Revenue Management by using AI and Other Methods

Subhashish Samaddar, Georgia State University, Managerial Science, P.O. Box 4014, Atlanta, GA, 30302-4014, United States, s-samaddar@gsu.edu, Somnath Mukhopadhyay, Satish Nargundkar

Forecast accuracy is the most important factor for achieving additional revenue from hotel revenue management (HRM) models. HRM analyst can forecast product demands for all revenue buckets of the room inventory products to maximize the overall revenue. However, the literature on HRM is sparse on details of RM forecasts. This article uses archived hotel data from a major hotel chain to compare room bookings forecast accuracies of traditional forecasting methods, Bayesian Networks (BN) methods, random forest methods and AI methods such as neural networks (NN).

4 - Analysis of HealthcareService Quality from Hospital Data at the National Level

Satish V. Nargundkar, Georgia State University, 2802 Fairlane Dr., Atlanta, GA, 30340, United States, snargundkar@gsu.edu, Subhashish Samaddar

The secondary data from patient surveys from all hospitals in the US is obtained from Medicare and different attributes of healthcare service is analyzed at the city, state and national levels.

5 - Analyzing Disease Data for Detection: A Comparison of Methods

Subhashish Samaddar, Georgia State University, Atlanta, GA, United States, subhashish.samaddar@gmail.com, Somnath Mukhopadhyay

Clinical data is used for disease detection and the error rates obtained by using Neural Network, Linear Programming, and Decision Trees are compared and reported.

■ MC65

370F

Maritime Transportation

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Harilaos Psaraftis, hnpsar@dtu.dk

Co-Chair: Thalis Zis, Technical University of Denmark, Lyngby, 2800, Denmark, tzis@dtu.dk

1 - A Hub-and-spoke Approach to the Liner Shipping Network Design

Rommert Dekker, Professor of Quantitative Logistics, Erasmus University-Rotterdam, Burg. Oudlaan 50, P.O. Box 1738, Rotterdam, 3000 DR, Netherlands, rdekker@ese.eur.nl, Judith Mulder

We present an hub-and-spoke approach to the Liner Shipping Network Design problem with transhipment costs. We apply it to the cases from Brouer et al (2016) and show that for large instances costs can be reduced considerably. Finally we show an application to the Asia-Europe lane.

2 - Optimal Investment for a Resilient Global Port Network

Ali Asadabadi, University of Maryland, 7700 Adelphi Road, Apt 34, Hyattsville, MD, 20783, United States, ali.asadabadi@gmail.com, Elise Miller-Hooks

Ports are critical components of the global supply chain, supplying key connections between land- and maritime-based transport modes. They operate in cooperative, but competitive environments wherein individual port throughput is linked through an underlying transshipment network. This presentation models and analyzes protective investment strategies aimed at enhancing resilience to disruption and protecting a port's market share.

3 - Berth Scheduling to Reduce In-port Emissions with Cold Ironing Provision

Thalis Zis, Technical University of Denmark, Lyngby, 2800, Denmark, tzis@dtu.dk, Harilaos ZisPsaraftis3, Michail ZisGkolias

Cold Ironing is a technology that allows vessels at berth to receive shorepower for their energy requirements at the port. This paper studies the (discrete space & dynamic arrival) berth scheduling problem with berth cold ironing capabilities. The problem is formulated as a multi-objective problem where the terminal operator seeks to simultaneously maximize the utilization of its cold ironing berths (i.e., minimize emissions) and customer satisfaction. Problem instances are solved for various penetration rates of cold ironing capabilities by vessels calling at the port, and a sensitivity analysis on the number of cold ironing-ready berths is conducted.

4 - Vessel Scheduling Problem in a Liner Shipping Route with Perishable Products

Maxim A. Dulebenets, Florida A&M.University-Florida State University, 2300 Bluff Oak Way, Apt. 8408, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Eren Erman Ozguven, Ren Moses, Thobias Sando

Some of the products, transported in a containerized form by vessels, are perishable in nature. Perishable products deteriorate due to certain operational and environmental factors. This study proposes a novel non-linear mixed integer mathematical model for the vessel scheduling problem with perishable products, which explicitly captures decay of perishable products on board the vessels. Numerical experiments demonstrate that the developed mathematical model can serve as an effective planning tool for liner shipping companies and tackle important operational aspects.

■ MC66

371A

Electric Vehicle Charging

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Eleftheria Kontou, National Renewable Energy Laboratory, Golden, CO, United States, ria.kontou@nrel.gov

1 - Data-driven Planning of PHEV Taxi Charging Stations in Urban Environments- A Case in Central Area of Beijing

Ziyang Guo, Sparkzone Research Group, Room6, yard 7, Fenzi Hutong, Xidan North, Street, Xicheng District, Beijing, China, Beijing, China, 1872371084@qq.com, Yinghao Jia, Yinghao Jia, Yide Zhao

Plug-in hybrid electric taxis (PHETs) contribute to energy and environmental challenges. In this study, we provide a spatial and temporal PHET charging demand forecasting method based on one-month Global Positioning System(GPS)-based taxi travel data in Beijing. Then, a mixed integer linear programming (MILP) model is formulated to plan PHET charging stations which minimizes investment and operation costs of all the PHET charging stations and takes into account the service radius of charging stations, charging demand satisfaction and rational occupation rates of chargers. At last, the plan is carried out numerically through simulation and the analysis is complemented according to the results

3 - Risk-averse Joint Capacity Evaluation of PV Generation and Electric Vehicle Charging Stations in Distribution Networks

Yu Xin, Sparkzone Research Group, Beijing, 100084, China, lewis_xy@hotmail.com, Yide Zhao, Yinghao Jia, Yinghao Jia

Increasing penetration of distribution generation(DG) and electric vehicles (EVs) calls for an effective way to estimate the achievable capacity connected to the distribution systems, but uncertainties of DG outputs and EV charging loads make it challengeable. This study provides a joint capacity evaluation method for photovoltaic (PV) generation and EV charging stations. The method is formulated as adistributionally robust joint chance constrained programming model. And the worst-case conditional value at risk approximation and an iterative algorithm based on semi definite program (SDP) are used. Finally, the test is carried out numerically on IEEE 33-bus radial distribution system.

4 - Integrated Two-level Inventory Problems: Applications to Electric Vehicle and Drone Battery Management

Amin Asadi, University of Arkansas, Fayetteville, AR, United States, asadi@email.uark.edu, Sarah G.Nurre

We examine a new class of integrated two-level inventory problems (ITLIP) with applications in drone and electric vehicle battery management. In this class of problems, the first level inventory corresponds to battery capacity and the second-level the battery charge. The two-levels of inventory are integrated in which the first-level is depleted (capacity) as a direct result of the replenishment and satisfaction of demand for the second-level (battery charge, discharge, and use). We formulate a Markov Decision Process model for an ITLIP problem to determine optimal policies for inventory management and equipment replacement for an electric vehicle battery swap station application.

6 - Incentive Schemes for Maximizing the Benefits from Battery Electric Vehicle Adoption

Eleftheria Kontou, Postdoctoral Researcher, National Renewable Energy Laboratory, 15013 Denver West Parkway, Golden, CO, 80401, United States, ria.kontou@nrel.gov, Yafeng Yin

Battery electric vehicles (BEVs) promise elimination of tank-to-wheel emissions and, thus, are widely recognized as a means towards reaching greenhouse gas abatement goals from the passenger transportation sector. Such vehicles are promoted by local and national governments by allocating financial incentives to directly subsidize their sales, or through funding charging stations. This work aims to answer the following research question: what is the optimal magnitude and timeframe of BEV subsidies and chargers investment allocation that the government should plan for to maximize the monetized social benefits from the household vehicle electrification?

■ MC67

371B

Technometrics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Daniel Apley, Northwestern University, Evanston, IL, 60208-3119, United States, apley@northwestern.edu

1 - Modelling Regression Quantile Processes using Monotone B-splines

Yuan Yuan, Research Scientist, IBM.Research Singapore, Singapore, Singapore, idayuan@sg.ibm.com, Nan Chen, Shiyu Zhou

Quantile regression studies the covariate effects on the entire response distribution by fitting quantile regression models at multiple different quantiles or even fitting the entire regression quantile process. However, estimating the regression quantile process is inherently difficult because the induced conditional quantile function needs to be monotone at all covariate values. We proposed a regression quantile process estimation method based on monotone B-splines, which can easily ensure the validity of the regression quantile process, and offers a concise framework for variable selection and adaptive complexity control. We demonstrated its use and effectiveness in real problems.

2 - Pairwise Estimation of Multivariate Gaussian Process Models with Replicated Observations: Application to Multivariate Profile Monitoring

Qiang Zhou, University of Arizona, Tucson, AZ, United States, q.zhou@arizona.edu, Yongxiang Li, Li Zeng

Existing profile monitoring methods almost exclusively deal with univariate profiles, but multivariate profiles are increasingly encountered. In this paper, we advocate the use of multivariate Gaussian process model for such data, which offers a natural way to accommodate both within-profile and between-profile correlations. To mitigate the high computation, a pairwise estimation strategy is adopted and its asymptotic properties are investigated.

3 - Additive Gaussian Process for Computer Models with Qualitative and Quantitative Factors

Xinwei Deng, Department of Statistics, Virginia Tech, 406 Hutcheson Hall, Blacksburg, VA, 24061, United States, xdeng@vt.edu, Devon Lin, K-W. Liu, R. K. Rowe

Computer experiments with qualitative and quantitative factors occur frequently in various applications. In this work, we propose an additive Gaussian process model for computer experiments with qualitative and quantitative factors. The proposed method considers an additive correlation structure for qualitative factors, and assumes that the correlation function for each qualitative factor and the correlation function of quantitative factors are multiplicative. The merits of the proposed method are illustrated by several numerical examples and a real data application.

■ MC68

371C

Knowledge-driven Analytics for Data-rich Environments

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Wenmeng Tian, Virginia Tech, Blacksburg, VA, 24060-6507, United States, tian0414@vt.edu

1 - Physics-based Attacks Detection in Machining Cyber-physical Systems using In-situ Sensors as Side Channels

Mohammed Shafae, Virginia Tech, 1145 Perry Street, Virginia Te, Durham Hall, Room 250, Blacksburg, VA, 24061, United States, shafae1@vt.edu

Physics-Based Attacks Detection in Machining Cyber-Physical Systems Using In-Situ Sensors as Side Channels

2 - Knowledge Based Data Monitoring in Advanced and Additive Manufacturing

Bianca Maria Colosimo, Politecnico di Milano, Via La Masa, 1, Milan, I-20156, Italy, biancamaria.colosimo@polimi.it

The contribution describes different applications where knowledge of the manufacturing signature can aid quality optimization, monitoring and control. Examples in foam production and additive manufacturing are presented.

3 - Self-segmented Classification via Adaptive Network Lasso with Application in Purchase Prediction
Shuyu Chu, IBM T.J. Watson Research Center, Yorktown Heights, Yorktown Heights, NY, 10598, United States, cshuyu@vt.edu, Huijing Jiang, Xinwei Deng, Zhengliang Xue, Naoki Abe

Predicting the purchase likelihood of potential clients is essential in finding the optimal pricing strategy in business. However, the heterogeneity within clients and products lead to different purchase behaviors. Thus, building one global model on all data is no longer appropriate. In this work, we created a self-segmented classification method to perform segmentation and model fitting simultaneously. This method ensures that the estimated models under different segments are distinctive and data points with a common model structure are grouped into the same segment. The performance of the method and its merits are illustrated by numerical examples and a case study with the IBM pricing data.

4 - A Spatial Statistical Method for Designing 3D Laser Scan Paths
Romina Dastoorian, Western Michigan University, Kalamazoo, MI, United States, romina.dastoorian@wmich.edu, Lee Wells

The emergence of 3D laser scanning technologies has significantly enhanced inspection system capabilities by providing high-density point cloud data. However, these new capabilities also bring new challenges regarding both the effective and efficient use of point cloud data. To improve the analytical power these datasets provide, it is essential to reduce or eliminate measurement noise. This presentation will introduce a methodology for modeling scan-path induced measurement. This methodology is based upon a spatial statistics model that assumes a point cloud's spatial correlation is the combined effect of both surface induced and scan-path induced is variation.

■ MC69

371D

Optimization Models in Environment and Sustainability

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Hadi Karimi, Clemson University, hkarimi@g.clemson.edu

1 - Grow your Own Feedstock to Mitigate the Impact of Biomass Supply Uncertainty: A Case of Cellulosic Biofuel Investment
Yihua Li, Graduate Student, Iowa State University, 230 Raphael Ave, Unit 12, Ames, IA, 50014, United States, yihuali@iastate.edu, Guiping Hu

A decision-maker wants to enter the cellulosic biofuel market, where his primary option is to invest in a biofuel facility. Corn stover can serve as a main feedstock, while its yield fluctuates due to change in weather conditions. To hedge against supply uncertainty, he has a secondary option of investing in a land to grow his own feedstock (e.g., switchgrass) to achieve dual sourcing in biomass supply. The optimal investment timing for both investments are investigated via a real options approach. The effect of facility and land lead times, as well as risk aversion, are also discussed

2 - Meeting Corporate Renewable Power Targets
Danial Mohseni-Taheri, TA Coordinator, University of Illinois, Chicago, IL, 60607, United States, smohse3@uic.edu, Selvaprabu Nadarajah

We study the procurement problem faced by a firm trying to purchase a target percentage of its power demand from renewable sources by a future date and sustain this target going forward. We provide analytical insights into the structure of the procurement portfolio when employing recent variants of power purchase agreements. In addition, we discuss the challenges of setting up such a portfolio over a long time horizon and provide computational solutions.

3 - The Optimal Operation Policy of a Grid-connected Microgrid
Jong-hyun Ryu, Hongik University, 2639 Sejong-ro, Jochiwon-eup,, Sejong, 30016, Korea, Republic of, jongh.ryu@gmail.com, Dong Gu Choi, Daiki Min

This work considers the optimal operation of a gird-connected microgrid which comprises renewable energy resources, energy storage devices, controllable loads, and controllable generators. To satisfy the increasing electricity demand in a sustainable way, the efficient use of renewable energy is needed and the microgrid concept is one of the approaches. In this work, the optimal operating policy to minimize the generation cost in the microgrid is identified considering the uncertainty in renewable energy generation and load demand.

4 - A Stochastic Multiobjective Optimization Model to Analyze the Economic and Environmental Impacts of Biopower Supply Chains
Hadi Karimi, Clemson University, 1108 Tiger Blvd., Apt. 117, Clemson, SC, 29631, United States, hkarimi@clemson.edu, Sandra D. Eksioglu, Michael Carbajales-Dale

In this study we propose a stochastic multiobjective optimization model to analyze the economic and environmental impacts of biomass power supply chains. While generating electricity from biomass is known to provide an economically attractive option for coal-fired power plants to comply with emission regulations, the total footprint of the associated supply chain still needs to be carefully investigated. The multiobjective model aims at maximizing the potential profits and minimizing the life cycle emissions in the biomass supply chain. We consider the uncertainty in biomass feedstock quality and use sampling-based chance constraints to capture the uncertainties in the optimization model.

■ MC70

371E

Data Mining

Contributed Session

Chair: Matthew Lanham, Purdue University, West Lafayette, IN, United States, lanhamm@purdue.edu

1 - Graph Regularization Based Framework for Product Filtering in E-commerce
Mukul Gupta, Indian Institute of Management Indore, Indore, 453331, India, mukulg@iimidr.ac.in, Rajhans Mishra

The multitude of choices for users of e-commerce has created a challenging problem for them to select the product of their choice in a reasonable time. Product filtering for helping a user to narrow down to a product of their choice is getting the tremendous attention of researchers. In this work, we propose a preference diffusion approach using graph regularized framework for product filtering. The user-product network with the attribute information of products is formed to diffuse the preference of a user to generate recommendation after filtering of less relevant products for that user.

2 - A Cognitive Framework for Optimal Service Composition
Ahmed Nazeem, Research Staff Member, IBM.Research, IBM.Almaden Research Center, San Jose, CA, 95123, United States, nazeem.35@gmail.com

With the evolution of the cloud based services and the Internet of things, there is an increasing need to develop an end-to-end framework that automates the solution design.

3 - Recommendation System Incorporating User Profile and Sequential Information
Rajhans Mishra, Indian Institute of Management-Indore, Faculty Block B, First Floor, Rau, Indore, 453331, India, rajhans111@gmail.com, Mukul Gupta

Recommendation system generates suggestions to the users as per their preferences with respect to various products and services. The proposed work focuses on generation of recommendations using user profile, content and sequential information with respect to user activities. User profiling may be done on various user specific parameters while sequential and content information can be captured through user activities as web navigation, product /service selection etc. Considering user profile, content, and sequential information collectively may help to capture the preferences of the users.

4 - A Text Based Decision Support System to Detect Fraudulent Bank Activity
Matthew A. Lanham, Clinical Assistant Professor, Purdue University, West Lafayette, IN, United States, lanhamm@purdue.edu, Jeffery Mei, Alan Abrahams, Rich Gruss

We develop a text analytics decision support system to detect fraudulent bank account activity. This research is motivated by the 2016 Wells Fargo scandal which entailed a $190 million settlement with federal regulators and prosecutors for opening more than two million deposit and credit card accounts without customer authorization. We show that our DSS can be used by regulators and financial institutions for internal control.

■ MC71

371F

New Results on Integer Programming

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Daniel Bienstock, Columbia University, New York, NY, 10027, United States, dano@columbia.edu

1 - Extension Complexity Lower Bounds for Mixed-integer Extended Formulations

Robert Hildebrand, IBM T.J. Watson Research Center, Yorktown Heights, NY, United States, robDhildebrand@gmail.com

We prove that any mixed-integer linear extended formulation for the matching polytope of the complete graph on n vertices, with a polynomial number of constraints, requires $\Omega(\sqrt{\sfrac{n}{\log n}})$ many integer variables. By known reductions, this result extends to the traveling salesman polytope. This lower bound has various implications regarding the existence of small mixed-integer mathematical formulations of common problems in operations research. This provides a first non-trivial lower bound on the number of integer variables needed in such settings.This is joint work with Robert Weismantel and Rico Zenklusen.

2 - Cutting Planes from Reverse Polars of Disjunctive Sets

Egon Balas, Professor, Carnegie Mellon University, Posner Hall Rm 232B, 5000 Forbes Avenue, Pittsburgh, PA, 15213-3890, United States, eb17@andrew.cmu.edu, Aleksandr Kazachkov

Lift-and-project cuts from a union of polyhedra can also be obtained without lifting, from the intersection of the reverse polars of those polyhedra, involving their V-polyhedral representation.. In particular, strong cuts can be obtained from the intersection of the reverse polars of polyhedra representing the active leaves of a branch-and-bound tree. We explore and test this approach.

3 - Aggregation-based Cutting-planes

Santanu Subhas Dey, Georgia Institute of Technology, School of Industrial and Systems Engineering, 765 Ferst Drive Nw,, Atlanta, GA, 30332, United States, santanu.dey@isye.gatech.edu, Merve Bodur, Alberto Del Pia, Marco Molinaro, Sebastian Pokutta

We study the strength of aggregation cuts for packing and covering integer programs (IPs). Aggregation cuts are obtained as follows: Given an IP formulation, first generate a single implied inequality using aggregation of the original constraints, then obtain the integer hull of the set defined by this single inequality with variable bounds, and finally use the inequalities describing the integer hull as cutting-planes. We show that for packing and covering IPs, the aggregation closures can be 2-approximated by simply generating cuts from original formulation constraints. On the other hand, aggregation cuts can be arbitrarily stronger than cuts from individual constraints for general IPs.

4 - On Exploiting Submodularity in Conic Quadratic Mixed-0-1 Optimization

Andres Gomez, University of California, 2020 Delaware Street, Apt 3, Berkeley, CA, 94709, United States, a.gomez@berkeley.edu, Alper Atamturk

We describe convex valid inequalities for conic quadratic mixed-0-1 optimization. The inequalities are based on decomposing the quadratic term into two components, one of which is submodular. We prove that the proposed inequalities completely describe the convex hull of a single conic constraint over binary variables and unbounded continuous variables, and are also sufficient to describe the convex hull of rotated cone constraints with a diagonal quadratic term. Computational experiments with value-at-risk minimization and assortment optimization problems indicate that the inequalities strengthen the convex relaxations substantially and lead to significant performance improvements.

■ MC72

372A

Network Optimization Models and Applications

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Jorge A. Sefair, Arizona State Univerity, Tempe, AZ, 85287-8809, United States, jorge.sefair@asu.edu

1 - A Two Echelon Humanitarian Supply Chain Model

Chrysafis Vogiatzis, North Dakota State University, 1057 35th Street North, Apt 105, Fargo, ND, 58102, United States, chrysafis.vogiatzis@ndsu.edu

In this talk, we discuss two-echelon VRPs for logistics operations during a humanitarian crisis. It differs from typical multi-echelon supply chain management systems as there exist no intermediate facilities to organize goods for delivery; instead all decisions are made en-route. This paradigm offers advantages for logistics during extreme events, as it can parallelize the last mile of delivery. It also enables city logistics, where smaller, more flexible, and maneuverable vehicles are in charge of final delivery. Last, with the increasing availability of unmanned vehicles, it helps automate the supply process, while also serving areas that are difficult to reach or are rendered inaccessible.

2 - Toward the Development of Resilience Indices for Multi-echelon Assembly Supply Chain Networks

Huy Q. Nguyen, Rensselaer Polytechnic Institute, 110 8th Street, 5119 Center for Industrial Innovation, Troy, NY, 12180, United States, nguyeh7@rpi.edu, Thomas Sharkey, William A. Wallace, John E.Mitchell

We develop scheduling rules to optimize the recovery performance of multi-echelon assembly supply chain networks (MEASC) from large-scale disruptive events. Each supplier within the MEASC network assembles a component from a series of sub-components received from other suppliers. Utilizing these decision rules, we develop resilience indices to help supply chain managers evaluate the vulnerability of their networks to different types of disruptive events. Our decision rules and indices are applied on a data set modeling an industry partner's supply chain.

3 - An Optimization Model for Multiagent Path Selection and Scheduling with Geographic Conflict

Navid Matin Moghaddam, nmatinmo@asu.edu, Jorge A. Sefair

We study the problem of finding the minimum arrival time of multiple agents traveling between known origins and destinations in a network. Paths must not be conflicting, meaning that there must be a minimum distance between agents at any time. We discuss the problem complexity and present an optimization model to find the path and schedule for each agent to traverse the network. Typical examples of this problem include the transportation of hazardous materials and transportation operations under geographic failures. We present a cutting-plane exact solution approach to solve this problem.

4 - Restoration of Interdependent Infrastructures using Integrated Network Design and Scheduling Problems with Machine Movement Interdependence

Aniela Garay Sianca, University of Arkansas, Fayetteville, AR, 72701, United States, agaraysi@email.uark.edu, Sarah G. Nurre

Researchers have examined how to restore interdependent infrastructure systems by deciding what components are repaired, when the repairs are scheduled, and who performs each repair using integrated network design and scheduling problems. A main limitation of this work is the assumption that a machine can feasibly move using the transportation network when assigned two consecutive tasks. Flooding and other obstructions on the transportation network often prohibit such assignments. We present a new optimization model by explicitly including the machine movement interdependence. We present the results of computational experiments for the interdependent infrastructure networks of Panama.

■ MC73

372B

Statistical Learning and Optimization

Invited: Operations Research and the Future of Computing

Invited Session

Chair: Emma Frejinger, Universite de Montreal, Universite de Montreal, Montreal, QC, H3C 3J7, Canada, emma.frejinger@cirrelt.ca

1 - On the Role of (Machine) Learning in (Mathematical) Optimization

Andrea Lodi, École Polytechnique Montréal, Montréal, QC, Canada, andrea.lodi@polymtl.ca

In this talk, I try to explain my point of view as a Mathematical Optimizer — especially concerned with discrete (integer) decisions — on Big Data. I advocate a tight integration of Machine Learning and Mathematical Optimization (among others) to deal with the challenges of decision-making in Data Science and I discuss in details two areas in which machine learning techniques have been (successfully) applied to mixed-integer programming.

2 - Discrete-continuous Maximum Likelihood Estimation

Anna Fernandez-Antolin, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, anna.fernandezantolin@epfl.ch, Virginie Lurkin, Matthieu de Lapparent, Michael Bierlaire

In statistics, maximum likelihood estimation involves solving a nonlinear optimization problem, that is often non-convex. It generates statistical estimates of the unknown parameters of a model. In the context of discrete choice modeling, the structure of the model is also unknown. For instance, a nested logit model assumes a partition of the choice set. Obtaining the partition from the data assumes involving discrete variables into the maximum likelihood estimation problem. In this paper, we aim at formulating the problem as a mixed integer linear problem (MILP).

3 - Approximating an Integer Linear Program by Structured Prediction Models

Emma Frejinger, Université de Montréal, FAS, Pavillon Andre-Aisenstadt, Montreal, QC, H3C 3J7, Canada, emma.frejinger@cirrelt.ca, Eric Larsen, Yoshua Bengio, Simon Lacoste-Julien, Andrea Lodi

We consider an operational planning problem for which we have an ILP that can be solved in reasonable time using a commercial solver. We propose to learn a structured prediction model that allows to compute approximate solutions to the ILP in very short computational time. We generate data by simulating problem instances and computing the corresponding solutions to the ILP. We can hence control the characteristics of the data and its size can be as large as the computational budget allows. The input to the structured model defines the problem instance and the output its solution. The structured prediction model is part of the solution methodology to a tactical service network design problem.

4 - LP-based Misclassification Minimization

John W. Chinneck, Carleton University, Systems and Computer Engineering, 1125 Colonel By Drive, Ottawa, ON, K1S.5B6, Canada, chinneck@sce.carleton.ca

Placing a separating surface that misclassifies the minimum number of points can be cast as an instance of maxFS, the problem of finding the maximum subset of constraints that can be simultaneously satisfied in an infeasible linear program. Fast and effective heuristics for maxFS can thus be used to construct classifiers. These algorithms also allow for selecting features while placing the separator, and can guide the placement for purposes such as equalizing the prediction accuracies, protecting minority types, etc.

■ MC74

372C

Mixed-integer Two-stage Optimization Methodology and Applications

Sponsored: Computing

Sponsored Session

Chair: Leonardo Lozano, Clemson University, Clemson, SC, 29631, United States, llozano@g.clemson.edu

1 - Optimal Clustering on a Graph

Gokce Kahvecioglu, Northwestern University, Evanston, IL, United States, GokceKahvecioglu2014@u.northwestern.edu, David Morton

We study a clustering problem defined on an undirected graph with nonnegative weights on the edges. We remove a subset of edges to break the graph into smaller pieces, i.e., clusters. We incur a cost based on the weight of edges that are removed, and we obtain a gain in terms of the number of clusters we form. We consider the model from a bi-criteria perspective, and we aim to construct a family of solutions minimizing cost while maximizing gain.

2 - Vector-valued Multivariate Conditional Value-at-risk

Simge Kucukyavuz, University of Washington, Box 352650, Industrial & Systems Engineering, Seattle, WA, 98195, United States, simge@uw.edu, Merve Merakli

In this study, we propose a new definition of multivariate conditional value-at-risk (MCVaR) as a set of vectors for discrete probability spaces. We explore the properties of the vector-valued MCVaR (VMCVaR) and show the advantages of VMCVaR over the existing definitions given for continuous random variables when adapted to the discrete case. Finally, we discuss optimization of problems involving multivariate CVaR.

3 - Generalized Benders' Algorithm for Mixed Integer Bilevel Linear Optimization

Suresh Bolusani, Lehigh University, Bethlehem, PA, United States, sub214@lehigh.edu, Ted Ralphs

Mixed integer bilevel linear optimization provides a framework for modeling optimization problems involving multiple, independent decision makers with multiple, possibly conflicting objectives. In this talk, we present a generalized Benders' algorithm for solving these problems. As with any Benders' algorithm, the strategy is to project out the second-stage variables to obtain a reformulation involving only first-stage variables. This reformulation involves the value function of the bilevel optimization problem resulting from fixing the first-stage variables, which is then iteratively approximated. We present preliminary computational results with an open-source implementation.

4 - Robust Optimization with Evacuation Transportation under Boudedly Rationality User Equilibrium

Guanxiang Yun, University of Central Florida, Orlando, FL, 32816, United States, ygx8822@knights.ucf.edu, Qipeng Zheng

We proposed several models for the transportation path problems. We supposed that all the users in the system will obey the bounded rational user equilibrium principle. In real world instances, people will feel just fine even if they do not reach the best utility they can get but only attain a certain level. We proposed totally four conditions for our models with two of them having the pricing strategy, which will have a robust optimization model. We solved it by using the column and constraint generation. And Because of the huge number of variables and constraints we have in our system, we still used the column generation for the variables and also check the most violation constraint to check the convergency.

■ MC75

372D

Interactions of Optimization and Statistical Learning II

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Ethan Xingyuan Fang, Pennsylvania State University, University Park, PA, 16802, United States, xxf13@psu.edu

Co-Chair: Zhaoran Wang, Princeton University, Princeton, NJ, 08540, United States, zhaoran@princeton.edu

1 - Variance Reduction for Restricted Strong Convexity

Huan Xu, Georgia Institute of Technology, Industrial and Systems Engineering, Atlanta, GA, 30332, United States, huan.xu@isye.gatech.edu, Chao Qu

Computational challenges of statistical estimators and machine learnng algorithms are an active area of study. Stochastic first order methods based on variance reduction have attracted significant attention because of light computation load for each iteration, and fast convergence speed for strongly convex problems. Yet, many powerful statistical and machine learning models are not strongly convex, and sometimes even non-convex. In this talk, I will argue that a nice statisitical property of those problems - restricted strong convexity - ensures that linear convergence of variance reduced stochastic first order methods for those statistical models.

2 - Taming Nonconvexity with Data

Zhaoran Wang, Princeton University, Apt 302, 13 Lawrence Drive, Princeton, NJ, 08540, United States, zhaoran@princeton.edu

In this talk, I will illustrate how statistical thinking enables us to harness the power of nonconvex optimization. In specific, I will present an algorithmic framework for exploiting the latent geometry induced by the randomness of data. By integrating three new global exploration meta-algorithms — namely, homotopy continuation, tightening after relaxation, and noise regularization — with local search heuristics — such as the variants of gradient descent — this unified framework leads to new nonconvex optimization algorithms for a broad variety of challenging learning problems.

3 - Gradient Descent Converges to Local Minimizers

Jason Lee, University of Southern California, San Marino, CA, United States, jasondlee88@gmail.com

We show that saddlepoints are easy to avoid for even Gradient Descent — arguably the simplest optimization procedure. We prove that with probability 1, randomly initialized Gradient Descent converges to a local minimizer. Next we show that gradient descent takes exponential time to converge to a local minimizer with Gaussian initialization, yet stochastic gradient or trust-region method take only polynomial time. This is joint work with Max Simchowitz, Ben Recht, Michael Jordan, Simon Du, Chi Jin, Barnabos Poczos, and Aarti Singh.

4 - Non-stationary Streaming PCA

Apurv Shukla, Columbia University, New York City, NY, United States, as5197@columbia.edu, Daniel Bienstock, Seyoung Yun

Motivated by rapidly changing dynamics of energy systems and poor performance of machine learning algorithms in non-stationary noisy environments, we present a novel memory-limited streaming algorithm to track time-varying subspaces for detecting anomalies. Our main theoretical contribution includes a novel proof-technique for analyzing convergence of the algorithm. Our algorithm uses low storage memory and shows promising results as compared to other existing algorithms.

■ MC76

372E

Dynamic Programming Based Methods for Discrete Optimization

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Selvaprabu Nadarajah, College of Business, University of Illinois at Chicago, Chicago, IL, 60607, United States, selvan@uic.edu

Co-Chair: Andre Augusto Cire, University of Toronto-Scarborough, Toronto, ON, M1C-1A4, Canada, acire@utsc.utoronto.ca

1 - An Exact Algorithm for a Dynamic Knapsack Problem

Alejandro Toriello, Georgia Institute of Technology, Atlanta, GA, United States, atoriello@isye.gatech.edu, Daniel Blado

We examine a stochastic knapsack problem with random item sizes that are realized upon an attempted insertion. The goal is to maximize expected profit and the process ends after a failed insertion. We propose an exact algorithm based on a reformulation of the value function linear program that dynamically prices variables to refine a value function approximation and generates cutting planes to maintain a dual bound. We discuss the algorithm's theoretical properties and its empirical performance.

2 - Approximate Linear Programming for Discrete Optimization

Selvaprabu Nadarajah, College of Business, University of Illinois at Chicago, 601 South Morgan Street,, U. H.2406, Chicago, IL, 60607, United States, selvan@uic.edu, Andre Augusto Cire

We consider a hierarchy of approximate linear programming based approximations to a general class of discrete optimization problems. We present theory regarding the relative quality of these approximations and test them on challenging discrete optimization problems arising in practice.

3 - Toward Breaking the Curse of Dimensionality: An FPTAS for Stochastic Dynamic Programs with Multidimensional Action and Scalar State

Giacomo Nannicini, IBM T.J. Watson, 1101 Kitchawan Road, Yorktown Heights, NY, United States, nannicini@us.ibm.com, Nir Halman

We propose an FPTAS for stochastic dynamic programs with multidimensional action, scalar state, convex piecewise linear costs and linear state transition function. The action spaces are polyhedral and described by parametric linear programs. The FPTAS relies on the solution of polynomial-sized linear programs to recursively compute an approximation of the value function at each stage. Our paper enlarges the class of dynamic programs that admit an FPTAS by showing how to deal with multidimensional action spaces and with vectors of continuous random variables under suitable conditions, therefore getting one step closer to overcoming the curses of dimensionality of dynamic programming.

■ MC77

372F

Algorithms for Semidefinite Programming and Conic Optimization

Sponsored: Optimization, Linear and Conic Optimization

Sponsored Session

Chair: Sercan Yildiz, University of North Carolina at Chapel Hill, Statistical and Applied Mathematical Sciences Institute, 19 TW Alexander Drive, Research Triangle Park, NC, 27703, United States, syildiz@email.unc.edu

Co-Chair: David Papp, North Carolina State University, Raleigh, NC, 27606, United States, dpapp@ncsu.edu

1 - Solving Conic Systems via Projection and Rescaling

Negar Soheili Azad, University of Illinois-Chicago, 601 S. Morgan Street, University Hall 2416, Chicago, IL, 60607, United States, nazad@uic.edu, Javier F.Pena

We propose a projection and rescaling algorithm to solve conic feasibility problems. Our algorithm is inspired by previous work on rescaled versions of the perceptron algorithm and by Chubanov's projection-based method for linear feasibility problems. As in these predecessors, each main iteration of our algorithm contains two steps: a basic procedure and a rescaling step. We compare the performance of different basic procedures and study the rescaling algorithm's performance on linear feasibility problems.

2 - Convex Optimization via Domain Driven Barriers and Primal Dual Algorithms

Mehdi Karimi, University of Waterloo, 200 University Ave W, Waterloo, ON, N2L.3G1, Canada, m7karimi@uwaterloo.ca, Levent Tuncel

During the last two decades, primal-dual algorithms enjoyed significant advances in solving convex optimization problems in conic form over symmetric cones. However, many other highly demanded optimization problems lack such advances. To make the gap closer, we develop a theory of infeasible-start primal-dual algorithms for problems in the "Domain-Driven" setup, which covers many interesting problems including those with a "natural" conic formulation. After presenting our techniques, and our convergence theorems, we introduce our developing Matlab-based code, DDS, that solves a large class of problems including LP, SOCP, SDP, QCQP, geometric programming, and entropy programming.

3 - Polynomial Optimization with Sum-of-Squares Interpolants

Sercan Yildiz, University of North Carolina at Chapel Hill, SAMSI, 19 TW. Alexander Drive, Research Triangle Park, NC, 27703, United States, syildiz@email.unc.edu, David Papp

Sums-of-squares relaxations define a hierarchy of lower bounds for polynomial optimization problems. Although these relaxations can be represented as semidefinite programs, solving these semidefinite programs poses practical challenges at higher levels of the hierarchy. First, their size depends quadratically on the size of the sums-of-squares relaxation. Second, numerical problems are often encountered in their solution. In this talk, we show that non-symmetric conic programming and polynomial interpolation techniques can be used to optimize efficiently over the sums-of-squares cone.

■ MC78

381A

Electric Energy Storage Planning: Methods and Results

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Elaine Hale, National Renewable Energy Laboratory, elaine.hale@nrel.gov

1 - Investing in Grid-scale Energy Storage: Placement in Transmission vs. Distribution Systems?

Yury Dvorkin, New York University, 185 Stevens Way NE, Paul Allen Center, Room AE104R, New York, NY, 11201, United States, dvorkin@nyu.edu

If current trends continue, electrochemical energy storage will soon be widely deployed to perform various grid services in both transmission and distribution systems. It is expected that a significant portion of these devices will be owned by merchant, i.e. profit-seeking, entities. Since compensation and regulatory requirements in the distribution and transmission systems vary, merchant investors need to carefully optimize investments in energy storage to achieve maximum gains. This presentation will describe a modeling framework that makes it possible for merchant investors to trade-off investments in energy storage between the transmission and distribution systems.

2 - Optimized Dispatch for Concentrating Solar Power Subject to Forecast Uncertainty

Michael J. Wagner, National Renewable Energy Laboratory, 15013 Denver West Pkwy, MS-RSF033, Golden, CO, 80401, United States, Michael.Wagner@nrel.gov

Concentrating Solar Power (CSP) systems are capable of efficient storage of thermal energy that can then be dispatched to generate electricity at night or during cloudy periods. The optimal energy dispatch schedule depends on weather and pricing forecasts which are inherently uncertain. Furthermore, these forecasts and their uncertainty may be correlated depending on local market structure and prominence of renewable generators on the grid. We present methods and results for optimal dispatch of CSP systems subject to weather and pricing forecast uncertainty. The model is implemented in the publicly available System Advisor Model software, and design sizing sensitivity results are discussed.

3 - Planning for Concentrating Solar Power in the Western United States

Elaine Thompson Hale, National Renewable Energy Laboratory, 15013 Denver West Parkway, MS RSF300, Golden, CO, 80401, United States, elaine.hale@nrel.gov, Brady Stoll, Jennie Jorgenson

Concentrating solar power with thermal energy storage (CSP-TES) is a flexible renewable energy technology that could be an attractive complement to solar photovoltaics (PV) and wind in the Southwestern United States (U.S.). When and where such investments may be attractive depends on future policies, fuel prices, and cost trajectories of alternative technologies such as PV and battery storage. We apply the Resource Planning Model (RPM), which is a capacity expansion model designed for regional power systems and high levels of renewable generation and complementary flexible technologies, to this question for a region centered on current U.S. CSP deployment and looking out to 2035.

4 - Friend or Foe? the Impact of Energy Storage on Solar and Wind Investments

John Erik Bistline, Electric Power Research Institute, 3300 Sawtelle Blvd, Apt. 310, Los Angeles, CA, 90066, United States, john.bistline@gmail.com

Energy storage is often linked with improving the economic proposition of variable renewables like wind and solar, though few existing studies examine how low-cost storage simultaneously impacts electric sector operations and investments. This talk investigates the economics of grid-connected energy storage and its effect on system investments, emissions, and costs using the US-REGEN capacity planning and dispatch optimization model. Model experiments illustrate how the effects of storage depend on the supply responsiveness of different generators and vary across different market conditions, which may favorably or adversely influence solar and wind deployment.

5 - A Future Outlook on Wind, Solar, and Energy Storage Deployment

Cara Marcy, Renewable Electricity Analyst, U.S. Energy Information Administration, Washington, DC, 20585, United States, cara.marcy@eia.gov

EIA's National Energy Modelling System (NEMS) provides a future multi-decadal assessment of U.S. energy sectors, including electricity. Recently, variable technologies, such as wind and solar, have increased in market share. In NEMS, challenges arise in accounting for this variability in a manner that preserves computational time. In addition energy storage is one option that can take advantage of value streams presented from this variability, such as curtailments, as well as other market value streams. This presentation will review the model structure for energy storage and curtailments in NEMS, as well as highlight scenarios that study the relationship between renewables and energy storage.

■ MC78B

380B

Humanitarian Logistics

Contributed Session

Chair: Shreya Gupta, The University of Texas-Austin, Austin, TX, United States, shreya.gupta@utexas.edu

1 - Exact and Heuristic Approaches for Bidirectional Leaf Trajectory Optimization in Intensity-modulated Radiotherapy

Seyedali Mirzapour, Wichita State University, 203A-Engineering Building, 1845 Fairmount St,, Wichita, KS, 67260, United States, mirzapour.ie@gmail.com, Ehsan Salari

Traditionally, unidirectional leaf-sweeping schemes have been used to dynamically modulate radiation beams in radiotherapy. However, the unidirectional leaf-motion restriction may lead to poor beam modulation when the available beam-on time is limited. This research investigates the potential gain in beam-modulation quality and delivery efficiency obtained from relaxing this restriction and allowing for bidirectional leaf trajectories. A mixed-integer programming formulation with exact and heuristic solution methods are developed to optimize for bidirectional piecewise-linear leaf trajectories.

2 - Optimal Child Delivery Strategies for Hypertensive Disorders of Pregnancy

Aysegul Demirtas, PhD Candidate, Arizona State University, Tempe, AZ, United States, Aysegul.Demirtas@asu.edu, Esma S. Gel, Soroush Saghafian, Dean V. Coonrod

Hypertensive disorders of pregnancy (HDP) constitute one of the leading causes of maternal and neonatal mortality and morbidity. We study the decision problem of timing of child delivery for women with HDP. We formulate a Markov decision process (MDP) model that minimizes the risks of maternal and neonatal adverse outcomes, and assess its results with a probabilistic sensitivity analysis (PSA). In PSA, we construct instances by generating model parameters in restricted orders to incorporate physicians' intuition in part of the estimations with low sample size. We also build a robust MDP model that considers the sensitivity of transition probabilities while avoiding over-conservative policies.

3 - Analytic Advancements in the Project Data Sphere Open Access Data Sharing Platform

Steven B.Cohen, Vice President, RT.I.International, 701 13th Street NW, Washington, DC, 20005-3967, United States, scohen@rti.org

Project Data Sphere (PDS) is a research platform providing broad access to both de-identified patient-level data from oncology clinical trials and related analytic tools. Data providers are required to de-identify patient-level data by removing key demographic data. To address these analytic constraints, the patient-level cancer phase III clinical data has been augmented by linking the social, economic and health related characteristics of like cancer survivors from nationally representative health and healthcare-related survey data. This presentation will provide an overview of the methodologies used and an analysis of the association between these factors and patient outcomes.

4 - A Recommendation System for Managing Physical Fatigue in the Workplace

Lin Lu, Auburn University, 371 W. Glenn Ave, Apt 13, Auburn, AL, 36830, United States, lzl0032@auburn.edu, Fadel Mounir Megahed, Lora Cavuoto

In this talk, we propose a system for managing fatigue in the workplace based on combining principles from artificial intelligence, safety science and management. Our system consists of the following modules: (a) a knowledge base, (b) an inference engine, and (c) a user interface. The system recommends appropriate interventions based on the type of fatigue and the different constraints at the workplace.

5 - Using Decision Analytics to Provide Patient-centered Care in Battling Childhood Epilepsy

Shreya Gupta, PhD Student, The University of Texas-Austin, 3452 Lake Austin Blvd, Apt E, Austin, TX, 78703, United States, shreya.gupta@utexas.edu, John Hasenbein

We propose using decision analytics methods from operations research and statistics to improve quality of life and provide patient centered care in childhood epilepsy. Epilepsy researchers estimate that at least 90,000 children per year are not receiving the epilepsy treatment they need, leading to years of poor quality of life and increased mortality for these children. We propose building a Markov decision process (MDP) model of the decision process for childhood epilepsy, utilizing data analytics and personal utility analysis to provide decision support systems for both providers and patients. The primary advantage of such models is that they can be tuned for each patient and/or provider.

■ MC79

381B

Uncertainty-aware Expansion Planning in Complex Infrastructures

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Yuri Dvorkin, New York University, New York, NY, 11201, United States, dvorkin@nyu.edu

1 - The Value of Demand Response Controllability

Kenneth Bruninx, KU. Leuven, Celestijnenlaan 300, Post Box 2421, Leuven, B3001, Belgium, Kenneth Bruninx, EnergyVille, Genk, Belgium, Kenneth Bruninx, VITO, Mol, Belgium, kenneth.bruninx@mech.kuleuven.be

Demand response (DR) resources, such as thermostatically controlled loads, are not fully controlled by the system operator and their availability is limited by user-defined comfort constraints. We present an operational model that optimizes power plant scheduling in the presence of stochastic RES-based generation and DR resources (here: residential electric heating systems) that are partially controllable and governed by user-defined comfort constraints. This model is used to evaluate the operating cost savings that can be attained via DR on a model of the Belgian power system.

2 - Data-driven Stochastic Transmission Expansion Planning

Jianhui Wang, Southern Methodist University, Dallas, TX, United States, jianhui@smu.edu
Jianhui Wang, Argonne National Laboratory, Argonne, IL, United States, jianhui@smu.edu

We present a data-driven two-stage stochastic transmission expansion planning method with uncertainties. We first use a confidence set for the unknown distribution of the uncertain parameters. Then, a two-stage data-driven transmission expansion framework is developed considering the worst-case distribution within the constructed confidence set. A decomposition framework embedded with Benders' and Column-and-Constraint generation methods is used to solve the problem.

3 - Optimization of Integrated Gas-electric Systems under Uncertainty

Line Roald, Los Alamos National Laboratory, Los Alamos, NM, United States, lineroald@gmail.com, Sidhant Misra

The electric grid depends on gas-fired generation to balance the intermittent renewable energy production, resulting in time-varying and unpredictable gas flows. To ensure secure and economic operation of the integrated system, we solve an optimization problem that minimizes cost of operation, subject to constraints from both the electric and gas systems. The electric grid is modelled using chance constraints, which provide probabilistic bounds on the gas withdrawals. The gas constraints are modelled using partial differential equations, and are formulated as robust constraints based on monotonicity properties of the gas flows. We demonstrate the benefits of the method through a case study.

4 - Long-term Coordination of Transmission and Storage to Integrate Wind Power

Antonio J. Conejo, The Ohio State University, Department of Integrated Systems Engineering, 210 Baker Systems Building, Columbus, OH, 43210, United States, conejonavarro.1@osu.edu, Ning Zhang, Chongqing Kang, Yaohua Cheng

A power system with a high wind power integration requires extra transmission capacity to accommodate the intermittency inherent to wind power production. Storage can smooth out this intermittency and reduce transmission requirements. This presentation describes a stochastic optimization model to coordinate the long-term planning of both transmission and storage facilities to efficiently integrate wind power. Both long-term and short-term uncertainties are considered in this model. Long-term uncertainty is described via scenarios, while short-term uncertainty is described via operating conditions.

■ MC80

381C

Optimizing Distributed Energy Generation

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Alexandra M Newman, Colorado School of Mines, Golden, CO, 80401, United States, anewman@mines.edu

1 - Parameterization for Optimized Dispatch of Concentrating Solar Power Production

Will Hamilton, Colorado School of Mines, Golden, CO, United States, whamilton@mymail.mines.edu

Concentrated solar power technologies can store solar energy, decoupling electricity generation from time periods with solar resource. The decision to produce electricity or to store thermal energy for later use is complex and involves multiple inputs. We have developed a profit-maximizing mixed-integer linear program that determines start-up and shutdown times for the power cycle and solar receiver. Here, we present the results of sensitivity studies on these key plant performance parameters, which provide insight into the importance of the accuracy of each parameter to ensure the viability of operational decisions using optimal thermal energy storage dispatch.

2 - Power Curve Prediction through a Nonparametric Additive Multivariate Kernel Approach

David Perez, Texas A&M.University, College Station, TX, United States, dmp4@tamu.edu

This presentation intends to demonstrate how to estimate a wind turbine's power curve based on environmental conditions through an additive multivariate kernel (AMK) approach. The power curve represents the sigmoidal relationship between power output of a wind turbine and velocity. However, other environmental variables like wind direction and air density also impact power production. The AMK method uses these other variables to formulate an estimator of power production, taking advantage of the multiplicative, nonlinear relationship between the response and multiple explanatory variables. Finally, the AMK method is compared to other popular approaches for prediction accuracy.

3 - A Polyhedral Study of Min-up/-down and Ramping Polytope

Kai Pan, University of Florida, 411 Weil Hall, Gainesville, FL, 32611, United States, kpan@ufl.edu, Yongpei Guan

We present a comprehensive polyhedral study on the integrated minimum-up/-down time and ramping polytope, which has broad applications in power generation scheduling (on both transmission/distribution levels), manufacturing scheduling, chemical engineering, etc. Both theoretical and numerical results are provided to demonstrate the strength and applications of the proposed cutting planes.

■ MC81

382A

Data Driven Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Andrew Lim, National University of Singapore, National University of Singapore, Singapore, 119245, Singapore, andrewlim@nus.edu.sg

1 - Demand Forecasting for New Products in a Cosmetic Company

Shanshan Huang, shanshanhuang@u.nus.edu

We build a Bayesian structure model to study demand estimation for new products. Based on historical product covariates and sales, we are able to learn the sales pattern and forecast the future demand.

2 - Smart "Predict, then Optimize"

Adam Elmachtoub, Columbia University, 500 W. 120th St., New York, NY, 10027, United States, adam@ieor.columbia.edu, Paul Grigas

We consider a class of optimization problems where the objective function is not explicitly provided, but contextual information can be used to predict the objective based on historical data. A traditional approach would be to simply predict the objective based on minimizing prediction error, and then solve the corresponding optimization problem. Instead, we propose a prediction framework that leverages the structure of the optimization problem that will be solved given the prediction. We provide theoretical, algorithmic, and computational results to show the validity and practicality of our framework.

3 - Failing to Learn via Exploration Boosts

Michael Jong Kim, University of British Columbia, Vancouver, BC, Canada, mike.kim@sauder.ubc.ca, Ya-Tang Chuang

We investigate a class of sequential Bayesian maintenance optimization problems where parameters of the lifetime distribution are learned using right-censored failure data. We show that the optimal preventive maintenance (PM) time can be expressed as the sum of a myopic-optimal PM time plus an "exploration boost" that is proportional to the posterior variance. We conduct asymptotic structural and performance analysis of the optimal PM policy.

4 - A DC Optimization Approach to Sparse Spline Regression

Jun-ya Gotoh, Professor, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, jgoto@indsys.chuo-u.ac.jp, Yuichi Misawa

In this paper we consider the estimation of a spline regression with a constraint on the number of splines to be employed. Reformulating the cardinality constraint into a DC (difference of two convex functions)-constraint, we further reformulate the problem to an unconstrained one, where the DC constraint is moved to the objective after multiplying a positive constant. Then a proximal DC algorithm (Gotoh, Takeda, Tono, 2015) is applied, so that a stationary point can be efficiently attained. Numerical results will be presented in comparison with an existing l1-regularized formulation.

■ MC82

382B

Optimization under Multistage Uncertainty

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Kartikey Sharma, Northwestern University, Evanston, IL, 60208, United States, kartikeysharma2014@u.northwestern.edu

1 - Optimization under Connected Uncertainty

Kartikey Sharma, Northwestern University, Room C223, 2145 Sheridan Road, Evanston, IL, 60208, United States, kartikeysharma2014@u.northwestern.edu, Omid Nohadani

Distributionally robust and standard robust optimization methods provide a tractable way to address uncertainties. In many applications, past observations influence future uncertainties. In this presentation, we leverage this dependence via connected uncertaintysets, where the set parameters at each period depend on previous realizations. To find optimal here- and-now solutions, we reformulate distributionally robust and standard robust constraints for connected uncertainty sets. We illustrate the advantages of this framework with an application in portfolio optimization.

2 - Multistage Robust Optimization with Dynamic Uncertainty Sets for Power System Operations

Alvaro Lorca, Pontificia Universidad Catolica de Chile, Santiago, Chile, alvarolorca@uc.cl, Andy Sun

Motivated by the deep integration of volatile renewable energy sources such as wind and solar power, we will present robust optimization models for real-time and day-ahead power system operations, considering uncertainty in the power output of there sources. An essential component of the developments presented is the proposal of dynamic uncertainty sets to capture temporal and spatial correlations of wind and solar power. We will also discuss the solution methods designed for these challenging problems and the insight obtained from computational experiments.

3 - The Stochastic Container Relocation Problem: Sampling in Multi-stage Stochastic Optimization with Bounded Cost

Virgile Galle, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Building E40-130, Cambridge, MA, 02139, United States, vgalle@mit.edu, Setareh Borjian Boroujeni, Vahideh Manshadi, Cynthia Barnhart, Patrick Jaillet

The Container Relocation Problem (CRP) is concerned with finding a sequence of moves of containers that minimizes the number of relocations needed to retrieve all containers, while respecting a given order of retrieval. This paper studies the stochastic CRP, which relaxes the assumption of knowing the full retrieval order of containers (particularly unrealistic in real operations). We introduce a new multi-stage stochastic model, and propose an optimal algorithm based on pruning as well as a near-optimal algorithm with bounded average error. Algorithms are tested on existing instances.

■ MC83

382C

Stochastic Optimization and Variational Inequality Problems

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Konstantin Pavlikov, University of Florida, 1350 N. Poquito Road, Shalimar, FL, 32579-1163, United States, kpavlikov@ufl.edu

1 - SI-ADMM: A Stochastic Inexact ADMM Framework for Resolving Structured Stochastic Convex Programs

Yue Xie, Pennsylvania State University, 445 Waupelani Dr, Pennsylvania, PA, 16801, United States, yux111@psu.edu, Uday Shanbhag

We consider the resolution of the structured stochastic convex program: min $E[f(x,)] + E[g(y,)]$ such that $Ax + By = b$. To exploit problem structure and allow for developing distributed schemes, we propose a stochastic inexact ADMM (SI-ADMM) in which the subproblems are solved inexactly via stochastic approximation schemes. Based on this framework, we prove that (i) when the inexactness sequence satisfies suitable summability properties, SI-ADMM produces a sequence that converges to the unique solution a.s.; (ii) if the inexactness drops at a geometric rate, the sequence converges to the unique solution in a mean-squared sense at geometric rate, and the total sample complexity can be canonical.

2 - On the Variants of Projection and Extragradient Schemes for Stochastic Variational Inequality Problems

Shisheng Cui, Pennsylvania State University, University Park, PA, 16801, United States, cuishisheng05@gmail.com, Shanbhag Uday

The stochastic generalizations of the extragradient methods are complicated by a key challenge: the scheme requires two projections on a convex set and two evaluations of the map for every major iteration. It becomes a concern if the sets are complicated. Thus, we consider two related avenues where every iteration requires a single projection: (i) A projected reflected gradient method; and (ii) A subgradient extragradient method. We prove the almost sure convergence of the iterates to a random point in the solution set and show that the gap function associated with the averaged sequence diminishes to zero at the optimal rate.

3 - Multi-period Probabilistic Set Covering Problem

Konstantin Pavlikov, University of Florida, 1350 N. Poquito Road, Shalimar, FL, 32579-1163, United States, kpavlikov@ufl.edu

This study extends the classical probabilistic set coverage problem to a multi-period setting. The problem focuses on finding a least cost facility locations to cover random demand over one period of time with a specified probability. If facility engagement lasts more than one period of time, then little is known about how well the remaining operational facilities can satisfy demand in period two. Hence, the two-period model maximizes the probability of satisfying demand in period two by facilities not engaged in satisfying demand from period one. We demonstrate how solving multi-period version of the problem can be reduced to solution of a sequence of one-period probabilistic set coverage problems.

Monday, 3:10 - 4:00PM

■ Keynote

General Assembly A, Level 3

Keynote- INFORMing Process Improvement and Patient Safety in Healthcare

Invited Session

1 - INFORMing Process Improvement and Patient Safety in Healthcare

Victoria Jordan, Emory

Because of my previous position as Executive Director, Performance Improvement at the University of Texas (UT) M. D. Anderson Cancer Center, the conference committee asked me to share information about and the history behind the Texas Medical Center and MD Anderson. I will also discuss my role at UT as Chancellor's Fellow for Systems Engineering and how our team was able to establish partnerships between university faculty (in Business and Engineering) and healthcare professionals to spread the use of operations research and management science in healthcare. I will share some exciting accomplishments from those efforts as well as more general applications across the healthcare industry. I hope you will leave this session with a new understanding of the challenges in healthcare and an interest in using Operations Research and Management Science to address some of these challenges.

■ Keynote

General Assembly B, Level 3

Keynote: Systems Approach to Managing Risk in Human Spaceflight Missions

Invited Session

1 - Systems Approach to Managing Risk in Human Spaceflight Missions

Nancy Currie-Gregg, Texas A&M.(formerly NASA)

Human spaceflight is an inherently risky endeavor. From the first human space exploration missions to recent problems on the International Space Station, NASA has faced many challenges and has relied on creative and innovative engineering solutions to complete the mission and safely return the crew. However, over the past 50 years, NASA has also experienced three fatal accidents resulting in the loss of seventeen crewmembers. Addressing the complex interdependencies and systemic causes associated with these tragedies, including those associated with organizational culture and management, provides insight to the advantages of a systems approach to managing risk in high reliability organizations.

■ Keynote

Grand Ballroom C, Level 3

Keynote: IFORS Distinguished Lecture

Invited Session

1 - Biased Random-Key Genetic Algorithms: Components, Evolutionary Dynamics and Applications

Celso Ribeiro, Universidade Federal Fluminense

A biased random-key genetic algorithm (BRKGA) is a general search procedure for finding optimal or near-optimal solutions to hard combinatorial optimization problems. It is derived from the random-key genetic algorithm of Bean (1994), differing in the way solutions are combined to produce offspring. BRKGAs have three key features that specialize genetic algorithms. First, a fixed chromosome encoding using a vector of N random keys over the real interval [0, 1), where the value of N depends on the instance of the optimization problem. Second, a well-defined evolutionary process adopting a parameterized uniform crossover to generate offspring and thus evolve the population. Third, the introduction of new chromosomes called mutants in place of the mutation operator usually found in evolutionary algorithms. Such features simplify and standardize the procedure with a set of self-contained tasks from which only one is problem-dependent: that of decoding a chromosome, i.e. using the keys to construct a solution to the underlying optimization problem, from which the objective function value or fitness can be computed. In this talk, we review the basic components of a BRKGA and introduce a framework for quick implementations of BRKGA heuristics. We then illustrate the application of this framework to a few case studies in a network routing, load scheduling and data mining problems. We conclude with a brief review of other domains where BRKGAs have been applied.

Monday, 4:30 - 6:00PM

■ MD01

310A

Decision Analysis Awards

Sponsored: Decision Analysis

Sponsored Session

Chair: Jason Merrick, Virginia Commonwealth University, jrmerric@vcu.edu

1 - DAS Student Paper Award

Emanuele Borgonovo, Bocconi University, Bocconi University, Via Sarfatti 25, Milano, 20136, Italy, emanuele Borgonovo@unibocconi.it, John Hahn

The Student Paper Award is given annually to the best decision analysis paper by a student author, as judged by a panel of the Decision Analysis Society of INFORMS. Students who did not complete their PhD prior to May 1, 2016 are eligible for this year's competition.

2 - DAS Publication Award

Vicki Bier, University of Wisconsin, Dept of Ind. Eng. Mechanical Eng Bldg., 1513 University Avenue, Madison, WI, 53706, United States, bier@engr.wisc.edu

This award is given annually to the best decision analysis article or book published in the second preceding calendar year (i.e. calendar year 2015for consideration in 2017). The intent of the award is to recognize the best publication in "decision analysis, broadly defined." This includes, but is not limited to, theoretical work on decision analysis methodology (including behavioral decision making and non-expected utility theory), descriptions of applications, and experimental studies.

3 - DAS Practice Award

Gregory L. Hamm, Stratelytics, LLC, 933 Taylor Avenue, Alameda, CA, 94501, United States, ghamm@strts.com

The Decision Analysis Practice Award is awarded to the best example of decision analysis practice as judged by the Decision Analysis Practice Award Committee. The purpose of the award is to publicize and encourage outstanding applications of decision analysis practice. We will present the finalists and this year's winner.

4 - DAS Ramsey Medal

J. Eric Bickel, The University of Texas at Austin, Graduate Program in ORIE, 1 University Station, C2200, Austin, TX, 78712-0292, United States, ebickel@mail.utexas.edu

The Ramsey Medal of the Decision Analysis Society is awarded for distinguished contributions in decision analysis. Distinguished contributions can be internal, such as theoretical and procedural advances in decision analysis, or external, such as developing or spreading decision analysis in new fields. We will introduce the 2017 Ramsey Medal winner, followed by a presentation by the winner.

■ MD02

310B

Managing Surgical and Inpatient Capacity

Sponsored: Health Applications

Sponsored Session

Chair: Joonyup Eun, PhD, Vanderbilt University Medical Center, 1211 21st Avenue South, Medical Arts Building, Nashville, TN, 37212, United States, joonyup.eun@vanderbilt.edu

Co-Chair: Vikram Tiwari, Vanderbilt University Medical Center, Nashville, TN, 37221, United States, vikram.tiwari@vanderbilt.edu

1 - A Randomized Controlled Trial of a Predictive Modelling-based Scheduling System

Panagiotis Kougias, MD, Baylor College of Medicine, Houston, TX, United States, pkougias@bcm.edu

We randomly scheduled cases in a single operating room by predicting their length using either their historical mean (HM) duration or a regression modeling (RM) system that took into account operative and patient characteristics. Mean imprecision in predicting the end of operative day was higher with the HM approach (30.8 vs. 7.2 minutes, p=0.024). RM was associated with higher throughput (379 vs. 356 cases scheduled over the course of the study, p=0.04) and lower overutilization rate (34 vs. 51% of days with overutilization, p = 0.004). Mean length of overutilization (58 vs. 93 minutes, p=0.002) and undertulization (42 vs. 65 minutes, p=0.013) were superior in the RM arm.

2 - Real-time Bed Assignment Improves Patient Flow at Massachusetts General Hospital

Andrew Martin Vanden Berg, Massachusetts Institute of Technology, Cambridge, MA, United States, avdberg@mit.edu, Aleida Braaksma, Bethany Daily, Peter Dunn, Retsef Levi, Ben Orcutt, Ana Cecilia Zenteno

Assigning newly admitted patients to beds involves multiple constraints. Suboptimal patient-to-bed assignment may cause excessive patient wait times, crowding in upstream areas, and prolonged length-of-stays. We develop algorithms for real-time assignment of patients to beds, aiming at shortening patient wait times and decreasing upstream congestion. Through data-driven simulation, we quantify the benefits of the developed algorithms. Implementation of our results at Massachusetts General Hospital has resulted in significant decreases in patient wait times for beds, in addition to multiple other benefits.

3 - Risk-sensitive Stochastic Surgery Scheduling using CVAR

Amirhossein Najjarbashi, University of Houston, 6377 Chevy Chase Dr, Apt 210, Houston, TX, 77057, United States, amirhossein.najjarbashi@gmail.com, Gino J.Lim

This paper considers a daily surgery scheduling problem where surgical time requirements are stochastic with known probability distributions. A scenario-based mixed-integer linear programming formulation is proposed to minimize the conditional value-at-risk (CVaR) of overtime costs. Besides having desirable mathematical properties, applying CVaR enables hospital managers to adjust their approach toward the uncertainty using different probability levels. A set of benchmark instances is solved to evaluate the effectiveness of the proposed approach in providing low-cost and risk-averse schedules.

4 - Is More Information Always Better in Predicting Daily Surgical Case Volume?

Joonyup Eun, Vanderbilt University Medical Center, 1211 21th Avenue South, Medical Arts Building, Nashville, TN, 37212, United States, joonyup.eun@vanderbilt.edu, Vikram Tiwari, Warren S. Sandberg

We evaluate the tradeoff among two different dimensions of information - quality and quantity of information, by testing the accuracy of a series of data models to predict the daily surgical case volume. We retrieve detailed data of surgeons' working patterns from several information sources. We find that greater amount of information may not improve prediction accuracy if the additional information is prone to errors; however, deploying analytical data treatment strategies to ameliorate those errors improves information quality and results in better surgical case volume predictions.

■ MD03

310C

4:30- 5:15 Gurobi / 5:15 - 6:00 Princeton Consultants Inc.

Invited: Vendor Tutorial

Invited Session

1 - Optimization with R

Renan Garcia, Gurobi Optimization, Houston, TX, United States, garcia@gurobi.com

Are you interested in leveraging mathematical programming technology from within R? This tutorial will survey some of the more popular optimization-related packages in the vast R ecosystem. This includes an overview of the Gurobi R package, along with detailed examples of how to build the optimization models you are looking to solve.

2 - Analytics Model Review and Validation

Irvin J.Lustig, Princeton Consultants, 25 Sylvan Way, 2 Research Way, Short Hills, NJ, 07078, United States, irv@princeton.com

Acting as an independent third party, Princeton Consultants reviews analytics models and how they are deployed in a business. Through our Advanced Analytics Model Review and Validation service, we ask questions such as: What is a correct model? What data is being integrated and how? How are solutions published and used in the business? How sensitive are the answers to the inputs? Did the implemented model reflect the intentions of the practitioner? In this tutorial, Irv Lustig will illustrate the importance of addressing these questions in the context of deploying advanced analytics models in practice.

■ MD03A

Grand Ballroom A

Markov Decision Processes, Alpha Go, and Monte Carlo Tree Search: Back to the Future

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, 77204, United States, jopeng@Central.uh.edu

Co-Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Markov Decision Processes, AlphaGo, and Monte Carlo Tree Search: Back tothe Future

Michael Fu, University of Maryland-College Park, Robert H.Smith School of Business, Van Munching Hall, College Park, MD, 20742, United States, mfu@rhsmith.umd.edu

In 2016, a computer Go-playing program called AlphaGo stunned the (human) world by winning a match (4 games to 1) against the reigning human world champion, a feat more impressive than previous victories by computer programs in chess (Deep Blue) and the TV game show Jeopardy (Watson). The main engine behind AlphaGo combines machine learning approaches in the form of deep neural networks with a technique called Monte Carlo tree search, whose roots can be traced back to an adaptive multistage sampling simulation-based algorithm for Markov decision processes (MDPs) published in Operations Research back in 2005 (and introduced even earlier in 2002). This tutorial describes AlphaGo and the simulation-based MDP algorithm, as well as providing contextual and historical background material for both, and uses simple examples to illustrate the main ideas behind Monte Carlo tree search.

■ MD03B

Grand Ballroom B

Operations and Economics of Ride-Hailing Networks

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Costis Maglaras, Columbia University, New York, NY, 10027, United States, c.maglaras@columbia.edu

Co-Chair: Philipp Afeche, University of Toronto, Toronto, ON, M5S 3E6, Canada, afeche@rotman.utoronto.ca

1 - Designing Incentives to Scale Marketplaces

Ashish Kabra, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, ashish.kabra@insead.edu, Elena Belavina, Karan Girotra

Marketplace operators run aggressive incentive schemes to achieve scale, that is key to the efficacy, survival and eventual domination of a marketplace. This study quantifies and compares the effect of incentives given to the "buyer" side and "seller" side using data from a leading ride-hailing market. We build a structural model to accurately capture the driver and passenger response to incentives, and the nature of incentives. Driver effort on the platform is unobserved, for which we devise a novel local matching model based imputation method. We find that in short-term (current week) passenger incentives are more effective while the opposite is true in the long-term (next 3 months).

2 - We are on the Way - Analysis of On-demand Ride-hailing System

Zizhuo Wang, University of Minnesota, 1009 5th Street SE, Minneapolis, MN, 55414, United States, zwang@umn.edu, Guiyun Feng, Guangwen Kong

In this paper, we build a stylized model to analyze the efficiency (average waiting time of passengers) of on-demand ride-hailing systems and compare it to the traditional street-hailing systems. We find that the on-demand matching mechanism could result in higher or lower efficiency than the traditional street-hailing mechanism, depending on the parameters of the system. We further propose adding response caps to the on-demand hailing mechanism and develop a heuristic method to calculate a near-optimal cap.

3 - The Costs and Benefits of Sharing: Sequential Individual Rationality and Fairness

Ragavendran Gopalakrishnan, Research Scientist, Conduent Labs India, Etamin Block, 4th Floor, Wing - A, Prestige Technology Park.- II, Bangalore, 560103, India, ragavendran.gopalakrishnan@conduent.com, Koyel Mukherjee, Theja Tulabandhula

We introduce the notion of sequential individual rationality in dynamic shared service systems, that requires that the disutility of existing customers is nonincreasing as the system state changes due to new customer arrivals. Given SIR, cost sharing can also be viewed as benefit sharing, under which we introduce a natural definition of sequential fairness—-the total incremental benefit from a new customer is shared among existing customers in proportion to the incremental inconvenience suffered. We demonstrate the effectiveness of these notions by applying them to a ridesharing system, where unexpected detours taken to pick up subsequent passengers inconvenience the existing passengers.

4 - A Tale of Timescales: Transient Network Dynamics, Demand Hot Spots, and Surge Pricing

Zhe Liu, Columbia University, New York, NY, United States, zliu18@gsb.columbia.edu, Philipp Afeche, Costis Maglaras

We consider an online platform that operates a ride-hailing network with price and delay sensitive passengers and strategic drivers that supply processing capacity. We study the interplay between demand shocks and surge pricing that is meant to a) moderate demand, and b) incentivize supply to reposition to demand hot spots, exploring the impact of travel delays on drivers' responsiveness to the surge signals.

■ MD03C

Grand Ballroom C

Empirical Studies on Pricing

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Antonio Moreno-Garcia, Kellogg School of Management, Evanston, IL, 60201, United States, a-morenogarcia@kellogg.northwestern.edu

1 - The Hidden Costs of Dynamic Pricing Empirical Evidence from Online Retailing in Emerging Markets

Richard Zhiji Xu, PhD Student, Kellogg School of Management, Evanston, IL, United States, zhiji-xu@kellogg.northwestern.edu, Antonio Moreno-Garcia, Chaithanya Bandi

We investigate how dynamic pricing can lead to higher operational costs through more product returns in the online retail industry. Using detailed sales data of more than 2 million transactions with return information from the Indian online retail market, we document two types of strategic customer behavior, opportunistic returns and strategic choice of payment method, which have not been considered by previous research.

2 - Managing Market Thickness in Online B2b Markets

Wenchang Zhang, Robert H. Smith School of Business, 7621 Mowatt Lane, PHD Carrel, College Park, MD, 20740, United States, wzhang@rhsmith.umd.edu, Kostas Bimpikis, Wedad Jasmine Elmaghraby, Kenneth Moon

Excess inventory amounts to $424 billion a year, and much of this inventory is sold through online auctions. Based on a natural experiment on a major B2B auction platform, we find that increasing the market thickness by concentrating the auction ending times to certain days of the week has a significant positive effect on the platform's revenues. This finding illustrates the role of listing policies in matching supply to demand and provides evidence of trading frictions. We develop a structural model, which characterizes the bidders' equilibrium strategies. The counterfactual analysis provides a systematic way for the platform to design its listing policy and other market design levers.

3 - Customer Perceptions of Dynamic Pricing in on Demand Services

Nil Karacaoglu, Kellogg School of Management, 531 Grove Street, Evanston, IL, 60201, United States, n-karacaoglu@kellogg.northwestern.edu, Antonio Moreno-Garcia

On-demand services adopt dynamic pricing practices to match supply and demand. We investigate how customers perceive the trade-offs between increased prices, waiting time, and unavailability. We examine ways of reducing negative effects of dynamic pricing on customers' fairness perceptions and satisfaction by controlling price and the supply representation.

4 - Dynamic Pricing of the Ride Sharing Market in a Spatial Search Model

Weiming Zhu, IESE Business School, Barcelona, Spain, zhuwm923@gmail.com, Jingting Fan, Wenlan Luo, Liu Ming

Ride-sharing platforms employ flexible pricing during peak hours to match supply with demand. We build a spatial search model to study the geographic dynamics among drivers. Utilizing data from a leading ride-sharing platform, we assess the impact of different pricing schemes on drivers' capacity distribution, platform profit and consumer surplus.

■ MD04

320A

Sustainability and Social Responsibility in Operations

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Sang Kim, Yale University, New Haven, CT, 06520, United States, sang.kim@yale.edu

1 - Ensuring Corporate Social and Environmental Responsibility through Vertical Integration and Horizontal Sourcing

Adem Orsdemir, University of California Riverside, Anderson Hall, Riverside, CA, 92507, United States, orsdemirademe@gmail.com, Bin Hu, Vinayak V. Deshpande

We investigate vertical integration as an alternative strategy for ensuring corporate social and environmental responsibility (CSER) at a supplier in a competitive setting. We show that when horizontal sourcing from a competitor is not feasible, NGOs' tighter scrutiny may discourage a firm from vertically integrating with its supplier and becoming responsible. However, we also find that possibility of supplying a competitor and existence of demand externalities due to violation exposures may fundamentally change firms' behaviors and CSER outcome.

2 - Can Brands Claim Ignorance? Unauthorized Subcontracting in Apparel Supply Chains

Anna Saez de Tejada Cuenca, UCLA, Anderson School of Management, Los Angeles, CA, United States, anna.sdtc.1@anderson.ucla.edu, Felipe Caro, Leonard Lane

The collapse of the Rana Plaza building in Bangladesh brought into focus the poor safety conditions faced by many workers in the apparel industry. A common way in which safety and environmental standards are violated is through unauthorized subcontracting. We analyze empirically some factors that can lead suppliers to outsource their production to third parties without their retailers' knowledge. We use data provided by a supply chain manager that consists of over 30,000 orders, including 36% of subcontracted ones. Our results provide managerial insights to retailers on what factory and order characteristics increase the probability of unauthorized subcontracting, and how it can be prevented.

3 - Design of Public Warning Systems

Saed Alizamir, Yale University, 339 Willow St., New Haven, CT, 06511, United States, saed.alizamir@yale.edu, Francis E. De Vericourt, Shouqiang Wang

We study the design of public warning systems in a multi-period model. In each period, the sender (she) receives an imperfect signal about the true state of the world (dangerous or safe), and has to decide whether to warn the receiver to act. Depending on the true realization of the random event, the receiver updates his belief about sender's credibility. The sender, therefore, has to dynamically manage her reputation over time, while also incentivizing the receiver to act on her warnings. We characterize the optimal warning policy, and gain insights into why it may sometimes be optimal for the sender to distort her signal.

■ MD05

320B

Applications of Stochastic Models in Medical Decision Making Problems

Sponsored: Health Applications

Sponsored Session

Chair: Saeideh Mirghorbani, University of Alabama, Tuscaloosa, AL, 35401, United States, smirghorbani@crimson.ua.edu

1 - The Effect of Adherence on the Anti-Hypertensive Therapy Plans in Patients with Type 2 Diabetes

Saeideh Mirghorbani, University of Alabama, 1214, 12th St, Apt 17, Tuscaloosa, AL, 35401, United States, smirghorbani@crimson.ua.edu, Sharif Melouk, John Mittenthal

The importance of adherence to the anti-hypertensive medications in patients with diabetes has been emphasized. Adherence is the extent to which the patient follows medical instructions and has been identified as the primary reason for suboptimal clinical benefits. In this research, we address the optimal antihypertensive therapy plans while considering patient adherence, the medication side-effects, and the cardiovascular complications. We develop a finite horizon, discounted Markov decision process in which patients transition through health states. The objective is to maximize the expected quality-adjusted life years.

2 - Challenges in Modelling Time-dependent Transitions in Markov Cost-effectiveness Analysis

Jiaru Bai, Binghamton University, School of Management, Binghamton, NY, 13902, United States, jiarub@uci.edu, L. Robin Keller

We propose challenges in estimating Markov model parameters with limited clinical data. With limited data from registration trials, we developed a way to estimate time-dependent transition probabilities in a Markov model for cancer progression. The method is applied to cervical cancer data in a clinical study.

3 - Yardstick Competition for Service Systems

Ozlem Yildiz, Assistant Professor, University of Virginia, Darden School of Business, Charlottesville, VA, United States, YildizO@Darden.virginia.edu, Nicos Savva, Tolga Tezcan

We study whether an alternate pay-for-performance method can alleviate Emergency Department (ED) overcrowding through incentivizing socially-desired ED capacity levels, although the healthcare regulator does not know the capacity cost structure. Using yardstick competition, we propose a regulatory scheme that achieves this using the waiting time and arrival rate information of each ED.

4 - Optimal Treatment Model for Choosing Art Initiation Time

Huaiyang Zhong, Stanford University, 119 Quillen Ct, Apt 217A, Stanford, CA, 94305, United States, hzhong34@stanford.edu, Xiaocheng Li, Margaret L. Brandeau

HIV is now a chronic disease with the more and more availability of antiretroviral therapy (ART). WHO is advising that an infected individual should start ART as soon as the CD4 level drops to 500. However, because of diverse characteristics and different risk attitude of each patient, a personalized starting time of ART for each patient becomes very important. In this presentation, we present a new algorithm of Markov Decision Process (MDP) which will take into account of risk attitude and it will help solve the problem presented above.

■ MD06

320C

Hospital Operations Management II

Sponsored: Health Applications

Sponsored Session

Chair: Hui Zhang, University of Chicago, Chicago, IL, 60637, United States, corinnaz@uchicago.edu

Chair: Thomas Best, tbest3@bsd.uchicago.edu

1 - A Queueing Framework for Evaluating Adoption of New Diagnostic Tests into Clinical Workflow with Application to Pulmonary Embolism in EDS

Zhongjie Ma, Purdue University, West Lafayette, IN, 47906, United States, zhongjiema@purdue.edu, Pengyi Shi, H. Sebastian Heese, Jonathan Helm, Alice Marina Mitchell

In medical research, new diagnostic tests are developed and evaluated solely on their efficacy in detecting a disease. However, ignoring the workload impact of introducing new tests into existing workflow can create barriers to adoption, particularly in busy units e.g. Emergency Department (ED). In collaboration with an ED physician, we develop a queueing framework for evaluating the workload impact of adopting new tests to bridge the gap between medical research and clinical workflow. We apply the framework to a new test, D-dimer, for detecting Pulmonary Embolism in EDs to understand what characteristics make adopting this test feasible and how to best integrate it into the ED workflow.

2 - Simulation-based Optimization to Improve Hospital Inpatient Placement under Capacity Strain

Hui Zhang, University of Chicago, Chicago, IL, 60637, United States, corinnaz@uchicago.edu, Thomas Best, Anton Chivu, David O.Meltzer

Many hospitals are confronted with capacity strain at their inpatient units resulting in delayed patient admissions, rejected admissions, and physician burnout. We develop a simulation-based optimization framework to improve hospital resource utilization using inpatient placement and overflow strategies. We use Discrete-Event Simulation approach and formulate an optimization model that maximizes hospital and physician revenue while accounting for various impact of patient overflow. We apply the model to a case study of hospitalist inpatient sector in University of Chicago Medical Center. Our findings inform hospital decision makers of how to address the capacity strain challenge.

3 - Diagnosing Variations of Length of Stay through Integrating Control Charts and Lean Management Practices within the Crisp DM Framework

Fadel Mounir Megahed, Miami University, Oxford, OH, fmegahed@miamioh.edu, Nasibeh Azadeh-Fard, Fatma Pakdil

In-patient length of stay (LOS) at hospitals is considered a critical metric because it is widely used to measure the overall efficiency of healthcare services. Given the fact that abnormal LOS results in increasing cost both for hospitals and patients, this study proposes a new methodology, based on CRISP-DM framework including control charts and lean management understanding, for monitoring and improving LOS. The utility of the proposed method is demonstrated through a case study involving 11,722 internal medicine patients at a large hospital in Southwest Virginia.

4 - Simulation of Interdependent Operations in Outpatient Clinics: A Case Study

Vahab Vahdat, PhD Candidate, Northeastern University, 334 Snell Engineering, 360 Huntington Avenue, Boston, MA, 02215, United States, vahdatzad.v@husky.neu.edu, Jacqueline Griffin

Many patients require multiple services provided by different clinics during one visit to a health center. In this research an example of interdependencies among three outpatient clinics in Massachusetts, USA are explored. While orthopedic and rheumatology outpatient clinics both work independently, their operations are interdependent with the radiology clinic that provides imaging services for both clinics. In order to improve patient length of stay, a discrete-event simulation model is constructed to model day-to-day operations of each clinics and evaluate the impact of integrated decisions in patient scheduling and resource allocation.

■ MD07

322A

Models and Algorithms for Scheduling Healthcare Providers

Sponsored: Health Applications

Sponsored Session

Chair: Amy Cohn, University of Michigan, Ann Arbor, MI, 48109, United States, amycohn@umich.edu

1 - Algorithms to Generate Annual Rotation Schedules for Medical Residents

William Pozehl, University of Michigan, Ann Arbor, MI, United States, pozewil@umich.edu, Amy Cohn

An ever-growing list of educational requirements and service coverage needs make generating high-quality annual rotation schedules for medical residents increasingly difficult. On top of these rules, program leadership wishes to satisfy as many of the residents' requests as possible to reduce the risk of burnout and prepare the residents for their desired career paths. We explore algorithms to generate schedules that not only meet the needs of the residents and services under these complex conditions, but also do so rapidly.

2 - Optimal Bed Assignment in Multi-occupancy Facilities

Ruben Proano, Associate Professor, Rochester Institute of Technology, Gleason College of Engineering, 81 Lomb Memorial Drive, Rochester, NY, 14623, United States, rpmeie@rit.edu, Brenden M. Hoff

In many parts of the globe, hospitalizations take place in multi-occupancy rooms. The need to admit as many patients as possible, and mitigate the risk of exposing inpatients to infections carried by other patients results in a constant shuffle of patients across different rooms. This study proposes a multi-stage optimization model that minimizes the impact of patient shuffles, and maximizes unit occupation. Experimentally, the model is also used to illustrate the effect of relying on batch bed-assignments to mitigate the need of shuffles.

■ MD08

322B

Stochastic Models in Public Policy

Sponsored: Health Applications

Sponsored Session

Chair: Ebru Korular Bish, Virginia Tech, Blacksburg, VA, 24060, United States, ebru@vt.edu

1 - Using Genetic Information to Guide Cholesterol Treatment Planning

Wesley Marrero, University of Michigan, Ann Arbor, MI, United States, wmarrero@umich.edu, Suzanne Butler, Jeremy Sussman, Mariel Sofia Lavieri

We derive optimal cholesterol treatment plans for patients at risk of cardiovascular events due to clinical and genetic factors using a Markov decision process. We also introduce a simulation-based framework to estimate the risk of a coronary heart disease event due to genetic factors.

2 - Optimal Inventory Control for Adaptive Trial Supply

Wei-An Chen, Purdue University, 610 Purdue Mall, West Lafayette, IN, United States, chen1702@purdue.edu, Nan Kong

As adaptive clinical trials receive growing attention in the past decade, a clinical supply management tool is required to address the adaptiveness. Our research aims at bringing more flexibility to drug supply and coordinate it with adaptive trial design. Our stochastic optimization model is founded on drug inventory control and used to address several important aspects of drug supply, e.g., drug wastage, resupply policy, trial span, and overall cost, under the uncertainty of participant enrollment. With the focus of trial size and length re-estimation, we also consider jointly optimize the trial design parameters and supply decisions while incorporating the patient response uncertainty.

3 - Optimal Risk-based Group Testing

Hrayer Y Aprahamian, Virginia Tech, 1145 Perry Street, Blacksburg, VA, 24060, United States, ahrayer@vt.edu

Group testing, i.e., testing multiple subjects simultaneously within a group, is an essential tool for classifying subjects as positive or negative for a binary characteristic; and is utilized in a variety of settings. We study optimal group testing schemes that incorporate subject-specific risk characteristics into the testing design. We consider various objectives, and characterize key structural properties of optimal testing designs. These properties allow us to develop efficient algorithms and derive important insights on the trade-offs being incurred. Our case study considers Chlamydia screening, and demonstrates the value of risk-based testing within a public health framework.

4 - Optimal Timing of ALS Interventions to Improve the Disease Course

Kalyan Pasupathy, Mayo Clinic, Rochester, MN, 4Mayo Clinic, Rochester, MN, Contact: pasupathy.kalyan@mayo.edu, Ozden Onur Dalgic, Fatih S. Erenay, Osman Yalin Ozaltin, Mustafa Y. Sir, Brian A. Crum

ALS is a neurodegenerative disease causing continuous decay of motor neurons and muscle atrophy. Patients suffer from losing their abilities to speak, eat, move and breath. Due to having no permanent treatment, ALS eventually affects all abilities but disease progression shows a great variability. Using medical records of over 400 patients from Mayo Clinic, we analyze the ALS progression pathways, and estimate risks of losing abilities and needing medical interventions (e.g., feeding tube, ventilator). We then develop a stochastic natural history model to optimize the timing of ALS interventions for improving patients' well-being in their disease course.

■ MD09

330A

Robust Optimization and its Application

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Daniel Long, zylong@se.cuhk.edu.hk

1 - Matching Supply with Demand for Online Retailing

Yun Fong Lim, Associate Professor, Singapore Management University, 50 Stamford Road, 04-001, Singapore, 178899, Singapore, yflim@smu.edu.sg, Song Jiu, Marcus Teck Meng Ang

We consider an online retailer selling multiple products over a multi-period setting. At the start of each period, the retailer replenishes her products from multiple suppliers. After receiving the products, the retailer allocates the inventory to different fulfillment centers. At the end of each period when the demands for the products from different zones are realized, the retailer fulfills them from different fulfillment centers. We formulate a robust optimization model to determine the replenishment and allocation decisions at the start of each period and the fulfillment decisions at the end of the period. Our approach can handle large-scale problem instances with good quality solutions.

2 - A Study of Distributionally Robust Multistage Stochastic Optimization

Yongpei Guan, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611, United States, guan@ise.ufl.edu, Kezhou Zhou, Jianqiu Huang

In this talk, we focus on a data-driven risk-averse multistage stochastic programming (RMSP) model considering distributional robustness. We optimize the RMSP over the worst-case distribution within an ambiguity set of probability distributions constructed directly from historical data samples. The proposed RMSP is intractable due to the multistage nested minimax structure in its objective function, so we reformulate it into a deterministic equivalent that contains a series of convex combination of expectation and conditional value at risk (CVaR), which can be solved by a customized stochastic dual dynamic programming (SDDP) algorithm. As the size of collected data samples increases to infinity, we show the consistency of the RMSP with distributional robustness to the traditional multistage stochastic programming.

3 - Risk Minimization in Robust Inventory Routing Problem
Zheng Cui, Chinese University of Hong Kong, Hong Kong, zcui@se.cuhk.edu.hk, Daniel Zhuoyu Long, Jin Qi, Lianmin Zhang

We study a finite horizon stochastic inventory routing problem. In this problem, the supplier acts as a central planner who determines the replenishment quantities as well as the times and routes to all customers. We allow ambiguity in the probability distribution of uncertain demand at each customer. To quantify the risk in fulling the demand, we propose a decision criterion called Collective Requirement Violation (CRV) Index, which takes into account both the frequency and magnitudes of violation. The whole problem can be formulated as a mixed integer programming problem and the exact optimal solution can be found effectively. We compare the performance of our solutions with several benchmarks.

4 - A Convex Optimization Approach for Computing Correlated Choice Probabilities with Many Alternatives
Xiaobo Li, University of Minnesota, Minneapolis, MN, 55414, United States, lixx3195@umn.edu, Karthik Natarajan, Selin Damla Ahipasaoglu

The Cross Moment model (CMM) has been proposed as an alternative to MNP when the covariance information is available. Computing the choice probabilities with many alternatives is challenging in CMM. We develop a simpler formulation as a representative agent model by maximizing over the choice probabilities in the unit simplex. We develop a simple first order gradient method with inexact line search to compute choice probabilities and establish local linear convergence of this algorithm. Numerical experiments show that this method can compute choice probabilities for a large number of alternatives within a reasonable amount of time while explicitly capturing the correlation information.

■ MD10

330B

Social Responsibility in Sourcing

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Goker Aydin, Johns Hopkins University, Baltimore, MD, 21202, United States, goker.aydin@jhu.edu

1 - Supply Risk Mitigation via Supplier Diversification and Improvement: An Experimental Evaluation
Basak Kalkanci, Georgia Institute of Technology, 3151 Stillhouse Creek Dr SE, Apt 25517, Atlanta, GA, 30339, United States, basak.kalkanci@scheller.gatech.edu

We use lab experiments to evaluate two sourcing strategies developed for mitigating supply risks of a buyer firm with heterogeneous suppliers: dual sourcing and single sourcing with supplier improvement. We also develop behavioral theories to elucidate the decision-making process of the buyer more effectively. With dual sourcing, human buyers allocate orders between suppliers more evenly than theory and exhibit quantity hedging behavior. We propose and empirically validate a theory of order allocation error minimization to explain this phenomenon. Human buyers use supplier improvement relatively successfully, despite being subject to supplier selection errors due to bounded rationality.

2 - Coordinating Supply Chains via Advance-order Discounts, Minimum Order Quantities, and Delegations
Prashant Chintapalli, University of California Los Angeles, Los Angeles, CA, United States, prashant.chintapalli.1@anderson.ucla.edu, Stephen M. Disney, Christopher S. Tang

Buyers often place rush orders with suppliers only after they receive firm orders from their customers. Rush orders are coslty for both the parties because the supplier incurs higher production costs. We show that though an advance-order discount (AOD) contract alone cannot coordinate the supply chain, the contract when combined with pre-specified minimum-order-quantity as a qualifier for the buyer to avail the discount, can coordinate the supply chain. We analyze another contract in which the buyer delegates the inventory decisions to the supplier in return for a discount on all units procured. We find both the combined contracts coordinate the supply chain in a Pareto improving manner.

3 - Curbing the Usage of Conflict Minerals: A Supply Network Perspective
Han Zhang, Student, Indiana University-Bloomington, Bloomington, IN, 47405, United States, hz8@indiana.edu, Goker Aydin, H. Sebastian Heese

Legislation and NGOs pressure manufacturers to disclose their sources of "conflict minerals" — natural resources whose trade might finance conflicts. We study the effect of such interventions, using a model of a supply network consisting of mines, smelters, and manufacturers. We show that imposing penalties on manufacturers alone is not sufficient to eliminate conflict minerals from supply chains, and that an industrial alliance to pool auditing costs among compliant manufacturers is effective in reducing the equilibrium quantity traded of non-certified metals.

■ MD11

332A

Empirical Studies of Operational Quality

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Robert L. Bray, Northwestern University, IL, United States, robertlbray@gmail.com

1 - Show or Tell: A Tanzanian Mobile Money Field Experiment on the Impacts of SMS Messages on Agent Performance
Christopher Parker, Penn State, State College, PA, United States, chris.parker@psu.edu, Jason Acimovic, David F. Drake, Karthik Balasubramanian

Mobile money allows consumers without physical bank accounts to conduct financial transactions through a wireless provider's network. Deposits and withdrawals are performed by agents who decide how much physical and electronic cash to stock each day in order to fulfill customer demands for deposits and withdrawals. We implement an experiment in Tanzania to test whether sending explicit recommendations for cash levels or informative estimates of transaction volume are better for reducing agents' stockout rates. Treated agents had a lower proportion of days-stocked-out by 80 basis points as compared to the control group. We also investigate treatment heterogeneity using agent characteristics.

2 - Menu Costs and the Bullwhip Effect: Empirical Evidence
Ioannis (Yannis) Stamatopoulos, The University of Texas at Austin, McCombs School of Business, Austin, TX, United States, Yannis.Stamos@mccombs.utexas.edu, Soheil Ghili

We empirically study the question of whether lower menu costs (operational costs of pricing) at a brick and mortar retail store imply higher or lower sales variability, and hence higher or lower bullwhip. We develop a theory for this question and test it using a structural estimation approach on data from a natural experiment.

3 - Supply Chain Proximity on Product Quality
Juan Serpa, McGill University, juan.serpa@mcgill.ca

We xplore the effect of supply chain proximity on product quality. To study this relationship, we merge five independent data sources from the automotive industry, collecting (i) auto component failure rates, (ii) upstream component factory locations, (iii) downstream assembly plant locations, and (iv) product-level links connecting the upstream and downstream factories. Combining these datasets yields one of the most detailed supply chain samples ever created, detailing the flow of 27,807 products through 529 supplier factories and 175 assembly plants. We find that, on average, the defect rate of a component increases by 0.21 percent when the distance increases by 100 kilometers.

4 - How Does Servers' Workload Impact Customer Lifetime Value? An Empirical Study
Qiuping Yu, Kelley School of Business, Indiana University, 1309 E. Tenth Street, Bloomington, IN, 47405-1701, United States, qiupyu@indiana.edu, Masoud Kamalahmadi, Yong-Pin Zhou

Using a rich data set from a casual dining restaurant chain, we explore how servers' workload impact customer repurchasing behavior thus their lifetime value. Through counterfactual studies, we demonstrate its implication in firm's staffing decisions.

■ MD12

332B

Social Networks and Service Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Gad Allon, PA, United States, gadallon@wharton.upenn.edu

Co-Chair: Eren Basar Cil, University of Oregon, Lindquist College of Business, Eugene, OR, 97403-1208, United States, erencil@uoregon.edu

1 - Managing Workplace Flexibility: the Case of Agents with Task Preferences

Vasiliki Kostami, London Business School, London, United Kingdom, vkostami@london.edu, Rouba Ibrahim

Flexibility in operations is beneficial in matching supply and demand in both the manufacturing and service industries but it does not come for free. In many workplaces, employees are expected to excel in different skills as part of their job but they are also heterogeneous in their preferences to perform certain tasks associated with their employment. We study and compare two innovative flexibility arrangements in the workplace that are related to the task assignment against the traditional one where the task routing is a decision made by the firm with the ultimate objective of improving both the employees' welfare and the employer's revenue.

2 - Multiple Equilibria When Servers Value Idleness and Compensation

Dongyuan Zhan, University College London, UCL.School of Management, Gower Street, London, WC1E 6BT, United Kingdom, d.zhan@ucl.ac.uk, Amy R.Ward

Most common queueing systems used for service system design assume the servers work at fixed rates. However, real-life service system are staffed by people, who may change their service speed in response to their compensation incentives and idleness utility. We study the equilibrium service rate under this setting. We find that depending on the servers' idleness utility function, two equilibria, which allow different service rates and amount of idleness, may exist. The system manager may induce one of the equilibria by imposing more restrictions on servers' behavior.

3 - Hidden-City Travel and its Impact on Airfare

Woonghee Tim Huh, University of British Columbia, Sauder School of Business, Operations and Logistics Division, Vancouver, BC, V6T.1Z2, Canada, tim.huh@sauder.ubc.ca, Jaelynn Oh

We study the cause of hidden city fare and the effect of hidden city travelers on airfare when airlines price compete on hub-and-spoke flight networks.

4 - Does Marginal Wage Reveal your Cost of Waiting?

Simin Li, Kellogg School of Management, Northwestern University, 2211 Campus Drive, Evanston, IL, 60208, United States, simin.li@kellogg.northwestern.edu, Achal Bassamboo, Martin Lariviere

We investigate how an agent's cost of waiting depends on income structure and non-market activities. We find the conventional metric, marginal wage, is only a fair estimation to marginal cost of waiting if earnings are smooth. The equality breaks down once any friction is introduced. The marginal wage can over or under estimate agents' true cost of waiting.

5 - Skill Management in Large-scale Service Marketplaces

Eren Basar Cil, University of Oregon, 1208 University Of Oregon, Lindquist College of Business, Eugene, OR, 97403-1208, United States, erencil@uoregon.edu, Gad Allon, Achal Bassamboo

We consider a large-scale service marketplace where the moderating firm can run two skills tests on agents to assess if their skills are above certain thresholds. Our main objective is to evaluate the effectiveness of skill screening as a revenue maximization tool. We find that skill screening leads to negligible revenue improvements in marketplaces where agent skills are highly compatible. As the compatibility of agent skills weakens, we show that the firm starts to experience as much as 25% improvement in revenue from skill screening. Apparently, the firm can reap the most of these substantial benefits when it runs only one test.

■ MD13

332C

Game Theory

Contributed Session

Chair: Alok Raj, IIM Lucknow, Lucknow, India, fpm15002@iiml.ac.in

1 - Consolidation in Urban Goods Distribution - Cost Allocation Based on Approximate Solutions

Joen Dahlberg, Linköping University, Norrköping, Sweden, joen.dahlberg@liu.se, Stefan Engevall, Maud Göthe-Lundgren, Jenny Karlsson

We consider the cost allocation problem that arises when a number of stakeholders, responsible for the distribution of goods in an urban area, collaborate by goods consolidation. This problem is formulated as a cooperative game, where the characteristic function value is defined as the cost of a Vehicle Routing Problem (VRP). For large sized problems, it is impractical to solve the VRP to optimality. We investigate the effects of allocating costs based on approximate VRP solutions. The viability, quality and validity of the method are verified by applying the method on instances of real life data.

2 - Bileratal Competition in Crowd Logistics with Game Theory and Emotion Theory

Yi Song, Huazhong University of Science and Technology, Wuhan, China, songyi@hust.edu.cn, Bin Hu

With the increasingly use of sensor-embedded smartphones, many crowdsourcers and a large population of service providers form a bilateral competition market, where crowdsourcers compete for the limited logistics service and service providers compete for the limited budget. In this paper, we present emotion theory embedded with a game theory of such market. We formulate the dynamics behavior of service providers as an evolutionary game, take their feelings of crowdsourcers and then present a simulation model for the implementation of the evolution process. For crowdsourcers, we use a non-cooperative game. Through this paper, we can understand the dynamic evolution of the crowd logistics market.

4 - An Ascending Auction for Freight Forwarders Collaboration in Capacity Sharing

Minghui Lai, Assistant Professor, Southeast University, China, Room A-411, Economics and Management Building, Southeast University (Jiulonghu Campus), Nanjing, China, laimh@seu.edu.cn

We propose an ascending auction mechanism for the capacity sharing problem, where each forwarder submits a set of bundles of capacity for their shipping requests. To achieve strategy-proofness, all the winning bundles for an accepted request must have the same payment and the payment is ascending during the iterations. To improve social welfare, the mechanism iteratively expands the set of bundles and approximates the loss of private revenues to search optimal allocations, using the dual solution derived from minimizing primal-dual slackness. We prove that the mechanism is strategy-proof, individually rational, weakly budget balanced, and finitely convergent.

5 - Sustainable Supply Chain Channel Coordination using Game Theoretic Approach

Alok Raj, IIM.Lucknow, Lucknow, India, fpm15002@iiml.ac.in

The importance of triple bottom line has been widely recognized by both industry and supply chain (SC) literature. However, in the context of SC coordination, simultaneous treatment of greening effort, social responsibility, and profit have received scant attention in the extant literature. This paper focuses on this gap and we propose a generalized analytical model for a dyadic supply chain with triple bottom line approach. We formulate a supplier-buyer stackelberg game and design linear two-part tariff contract for coordination. Our generalized analytical model is able to capture the dynamics of pure profit maximizing SC, green SC, and socially responsible SC as special cases.

■ MD14

332D

Mathematical Models and Empirical Methods for Improving Healthcare Operations

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Goh Joel, jgoh@hbs.edu

1 - Maximizing Intervention Effectiveness

Brian Rongqing Han, Marshall School of Business, USC, Los Angeles, CA, United States, rongqing.han.2019@marshall.usc.edu, Vishal Gupta, Song-Hee Kim

In the emerging paradigm of evidence-based decision making in healthcare and social science, policymakers often face challenges when deciding whom to receive an intervention that has previously been proven effective. With heterogeneous intervention effects and no access to raw experimental data, who should be selected for intervention? We propose a novel robust optimization framework that uses only summary statistics from a published paper to select a subset of the candidate population to maximize intervention effectiveness. We assess the practical significance of our method using data from a large teaching hospital who wants to reduce frequent Emergency Department visits.

2 - Issuing Policies for Hospital Blood Inventory

Alireza Sabouri, Haskayne School of Business, University of Calgary, 2500 University Dr. NW, SH132, Calgary, AB, T2N.1N4, Canada, alireza.sabouri@haskayne.ucalgary.ca, Tim Huh, Steven Shechter

We propose a model for allocating red blood cells for transfusion to patients, which is motivated by recent evidence suggesting that transfusing older blood is associated with increased mortality rate. We study the properties of blood issuance policies that balance the trade-off between "quality" measured in average age of blood transfused and "efficiency" measured in the amount of shortage. Based on our analysis, we design efficient issuance policies and evaluate their performance.

3 - An Empirical Study of Adding Physician Assistants to Critical Care Rapid Response Teams

Carri Chan, Columbia Business School, 3022 Broadway, Uris Hall, New York, NY, 10027, United States, cwchan@columbia.edu, Mor Armony, Yunchao Xu

Physician assistants (PAs) can sometimes be cost-effective alternatives to physicians in healthcare systems, but their impact on critical care delivery remains unclear. Over the course of 18 months, PAs were incrementally added to the Critical Care Rapid Response team at a major urban hospital system. We empirically measure the impact of part-time versus full-time PA coverage. We find that adding PAs can reduce the average time-to-transfer for all ICU patients and reduce mortality risk for low-severity patients. Interestingly, we do not find evidence that the benefits of having PAs further improves patient outcomes when adding PAs on non-weekdays.

4 - Gate Keeping under Uncertainty: An Empirical Study of Referral Errors in the Emergency Department

Michael Freeman, INSEAD, 1 Ayer Rajah Avenue, 138676, Singapore, mef35@cam.ac.uk, Susan Robinson, Stefan Scholtes

We study admission decisions made by physicians in a congested emergency department (ED) using data from 600,000 visits over 7-years. As the ED becomes congested, we find that ED physicians respond by admitting to hospital more patients for short observational stays while also making fewer discharge errors. This causes a bullwhip-type effect: demand surges in the ED lead to relatively greater demand pressures in the hospital. We then show that replacing the direct one-stage (ED physician to hospital) referral system with a two-stage process in which ED physicians can stream patients with high diagnostic uncertainty to an intermediate "semi-specialist" referral unit can improve routing decisions.

■ MD15

332E

Business Model Innovation

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Simone Marinesi, Wharton, Philadelphia, PA, 75003, United States, marinesi@wharton.upenn.edu

1 - Dynamic Contests in the Lab

Mohamed Mostagir, University of Michigan, 701 Tappan Ave, Ann Arbor, MI, 48109, United States, mmostagir@yahoo.com, Yan Chen, Iman Yeckehzaare

We develop Knapsack Contests. An experimental framework where agents compete in a contest whose feasibility is uncertain. They learn about feasibility from their actions as well as from the progress of their competitors. A contest designer is interested in maximizing the efforts that agents exert, and utilizes the contest's information disclosure mechanism as a lever to that end. We examine several information disclosure designs that a contest designer can utilize and we compare their properties in terms of the designer's objective and the contestants' welfare.

2 - Referral Priority Program: Leveraging Social Ties via Operational Incentives

Luyi Yang, Johns Hopkins University, Baltimore, MD, 21202, United States, luyi.yang@jhu.edu, Laurens G. Debo

The referral priority program, an emerging business practice adopted by a growing number of technology companies that manage a waitlist of customers, enables existing customers on the waitlist to gain priority access if they successfully refer new customers to the waitlist. We study the effectiveness of such a scheme as a marketing tool for customer acquisition and an operational approach for waitlist management.

3 - Competitive Equilibria in two Sided Matching Markets with Non-quasilinear Utility Functions

Azarakhsh Malekian, Rotman School of Management, 105 Saint George, malekian, Toronto, ON, 02143, Canada, azarakhshm@gmail.com

We consider two sided matching markets consisting of agents with non-transferable utilities; agents from the opposite sides form matching pairs (e.g., buyers-sellers) and negotiate the terms of their math which may include a monetary transfer. Competitive equilibria are the elements of the core of this game. We present the first combinatorial characterization of competitive equilibria that relates the utility of each agent at equilibrium to the equilibrium utilities of other agents in a strictly smaller market excluding that agent; thus automatically providing a constructive proof of existence of competitive equilibria in such markets.

4 - Choosing the Right Campaign Mode in Crowdfunding

Simone Marinesi, Wharton, 201 S.25th Street, Apt 621, Philadelphia, PA, 75003, United States, marinesi@wharton.upenn.edu, Karan Girotra

We compare the two most popular campaign modes employed by reward-based crowdfunding platforms: All-or-Nothing, in which the entrepreneur (creator) collects the money pledged by consumers (backers) only if the project is fully funded, and Flexible Funding, in which the entrepreneur collects the money even when the project is partially funded. A comparison between the two campaign modes reveals that an entrepreneur should choose a Flexible Funding campaign for projects with a low budget, high market prospects, or if capital markets are particularly accessible.

■ MD16

332F

Inventory Management

Contributed Session

Chair: Yang Zhou, Huazhong University of Science and Technology, Wuhan, China, m201673799@hust.edu.cn

1 - An Analysis of Production Process Considering Yield Distribution

Sungyong Choi, Assistant Professor, Yonsei University, College of Government and Business, 1 Yoneseidae-gil, Wonju, 26493, Korea, Republic of, sungyongchoi@gmail.com, Sumin Jeon, Jinmin Kim, Kwangtae Park

We study a binomial yield production process using a newsvendor approach by incorporating underage and overage costs. We provide a reformulation of the original model to convert the discrete and exact model to the continuous and approximate model via normal approximation. We conduct comparative static analysis for model parameters in the approximate model and derive the monotone properties of the optimal solution. All of the analytical results are consistent with our insights and supported by economic explanations. Our numerical study with sample-based optimization indicates that the approximate model is close to the exact model in most of the real world examples including some limiting cases.

2 - Single Period Inventory Problem under Differentiated Service Levels using a Responsive Allocation Policy

Pablo Escalona, Universidad Técnica Federico Santa María, Av Espana 1680, Valparaiso, 2390123, Chile, pablo.escalona@usm.cl

We study the rationing of a single order quantity among multiple customer classes under stochastic demands and differentiated service levels using a responsive allocation policy when demand is made during the lead time. The problem is formulated as a nonlinear problem with chance constraints, for which we exploit the geometrical properties of the model, to propose a decomposition technique to solve it. Although the heuristic does not guarantee an optimal solution, our computational experiments have shown that it provides good-quality solutions that, under a mild assumption, are epsilon-optimal.

3 - Optimality of Price-setting Newsvendor Problems Subject to Mean-variance Risk Measures: An Elasticity Approach
Javier Rubio-Herrero, Assistant Professor, St. Mary's University, One Camino Santa Maria, San Antonio, TX, 78228, United States, jrubioherrero@stmarytx.edu, Melike Baykal-Gursoy

We introduce a set of sufficient conditions for the optimality of certain price-setting newsvendor problems in terms of three different elasticities, namely, the lost sales rate elasticity, the optimal price elasticity, and the elasticity of the excess of safety stock. Our idea is to give a more managerial approach to the assessment of optimality in price and inventory decisions for this type of inventory problems.

4 - Inventory Model for a Fixed Life Perishable Product with Price and Inventory Level Dependent Demand
Nilesh Asnani, Doctoral Candidate, Indian Institute of Management Indore, Rau-Pithampur Road, Indore, 453331, India, f14nilesha@iimidr.ac.in, Hasmukh Gajjar, Bhavin J. Shah

In this study, we consider a deterministic demand that depends upon deterioration rate, price discount, and displayed inventory level. We propose inventory model to optimize retailer's profit by optimally determining order quantity, shelf space, and price discount.

5 - Inventory Strategy in O2O Supply Chain Based on Drop Shipping by the Retailer
Yang Zhou, Huazhong University of Science and Technology, Wuhan, China, m201673799@hust.edu.cn, Shihua Ma

In order to solve the order delivering dilemma of manufactures' electronic channel, O2O model based on drop shipping by the retailer was proposed. Taking newsvendor model to analyze the optimal stocking decisions in three different models of manufacturers and retailers. Furthermore, through numerical experiments, we analyze the impact of demand uncertainty and drop shipping fee on the optimal inventory levels and the optimal choices of manufacturers and retailers.

■ MD17

340A

Storage and Flexibility in Energy Systems

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Rodrigo Moreno, University of Chile, Tupper 2007, Santiago, 2007, Chile, rmorenovieyra@ing.uchile.cl

1 - Application of Stochastic Dual Dynamic Programming to the Real-Time Dispatch of Storage under Renewable Supply Uncertainty
Anthony Papavasiliou, CORE, UCL, Voie du Roman Pays 34, L1.03.01, Office b.114, Louvain la Neuve, 1348, Belgium, tpapva@hotmail.com

This talk presents a multi-stage stochastic programming formulation of transmission constrained economic dispatch subject to multi-area renewable production uncertainty, with a focus on optimizing the dispatch of storage in real-time operations. This problem is resolved using stochastic dual dynamic programming. The applicability of the proposed approach is demonstrated on a realistic case study of the German power system calibrated against the solar and wind power integration levels of 2013-2014, with a 24-hour horizon and 15-minute time step. The value of the stochastic solution relative to the cost of a deterministic policy amounts to 1.1%, while the value of perfect foresight relative to the cost of the stochastic programming policy amounts to 0.8%. The relative performance of various alternative real-time dispatch policies is analyzed, and the sensitivity of the results is explored.

2- Power System Planning Considering Flexibility Requirements: Impact of Energy Storage
Angela Flores, University of Chile, Av Tupper 2007, Santiago, Chile, angelafq@gmail.com, Kai Strunz

The capacity planning problem with high penetration of variable renewable generation is addressed by a multi-stage stochastic model including unit commitment constraints such as: minimum operating times, ramp rates, operating reserves and start-up costs. Different energy storage technologies are modeled and included as investment options. The resulting large-scale MILP is solved by the column generation algorithm. The impact of different energy storage systems in the optimal power mix and their role in the integration of renewables are analyzed.

3 - Co-optimizing Network and Storage Investments in Electricity Systems: A Stochastic Optimization Approach
Rodrigo Moreno, University of Chile / Imperial College, Tupper 2007, Santiago, 2007, Chile, rmorenovieyra@ing.uchile.cl, Hector Otarola, Angela Flores

We present a stochastic optimization model to determine optimal investment decisions in planning under uncertainty in the long term. The model optimizes new network investments along with energy storage investments to minimize both investment and system operational costs. Uncertainty is associated with long-term scenarios of investment costs, operational costs, demand growth and policy incentives. We solve the optimization model through a column generation algorithm which is compared against the performance of progressive hedging. We conclude on computational performance and quality of the solutions to appropriately allocate investments in new transmission lines and storage plants.

■ MD18

340B

NSF Funding through Operations Engineering Program

Invited: NSF

Invited Session

Chair: Irina Dolinskaya, National Science Foundation, National Science Foundation, Herndon, VA, 20170, United States, irina.s.dolinskaya@gmail.com

1 - Navigating NSF: Funding Opportunities at NSF
Georgia-Ann Klutke, National Science Foundation, National Science Foundation, Arlington, VA, 22230, United States, gaklutke@nsf.gov, Irina Dolinskaya

The National Science Foundation (NSF) offers funding opportunities for investigators working in industrial engineering & operation research, within the disciplinary programs in Engineering and other directorates, and through cross-cutting initiatives that are foundation-wide. This presentation will describe opportunities that are relevant to the Industrial and Operations Engineering communities, with particular emphasis on the Operations Engineering program in the Division of Civil, Mechanical & Manufacturing Innovation. The talk will describe guidelines for proposal preparation and NSF's Intellectual Merit and Broader Impacts criteria. Q & A session will follow the presentation.

■ MD19

342A

Operations Decisions in the Presence of Tax

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Vernon Hsu, Shatin, Hong Kong, vhsu@cuhk.edu.hk

1 - Ex-post Transfer Pricing in a Multinational Firm
Zhu Kaijie, Chinese University of Hong Kong, Shatin, Hong Kong, kzhu@baf.msmail.cuhk.edu.hk, Vernon Hsu, Xiaopeng Zhang

We study a decentralized transfer-pricing model in which regional divisions of a multinational firm decide retail prices to maximize their respective profits before its headquarter determines the transfer price to maximize the firm-wide after-tax profit. Our analysis indicates such ex-post transfer pricing may render gaming behaviors by the regional divisions and thus a distortion in their decision making. The gaming behaviors can cause severe consequences, e.g., the firm's profit being decreased in the presence of tax rate reduction. We present approaches to mitigating the gaming behaviors.

2 - The Impact of Arm's Length Principle (ALP) on a Supply Chain and Consumers when a Rival is Also a Customer
Kun Soo Park, Associate Professor, KAIST, 85 Hoegiro, Dongdaemum-Gu, Seoul, 130-722, Korea, Republic of, kunsoo@kaist.ac.kr, Woonghee Tim Huh, Se Youn Jung

We consider a supply chain with a vertically integrated producer (VIP) and a rival retailer who is also a wholesale customer of the VIP. We study the wholesale pricing decision of the VIP and the quantity decisions of both retailers whose retail expertise in the market are not necessarily the same. In particular, we investigate the impact of the regulation on the transfer pricing of the VIP, which is commonly referred to as the arms length regulation, on the operational decisions of each entity in this supply chain and consumers.

3 - The Internal Decentralization Effects in Off-sourcing Procurement
Gangshu Cai, Santa Clara University, Department of OMIS, 216n Lucas Hall, Santa Clara, CA, 95053, United States, gcai@scu.edu, Zhiqiao Wu, Jiafu Tang

We study the internal decentralization effects in different types of offshore procurements and show that a firm can benefit from more internal decentralization.

■ MD20

342B

TIMES Distinguished Speaker

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Juliana Hsuan, Copenhagen Business School, Department of Operations Management, Solbjerg Plads 3 B 5.27, Frederiksberg, DK-2000, Denmark, jh.om@cbs.dk

1 - What's Industry Got to do with it?

John Paul MacDuffie, University of Pennsylvania, Wharton School, Philadelphia, PA, United States, macduffie@wharton.upenn.edu

Studies of technological change and the management challenges it can create for incumbents commonly strive (like most social science) for theoretical insights and empirical findings that can be generalized to all settings. My research experiences have, through a mix of good luck, choice, and inertia, given me the opportunity for deep and prolonged study of a single context, the global automotive industry. This "industry of industries" (to quote Peter Drucker) has, over more than a century, seen an evolution in production system paradigms from craft to mass to lean production and is now facing a time of tremendous ferment as new technologies combine with new business models in a broader ecosystem of mobility services. Many analysts observing this time of ferment are applying the lens of theories of industry change developed during the rise of ICT/digital tech companies, with expectations of rapid transformation. I will argue that the application of these lenses can often be misguided, creating distorted assessments and misleading predictions, and revealing the need for better theorizing about contingencies and mechanisms as well as different research designs and methods. I will extract from my immersion in "industry studies" (both my research and my participation as a founding board member of the Industry Studies Association) some lessons for TIMES scholars about the advantages of bringing deep contextual knowledge about industries to the study of technological change and ecosystem evolution.

■ MD21

342C

Decision Analysis and Natural Hazards

Invited: InvitedNatural Hazard Planning

Invited Session

Chair: Sara Shashaani, University of Michigan, sshashaa@umich.edu

1 - Modeling Uncertainty: the Cost of Wrong Assumptions in Infrastructure Disaster Risk Modeling

Benjamin Rachunok, Purdue University, West Lafayette, IN, United States, brachuno@purdue.edu, Roshanak Nateghi

Risk modeling is a stochastic endeavor which commonly requires selecting a probability distribution to represent uncertainty in model inputs. No empirical data truly follows a theoretical distribution, as such distributions impose additional assumptions whenever they are used. In this talk, we aim to assess the cost of making incorrect assumptions in infrastructure disaster risk analyses. We present examples using publicly available tropical cyclone data (from NHC) and severe-weather related power outages (from the DoE) to illustrate the consequences of making incorrect assumptions in modeling risk, that can lead to over/under investments in infrastructure resilience.

2 - Preemptive Decision-making to Support Power System Resilience

Andrea Staid, Sandia National Labs, 412 Morningside Dr NE, Albuquerque, NM, 87108, United States, astaid@sandia.gov, Jean-Paul Watson, Michael Bynum, Bryan Arguello

The electric power system is vulnerable to natural hazards; consequences can have huge financial, social, and health impacts. To improve power system resilience, we must first understand the critical threats, potential damage, and how consequences can propagate through the system. Here we focus on improving resilience to by identifying optimal actions to take in advance of adverse weather. We use data from a large electric utility company to develop realistic scenarios of transmission system outages for use in a stochastic programming formulation using a DC optimal power flow model. We evaluate several mitigation strategies and characterize the impact on system resilience.

3 - Hurricane Power Outage Prediction with Out of Bag Feature Selection Approaches

Sara Shashaani, University of Michigan, 1777 Plymouth Rd Apt 2C, Ann Arbor, MI, 48105, United States, sshashaa@umich.edu, Seth Guikema

Predicting hurricane power outages facilitates natural hazards response decisions. However the spatial data is largely zero-inflated with a sizable number of explanatory variables, and finding statistical models that can provide reliable predictions remains to be a challenge. We study a feature selection approach by using out of bag performance of the predictors for such datasets. A combinatorial optimization model is developed to seek contributing variables to the accuracy of the prediction model. We found promising results experimenting on actual central gulf coast outage data.

■ MD22

342D

Multi-armed Bandit and its Applications to Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Xi Chen, New York University, New York, NY, 10012, United States, xchen3@stern.nyu.edu

1 - Optimal Maximum GAP Estimation in Multi-armed Bandit

Yuan Zhou, Indiana Unviersity at Bloomington, Bloomington, IN, 47401, United States, yzhoucs@indiana.edu, Chao Tao, Xi Chen

In this paper, we study the problem of maximum gap estimation in multi-armed bandit. We propose a new PAC-learning algorithm named MaxGapEst, which provides an $\eps$-close estimate of the maximum gap with probability $1-\delta$. The algorithm achieves the optimal sample complexity $\Theta(\frac{n}{\eps^2} \ln \\delta^{-1})$ for sufficiently small $\eps$. As a subroutine of the MaxGapEst, we propose a new algorithm for cost-sensitive best-arm identification problem, which assumes that sampling different arms incurs different costs. This result generalizes the classical results on the problem of best-arm identification with uniform sampling cost, which is of independent interest.

2 - Deep Exploration in Reinforcement Learning via Randomized Value Functions

Daniel Russo, 3170 N. Sheridan Road, Apt. 1216, Chicago, IL, 60657, United States, Dan.Joseph.Russo@gmail.com

Reinforcement learning algorithms learn to optimize performance in complicated MDPs by using observed state transitions. A major challenge is the ability to collect the right training data, and even important breakthroughs have relied on highly naive exploration, or the imitation of humans who have mastered the control task. We study the use of randomized value functions to guide sophisticated deep exploration in RL. This offers an elegant means for synthesizing statistically and computationally efficient exploration with common approaches to value function learning. We develop RL algorithms that leverage randomized value functions, and present computational studies and regret bounds.

3 - Non-stationary Stochastic Optimization with Local Spatial and Temporal Changes

Yining Wang, Carnegie Mellon University, 5000 Forbes Avenue, 8203 Gates-Hillman Center, Pittsburgh, PA, 15213, United States, ynwang.yining@gmail.com

We study the non-stationary stochastic optimization problem with local temporal and spatial changes by imposing an L_{p,q} norm constraints on the changes of functions between consecutive time epochs. We derive matching upper and lower bounds for our considered model, which have a few notable differences from the classical non-stationary stochastic optimization model where no locality of changes is imposed. In particular, we show a curse of dimensionality under our setting, which means the optimization problem gets harder when the problem dimension increases.

4 - Thompson Sampling Approach for Dynamic Assortment Selection

Vashist Avadhanula, Columbia University, Industrial Eng. and OR, 423 SW Mudd Building, New York, NY, 10027, United States, vavadhanula18@gsb.columbia.edu, Shipra Agrawal, Vineet Goyal, Assaf Zeevi

We consider a sequential subset selection problem under parameter uncertainty, where at each time step, the decision maker selects a subset of cardinality K from N possible items (arms), and observes a (bandit) feedback in the form of the index of one of the items in said subset, or none. Each item in the index set is ascribed a certain value (reward), and the feedback is governed by a Multinomial Logit (MNL) choice model whose parameters are a priori unknown. The objective of the decision maker is to maximize the expected cumulative rewards over a finite horizon T, or alternatively, minimize the regret relative to an oracle that knows the MNL parameters. We refer to this as the MNL-Bandit problem. This problem is representative of a larger family of exploration-exploitation problems that involve a combinatorial objective and arise in several important application domains. We present an approach to adapt Thompson Sampling to this problem and show that it achieves near-optimal regret as well as attractive numerical performance.

■ MD23

342E

Revenue Management and Control of Operational Problems

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Arnab Bisi, Johns Hopkins Carey Business School, 100 International Drive, Baltimore, MD, 21202, United States, abisi1@jhu.edu

1 - Healthcare Payment Models under Competition

Zheng Han, University of Kansas, Lawrence, KS, United States, hanzheng@ku.edu, Mazhar Arikan, Suman Mallik

We consider two hospitals competing as profit-maximizers by choosing their own quality levels under different payment schemes (i.e., bundled payment (BP) vs. fee-for-service (FFS)). A game-theoretic model is built to analyze equilibrium outcomes. We show that: BP (FFS) is not always associated with high (low) equilibrium quality, and identify threshold payments for both FFS and BP that can lead the corresponding hospital to choose the highest or lowest level of quality; a higher reimbursement for hospital readmissions under FFS may result in quality improvement, rather than deterioration; a higher reimbursement from either FFS or BP does not necessarily result in a higher beneficiary welfare.

2 - Dynamic Pricing or Dynamic Logistics?

Thunyarat (Bam) Amornpetchkul, NIDA Business School, Bangkok, Thailand, thunyarat.a@nida.ac.th
Thunyarat (Bam) Amornpetchkul, Boston College (Visiting), Chestnut Hill, MA, United States, thunyarat.a@nida.ac.th, Hyun-Soo Ahn, Ozge Sahin

Retailers who sell their products through multiple channels often hold inventory at separate locations, dedicated for demand arriving at each channel. When inventory level does not match with demand, transshipment across channels may be beneficial. We characterize and compare the effectiveness of the retailer's optimal pricing and transshipment policy. Furthermore, we investigate how the optimal pricing policy is affected by the transshipment policy, and vice versa.

3 - An Inventory System with Partial Backorders and Inventory Holdback

Arnab Bisi, Johns Hopkins Carey Business School, 100 International Drive, Baltimore, MD, 21202, United States, abisi1@jhu.edu, Yanyi Xu, Maqbool Dada

We consider a periodic-review base stock inventory system with partial backorders. In each period, an order of q is placed for delivery one period later and as much as possible of the realized demand is filled immediately from inventory on-hand. Of the excess demand above the inventory on-hand, up to q - k units are backordered to be filled from future orders. The on-order quantity k denotes the reservation quantity held back for use in subsequent periods. Our model yields the full lost sales and full backorder models as special cases. For both finite and infinite horizon problems, we determine structural properties of the optimal policy and discuss how to find the optimal base stock and hold back quantity.

■ MD24

342F

Topics in Approximate Dynamic Programming

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Dan Zhang, University of Colorado, Boulder, CO, 80309, United States, dan.zhang@colorado.edu

Co-Chair: Rui Zhang, University of Colorado Boulder, Columbia, MD, 21045, United States, rui.zhang@colorado.edu

1 - Index Policies and Performance Bounds for Dynamic Selection Problems

James E.Smith, Duke University, Fuqua School of Business, Box 90120, Durham, NC, 27708-0120, United States, jes9@duke.edu, David Brown

In this work, we study heuristics and performance bounds for dynamic selection problems. Examples of dynamic selection problems include assortment planning with demand learning, design of clinical trials, and screening a pool of applicants (e.g., for admission to colleges). We study a number of index-based policies, including one based on a Lagrangian relaxation of the problem. We characterize the performance of this Lagrangian index policy compared to an optimal policy. We also develop performance bounds that combine Lagrangian relaxations with information relaxations and show that these new performance bounds outperform standard Lagrangian relaxation bounds.

2 - Naloxone Procurement and Distribution in the Presence of High Drug Prices

Yijia Wang, University of Pittsburgh, Pittsburgh, PA, United States, YIW94@pitt.edu, Daniel Jiang

Naloxone, a drug for treating opioid overdose, is vital for public health agencies' efforts to combat the opioid epidemic. However, naloxone prices have recently surged so it is essential for public health agencies to effectively manage procurement and distribution of naloxone. The goal is to maximize naloxone distribution into affected communities under funding and storage constraints; this problem will be solved through a novel formulation of a hierarchical MDP along with an associated approximate dynamic programming technique. The main policy question we will answer is: under optimal operations, what is the effect of increasing prices on our ability to distribute Naloxone kits?

3 - An Origin-Destination Decomposition Method for Network Revenue Management

Rui Zhang, University of Colorado Boulder, 5377 Racegate Run, Boulder, CO, 21045, United States, rui.zhang@colorado.edu, Dan Zhang

In this paper, in contrast to resource-based decomposition method, we consider a decomposition method where the approximate linear programming of the network revenue management problem is decomposed into a collection of subproblems, each corresponding to an origin-destination pair, which we call the OD- based decomposition. We show that OD-based decomposition provides an upper bound to the total expected revenue and alternative heuristic control policies. We identify conditions under which the OD-based decomposition gives tighter upper bounds and better heuristic policies than the resource-based decomposition.

4 - An Approximate Dynamic Programming Approach to a Rolling-horizon Appointment Scheduling Problem

Fan You, University of Colorado-Boulder, 995 Regent Dr, Boulder, CO, 80302, United States, fayo4612@colorado.edu, Thomas Vossen, Dan Zhang

We consider a rolling-horizon appointment scheduling problem with multiple patient classes. The problem is formulated as an infinite horizon discounted cost Markov decision process. We consider affine and finite-horizon approximations and show that they admit compact representations and can be efficiently solved as small scale linear programs. A numerical study illustrates the performance of the heuristic control policies based on the approximations.

■ MD25

350A

Power Generation Scheduling

Invited: Energy Systems Management

Invited Session

Chair: Kai Pan, University of Florida, Gainesville, FL, 32611, United States, kpan@ufl.edu

1 - A Novel Matching Formulation for Startup Costs in Unit Commitment

Bernard Knueven, University of Tennessee, 525K.Tickle Building, Knoxville, TN, 37996, United States, bknueven@vols.utk.edu, Jim Ostrowski, Jean-Paul Watson

We present a novel formulation for startup cost computation in unit commitment (UC). Both the proposed formulation and existing formulations in the literature are placed in dominance hierarchy based on their respective linear programming relaxations. The proposed formulation is tested empirically against existing formulations on large-scale unit commitment instances drawn from real-world data. Our proposed formulation is empirically demonstrated to be as tight as a perfect formulation for startup costs. This tightening reduces the computational burden in comparison to existing formulations, especially for UC instances with large variability in net-load due to renewables production.

2 - Data-driven Chance-constrained Stochastic Unit Commitment under Wind Power Uncertainty

Ali Bagheri, Oklahoma State University, 320 E McElroy Road, Apt 508, Stillwater, OK, 74075, United States, ali.bagheri@okstate.edu

Rapid integration of cheap, clean but highly intermittent wind energy into power systems brings challenges to ISOs to maintain the system reliability. Stochastic programs may result in biased and unreliable unit commitment (UC) and economic dispatch (ED) decisions by fixing the probability distribution of wind output. Robust optimization (RO) approaches sacrifice system's cost-effectiveness in exchange of reliable UC and ED schedules. We develop a data-driven chance-constrained stochastic UC model, where the data-driven chance constraint limits the worst-case chance of load imbalance to be no more than a specified tolerance, by taking advantage of historical data.

3 - Optimal Bidding Strategy for Market Participants Considering Both Renewable Generation and Price Uncertainties

Kai Pan, University of Florida, 411 Weil Hall, Gainesville, FL, 32611, United States, kpan@ufl.edu, Yongpei Guan

We present an optimal bidding strategy which is adaptive for the independent power producers to participate in both day-ahead and real-time markets by considering both renewable generation and price uncertainties. This proposed strategy is theoretically justified of its significant advantages over existing alternative ones. To improve the computational efficiency, polyhedral structures have been explored to strengthen the corresponding deterministic equivalent formulation.

4 - Economic Impacts Caused by the Diffusion of Hydrogen Energy

Tetsuya Tamaki, assistant professor, Kyushu University, 744 Motooka, Fukuoka City, 8190395, Japan, tamaki@doc.kyushu-u.ac.jp, Shunsuke Managi

This research focuses on the economic impacts of the diffusion of hydrogen energy, which is an environment-friendly source of energy. Hydrogen energy is expected to reduce CO2 emission from not only the transportation sector but also the energy sector. However, the related technology is still expensive, and the usage and effects of hydrogen energy will change by the difference of the cost. In this research, to estimate the economic impacts caused by the diffusion of hydrogen energy, we use a dynamic optimization model that analyzes the economics related to climate change and also prescribe a policy for the use of hydrogen energy in society.

■ MD26

350B

MAS Special Speaker: Mission-based Forecasting for Military Operations

Sponsored: Military Applications

Sponsored Session

Chair: Greg H Parlier, North Carolina State University, 255 Avian Lane, Madison, AL, 35758, United States, gparlier@knology.net

1 - Mission-based Forecasting for Military Operations

Greg H. Parlier, North Carolina State University, 255 Avian Lane, Madison, AL, 35758, United States, gparlier@knology.net

The US Department of Defense operates the world's most complex global supply chains. To address persisting problems the US Army established the project to Transform Army Supply Chains (TASC) in order to investigate the nature, causes, and consequences of demand uncertainty and supply variability. Mission-Based Forecasting is a new concept for demand planning which relates resource investment levels and distribution policies directly to mission performance outcomes, thereby enabling the "resources-to-readiness" linkage. MBF improves forecast accuracy and reduces backorders, excess inventory, and costly work-arounds while increasing equipment readiness in military organizations.

■ MD27

350C

Mining Text and Graph Data from Online Platforms

Invited: Social Media Analytics

Invited Session

Chair: Theodoros Lappas, Stevens Institute of Technology, 310 10th St, Hoboken, NJ, 07030, United States, tlappas@stevens.edu

1 - Social Connections and Venture Investments

Chuanren Liu, Drexel University, Philadelphia, PA, United States, chuanren.liu@drexel.edu

We present a Social-Adjusted Probabilistic Matrix Factorization (PMF) model to exploit the social relationship information from VC firms and startups for startup investment recommendations. Unlike previous studies, we make use of the directed social connections and quantify the variety of social network groups. As a result, this brings in much more flexibility, and the modeling results inherently provide meaningful managerial implications for the operators of VC firms and start-up companies. We evaluate our model on both synthetic and real-world data. The results show that our approach outperforms the baseline algorithms with a significant margin.

2 - Measuring Reputation Inflation in Online Platforms

Apostolos Filippas, New York University, New York, NY, United States, afilippa@stern.nyu.edu

In many online marketplaces, the distribution of feedback scores seems implausibly rosy. Using data from a large online marketplace, we show that average feedback scores have risen sharply over time, leading to substantial top-censoring. However, the increase in reputation could be either due to more satisfied raters, or raters who are lowering their standards. We employ a text-analytic approach to disentangle the two reasons, and we show that 36 to 48 percent of this increase is due to a phenomenon akin to inflation. We discuss the implications for our results for online marketplace design.

3 - Text-based Industry Classification and Network

Feng Mai, Stevens Institute of Technology, Hoboken, NJ, United States, feng.mai@stevens.edu, Lei Zheng

Traditionally, firms are placed within predefined industry groups using SIC or NAICS codes. These classifications are time-invariant and are not robust to changing primary business activities. We propose and validate a new text-based method that can quantify how firms differ from their competitors and redefine industry boundaries.

4 - Arousal, Hedonism, and Utility in Online Reviews

Jie Ren, Fordham University, New York, NY, United States, jren11@fordham.edu, Jeffrey V. Nickerson

To explain sales, in addition to online review valence and volume, this paper bases its argument on one less-studied hedonic versus utilitarian dimension of product type and also on a less-studied online review dimension - arousal, a measure that is extracted from individual review texts. Using panel data analysis on 26,357 Amazon products and an online experiment involving 600 subjects, the findings consistently show that product type moderates the impact of the three dimensions of online reviews (valence, volume, and arousal) on sales. These findings explain why sometimes online review valence is more influential than volume with respect to sales and why sometimes it is the other way around.

■ MD28

350D

Matching Theory

Invited: Auctions

Invited Session

Chair: Umut Dur, NCSU, Raleigh, NC, 27695, United States, umutdur@gmail.com

1 - Parallel versus Sequential School Admissions: A Tale of Two Countries

Onur Kesten, Associate Professor of Economics, Carnegie Mellon University, 5000 Forbes Avenue, POS.- Posner Hall - Room 249, Pittsburgh, PA, 15213, United States, okesten@andrew.cmu.edu

This paper studies the recent reforms in the student assignment systems in Turkey and Sweden. There are two types of high schools in both countries: public and private schools. Public school admissions are administered in a centralized manner, whereas private school admissions are done in a decentralized manner. In Turkey, starting from 2014, private school assignments are carried out in a first round along with a policy change in the terms re-entry into the second round. We study the performance of old and new sequential assignment systems in both countries and show that alternative solutions that outperform both systems are available.

2 - Matching with Limited Information: A Case for Neighborhood Schools

Peter Troyan, Assistant Professor, University of Virginia, Charlottesville, VA, 22904, United States, pgt8y@virginia.edu, Andrew Kloosterman

Deferred acceptance is a popular school choice mechanism because it is strategyproof and stable. However, this relies on the assumption that all agents know their own preferences. We relax this by allowing agents to be either informed or uninformed. Ex-post stable outcomes need not exist, as uninformed agents may form a blocking pair after learning their match and updating their beliefs. Further, we find that informed agents gain at the expense of uninformed agents, who are more likely to be left with underperforming schools. Positive results can be recovered by giving all students a "neighborhood school": the equilibrium outcome is ex-post stable, and uninformed students are made better off.

3 - Sequential School Choice Theory and Evidence from the Field and Lab

Umut Dur, NCSU, Raleigh, NC, United States, umutdur@gmail.com, Robert Hammond, Thayer Morrill, Onur Kesten

We analyze sequential preference submission in matching problems. Our motivation is school districts that use a website where students submit preferences sequentially. Comparing the Boston Mechanism (BM) to the Deferred Acceptance (DA), we show that sequential BM is more efficient than sequential DA. Any equilibrium outcome under BM Pareto dominates the student optimal stable matching. We present two sets of empirical tests. First, we study a field setting in which sequential BM was used. The field data provide evidence that is consistent with our theory. Second, we conduct an experiment to do comparison in a lab. BM improves upon DA when students submit sequentially but not simultaneously.

4 - On Finding Stable and Efficient Solutions for the Constrained Coalition Formation Problem

Hoda Atef Yekta, PhD Candidate, University of Connecticut, 2100 Hillside Rd,, Storrs, CT, 06869, United States, hoda.atefyekta@business.uconn.edu, David Bergman, Robert Day

This research explores the constrained coalition formation problem with constraints on the size of each coalition and the characteristics of the members of each coalition. We develop a branch-and-cut-and-price (BCP) algorithm to address both minimizing the maximum instability, and maximizing total utility, simultaneously. This problem arises in a variety of real-world settings, including project management, military platooning, and peer-to-peer ride-sharing

■ MD29

350E

Making Computationally Difficult Decisions

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Meisam Razaviyayn, Ph.D., University of Southern California, 3715 McClintock Ave, Los Angeles, CA, 90089, United States, razaviya@usc.edu

1 - Stochastic Primal-Dual Methods and Sample Complexity of Markov Decision Processes

Yichen Chen, Graduate Student, Princeton University, 751 Hibben Magie Road, Apt 109, Princeton, NJ, United States, yichenc@princeton.edu

We study the online estimation of the optimal policy of a Markov decision process (MDP). We propose a class of Stochastic Primal-Dual (SPD) methods which exploit the inherent minimax duality of Bellman equations. The SPD methods update a few coordinates of the value and policy estimates as a new state transition is observed. We first consider a basic version of SPD that uses Euclidean projection for both the primal and dual updates. We then propose an accelerated version of SDP that uses relative entropy projection in the dual update. For MDPs that are "sufficiently" ergodic, the improved SPD has a near-optimal sample/running-time complexity.

2 - Nonnegative Polynomials, Nonconvex Polynomial Optimization, and Applications to Learning

Georgina Hall, Princeton University, Charlton Street, Sherrerd Hall, Princeton, NJ, 08544, United States, gh4@princeton.edu

We give a brief overview of the developments in the field of sum of squares optimization and show how it can be applied to two problems at the interface of machine learning and polynomial optimization. In part (i), we study the problem of learning a monotone polynomial from data. This is motivated by regression problems where the underlying function to be learned is monotone (consider the price of a car as a function of its fuel efficiency). In part (ii), we study the problem of optimally decomposing a multivariate polynomials as the difference of two convex polynomials. This is motivated by certain majorization-minimization algorithms used in nonconvex optimization that require such a decomposition.

3 - Learning to Optimize: Training Deep Neural Networks for Wireless Resource Management

Mingyi Hong, University of Virginia, 3019 Black Engineering Building, IMSE Department, Ames, IA, 50011, United States, mingyi@iastate.edu

We propose a new learning-based approach for wireless resource management. The idea is to treat the input and output of a resource allocation algorithm as an unknown non-linear mapping and use a deep neural network (DNN) to approximate it. If the non-linear mapping can be learned accurately and effectively by a DNN of moderate size, then such DNN can be used for resource allocation in almost real time, since passing the input through a DNN to get the output only requires a small number of simple operations. We first characterize a class of 'learnable algorithms' then design DNNs to approximate some algorithms of interest in wireless communications. We use extensive numerical simulations to demonstrate the superior ability of DNNs for approximating two considerably complex algorithms that are designed for power allocation in wireless transmit signal design.

4 - From Predictive Methods to Missing Data Imputation: An Optimization Approach

Colin F. Pawlowski, Massachusetts Institute of Technology, Cambridge, MA, 02143, United States, cpawlows@mit.edu, Dimitris Bertsimas, Ying Zhuo

We propose a framework based on optimization to impute missing data which can readily incorporate predictive models including K-NN, SVM, and decision tree based methods. We derive a family of fast first-order methods opt.impute that obtains high quality solutions in seconds for data sets with 100,000s of missing values. In large-scale synthetic and real data experiments, opt.impute produces the best overall imputation in almost 80% of all data sets benchmarked against state-of-the-art methods. We also discuss extensions to explicitly account for multi-class categorical variables.

■ MD30

350F

Topics in Text Analytics

Invited: Social Media Analytics

Invited Session

Chair: Zachary Davis, Virginia Tech, 1007 Pamplin Hall, Blacksburg, VA, 24061, United States, zached1@vt.edu

Co-Chair: Alan Abrahams, Virginia Institute of Technology, Blacksburg, VA, 24061, United States, abra@vt.edu

1 - How to Make a Persuasive Pitch: An Extended Text-mining Model for Crowdfunding Analysis

Sukhwa Hong, Virginia Tech, Pamplin College of Business, 880 West Campus Drive, Blacksburg, VA, 24061, United States, sukhwa@vt.edu, David Michael Goldberg, Onur Seref, Christopher Zobel

Crowdfunding is a new funding source and growing in popularity, providing a vital service to individuals especially in developing countries, who could not otherwise get the financial resources they need. Understanding factors that determine the funders' decisions is important in writing persuasive crowdfunding pitches for successful projects. In this paper, we present an integrated text-mining model that combines the Bag-of-Words model and related variables for predicting the success of crowdfunding projects in Kiva. Furthermore, association rule mining is used to identify factors that influence the funders' decisions for writing persuasive crowdfunding pitches for successful projects.

3 - Temporal Effects, Opinion Extremity, and Information Quality in Online Word of Mouth

David Michael Goldberg, Virginia Tech, Blacksburg, VA, 24061, United States, goldberg@vt.edu

Online text frequently describes increasingly extreme opinions over time as additional contributors seek to differentiate their opinions from the crowd. We examine how information quality is affected by this phenomenon, as these extreme viewpoints may not reflect the general consensus.

4 - Impact of Health Social Media on the Health State of Patients with Chronic Illness

Zachary Davis, Virginia Tech, 1007 Pamplin Hall, Blacksburg, VA, 24061, United States, zached1@vt.edu, Qianzhou Du, Alan Gang Wang, Christopher Zobel, Lara Z Khansa

Online health communities are utilized by a vast number of people with limited objective evidence regarding the impact on their actual health state. We examine an online health community consisting of members managing a chronic illness and empirically analyze objective and fully observable data regarding their health state to determine if participation and the giving and receiving of social support has an impact on the overall health state. Our novel contribution is the identification of the observable measure of the health state and our preliminary findings indicate that the use of health social media has a positive impact on the health state.

■ MD31

351A

Social Media Analytics

Invited: Social Media Analytics

Invited Session

Chair: Fujie Jin, jinfujie@wharton.upenn.edu

1 - Online vs. Offline: A Structural Estimation of Consumer Purchase Behavior

Luna Zhang, PhD, Lehigh University, College of Business and Economics, xiz313@lehigh.edu, Daisy Dai, Oliver Yao

Using large-scale POS datasets, we develop a structural model and estimate the demand for consumer packaged goods in both online and offline channels. Based on our structural model estimates, we conduct counterfactual analyses and examine consumer purchase behavior between the focal product and substitute products when the price changes and stockout occurs. We find that: 1) online own-price elasticity is 1.41 times higher than offline own-price elasticity 2) offline cross brand cross-price elasticity is 2.49 times higher than that online; 3) offline consumers are 3.96 times more likely to purchase substitute brands when the focal brand is out-of-stock as compared with online consumers.

2 - Enterprise Information Systems and Value Creation in Mergers and Acquisitions

Chengxin Cao, PhD, Iowa State University, caoxx161@umn.edu

This paper examines the impact of enterprise systems (ES) on the premium and the capital market reaction of mergers and acquisitions (M&A). Our results that the extensiveness and standardization of ES are significantly associated with both market value enhancement of the acquirer and target highlights the important role information systems play in the creation as well as the deployment of firm resources and capabilities that deliver competitive advantages to firms. Also, the ES capability enables the acquirers to accurately assess the unique synergy that can be realized in the acquisition, thus preventing the acquirer from overpaying for the acquisition.

3 - Tempting Fate: Social Media Posts by Firms, Customer Purchases, and the Loss ofFollowers

Shuting (Ada) Wang, Temple University, Philadelphia, PA, United States, tuf49919@temple.edu, Brad Greenwood, Paul A. Pavlou

In this study, we examine how a firm's social media posts influence the propensity of its followers to purchase products and unfollow the firm, both in the short and the long term. Using a unique dataset from a fashion retailer, we find that while social media posts do increase the retailer's sales by 5% in the short-term, they also amplify the followers' propensity to unfollow the firm by 300%. Strikingly, results also indicate that posts cannibalize long-term cumulative sales. The negative effects of posts on unfollowing and sales are exacerbated in more crowded cities and during peak traffic hours. The study contributes to the emerging IS literature on social media and informs managerial practice on how to leverage social media posts for enhancing sales and preventing the loss of followers.

4 - Empirical Analysis on Online Job Reviews, Social Media Usage and Firm Performance

Fujie Jin, Kelley School of Business, Indiana University, 1309 E.Tenth Street, H H.4100, Bloomington, IN, 47401, United States, jinf@indiana.edu

In this study, we look at how employee-contributed job reviews and firm-managed social media posts jointly build up "employer brand" as an intangible asset and influence market valuation. Using a unique dataset combining job reviews, social media posts and firm performance data, we find that positive job reviews increase firm market value, particularly in labor-intensive industries, and for positions with higher employee mobility. In addition, firms can complement this effect by including more employee-related content on their social media pages. This is likely because different sources of information could jointly influence employees' job movement decisions, and firms with stronger employer brands are likely to retain key employees for longer periods of time and save costs in recruiting. Overall, our results indicate that firms should have coordinated strategies across platforms, presenting a consistent employer brand, to maximize their market valuation.

■ MD32

351B

Operations/Economics Interface

Contributed Session

Chair: Jinpeng Xu, Xidian University, Xi'an, China, jinpxu@foxmail.com

1 - Optimal Ordering Policy for Defective Items under Temporary Price Discount with Inspection Errors and Investment to Increase the Screening Rate

Guiyang Zhu, Xi'an Jiaotong University, 28 Xianning West Road, Xi'an, China, zhuguiyang@stu.xjtu.edu.cn, Tao Jia

When a supplier offers temporary price discount for defective items, the demand would be stimulated, implying that the items screened as good may not satisfy the increased demand. Besides, the retailer's inspection errors are often considered in the quality checking process. A straightforward solution is to increase the screening rate through investments. Thus, this paper studies an inventory model for defective items under temporary price discount with inspection errors. The three profit functions are derived to find optimal solutions. Via sensitivity analyses, a high defective probability would spur the system to invest more intensively into improving the quality checking process.

2 - Coordination of the Supply Chain with Quality Improvement and Customer Returns

Xinghao Yan, Assistant Professor, University of Toledo, 105 Howald Farm Ct., Toledo, OH, 43551, United States, yanxinghao@gmail.com

This paper studies the supply chain with both quality improvement and customer returns. We analyze the retailer's incentives for refund price and the supplier's incentive for quality improvement. We also design coordinating contracts for the supply chain, which is influenced by several factors, profit negotiation, first-mover right, and information asymmetry.

3 - Information Sharing in Supply Chain of Durable Goods

Neda Khanjari, Rutgers University, 227 Penn St, BSB 260, Camden, NJ, 08102, United States, neda.khanjari@rutgers.edu, Hyoduk Shin, Seyed Iravani

We study a supply chain of a durable good product in which the retailer has advance demand information. We study how the policy of the retailer to share his information with the manufacturer depends on durability of the product. We show the retailer should share his information with the manufacturer when (i) the production cost is large and product is not very durable, or (ii) when the production cost is small and the product is very durable, or (iii) the production cost is intermediate and the durability of the product is intermediate.

4 - The Role of Market Evolution in Channel Contracting

Long Gao, University of California-Riverside, 900 University Avenue, 221 Anderson Hall, AGSM, Riverside, CA, 92521, United States, long.gao@ucr.edu

We study the contracting problem in a bilateral channel where the retailer has private information about evolving market conditions. We show market inertia offers a new coordination mechanism that dictates how the channel should adapt. Further, market inertia highlights the reach and limitation of existing models. We reveal that the dynamics by themselves do not preclude simple contracts; it is the nature of the dynamics—-market inertia—-that determines the contract complexity. Hence, simple contracts can arise as firms' best response to evolving market conditions. This work advances our understanding on when and how to use dynamic private information in channel contracting.

5 - Comparing Uniform and Differential Pricing Strategies in Multichannel Retailing

Jinpeng Xu, Xidian University, Xi'an, 710126, China, jinpxu@foxmail.com, Yufei Huang

We consider a retailer sells a product in both online and offline channels and his rival only operates in only online channel, and investigate his pricing strategy. We suppose consumers can be divided into three types by their channel performance, i.e., offline consumers, online consumers and channel-agnostic consumers. We derive the equilibrium prices for the two retailers when the retailer adopts uniform and differential pricing strategy across channels respectively. We compare the profits and find that differential pricing strategy does not always outperform uniform pricing strategy for the retailer. We also evaluate the consumer surplus and social welfare to derive managerial insights.

■ MD33

351C

Applied Analytics in Aviation

Sponsored: Aviation Applications

Sponsored Session

Chair: Ehsan Nobakht, Boeing Vancouver, Advanced Analytics Group, 1146 Homer Street, Vancouver, BC, V6B 2X6, Canada, ehsan.nobakht@boeing.com

1 - Performance Based Contingency Fuel Planning

Luis Mesen, United Airlines, Chicago, IL, United States, luis.mesen@gmail.com

With the FAA's revision to OpSpec B343, performance-based contingency fuel planning is now available to US operators. This revision is meant to harmonize with ICAO Annex 6, Part 1 and take advantage of air carriers' considerable investment in fuel-planning technology. Unplanned contingency fuel can now be calculated using statistical estimation rather than using a prescriptive amount. This presentation will walk through some of the statistical, modeling, automation and validation techniques UAL used to become the first U.S. airline to fly under PBCF flight rules.

2 - Hackathons as a Vehicle for High Velocity Collaboration Between Engineers and Data Scientists

Ehsan Nobakht, Boeing Vancouver, Advanced Analytics Group, 1146 Homer Street, Vancouver, BC, V6B 2X6, Canada, ehsan.nobakht@boeing.com, Dawen Nozdryn-Plotnicki

Because of the vast amount of information captured by the CMC, specialized data science tools and techniques are required to work efficiently with the data. Additionally, the complex nature of modern aircraft like the C-17 requires specialized systems knowledge in order to interpret and find meaningful insights in the data. As these two skillsets are rarely possessed by the same person, it becomes imperative to create a forum that allows data scientists and systems engineers to work together when tackling big data problems.This presentation will focus on best practices for hosting concentrated working sessions, referred to as hackathons, as a means of bringing data scientists and systems engineers together.

3 - An Unpaired Pickup and Delivery Problem with Time-Dependent Assignment Costs

Farshid Azadian, Embry-Riddle University, 600 S Clyde Morris Blvd., College of Business, Daytona Beach, FL, 32114, United States, azadianf@erau.edu, Alper E. Murat, Ratna Babu Chinnam

This study considers a freight forwarder's operational implementation of alternative access airport policy in a multi-airport region for cargo transportation. Given a set of heterogeneous air cargo customers, the forwarder's problem is to simultaneously select air cargo flight itineraries and schedule the pickup and delivery of customer loads to the airport(s). This problem is formulated as a novel pickup and delivery problem, where the delivery cost is both destination and time dependent. A mixed-integer linear model in presented and an efficient solution method based on decomposition is developed. The performance of the solution algorithm is evaluated by computational experimental study.

4 - A Comprehensive Approach to Understanding the Future of Air France KLM's CDG Hub

Richard Solene, Air France/KLM, Paris, France, na/nasorichard2@airfrance.fr

Scheduling and Operations have always been fighting over the hub. Should the hub be peaked in banks of activity to improve the intrinsic connectivity of the network and its attractiveness, at the risk of driving up the costs of operations? Or should we flatten the hub activity to lower the costs of operations, while reducing connectivity opportunities for passengers in the meantime? With state-of-the-art machine learning and operations research techniques, we were able to develop a comprehensive two-sided tool, one side for computing the potential revenue of flight schedules, and one side for estimating their total cost of operations. Best practices and recommendations emerging from this tool helps Air France KLM in the building of the perfect schedule.

■ MD34

351D

Military Applications Awards

Sponsored: Military Applications

Sponsored Session

Chair: Andrew Oscar Hall, United States Military Academy, West Point, NY, 10996, United States, andrew.hall@usma.edu

Chair: Francisco R Baez, US Army, US Army, Woodbridge, VA, 22193, United States, francisco.r.baez.mil@mail.mil

1 - Koopman Award Winner

Jun Zhuang, University at Buffalo, SUNY, 317 Bell Hall, Buffalo, NY, 14260, United States, jzhuang@buffalo.edu

Abstract not available.

■ MD35

351E

Supply Chain Management

Contributed Session

Chair: Ryan Sanders, University of Arkansas, Cave City, AR, United States, rpsander@uark.edu

1 - A Decision Model to Examine the Impact of Flexibility and Agility on Mitigating Supply Chain Disruptions

Mansoor Shekarian, Graduate Student, North Carolina A&T.State University, 3100 N Elm St., Apt #22L, Greensboro, NC, 27408, United States, mshekarian@aggies.ncat.edu, Mahour Parast, Seyed Vahid Reza Nooraie

This paper examines the effect of flexibility and agility on improving supply chain responsiveness. We examine a multi-site, multi-period, multi-transportation channel, and multi-product planning in a supply chain under supply risk and demand risk. We determine the relationship between three objective functions related to responsiveness, risk, and cost, and discuss the impact of agility and flexibility on mitigating supply chain disruptions.

2 - Disruption Risk Management for Two-echelon Supply Chains: Early Commitment to Finished Goods

Florian Lücker, Kellogg School of Management, Evanston, IL, United States, florian.lucker@kellogg.northwestern.edu
Florian Lücker, Swiss Federal Institute of Technology EPFL, Lausanne, Switzerland, florian.lucker@kellogg.northwestern.edu, Sunil Chopra, Ralf W. Seifert

We consider the two-echelon inventory problem for different supply chain topologies (serial, assembly and distribution) in the presence of disruption risk and stochastic demand. For the assembly supply chain we show that in the presence of disruption risk downstream inventory is larger in the assembly supply chain compared to a serial supply chain. We call this effect early commitment as the finding is different from optimal safety inventory policies in assembly supply chains where often a delayed differentiation is optimal. In addition, we elaborate on when early commitment occurs in distribution supply chains.

3 - Differences in the Way Inventory and Reserve Capacity are Used to Deal with Supply Disruption Risk in Two-echelon Supply Chains

Florian Lücker, Kellogg School of Management, Evanston, IL, United States, florian.lucker@kellogg.northwestern.edu
Florian Lücker, Swiss Federal Institute of Technology EPFL, Lausanne, Switzerland, florian.lucker@kellogg.northwestern.edu

This research focuses on managing supply chain disruption risks using inventory and reserve capacity in a two-echelon supply chain under stochastic demand. We show that in assembly supply chains optimal reserve capacities are higher upstream whereas optimal inventory levels are lower downstream relative to a comparable serial supply chain. We further illustrate differences in the use of reserve capacity versus inventory held to deal with supply disruption risk.

4 - Integrated Supply Chain Design and Planning: A Risk Management Perspective

Nasim Nezamoddini, State University of New York-Binghamton, 222 Main Street, Apt 1, Binghamton, NY, 13905, United States, nasim.nezam@gmail.com

This research proposes an optimization framework to manage internal and external risks during strategic, tactical, and operational level decisions. The proposed model addresses uncertainties associated with demands, disruptions, delays, and failures. The structural design and communications plans between different centers are determined based on the risk perspective of the decision maker. A modified genetic algorithm is designed to solve the model. The experimental results show that increasing the backup paths and capacities makes the supply chain more robust against the potential risks.

5 - Cash to Cash and the Zone of Concern

Joyaditya Laik, University of Pittsburgh, 241 Mervis Hall, Katz Business School, University of Pittsburgh, Pittsburgh, PA, 15260, United States, joyaditya.laik@pitt.edu, Prakash Mirchandani

A firm which refers Cash Conversion Cycle (C2C) as a test of operational efficiency, might embark upon improvement projects which require costly investments. We contend that such steps may be uncalled for, since what is 'inferior' to a benchmark value, may really be an unfavorable fiscal cycle or seasonality in comparison to the benchmark firm. The effect of such idiosyncrasies limit the vision of firms to a 'zone of concern' which is a subset of the period of financial reconciliation, thereby rendering the firm's actions myopic. We propose that use of C2C without 'relevant' business context may be precarious which managers must be observant of.

5 - Development of a Logistics Risk Assessment Tool

Ryan Sanders, University of Arkansas, 2550 Sunset Ridge, Cave City, AR, 72521, United States, rpsander@uark.edu

This research aims to better understand what risks are present along each point in the supply chain and to develop a way to assess those risks. By organizing findings from literature and implementing an online risk assessment tool, we hope to allow organizations to identify and quantify risks along their supply chains. This user-friendly, web-based risk assessment tool is two-fold; a gap analysis will indicate which specific area of the supply chain a company should focus on improving, and a multi-objective decision analysis will quantify the benefit of different practices a company could use.

■ MD36

351F

Best Service Science Cluster Award Paper Competition #II of II

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Pennsylvania State University, Malvern, PA, 19355, United States, robinqiu@psu.edu

1 - An Instrumental Variable Tree Approach for Detecting Heterogeneous Treatment Effects in Observational Studies

Guihua Wang, University of Michigan, 1169 McIntyre Drive, Ann Arbor, MI, 48105, United States, guihuaw@umich.edu, Jun Li, Wallace Hopp

We develop a new Instrumental Variable (IV) tree approach for detecting heterogeneous treatment effects in observational studies. We show that the IV tree approach effectively corrects for endogeneity issues and partitions subjects into groups such that those in the same group have similar treatment effects and those in different groups have different treatment effects. We demonstrate the practical application of the IV tree approach by using colectomy as the clinical setting to compare teaching (treatment) and non-teaching (control) hospitals and find that the outcome differences between teaching and non-teaching hospitals are heterogeneous across patient types.

2 - A Data-Driven Approach to Personalized Bundle Pricing and Recommendation

Anna M. Papush, Massachusetts Institute of Technology-ORC, Somerville, MA, 02143, United States, apapush@mit.edu, Georgia Perakis, Pavithra Harsha

The growing trend in online shopping has sparked the development of increasingly more sophisticated product recommendation systems. We construct a model that recommends a personalized discounted product bundle to a shopper that considers the trade-off between profit maximization and inventory management, while selecting relevant products to the consumer's preferences. We develop two classes of approximation algorithms to produce output in real-time. We provide analytical performance guarantees and implement our algorithms on data from a large U.S. e-tailer and a premier global airline. Our results show significant lifts in expected revenue over current practices on the order of 2-7%.

3 - Coopetition and Profit Sharing for Ride-sharing Platforms

Renyu Zhang, New York University Shanghai, Shanghai, China, renyu.zhang@nyu.edu, Maxine Cohen

The recent introduction of on-demand ride-hailing and ride-sharing platforms totally changed the way people commute. We consider a setting in which two competing platforms engage in a profit sharing contract by introducing a new hybrid service. We model the price competition between the platforms by using the Multinomial Logit model, and show that a unique equilibrium exists. Then, we analyze the impact of introducing the new joint service to the market. Interestingly, we show that a well-designed profit sharing contract benefits every single party (riders, drivers and both platforms).

■ MD37

352B

Border Security, Risk Management and Resilience for Global Supply Chains

Sponsored: Service Science

Sponsored Session

Chair: Eleftherios T. Lakovou, Texas A&M Engineering Experiment Station, Texas A&M Engineering Experiment Station, College Station, TX, 77840, United States, eiakovou@tamu.edu

1 - Evaluating a Wicked Problem: A Conceptual Framework on Seaport Resiliency

Amir Gharehgozli, Texas A.& M.University, P.O. Box 1675, Galveston, TX, 77553, United States, gharehga@tamug.edu

Seaport infrastructure by virtue of its location can be severely impacted from disruptive adverse weather events. Disruptive adverse events range from long-term changes such as sea level rise caused by climate change to short-term impacts such as hurricanes. This paper proposes a new conceptual framework for evaluating how ports currently strategize against the risks associated with these potential events and how they plan to ensure port resiliency.

2 - Information Dashboards for Enabling Business Continuity and Risk Management

Jim Wall, Texas A&M.University, TEES.Headquarters, 3470 TAMU, College Station, TX, 77843-3577, United States, jim-wall@tamu.edu, Keith Biggers

Decision makers routinely need quick access to dependable and relevant data to adequately assess risk to inform necessary decision making processes. We provide an overview of ongoing research and development of a technology platform for enhancing situational awareness and decision support including the implications for training. This platform allows for visual integration of disparate real-world data streams into a common user-defined operational picture. Data sources can include databases, sensors, and results from simulations. We will illustrate how this platform can support business continuity, logistics, and risk and consequence management across a range of real-world applications.

3 - A Game Theory-based Strategic Framework for Border Security Control and Risk Management for Protecting Globalized Supply Chains Against Illicit Use

Yanling Chang, Texas A&M.University, 1550 Crescent Pointe Pkwy, APT.1206, College Station, TX, 77845, United States, yanling.chang@tamu.edu, Eleftherios Iakovou, Jim Wall, Keith Biggers

Adversaries often utilize global supply chains as targeted delivery platforms by transporting illegal or unauthorized goods into the U.S. Such breaches may result in negative economic ramifications for all supply chain stakeholders or for launching a terrorist attack. This research aims to develop a novel, dynamic, quantitative strategic framework based on game theory to capture and understand the supply chain risk imposed by such adversaries for ensuring border security along with business continuity and supply chain resilience, while further securing the four flows of supply chains - products, process/work, information, and cash across the border.

■ MD38

352C

Analytic Network Process (ANP) Best Practices

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Orrin Cooper, University of Memphis, Memphis, TN, 38152, United States, olcooper@memphis.edu

1 - Implications of Coherency: A Literature Review

Orrin Cooper, University of Memphis, 332 Ba, Memphis, TN, 38152, United States, olcooper@memphis.edu, Enrique Mu, Michael Peasley

Coherency is an important test to run when creating ANP models. This claim is further motivated by reviewing all ANP publications from 2015 in the SSCI Index. Summary data of the publications' coherency levels and impacts on the final results when attempts were made to improve coherency are presented. These results provide additional motivation for Coherency testing. Simulations results are presented to generalize the effect incoherency can have on the results of an ANP model.

2 - After 25 Years ANP Best Practices

Enrique Mu, Carlow University, 3333 Fifth Avenue, Pittsburgh, PA, 15213, United States, emu@carlow.edu

The rule of thumb for scientific reports has been to provide enough information so the study can be understood, assessed its methodological validity and -given access to the proper dataset- to allow its replication. We have reviewed SSCI-indexed ANP studies published during 2015 and found that most of them are inconsistent in terms of what they report. While there are currently no specific rules about how to report ANP studies, we propose here some guidelines -to our knowledge, for the first time- to properly report them.

3 - Does a Shared-decision Making Model for Colorectal Cancer Screening Lead to Better Medical Outcome?

M. Gabriela Sava, College of Business, Clemson University, Clemson, SC, United States, msava@clemson.edu, Luis G. Vargas, Jerrold H. May, James G. Dolan

Choosing the most appropriate colorectal cancer screening option should be a joint decision, made by both the patient and the healthcare provider. We propose a multi-criteria decision making model that combines the patient's preferences regarding the currently available cancer screening options with the healthcare provider's expertise. The most preferred option is further analyzed, to assess its sensitivity and stability as additional medical information might be brought into the discussion.

■ MD39

352D

Practice/Healthcare I

Contributed Session

Chair: Xueping Li, University of Tennessee, 1350 Pershing Hill Lane, Knoxville, TN, 37919-0700, United States, xueping.li@gmail.com

1 - Understanding Treatment Strategies of Sepsis using a Decision Framework

Zhenzhen Shi, Post Doctoral Fellow, Kansas State University, P200 Mosier Hall, Manhattan, KS, 66506, United States, szztracy@ksu.edu, David Ben-Arieh, John C.Wu, Majid Jaberi-Douraki

Strategies for sepsis treatment have been discussed extensively in recent years, but no general agreement exists regarding efficacy of these strategies. This lack of consensus is due to the complex nature of what causes sepsis to progress, including heterogeneous groups of patients with infections caused by various microorganisms. Based on our computational-based decision framework, we found out the efficacy of treatment strategies is dependent on various parameters including the type of treatment, the time of treatment administration, the amount of treatment implementation, and the various groups of individuals.

2 - Doctors Performance in Emergency Room

Amir Mousavi, George Washington University, 475 K.St NW, Apt 419, Washington, DC, 20001, United States, ahmn00@gmail.com, Hernand Abeledo, Imad Khojah

Emergency Rooms are known as a fast paced and extremely vital ward in a hospital. Improving the efficiency in the ER has been a challenging question for researchers. Throughout the academic literature, people have defined different efficiency indexes and different decision variables in order to tackle this problem. This research aims to apply DEA techniques in order to identify the performance (i.e. productivity) variation among doctors and use this result as a component of the optimization model in order to improve the efficiency of the system.

3 - Predictive Modeling for Toxicities in Head and Neck Cancer Patients

Wei Jiang, Research Assistant, Department of Civil Engineering, Johns Hopkins University, Latrobe Hall, 3400 N. Charles Street, Baltimore, MD, 21218, United States, wjiang16@jhu.edu, Pranav Lakshminarayanan, Zhi Cheng, Xuan Hui, Sauleh Ahmad Siddiqui, Ilya Shpitser, Russell H. Taylor, Todd McNutt

Head and neck cancer patients experience acute and long-term toxicities such as weight loss, dysphagia, and xerostomia due to radiotherapy. Oncospace is a learning health system developed at Johns Hopkins University that is accumulating a large volume of patients' treatment data (imaging and radiation dose distributions) and clinical data (toxicities and demographic data). We build a machine learning model to predict head and neck cancer patients' toxicities and investigate the influence of the radiation dose distribution in specific organs. The goal is to better understand where we can improve our delivery of radiation to reduce toxicity while maintaining adequate treatment of cancer.

4 - Studying Length of Stay and Early Readmissions in General Surgery Service Line: A Data Analysis Approach

Wareef Al Najjar, Binghamton University, Binghamton, NY, United States, walnajj1@binghamton.edu, Khalid Aram

Patient Length of Stay (LOS) and hospital readmissions should be given attention by healthcare organizations. LOS and readmission rates have been used to measure efficiency and effectiveness of care respectively. In this study, we focus on LOS in general surgery service line and its association to readmissions and other factors in a hospital in middle Georgia. First, we identified Diagnosis-Related Groups that have major contribution to average LOS based on some factors. Then we applied data analysis techniques and built a predictive model which will predict readmission cases earlier in their stay, to help in providing early interventions to avoid readmissions, while shortening their stay.

5 - A Least Squares Monte Carlo Approach to Appointment Scheduling under Patient Cancellation and No-show Behavior

Jason Xiaotian Dou, PhD Student, University of Colorado Boulder, 995 Regent Dr, Boulder, CO, 80302, United States, xido4892@colorado.edu, Manuel Laguna, Dan Zhang

Patient cancellation and no-show behavior is a major challenge in appointment scheduling. A stochastic dynamic programming model for appointment scheduling is introduced. We develop a least squares Monte Carlo approach to tackle the problem and show promising performance via extensive numerical experiments.

■ MD40

352E

Daniel H. Wagner Prize Competition III

Invited: Daniel H. Wagner Prize Competition

Invited Session

Chair: Patricia Neri, SAS Institute, Inc., 104 Grandtree Ct., Cary, NC, 27519, United States, patricia.neri@sas.com

1 - Outcome-Driven Personalized Treatment Design for Managing Diabetes

Eva Lee, Georgia Tech, Industrial & Systems Engineering, Ctr for Operations Research in Medicine, Atlanta, GA, 30332-0205, United States, evakylee@isye.gatech.edu

This work is joint with Grady Health Systems and Morehouse School of Medicine. We present a drug-effect-based personalized approach to improve treatment outcome for diabetic patients. First, a pharmacokinetic and pharmacodynamics (PK/PD) model is established to uncover drug effect based on analysis of anti-diabetic drug dosage and the blood glucose level recorded in the titration period of each patient. This personalized evidence is then utilized within a treatment plan model that optimizes the glycemic control and drug dosage. The optimized plans provide better glycemic control while using less drug.

2 - Dispatch Optimization in Bulk Tanker Transport Operations

Ted L.Gifford, Schneider National Incorporated, PO Box 2545, Green Bay, WI, 54306-2545, United States, giffordt@schneider.com, Tracy Opicka, Ashesh Sinha, Daniel Vanden Brink, Andy Gifford, Robert Randall

All modes of freight transportation are subject to flow imbalances that impact the efficiency of asset utilization. The use of Mathematical Programming optimization models has a rich history of application to this problem. We address a particularly difficult variant of this problem that occurs in bulk chemicals transport. This difficulty is created by a large volume of activity, requiring 1,000 tractors and 1,600 tankers, coupled with complex product-sequencing constraints, tanker wash and preparation processes, and driver work rule constraints. To address this problem the engineering group at Schneider has designed and implemented a multi-phase, multi-dimensional matching algorithm and associated software system that enables business planners to leverage optimized solution recommendations.

■ MD41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Salar Ghamat, Ivey Business School, London, ON, Canada, sghamat.phd@ivey.ca

1 - Modeling Kidney Transplantation Decisions: Optimal Regulatory Oversight

Zahra Gharibi, SMU, Bobby B. Lyle School of Engineering, Dallas, TX, 75205, United States, zgharibi@smu.edu, Michael Hahsler, Mehmet Ayvaci

Regulatory oversight with report card programs are designed to evaluate transplant centers' performance, but it is controversial whether behavioral responses to such programs improve patient outcomes. I propose a stochastic model that determines the socially optimal kidney transplant decision and calculates social loss under no oversight. I introduce a game theoretical solution to derive optimal regulatory oversight implemented as a citation policy which minimizes social loss.

2 - The Interaction of Outbreaks and the Healthcare System: Closing the Feedback Loops for Disease Modeling

Craig Bakker, Pacific Northwest National Laboratory, 902 Battelle Blvd, Richland, WA, 99352, United States, craig.bakker@pnnl.gov, Matthew Robert Oster, Brent Daniel, Romarie Morales Rosado, Tim McPherson

Healthcare services affect and are affected by disease outbreaks. We have developed a disease model that incorporates the public health system and explicitly considers the two-way interaction between that system and the disease. Here, we model the baseline spread of an outbreak along with the potential impact of the outbreak on the public health workforce. We then explore the potential impacts of various treatment options, resource constraints, and interruptions on the outbreak's evolution. Finally, we discuss healthcare supply chain issues and how to incorporate them into our model.

3 - A Machine Learning Approach to Personalization from Observational Data

Nishanth Mundru, Massachusetts Institute of Technology, Operations Research Center, E40, Cambridge, MA, 02139, United States, nmundru@mit.edu, Dimitris Bertsimas

We consider the problem of assigning the best treatment option out of a finite number of choices to a patient/user depending on his/her observed features. Given historical observational data of patients which consists of their features, assigned treatments and their corresponding outcomes, we learn the optimal treatment policy for each patient in an offline setting. Using an optimization and machine learning approach, we demonstrate that our method outperforms the commonly used regress-and-compare methods on real data sets.

■ MD42

360A

Additive Manufacturing - Data Analytics and OR II

Invited: Advanced Manufacturing

Invited Session

Chair: Alaa Elwany, Texas A&M University, Engineering, College Station, TX, 77843, United States, elwany@tamu.edu

1 - Locating AM Hubs in the United States via Hybrid Manufacturing

Guha Manogharan, Pennsylvania State University, University Park, PA, United States, gum53@engr.psu.edu, Michael G.Kay

The ever-growing applications of Additive Manufacturing (AM) in the production of low volume- high value metal parts can be attributed to improved AM processing capabilities and complex design freedom. However, secondary post-processing using traditional processes such as machining, grinding, heat treatment and hot isostatic pressing, i.e. Hybrid Manufacturing is required to achieve Geometric Dimensioning and Tolerancing (GD&T), surface finish and desired mechanical properties. It is often challenging for most traditional manufacturers to participate in the rapidly evolving supply chain of direct digital manufacturing (DDM) through in-house investments in cost prohibitive metal AM. This research investigates a system of strategically-located AM hubs which can integrate hybrid-AM with the capabilities and excess capacity in multiple traditional manufacturing facilities. Using North American Industry Classification System (NAICS) data for machine shops in the US, an uncapacitated facility location model is used to determine the optimal locations for AM hub centers based on: (1) geographical data, (2) demand, and (3) cost of hybrid-AM processing. Results from this study have identified: (a) candidate US counties to build AM hubs, (b) total cost (fixed, operational and transportation) and (c) capacity utilization. It was found that uncapacitated facility location models identified demand centroid as the optimal location and was affected only by AM utilization rate. The constrained p-Median model has identified 22 AM hub locations as initial sites for

AM hubs which grows to 44 AM hubs as demand increases. It was also found that transportation cost was not a significant factor in the hybrid-AM supply chain. Findings from this study will help both AM companies and traditional manufacturers to determine establishing and growing metal hybrid-AM supply chain.

2 - Random Planar Graphs to Quantify the Evolution of Surface Topography During Polishing Operations

Ashif S.Iquebal, Texas A&M.University, 3120 Texas A&M.University, Apt 1002, College Station, TX, 77843, United States, ashif_22@tamu.edu

We present a random planar graph representation to model the topography of the surface where the nodes represent the individual asperities, and the edges represent the propensity of the neighboring asperities to form a bridge. We provide theoretical bounds on spectral quantifiers of the graphs by invoking the packing density of hard spheres, that connote the various stages, including the end, of polishing.

3 - Process Control for Quality in Custom Additive Manufacturing

Neil Diaz, Texas A&M.University, College Station, TX, United States, nodiaz@tamu.edu, Jin Xu, Harshit Chawla, Satish Bukkapatnam, Natarajan Gautam

While additive manufacturing is a promising approach for customized products, because of variability each product could have different parameters. Thus to avoid defects which further increase the already long production times, we explore adaptive control strategies to set parameters on the fly using sensor-based measurements. To that end, we develop stochastic control methods with the objective of minimizing the expected cycle times.

4 - Multivariate Calibration of Computer Simulation Models for Additive Manufacturing

Alaa Elwany, Texas A&M.University, College Station, TX, United States, elwany@tamu.edu, Mohamad Mahmoudi, Gustavo Tapia, Brian Franco, Ji Ma, Ibrahim Karaman, Raymundo Arroyave

Computer simulation models are widely used to predict various additive manufacturing (AM) processes. Simulating the melt pool particularly for metal AM processes is the key step for understanding the microstructure and properties of the parts. We present a two-stage Bayesian approach to conduct multivariate calibration of simulation model parameters such that the predictions agree with experimental measurements. First, multivariate Gaussian processes are used to construct a surrogate of the original simulation model. Next, experimental measurements are obtained using a commercial AM machine and titanium alloy powder to compute the posterior distributions of the calibration parameters.

■ MD43

360B

Humanitarian Logistics in Public Sector OR

Sponsored: Public Sector OR

Sponsored Session

Chair: Sung Hoon Chung, Binghamton University, Binghamton, NY, 13902, United States, schung@binghamton.edu

1 - An Algorithm for Efficient Evacuation Planning in Congested Multi-class Time-expanded Networks

Changhyup Oh, POSTECH, Pohang, 37673, Korea, Republic of, changhyup.oh@postech.ac.kr, Min Hee Kim, Byung-In Kim, Jang Won Choi, Young Myung Ko

In this study, we present an efficient heuristic algorithm that generates an evacuation plan close to the optimal one in time-expanded multi-class networks. The proposed algorithm significantly reduces computational time compared with other approaches based on mixed integer programming (MIP) models. We construct several networks from real world data including a multiplex cinema and a subway station as well as a generated network for intuition. Numerical results show that the proposed algorithm produces high quality evacuation plans with short computational time and is scalable in terms of population and network size.

2 - Drone Assisted Last Mile Delivery for Disaster Relief Operations

Jinkun Lee, Binghamton University, Binghamton, NY, United States, jinlee@binghamton.edu, Sung Hoon Chung, Duaa Serhan, Sang Won Yoon

We consider the use of unmanned aerial vehicles, also known as drones, as an assistant to conventional vehicle routing for disaster relief operations. The advantage can be summarized in two folds: 1) faster delivery of critical supplies and 2) expanded delivery areas. A mixed integer programming problem is formulated and multiple objectives, such as minimizing population-weighted arrival times, minimizing total traveling times, and minimizing the latest arrival time, are considered. As the model gets much more complicated, a hybrid heuristic method, utilizing adaptive neighborhood search, insertion algorithm, and tabu search, is proposed. We present case study examples.

3 - Mobile Pharmacies for Reducing Supply Chain Inequities in Low Resource Settings

Biplab Bhattacharya, University at Buffalo, 82 Springville Ave, Amherst, NY, 14226, United States, biplabsu@buffalo.edu, Rajan Batta, Li Lin

Needs of medical drug supplies are not sufficiently addressed by an equal distribution approach. Equity, different from equality, provides a realistic perspective to identify medical drug demand. A measure is developed that incorporates factors affecting inequity. A mobile-pharmacy location-tour model uses that inequity measure as a criterion to choose communities to serve. The model formulation consists of two parts; the first part involves location selection and frequency determination; the second part is a tour based integer programming formulation. Lastly, a modified Gini coefficient that takes into account demand is used to observe changes in inequity.

4 - Values-based Performance Measures in Humanitarian Relief

Michael Veatch, Gordon College, Wenham, MA, 01984, United States, mike.veatch@gordon.edu

Models and assessments of humanitarian relief efforts need to incorporate additional factors, beyond quantity or cost of relief delivered, in performance measures. These factors include humanitarian principles, specific values of faith-based organizations, donor priorities, and fundraising considerations. We review some performance measures that have been proposed and report on our efforts to construct empirically-based performance measures for disaster response that incorporate values of the organization.

■ MD44

360C

Marketing

Contributed Session

Chair: Yifei Luo, University of Science and Technology of China, Hefei,Anhui, China, ustclyf@foxmail.com

1 - Buyer-induced and Seller-induced Learning when Product Quality is Uncertain

Lu Zhang, School of Management, University of Science and Technology of China, Hefei, China, zlu@mail.ustc.edu.cn, Chuanyong Xu, Yong Zha

As product uncertainty can be reduced by consumer learning in different ways, we investigate the impact of learning mechanisms on seller's pricing decisions. We build a two-period pricing model to explore buyer-induced learning and seller-induced learning. We find that under buyer-induced learning the learning rate target increases with consumer learning efficiency, leading to lower prices. Moreover, under seller-induced learning, the learning rate target is not continuous in seller's education efficiency, implying a shift in pricing strategy.

2 - Coordination through Cooperative Advertising in a Two Period Consumer Electronics Supply Chain

Xiaohang Yue, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, xyue@uwm.edu, Qingyun Xu, Yi He

Firms in the consumer electronics industry frequently launch new styles of their products, which leads to a "two-period" phenomenon of their product sales. Only a few published articles have considered two-period models in cooperative advertising. This paper investigates co-op advertising strategies in a two-period supply chain consisting of single manufacturer and single retailer. Utilizing the game theory, we consider two different scenarios: decentralized scenario with a cooperative advertising program and integrated scenario. Aside from these scenarios, we propose a supply chain contract to coordinate this supply chain system.

3 - The Addition of Social Attributes and Product Differentiation

Qingyuan Zhu, University of Science and Technology of China, 1952 S.Orchard Street, Apt A, Urbana, IL, 61801-6196, United States, zqyustc@mail.ustc.edu.cn, Jiong Sun, Yunchuan Liu

This paper studies the addition of a social attribute onto a product line and its effects on product differentiation decisions. We show that the firm benefits more from adding a social attribute onto a high-quality product than onto a low-quality product, and adding a social attribute results in a non-monotonic impact of quality differentiation on profits and, hence, it alters the firm's product differentiation decision.

4 - The Effect of Aggregated Purchasing on Promotion of Quantity Discount in Social Network

Yifei Luo, PhD candidate, University of Science and Technology of China, School of Management, USTC, 96 Jinchai Road, Hefei,Anhui, 230026, China, ustclyf@foxmail.com, Yugang Yu, Jie Liu

Quantity discount, a traditional marketing tool as promotion, is commonly used by single consumers to buy more goods with cheaper price. But now in web-based network era, quantity discount is frequently used by a group consumers to aggregate purchase to share the benefit of quantity discount. Communication and purchase behavior in social network is a key factor determining the optimal profit . We consider how the firm set a discount to make it the optimal profit. We solve the optimal profit function in two categories of consumers. We show that the promotion with aggregated purchasing not necessarily inferior to traditional quantity discount even if the level of communication is sufficiently high.

■ MD45

360D

Revenue Management, Pricing

Contributed Session

Chair: Hasmukh Gajjar, Indian Institute of Management-Indore, Indore, India, hasmukh135@gmail.com

1 - Analyzing the Effect of Demand Cannibalization in Multi-channel Retailing

Yasamin Salmani, PhD Candidate, Drexel University, 3220 Market St., Philadelphia, PA, 19104, United States, ss3858@drexel.edu

Having multiple channels to sell the products has been regarded as a principal method to attract more customers. From the other side, a major concern in any multi-channel retailing is that adding a marketing channel may grab demand of other established channels to some extent. This paper investigates some fundamental reasons of this phenomenon, the so-called cannibalization, as well as propose some solutions to alleviate its effects on demand.

2 - Context-effect Models for Online Recommendations

Uzma Mushtaque, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY, 12180, United States, uzmamu@rpi.edu

Post filtering models are developed for online personalized assortments under a random utility framework. Four variants of MNLCE explicitly incorporate the impact of information overload by redefining item level representative utility. The models are novel as they capture the context of information overload and the notion of novelty and diversity in addition to the common goal of recommending high preference items.

3 - Should Retailers Open Outlet Malls?

Xiuli He, Associate Professor, UNC-Charlotte, 9201 University City Blvd, Charlotte, NC, 28223, United States, xhe8@uncc.edu, Guiping Li

We consider the manufacturer's quality decisions for outlet stores and regular malls.

4 - Pricing Decisions with Low-carbon Responsibility and Remanufacturing Competition in Closed-loop Supply Chain

Juhong Gao, Dr., Tianjin University, College of Management and Economics, 92 Weijin Road, Nankai, Tianjin, 300072, China, gaojuhong@tju.edu.cn, Zhen Huo, Mengmeng Li

Under the consideration of uncertain demand and remanufacturing, introduce the low-carbon responsibility, establish the pricing models of CLSC with remanufacturing competition with the goal about the system expected profit maximization, it is concluded that the pricing strategy of CLSC. Then, considering the low-carbon responsibility factor, the numerical examples further respectively analyze the influence of the uncertain demand and remanufacturing competition to pricing strategies and expected profits of CLSC. It is concluded that the pricing strategies of CLSC are under the condition of different market demand and remanufacturing competition.

5 - Managing Product Returns in Online Retailing

Hasmukh Gajjar, Associate Professor, Indian Institute of Management Indore, Rau-Pithampur Road, C-208, Prabandh Shikhar, Indore, 453331, India, hasmukh135@gmail.com, Bhavin J. Shah

We study the forward and reverse supply chain for product returns in online retailing. The first part of the study investigates the prominent reasons of it and seeks to identify the improvement areas to minimize the returns. Second part discusses ways to handle the return process more efficiently and effectively.

■ MD46

360E

Scheduling and Project Management

Invited: Project Management and Scheduling

Invited Session

Chair: Zhixin Liu, University of Michigan-Dearborn, Dearborn, MI, 48126-4100, United States, zhixin@umich.edu

1 - Production and Pricing Decisions in a Dual-channel Supply Chain under Remanufacturing Subsidy and Carbon Tax Policies

Ping He, Associate Professor, South China University of Technology, A309, Shantou Alumni Building, 381 Wushan Road, Guangzhou, 510641, China, phe17@scut.edu.cn, Kaiying Cao, Zhixin Liu

In recent years, governments pursue multiple policies to promote remanufacturing practice. We investigate the optimal production and pricing strategies of a manufacturer and a retailer in a dual-channel supply chain under two policies, i.e. remanufacturing subsidy policy (RSP) and carbon tax policy (CTP). We also explore which policy is better for the society by comparing the social welfares achieved under the two policies. The impacts of two policies on the production quantities of new and remanufactured products are presented. It is found that when the environmental cost coefficient is relatively low, RSP leads to greater social welfare; otherwise, CTP does.

2 - Scheduling of Continuous Slab Casters

Hairong Zhao, Purdue University Northwest, 2200 169 Street, Hammond, IN, 46323, United States, hairong@pnw.edu

The steel industry faces increasing competitive challenges. It is imperative for the steel manufactures to drastically cut costs while improving product quality and customer satisfaction in order to maintain their market positions. One of the tools in the drive to cut costs, increase quality and improve customer satisfaction has been improved planning and scheduling systems. This talk will describe a decision support system for the problem that is faced by a steel company. The system integrates the customer orders selection, and the planning and scheduling of continuous casters, thus makes synchronized production.

3 - Risk-adjusted NPV for Project Evaluation and Selection

Zhixin Liu, University of Michigan-Dearborn, 19000 Hubbard Drive, Dearborn, MI, 48126-4100, United States, zhixin@umich.edu, Nicholas G.Hall, Wenhui Zhao

We consider a company that schedules the tasks of its projects to maximize project net present value (NPV) under risk, and also selects from among its available projects using this measure. We model decreasing project risk by removing from the discount rate the risk factor associated with each task when it is completed. We formulate and solve the resulting problem of maximizing the risk-adjusted NPV of a project. We validate our contribution using two computational studies: the first demonstrates a significant increase in maximum project NPV from improved project scheduling; and the second demonstrates a significant increase in total project portfolio value from improved project selection.

■ MD47

360F

Theoretical Studies in Economics of Information Systems

Sponsored: EBusiness

Sponsored Session

Chair: Lin Hao, University of Notre Dame, Notre Dame, IN, 46556, United States, lhao@nd.edu

1 - Reward Scheme Design Decision under the Multinomial Logit Model in Online Reward-based Crowdfunding Market

Tongxin Zhou, University of Washington, 3927 Adams Lane NE, Seattle, WA, 98105, United States, txzhou5@uw.edu, Shengsheng Xiao

We study the reward scheme design decision for projects in reward-based crowdfunding market. Backers' reward item selection behavior follows the Multinomial Logit choice model with general utility function. Our basic reward design model shows that creators' modified profit margins from each reward item are the same at the optimal backing prices. We also extend the basic model by considering crowdfunding participants' behavior such as backers' altruism, heterogeneous beliefs on project's success probability and creators' reward updating, and derive similar quantitative properties to guide the optimal design decision. Finally, we provide sensitivity analysis of the model parameters.

2 - Mobile App Pricing Models

Jie Zhang, University of Texas, 701 South West Street, Room 520, Arlington, TX, 76019, United States, jiezhang@uta.edu, Xiaoxiao Luo

In the new App Economy, mobile apps market is becoming very crowded with apps in different categories. We theoretically model and compare three different types of common mobile app pricing models to derive implications for mobile developers.

3 - Real Currency or Virtual Currency: Selling Virtual Items in Digital Games

Zixuan Meng, University of Washington, 5000 25th Avenue NE, Room 6201C, Seattle, WA, 98105, United States, zxmeng@uw.edu, Lin Hao, Yong Tan

Providers of free-to-play games often gain profits from two sources - selling in-game virtual items and monetizing players' playtime (e.g. through advertising). Regarding selling virtual items, providers have choices between two popular strategies - (i) selling through real currency only, and (ii) selling through virtual currency only while allowing players to earn virtual currency through their playtime or real currency purchase. This paper studies the provider's optimal choice between those two strategies.

■ MD48

361A

Novel Research Contexts in Behavioral Operations

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Enno Siemsen, University of Wisconsin-Madison, Madison, WI, 53706, United States, esiemsen@wisc.edu

1 - Production Process Moves and the Impact of Functional Diversity and National Culture

Pettis Kent, University of Minnesota, 321 19th Avenue S, Suite 3-150, Minneapolis, MN, 55455, United States, kentx143@umn.edu

Changing customer demand, increasing production costs, and emerging growth opportunities often generate pressure on firms to relocate their production processes. Although it would be ideal if manufacturing plants could be moved quickly and easily, moving a process is disruptive and involves coping with a new learning curve to ramp-up production. Using behavioral experiments, we examine whether variables such as Functional Diversity and National Culture impact the effectiveness of a proven process template during a production move. Our findings help characterize how a firm's managers should leverage workforce diversity and how they should factor in cultural differences when planning a move.

2 - A Behavioral Study on Abandonment Decisions in Multi-stage Projects

Xiaoyang Long, HKUST.Business School, LSK.Business School, HKUST, Kowloon, Hong Kong, xlongaa@connect.ust.hk, J avad Nasiry, Yaozhong Wu

We experimentally investigate continuation/abandonment decisions in a multi-stage project under two conditions: when the project is reviewed at every stage and when review opportunities are limited. We find systematic deviations from the optimal solution: subjects may wrongly continue or abandon the project, and their decisions are path dependent. We propose a behavioral model which explains the behavioral regularities.

3 - A Behavioral Perspective on Inventory Sharing

Liang Xu, The Pennsylvania State University, 419A Business Building, Penn State University, State College, PA, 16801, United States, lzx103@psu.edu, Hui Zhao, Enno Siemsen

We examine inventory sharing effectiveness from a behavioral perspective. Using behavioral experiments, we show that decision makers do not stock enough to benefit from sharing, and the opportunity to share inventory leads to an even further reduction in the initial inventory stock. Further, decision makers are more likely to under-request inventory, leading to reduced demand signal processing among decision makers. We provide evidence that by reducing inventory transparency in the system and providing decision support, inventory sharing can become effective and increase profitability for participants.

4 - Biased Forecasts: the Impact of Service Level and Product Shelf Life

Tarkan Tan, Eindhoven University of Technology, School of Industrial Engineering, Den Dolech 2 Paviljoen F-07, Eindhoven, 5612AZ, Netherlands, t.tan@tue.nl, Meysam Arvan, Behnam Fahimnia, Enno Siemsen

Sales forecasts produced by the forecasting team are assumed to simply display the most likely value for product demand. This study aims to understand the extent to which this assumption holds in reality. We want to know if forecasts - in a real-world context for highly-perishable products - are treated as "the most likely values" or more like "decisions". We refer to the latter as "biased forecasts". We design an experiment to explore answers to the following questions: to what extent service level requirement and waste minimization are taken into account when developing the base forecasts, and is there a clear relationship between a forecaster's sustainability beliefs and under-forecasting?

■ MD49

361B

Cognitive Modelling & Experimentation

Invited: InvitedBehavioral Aspects of OR

Invited Session

Chair: Juan Pablo Torres, Universidad De Chile, Santiago, Chile, jtorresc@unegocios.cl

Co-Chair: Martin Kunc, University of Warwick, Coventry, CV4 7AL, United Kingdom, martin.kunc@wbs.ac.uk

1 - Neurocognitive Sources of Misperception of Feedbacks in Managerial Decisions

Juan Pablo Torres, Universidad de Chile, 257 Diagonal Paraguay, #1204, Santiago, Chile, jtorresc@unegocios.cl, René San Martin

This article explores some cognitive sources of misperception of feedback in dynamic environments. Operational Research literature has highlighted two key failures, which explain misperception of feedback: Stock-flow failure and failure to account for time delays. We develop a cognitive neuroscience experiment based on the traditional beergame to understand how the brain processes the stock and flow signals. We recorded and analysed brain electrical responses to the presentation of stock and flow information in an adapted version of the classical beer game. Our preliminary results suggest that, neurally, participants process stock and flow information differently in terms of their recruitment of both attentional and reward-processing circuits in the brain. We discuss how this might be a source of misperception of feedback.

2 - Microfoundation of Pricing Capabilities and its Performance

Juan Pablo Torres, Universidad de Chile, 257 Diagonal Paraguay, #1204, Santiago, Chile, jtorresc@unegocios.cl, Claudio Aqueveque, Pablo Tapia

We focus on analyzing how business decision-makers implement pricing decisions in complex environments. We developed a simulation-based experiment to test our hypotheses with 124 middle managers. We identified three microfoundations of pricing decisions: pricing flexibility, risk taking on pricing decisions, and strategic consistency of pricing decisions. Preliminary results suggest that information, which is structured as causal maps improve pricing decisions related to pricing flexibility and strategic consistency. This causal map also reduces inconsistencies in strategy implementation.

3 - Improving Mental Models by Haptic Perception of Internal System Dynamics

Martin Fg Schaffernicht, Universidad De Talca, Avenida Lircay S/N, Talca Maule, 34600, Chile, martin@utalca.cl, Stefan N. Groesser, Bärbel Fürstenau

We consider firms as dynamic resource systems. Internal and external interdependencies influence the development of the resources. The strength of interdependencies and their changes over time cannot be directly perceived in real systems or in on-screen experimental settings. Decision makers perform poorly. We conjecture that interdependency dynamics are more perceivable, performance and understanding improve. Physical levers which require continuous effort to control resources allow improved perception. A simulation with on-screen and haptic interfaces allows to test this hypothesis. We present the theoretic context and initial data.

4 - Effort Reduction in Repeated Rule-based Choices

Andres I. Musalem, U. de Chile, Beauchef 851, Santiago, 8370456, Chile, amusalem@duke.edu

We explore processes of effort reduction in repeated choices. Decision makers are asked to follow a set of lexicographic rules that are tedious, but easy to get right. Eye tracking reveals the processes that lead to effort reduction with experience. Major gains come from learning the locations and meaning of information in the choice tasks, and from limiting repeated attention to needed information. Smaller gains come from focusing fixations on needed information and spending less time per fixation. Rewards for speed enhance these gains but do not decrease accuracy, and greater effort reduction emerges when a trial period permits learning.

■ MD50

361C

Road and Parking Pricing and Coordination

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Sayeeda Ayaz, University of Massachusetts-Amherst, 990 North Pleasant Street, Apt B24, Amherst, MA, 01002, United States, sbayaz@umass.edu

1 - A Sensitivity Analysis Approach to Robust Toll Pricing Considering Boundedly Rational Network Users

Mahdi Takalloo, University of South Florida, Tampa, FL, 33620, United States, mtakalloo@mail.usf.edu, Changhyun Kwon

Considering an ambiguous system of preferences and lack of complete information, decision makers are not perfectly rational, but boundely rational. Under such behavior, users do not necessarily choose the shortest path, and system travel time can be greater than in the case of rational behavior. In this research, we study a robust toll pricing strategy in congested networks under boundedly rational behavior. Using sensitivity analysis approach, our goal is to find a toll vector that minimizes the system travel time of the worst-case tolled boundedly rational user equilibrium.

2 - Cooperative Scheme - An Alternative Approach to Equitable and Pareto-Improving System Optimum

Sayeeda Ayaz, University of Massachusetts-Amherst, 990 North Pleasant Street, Apt B24, Amherst, MA, 01002, United States, sbayaz@umass.edu, Song Gao, Hyoshin Park

An alternative approach is adopted to achieve equitable and Pareto-improving system optimum (SO) based on cooperation among travelers assisted by defector penalty. Preliminary analysis shows that under mild conditions, a cooperative scheme always exists for a single-origin-destination two-route network to ensure equitable and Pareto-improving SO. A cooperative scheme without financial transactions always exists where all travelers are cooperators due to high defector penalty. A more practical case is also discussed where a certain number of defectors exist. A constrained optimization problem ensuring equity among cooperators is formulated.

3 - A Bi-level Parking-pricing Problem

Hossein Fotouhi, George Mason University, 4630 Buckhorn Ridge, Fairfax, VA, 22030, United States, hfotouhi@gmu.edu, Elise Miller-Hooks, S.Bekhor

A bi-level, multi-period, parking-pricing problem is formulated with applicability for online reservation systems. In the upper level, multiple parking operators seek to maximize their own profits. User response to these upper-level decisions are obtained from a lower-level, parking-choice problem.

4 - Optimal Pricing for Priced Managed Lanes with Multiple Entrances and Exits

Venktesh Pandey, The University of Texas at Austin, Austin, TX, 78712, United States, venktesh@utexas.edu, Stephen D.Boyles

Priced managed lanes are being implemented in many cities. Dynamic pricing can be incorporated to achieve several objectives, such as maximizing system level throughput or revenue. We propose and compare different approximate dynamic programming algorithms for solving an optimal distance-based pricing for a managed lane corridor with multiple entrances and exits for a time dependent demand with varying value of time across the travelers. The results are compared against other non-optimal methods used in practice.

■ MD51

361D

Information Systems in Healthcare

Sponsored: Information Systems

Sponsored Session

Chair: YeongIn Kim, University of Texas-Dallas, Richardson, TX, 75080, United States, yxk130930@utdallas.edu

1 - The Effect of Online Reviews on Physician Demand: A Structural Model of Patient Choice

Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, United States, yxu@stern.nyu.edu, Mor Armony, Anindya Ghose

In this paper, we wish to derive the impact of online information on patient choice of outpatient care doctors. We are especially interested in how operational factors influence demand. To do so, we study a unique data set from one of the leading appointment booking websites in the United States, that contains online doctors' appointments made over a five-month period, along with other online information. We propose a random coefficient logit model to characterize consumer heterogeneity in doctor choices, taking into account both numeric and textual user-generated content with text mining techniques.

2 - The Impact of Health Information Exchanges on Physicians' Referral Patterns

Saeede Eftekhari, State University of New York-Buffalo, 304 Jacobs Management Center, Buffalo, NY, 14228, United States, saeedeef@buffalo.edu, Niam Yaraghi, Ram Gopal, Ram Ramesh

The objective of this research is to study how Health Information Exchanges (HIE) improves physicians' referral processes. Mainly, we argue that a primary care physician who has adopted HIE has access to a larger number of specialists than another physician who has not adopted HIE. This enables her to make a better decision in a referral process with regards to selecting an appropriate specialist. Second, we argue that a primary care physician who has adopted HIE tends to refer to the specialists who have also adopted HIE. This leads to better quality of care since HIE renders patient information readily available at the point of care. This study has significant implications for healthcare policy-making.

3 - Supervised Learning Methods for Predicting Healthcare Costs

Mohammad Amin Morid, University of Utah, 130 University Village, Salt Lake City, UT, 84108, United States, amin.morid@utah.edu

This study conducted a systematic literature review and identified five methods for predicting healthcare costs. We empirically evaluated the predictive performance of each reported approach, as well as other state-of-the-art supervised learning methods. In this comparative analysis, gradient boosting had the best predictive performance overall and for low to medium cost individuals. For high cost individuals, Artificial Neural Network (ANN) and the Ridge regression model, which have not been previously reported for use in healthcare cost prediction, had the highest performance.

4 - Physician and Patient Hybrid Community-based Recommender System for General and Diabetic Preventative Care

Pamella Howell, University at Buffalo, Buffalo, NY, United States, pamellah@buffalo.edu, Mohamed A.Abdelhamid

An under-explored area of recommender system research is e-health. Technology is essential in the lives of the aging population and millennials. Integrating technology with healthcare services using recommender systems could help providers transition to a Merit-based payment incentive system. We propose a recommender system that will provide general preventative care prescriptions based on context, personal health information, and domain knowledge.

5 - Standardization, Interoperability and the Patient Interest: How EHRS Influence the Hit Marketplace

Nicola Mountford, Director, UCD Connected Health, University College Dublin, Dublin, Ireland, nicola.mountford@ucd.ie, Rajiv Kohli, Georgiana Ifrim

Encouraged by EHR adoption incentives such as the Health Information Technology for Economic and Clinical Health (HITECH) Act, healthcare providers held bargaining power as buyers of HIT. As EHRs began to promote quality measurement and reimbursement that power shifted toward an oligopoly of EHR vendors. We explore an emerging power shift toward patients that is driven by consumerism and patients' control of information. We track this emergent power shift and the evolving role of EHR and discuss implications for providers, vendors and patients.

■ MD52

361E

Energy

Contributed Session

Chair: Shigeki Toriumi, Chuo University, Tokyo, Japan, toriumi@ise.chuo-u.ac.jp

1 - Coal Inventory Optimization for Electric Power Utilities

Chung-Hsiao Wang, LG&E and KU, 102 Spruce Lane, Louisville, KY, 40207-1701, United States, chunghsiao@hotmail.com, K. Jo Min

Electric power utilities that own coal power plants maintain coal inventory to hedge against coal burn and delivery uncertainties. Coal burn uncertainties are caused by fluctuations in load and generation unit availability. Delivery uncertainties are primarily caused by transportation disruptions. In this paper, we develop a mathematical model that considers those root causes to determine optimal coal inventory levels for electric power utilities.

2 - Evaluation of Risks for Power Plant Operators through Reconfiguration of Price Zones in Central Western Europe (CWE) using a Recombining Scenario Tree

Robin Leisen, Research Assistant, University Duisburg-Essen, Berliner Platz 6-8, Essen, 45127, Germany, robin.leisen@uni-due.de, Tim Felling, Caroline Deilen, Christoph Weber

In CWE a new price zone configuration (PZC) for electricity is discussed. A frequent change of PZC affects the risk for power plant operators as their expected net present value (NPV) varies depending on the PZC. Thereby the PZC is assessed using a hierarchical cluster algorithm. Using the new zonal prices, the contribution margin is determined. The net present value results from the probability-weighted average of the contribution margin of each scenario discounted to today. Among others, the scenario tree considers time steps, grid development, fuel prices and different zonal configurations.

3 - Evaluation of Importing Countries and Transportation Mode of Energy Resources Considering Uncertainty

Shigeki Toriumi, Chuo University, 1-23-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan, toriumi@ise.chuo-u.ac.jp, Ryuta Takashima

In this study, we evaluate country risk and transport risk of importing energy resources using two mathematical model. First, we develop a mathematical model that determines the quantity of imports considering country risk. Next, we develop a mathematical model that determines transportation mode and route considering transport risk. Then, we analyze import cost and risk using these models. As a result, for Japan, it was found that although the cost of pipeline transport is lower than that of ship transportation, the transport risk increases.

■ MD53

361F

Arterial and Highway Traffic Operations

Sponsored: TSL, Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Roger Lloret-Batlle, ITS Irvine, 7430 Palo Verde Road, Irvine, CA, 92617, United States, rlloretb@uci.edu

1 - Dynamic Optimal Realtime Algorithm for Isolated Signals

Xiubin Wang, Associate Professor, Texas A&M.University, 3136 TAMU, College Station, TX, 77845, United States, bwang@tamu.edu, Mark Cao, Changjun Wang

This work studies intersection signal control . The optimal control policy minimizes the overall intersection delay by deciding the green intervals for signal phases dynamically . It proposes an analytical model for intersection vehicle delay and derives optimal conditions for green signal switch. Two numerical algorithms are proposed: optimum based (DORAS) and queue-based heuristic respectively. Numerical tests are conducted via simulation.

2 - Connected Vehicle Enabled Proactive Signal Control for Congestion Mitigation on Arterial Corridors

Hao Yang, Visiting Assistant Professor, Lamar University, 2622 Cherry Engineering Building, Beaumont, TX, 77710, United States, yhharold@gmail.com, Xing Wu, Mm Haque

With increasing penetration rates of connected vehicles, signals are able to interact with real-time traffic conditions and to be operated more proactively with traffic prediction models to mitigate road congestions and to improve road capacities. This paper develops a proactive signal control system based on connected vehicles to minimize vehicle delay at multiple intersections. The system utilizes connected vehicles to predict the volumes entering the intersection accurately and to optimize phase sequence and durations of the intersections. The simulations and field experiments illustrate the effectiveness of the algorithm on reducing vehicle delays.

3 - Core-stable Queue Routing Policies for Multiserver Queue Facilities and Highway Control

Roger Lloret-Batlle, PhD Candidate, ITS.Irvine, 7430 Palo Verde Road, Irvine, CA, 92617, United States, rlloretb@uci.edu, R. Jayakrishnan

Transportation supply in multiserver queues and freeways is generally consumed in an FCFS basis. We explore game-theoretical solution concepts that allow agents to cooperate with each other and efficiently violate FCFS in a core-stable fashion. In particular, we develop a dynamic allocation as an n-level Stackelberg game, characterized as a partition function game which is strong-core stable.

■ MD54

362A

Challenges and Opportunities of Establishing Data-driven Agronomic Services to Smallholder Farmers Across the World

Invited: Agricultural Analytics

Invited Session

Chair: Daniel Ricardo Jimenez, International Center for Tropical Agriculture (CIAT), KM 17 recta Cali-Palmira, KM 17 recta Cali-Palmira, Palmira, 0057, Colombia, d.jimenez@cgiar.org

Co-Chair: Andrew Jarvis, a.jarvis@cgiar.org

1 - Increasing Agricultural Production and Resilience through Data Services and Decision Support Systems

Brenda Ortiz, Associate Professor, Auburn University, 201 Funchess Hall, Auburn, AL, 36849, United States, bortiz@auburn.edu, Wendy-Lin Bartels, Clyde Fraisse, David Zierden

The farming community is currently being challenged to build resilience to climate change and to increase crop productivity through the adoption of practices and technology. Our extension efforts have showed that low adoption of decision support systems is due to the lack of engagement with farmers during the conceptualization and development process. A success farmers engagement story is the Tri-state Climate Learning Network for Row Crop Agriculture. Through bi-annual meetings, we learned that awareness on the limitations of the data, the applicability of climate information to crop management, and the co-development of usable decision support tools are key elements of farmers' adoption.

2 - Simulation Based Fungal Disease Modeling in Agriculture using Big Data

Drew Marticorena, aWhere, Inc., Broomfield, CO, United States, drewmarticorena@awhere.com

The FAO estimates that over 1B MT of food are lost due to the fungal diseases yearly. In addition, associated toxins cause harmful health effects to both animals and people that consume the contaminated food. These issues are especially prevalent amongst smallholder producers. The ability to predict where and when fungal diseases are likely to occur would be of great value across the agricultural value chain and would improve the lives of smallholder producers. Using field datasets and modern parameter optimization techniques coupled with biological based models, aWhere has developed simulation based models that predict the incidence of fungal diseases with both high sensitivity and specificity.

3 - Agriculture 3.0: Crowed Sourced Data for Decision Making and Taking in Resilient Agrifood Systems

Bram Govaerts, CIMMYT, Mexico City, Mexico, b.govaerts@cgiar.org

Managing the hugely complex risks that are associated with the food system of the 21st century is a major challenge for decision makers in government, civil society and the private sector alike, and one that has been neglected for the past 30 years. Therefore complex agricultural innovation systems (AIS) that can support agrifood systems for nutrition, nature conservation and national and international security are required. While Knowledge Management (KM) is an important component of AIS, previous KM frameworks did not account for the fact that agricultural systems are complex systems and did not integrate innovation with KM. The results presented will show a case of an AIS that was implemented in Mexico including crowd sourcing of field scale data to develop complex decision support systems. The case presented shows that these approaches can boost performance and steer complex systems in ways that benefit all stakeholders.

4 - Data-driven Agro-climatic Services Improve Farmer Responses to Climate Variability

Julian Ramirez-Villegas, University of Leeds, Leeds, United Kingdom, Julian.ramirezvillegas@gmail.com

Climate is one of the most important factors influencing the performance farming systems. In Colombia, climate variability explains between 30-60 % of rice yield. Farmers, however, make decisions in their farms including issues related to planting date, what variety to plant, or whether to plant, at best, on the basis of no information. We develop data-driven seasonal crop-climate prediction analyses that feed into the development of a climate services platform. The analyses demonstrate that the combination of skillful seasonal climate forecasts, calibrated crop models, and a forecast platform tailored to users' needs can prove successful in establishing a climate service for agriculture.

■ MD55

362B

Financial Econometrics

Sponsored: Financial Services

Sponsored Session

Chair: Gustavo Schwenkler, Boston University, Boston, MA, 02215, United States, gas@bu.edu

1 - Estimating Dynamic Option Pricing Models using Large Panels
Kris Jacobs, University of Houston, Houston, TX, United States, kjacob@bauer.uh.edu

We estimate option valuation models on returns and large panels of option data using the particle filter.

2 - State-varying Factor Models of Large Dimension
Markus Pelger, Stanford University, 312 Huang Engineering Center, 475 Via Ortega, Stanford, CA, 94305, United States, mpelger@stanford.edu, Ruoxuan Xiong

This paper develops an inferential theory for state-varying factor models of large dimension. Unlike constant factor models, the loadings are general functions of some recurrent state process. Our estimator combines nonparametric methods with principal component analysis. We derive the rate of convergence and limiting normal distribution for the factors, loadings and common components. We develop a statistical test for the constancy of factor loadings in different states. In an empirical study on U.S. Treasury securities data, we find that the systematic factor structure is different in boom and recession times and in periods of high market volatility.

3 - The Discretization Filter: A Simple Way to Estimate Nonlinear State Space Models
Leland E. Farmer, University of Virginia, Charlottesville, VA, United States, farmer.leland@gmail.com

Existing methods for estimating nonlinear dynamic models are either too computationally complex to be of practical use, or rely on local approximations which often fail to adequately capture the nonlinear features of interest. I develop a new method, the discretization filter, for approximating the likelihood of nonlinear, non-Gaussian state space models. I apply results from the statistics literature on uniformly ergodic Markov chains to establish that the implied maximum likelihood estimator is strongly consistent, asymptotically normal, and asymptotically efficient (see paper for full abstract).

4 - Long-run Risk or Disasters? New Evidence from an Efficient Estimation Method for Multivariate Jump-diffusions
Gustavo Schwenkler, Boston University, 595 Commonwealth Ave, Boston, MA, 02215, United States, gas@bu.edu, Andrea M. Buffa, Yunjeen Kim

We study the dynamics of consumption growth in a series of countries over a time span of 200 years. We seek to answer whether long-run risk or disasters are features of models that yield good fit to consumption data. To accomplish this goal, we develop a new methodology for filtering and estimation of multivariate jump-diffusion processes with incomplete data. Our methodology is both statistically and computationally efficient, and enables the empirical analysis of previously intractable multidimensional models. Our estimates suggest that long-run risk is a predominant feature of consumption data, albeit of low persistence. Disasters are estimated to be small and frequent, yet necessary for a good model fit.

■ MD56

362C

Recent Advances on Facility Location and Network Design Problems I

Sponsored: Location Analysis

Sponsored Session

Chair: Sergio Garcia Quiles, University of Edinburgh, Edinburgh, EH9 3FD, United Kingdom, sergio.garcia-quiles@ed.ac.uk

1 - An Integer Programming Model of Route Assignment Problem for Reducing Traffic Congestion in Urban Area
Naoya Uematsu, Osaka University, Suita, Japan, naoya.uematsu@ist.osaka-u.ac.jp, Shunji Umetani, Hiroshi Morita

Despite of the spread of navigation services through smartphones, it has been still hard to resolve traffic congestion in urban area.We consider a large-scale combinatorial optimization problem that finds optimal routes for six million people to minimize the peak of congestion in the urban area, instead of solving shortest path problem for each user in individual.To avoid solving a large number of shortest path problems, we enumerate plausible candidate routes for each pair of origin and destination in advance and formulate this problem as a variant of the assignment problem.

2 - On the Spatial Separability of Uncapacitated Single Allocation P-hub Median Problems
Taghi Khaniyev, University of Waterloo, 200 University Ave., CP.H.3669, Waterloo, ON, N2L.3G1, Canada, thanalio@uwaterloo.ca, Samir Elhedhli, F. Safa Erenay

The spatial separability property of uncapacitated single assignment p-hub median problems (USApHMP) is studied. We illustrate that the optimal solutions to the well-known USApHMP instances can be partitioned into p allocation clusters, defined as the set of nodes which are allocated to the same hub, such that the convex hulls of the allocation clusters are disjoint. To exploit this property, a data driven approach to group the network nodes into regions and to obtain high quality solutions based on the solution of a smaller (low resolution) USApHMP is proposed. Experiments indicate the effectiveness of the proposed approach in generating high quality solutions within a reasonable amount of time.

3 - Solution Methods of Safe Walking Route Design Problem
Yuichiro Miyamoto, Sophia University, Tokyo, Japan, miyamoto@sophia.ac.jp, Ryuhei Miyashiro, Ken-ichi Tanaka

In the previous study, we proposed the safe walking route design problem (SWRDP) and analyzed exact optimal solutions using medium-sized problem instances. In this talk, we propose several solution methods of SWRDP for solving larger problem instances. We will also mention some variants of SWRDP.

4 - A Lagrangean Relaxation Algorithm for the Radius Formulation of the P-median Problem
Sergio Garcia Quiles, University of Edinburgh, School of Mathematics, James Clerk Maxwell Bldg, King's Building, Edinburgh, EH9 3FD, United Kingdom, sergio.garcia-quiles@ed.ac.uk, Minerva Martin del Campo Barraza

The p-median problem is a well-known problem in Discrete Facility Location, but at the same time still very challenging to solve for problems of large size. One of the proposed methods in recent years is the so-called radius formulation, which is based on using variables that rank the distances for each customer. This formulation has allowed to solve very large instances for some values of p but it fails for some others (e.g., for small values of p). In this paper we explore the usefulness of applying Lagrangian relaxation to the radius formulation.

■ MD57

362D

Simulation Optimization

Sponsored: Simulation

Sponsored Session

Chair: Mohammad Dehghani, Northeastern University, M.dehghani@northeastern.edu

1 - Triggering an Optimization Module within the Simulation Run: Introducing a New Iterative Optimization-based Simulation (IOS) Framework
Mohammad Dehghanimohammadabadi, Northeastern University, 170 Brookline Avenue, Unit 1025, Boston, MA, 02115, United States, mdehghani@neu.edu, Thomas K. Keyser, Hossein Cheraghi

A unique Iterative Optimization-based Simulation (IOS) framework is presented by integrating simulation, optimization and database managers. With this IOS model, optimization occurs frequently at the operational level in order to optimize system configuration during the simulation run. A trigger event momentarily pauses the simulation and prompts the optimization manager to solve a mathematical model in order to update the simulation model configuration. This promising IOS framework is applied in a manufacturing system and its results are compared with Simulation-Based Optimization (SBO).

2 - A Stochastic Flow Shop Maintenance Scheduling using a Simulation-optimization Approach
Javad Seif, University of Tennessee-Knoxville, 411 B.H. Goethert Parkway, Tullahoma, TN, 37388, United States, jseif@utsi.edu, Mohammad Dehghanimohammadabadi, Andrew Junfang Yu

In this study, preventive and corrective maintenance (PM and CM) activities are incorporated into a permutation flow shop scheduling problem. A set of usage-based and diverse PMs as well as random variables with different probability distributions that represent potential CMs are applied to the model. A hybrid simulation-optimization (SO) approach using mixed integer programming (MIP) and discrete event simulation (DES) is utilized to solve the problem. Finally, a numerical experiment is conducted to evaluate the performance of the provided methodology and its potentialities.

3 - Use of Simulation Optimization Technique in Operating Room Scheduling

Musa Demirtas, PhD, Western New England University, Springfield, MA, 01119, United States, musa.demirtas@wne.edu

Due to increasing number of patients, surgeries, and the healthcare industry needs to use their limited resources efficiently. Operating rooms (ORs) are considered among the most important and costly departments, and generate a significant portion of revenues. Also, planning and scheduling of surgeries for ORs is not an easy task due to uncertainties and limited resources. This study focuses on maximization of utilization of ORs and minimization of the patients' length of stay so that hospitals can decrease their costs while increasing the satisfaction of patients. We developed a simulation-optimization model to allocate limited resources to improve utilization and minimize the patients stay.

■ MD58

362E

Emerging Modalities and Multimodal Systems in Transportation

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Kostas Zavitsas, Imperial College London, 615, Skempton Building, Imperial College Road, London, SW72AZ, United Kingdom, k.zavitsas@gmail.com

1 - Optimization for Campaign-level Human Space Mission Design

Koki Ho, University of illinois at Urbana-champaign, Urbana, IL, United States, kokiho@illinois.edu, Takaya Ukai, Hao Chen

This presentation introduces an integrated method for campaign-level space mission design and optimization. Human space mission design process has become increasingly complex, and there is a larger demand for a rigorous optimization method to support it. Particularly, with more space infrastructure technologies such as lunar mining and on-orbit propellant depot, we need a multi-mission campaign-level design method to find an optimal deployment and utilization strategy of those infrastructure technologies. This presentation develops a method based on approximate dynamic programming and network optimization to efficiently optimize multi-mission space campaign over time.

3 - What Mode Should I Choose? Offering Travel Packages in Mobility-as-a-Service Era

Ali Arian, University of Arizona, 415 N.Park Avenue, Tucson, AZ, 85719, United States, arian@email.arizona.edu, Alireza Ermagun, Yi-Chang Chiu

Mobility as a Service (MaaS) concept aims at changing individual's mode choice from personal owned vehicles towards options that are consumed as a service, and offered by combination of private and public transportation providers. Users of this service can subscribe to packages or pay by trip. This study considering individual's activity pattern, proposes suitable personalized mobility packages. Algorithmic details alongside a case study using Metropia app data are presented.

4 - Optimal Multimodal Transport Networks Beyond Physical Infrastructures

Kostas Zavitsas, Research Associate, Imperial College London, 615, Skempton Building, Imperial College Road, London, SW72AZ, United Kingdom, k.zavitsas@imperial.ac.uk

Transport services have become increasingly complex in recent years with dynamic pricing strategies, smart path finding algorithms, live & personalised user notification, as well as new infrastructure and modes kicking in like automation and drones. The increasing complexity of transport services beyond the physical domain, make several of the systemic approaches dealing with multimodality in transport obsolete. Recognising that a major drive for this complexity is the increased availability and utilisation of data, this research attempts to establish a link between transport system performance and data utilisation.

■ MD59

362F

Joint Session RAS/Practice: Roundtable B - Driverless Technology Implications to Freight Railways

Sponsored: Railway Applications

Sponsored Session

Chair: Dharma Acharya, GE Transportation, Ponte Vedra, FL, 32081, United States, dharma.acharya@ge.com

Co-Chair: Carl D. Van Dyke, TransNetOpt, West Windsor, NJ, 08550, United States, carl@cvdzone.com

1 - Rail Renaissance: Responding to the Threat of Autonomous Trucks

David T. Hunt, Oliver Wyman, One University Square, Suite 100, Princeton, NJ, 08540, United States, david.hunt@oliverwyman.com, Jason Kuehn

SuperTrucks, platooning, and self-driving trucks will erode a large portion of the cost advantage rail intermodal currently holds for longer distance freight trips. Railroads will need to aggressively pursue cost reduction programs of their own to remain competitive in many large markets. This presentation will look ahead 10 years at the relative competitiveness of rail and truck under different scenarios, including implementation of a possible multi-phase strategy for lowering rail costs.

2 - Avoiding Irrelevance - A Future State of Railroading

Daniel Plonk, Norfolk Southern Corporation, 1200 Peachtree Street, Atlanta, GA, United States, dan.plonk@nscorp.com

Truckers have an "in" with Silicon Valley as well as with legislators and regulators. Meanwhile, railroads have been dragged by PTC to the technology table. This view presents not too "far out" ideas on how to achieve better competitiveness while reducing the operating ratio.

3 - The Evolution of Planning and Dispatching to Support Driverless Trains

Giampaolo Orrigo, GE Transportation, 1990 W. Nasa Boulevard, Melbourne, FL, 32904, United States, giampaolo.orrigo@ge.com

Autonomous train operation has been a desire of the rail industry for many years. The economics of it make it easy to see why: asset optimization, cost reduction, and safety. Autonomous systems are in use since the 90's in the rail transit industry. It has been difficult though to apply it to freight networks, due to size, openness of the network, cost of infrastructure, and lack of "intelligent" systems to plan and control. Thanks to recent introduction of new main line ATO, ATP, optimized planning and automatic routing, driverless freight trains now seem more in reach. This presentation will explore how the evolution of the centralized planning and dispatching system will help this transformation.

4 - A Possible Railroad Response to Autonomous Trucks: Higher Quality of Service

James Brooks, GE Global Research Center, Niskayuna, NY, United States, brooksja@ge.com

The railroad industry has long had a significant cost advantage over the trucking mode of transportation. With the possible onset of autonomous trucks, this advantage may significantly erode forcing the rail industry to evolve to provide higher quality of service. In this talk, we will discuss some key barriers and technology needs for the industry to dramatically improve their transportation service levels.

■ MD60

370A

Assessment Processes for OR/MS Education

Sponsored: INFORMEd

Sponsored Session

Chair: Sadan Kulturel-Konak, Penn State Berks, Reading, PA, 19610, United States, sadan@psu.edu

1 - Examining Student Attitudes Toward Statistics

Ping Wang, James Madison University, 1235 Sparrow Court, Harrisonburg, VA, 22802, United States, wangpx@jmu.edu, Susan Wright Palocsay

Statistics is receiving renewed attention in the "analytics movement". One avenue of investigation into student learning of statistics comes from educational psychology. Research findings suggest that students' psychological attributes play an important role in statistics education. We will describe an instrument for measuring attitudinal factors shown to affect acquisition and retention of statistical skills and present test results from a sample of undergraduate business students.

2 - Peer Assessment of Teamwork: Challenges & Solutions

Abdullah Konak, Penn State Berks, Tulpehocken Road, P.O. 7009, Reading, PA, 19610, United States, konak@psu.edu

Student peer evaluations have several problems such as very high peer and self-ratings inconsistent with students' expected skill levels. We redesign a peer assessment instrument from the literature based on behaviorally anchored rating scores in order to address some of these problems. In addition, we introduce new methods to identify anomalies in peer evaluations and incorporate them into the Peer Evaluation and Assessment Resource (PEAR) system, which is an online tool for peer evaluations.

3 - Assessing Engineering Students' Intercultural Competence
Sadan Kulturel-Konak, Penn State Berks, Tulpehocken Road, P.O Box 7009, Reading, PA, 19610, United States, sadan@psu.edu

Students must now be globally aware in order to remain competitive in today's globalized society. In order to effectively assess engineering students' intercultural competence development and engagement throughout their education, an instrument was developed. In this study we focus on students' responses to knowledge-based questions regarding different global content/issues. Our findings using the proposed assessment framework will be presented, and factors affecting engineering students' intercultural competence will be analyzed.

■ MD61

370B

Topics for PhD Students

Sponsored: Minority Issues

Sponsored Session

Chair: Maria Esther Mayorga, North Carolina State University, Raleigh, NC, 27695, United States, memayorg@ncsu.edu

1 - Topics for PhD Students
Maria Esther Mayorga, North Carolina State University, 400 Daniels Hall, Dept. of Industrial & Systems Engineering, Raleigh, NC, 27695, United States, memayorg@ncsu.edu

In this session, a group of panelists will discuss topics of interest to PhD students. The list of topics include: finding your research topic, mentoring, choosing a career path, preparing for the job market, and tips for success. Panelists range from new graduates to full professors, and are from business and engineering schools as well as industry. The amount of time spent on each topic will depend on questions from the audience.

2 - Panelist
Gabriel Zayas-Caban, University of Michigan, 1731 Broadview Lane, Ann Arbor, MI, 48105, United States, gzayasca@umich.edu

3 - Panelist
Shannon Harris, The Ohio State University, 1005 W. 5th Avenue, Unit 535, Columbus, OH, 43212-3085, United States, harris.2572@osu.edu

4 - Panelist
Mark E. Lewis, Cornell University, School of Ops Research & Information Engin., 221 Rhodes Hall, Ithaca, NY, 14853, United States, mark.lewis@cornell.edu

5 - Panelist
William Christian, US.Dept of Defense, Washington, DC, United States, wchristia@gmail.com

■ MD62

370C

IISE-Transaction Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Jianjun Shi, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, jianjun.shi@isye.gatech.edu

1 - A Multi-response Multilevel Model with Application in Nurse Care Coordination
Bing Si, Arizona State University, Tempe, AZ, 85287, United States, bingsi@asu.edu, Jing Li

The recently developed Nurse Care Coordination Instrument (NCCI) enables data to be collected for measuring nurse care coordination, which plays a vital role in promoting patients' safety and quality outcomes by a recent report by the Institute of Medicine. Driven by this, we propose a novel multi-response multilevel model with joint fixed/random effect selection across multiple responses and apply it to a dataset collected across four U.S. hospitals using the NCCI. Our study conducts the first quantitative analysis that links multiple care coordination metrics with multilevel predictors, and thus providing important insight into how care coordination might be impacted or improved.

2 - Identifying Multistage Nanocrystal Growth using in Situ TEM Video Data
Yanjun Qian, Texas A&M.University, 1501 Harvey Rd, Apt 806, College Station, TX, 77840, United States, qianyanjun09@gmail.com, Jianhua Z Huang, Yu Ding

The in situ transmission electron microscopy (TEM) technique is receiving considerable attention as it provides the capability of directly observing nanocrystal growth processes. As more and more TEM video data become available, one of the bottlenecks appears to be the lack of automated and dynamic processing tools. We introduce a method that analyzes the in situ TEM videos in an automated and effective way, which tracks the normalized particle size distribution and identifies the change points delineating the stages in nanocrystal growth. Using the outcome of the change-point detection, we propose a hybrid multi-stage growth model and test it on an in situ TEM video published in 2009 by Science.

3 - Scalable Prognostic Models for Large-scale Condition Monitoring Applications
Xiaolei Fang, Georgia Institute of Technology, 1546 Woodlake Dr NE, Apt F, Atlanta, GA, 30329, United States, xfang33@gatech.edu, Nagi Gebraeel, Kamran Paynabar

Capturing degradation of high-value engineering assets usually entails the use of various types of sensors, which generate massive amounts of data. Building a prognostic model for such large-scale datasets often presents two key challenges: how to effectively fuse the signals from a large number of sensors and how to make the model scalable to the large data size. To address the challenges, we present a scalable model designed for fusing multistream signals using two fusion algorithms developed from functional PCA. Using the algorithms, we identify fused features and predict the RUL via an adaptive (log)-location-scale regression framework. We validate our model using numerical and case studies.

■ MD63

370D

Energy and Climate 11

Invited: Energy and Climate

Invited Session

Chair: Ross Baldick, University of Texas at Austin, Austin, TX, 78712, United States, baldick@ece.utexas.edu

Co-Chair: Vaidyanathan Krishnamurthy, University of Texas-Austin, vaidyanathan@utexas.edu

Co-Chair: Sambuddha Chakrabarti, University of Texas-Austin, sambuddha.chakrabarti@gmail.com

1 - Contingency Analysis During Extreme Events for Electric Power Systems
Sambuddha Chakrabarti, University of Texas-Austin, Austin, TX, United States, sambuddha.chakrabarti@gmail.com, Vaidyanathan Krishnamurthy

Extreme events such as natural disasters and weapon of mass destruction attacks have a major impact on electric power resiliency. This talks discusses contingency analysis for the electric transmission grid considering the physical impact of extreme events on electric power infrastructure.

2 - The University of Texas at Austin - A Microgrid in Practice
Rossen Tzartzev, UT.Austin Utilities and Energy Management, Austin, TX, United States, tzartzev@gmail.com

The University of Texas at Austin has selected the microgrid approach to serving all of the campus energy needs - power, cooling, and thermal. The talk will explore the benefits, opportunities, and challenges presented by these interconnected energy systems, as well as their effect on the overall system resiliency.

3 - Enhancing Grid Resiliency
Robert Hebner, University of Texas-Austin, Austin, TX, United States, r.hebner@cem.utexas.edu

: Achieving the level of resilience needed in the future electricity grid requires hardening against aging infrastructure, malicious attacks, and disasters. Developing a more robust system requires modeling of the physics of failure, robust controls, and a grid that can quickly disaggregate. These are necessary, but not sufficient. There is also a need to understand the interconnection of disparate systems such as transportation, telecommunications, and power.

4 - Contingency Constrained Day-ahead Scheduling of Large-scale Power Systems
Ramtin Madani, Assistant Professor, The University of Texas at Arlington, Arlington, TX, United States, ramtin.madani@uta.edu, Edward Quarm

A computational method will be introduced for solving power system scheduling problems under load and generation uncertainty as well as contingency constraints. A polynomial-time solvable model is created, whose scalability is beyond the reach of standard branch and bound methods. It either fully determines the globally optimal decision or, in the worst case, offers a vastly simplified input to standard solvers.

5 - A Risk Hedging Strategy for Wind Power Producers in U.S. Electricity Markets via Financial Risk Exchange

Hunyoung Shin, University of Texas at Austin, 10050 Great Hills Trail, Unit 1218, Austin, TX, 78759, United States, hunyoung@utexas.edu

Wind power producers (WPPs) participating in forward electricity markets are exposed to real-time (RT) market risks from uncertain generation outputs and RT market prices. To mitigate this joint volume-price risks, we propose a financial instrument referred to as a risk exchange (REX) that enables the WPPs to trade random net payments from uncertain RT prices and MW outputs, after the day-ahead (DA) market is cleared. A negotiation of the REX is analyzed by a bargaining game based on a conflict of interest in determining the REX amounts. Numerical examples show that the REX can reduce RT market risks successfully and encourages the WPPs to sell more energy to the DA market.

■ MD64

370E

Predictive Medicine on Electronic Health Record

Sponsored: Data Mining

Sponsored Session

Chair: Kazim Topuz, Oklahoma State University, ktopuz@okstate.edu

1 - Cleaning Challenges and Algorithms for Electronic Health Record Data

Zhuqi Miao, Health Data Analyst, Oklahoma State University, 345 Business Building, Stillwater, OK, 74078, United States, zhuqi.miao@okstate.edu, Shrieraam Sathyanarayanan, Elvena Fong, William Paiva

Rich health data created via electronic health record (EHR) systems is stimulating the rapid development of EHR-based health research. EHR data can be very "dirty," but there is little discussion in the literature regarding specific summaries and taxonomies of dirty EHR data and associated cleaning methods. By leveraging Cerner Health Facts, one of the nation's largest EHR data warehouses, we identified prominent data cleaning challenges and developed algorithms to address these issues. Given the considerable similarities among various EHR systems, it is expected that the findings and algorithms based on Health Facts can be extended to cleaning EHR data in general.

2 - Developing a Synthetic Informative Minority Over-sampling (SIMO) Algorithm Embedded in Support Vector Machines to Learn from Imbalanced Datasets

Saeed Piri, Oklahoma State University, School of Industrial Engineering & Management, Engineering North, Stillwater, OK, 74078, United States, saeed.piri@okstate.edu, Dursun Delen, Tieming Liu

A dataset is called imbalanced when the distribution of different classes in the data is not similar. While a standard machine learning technique could have a good performance on a balanced dataset, when applied to an imbalanced dataset its performance deteriorates dramatically. In this study, we propose a synthetic informative minority over-sampling (SIMO) algorithm imbedded into support vector machine (SVM). In this algorithm, minority examples close to the SVM decision boundary are over-sampled. We assessed SIMO in comparison to other existing algorithms by using 15 benchmark datasets and it outperformed all of them. We also applied SIMO to a real-word dataset to predict diabetic nephropathy.

3 - Predicting 30-day Hospital Readmissions of COPD: A Data Mining Approach to Study the Effects of COPD Drug Therapies

Andrea Blair, Graduate Research Assistant, Oklahoma State University - Center for Health Sciences, 1111 W. 17th Street, Tulsa, OK, 74107, United States, andrea.blair@okstate.edu, Shrieraam Sathyanarayanan

Chronic obstructive pulmonary disease (COPD) is a leading cause of 30-day readmissions. Using data extracted from Cerner Health Facts, we built logistic regression, decision tree, and neural network models to predict 30-day readmissions using comorbidities, demographics, and drug therapies. Inpatients with COPD, prescribed one of three common COPD drug therapies (Advair, Symbicort, and Spiriva) or combination of drugs were included in analysis. We used SMOTE (synthetic minority oversampling) to balance the data. Of 52 variables modeled, 28 emerged as important in predicting 30-day readmission for COPD. Decision tree model performed better than other models (AUC DT=0.67, NN=0.66, LR=0.62).

4 - A Decision Support System to Predict Mortality in Sepsis

Akash Gupta, Oklahoma State University, 40 South University Place, Stillwater, OK, 747075, United States, akashg@okstate.edu, Tieming Liu, Scott Shepherd, William Paiva

We developed a decision tree frame work to predict 28-day mortality among suspected infected patients (58,231 encounters extracted from Cerner's health fact data) using the vital signs and laboratory tests observed within 24 hours of the admission time. A survival ensemble approach was also used to predict the time to mortality. Our model discriminate (AUROC) non-survival from survival with a accuracy of 0.77 (95% CI = 0.75-0.79). We performed sensitivity analysis to identify the relevant predictors of sepsis mortality. Compare to SOFA, our model uses fewer variables and perform equally well.

5 - Surgery Scheduling under Uncertainty

Vikrant Vaze, Dartmouth College, 14 Engineering Drive, Murdough Center, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu, Kazim Topuz, William Paiva

Surgery scheduling should account for uncertainty in the duration of surgical procedures to minimize delays and maximize resource utilization. We develop a data-driven approach to inform the surgery scheduling optimization process under uncertainty

■ MD65

370F

Planning Logistics Systems under Uncertainty

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Michael Hewitt, mhewitt3@luc.edu

1 - Multimodal Capacity Planning with Uncertainty on Contract Fulfillment

Mariangela Rosano, PhD Student, Politecnico di Torino, Corso Duca degli Abruzzi 24, Turin, 10129, Italy, mariangela.rosano@polito.it, Guido Perboli, Guido Perboli, Teodor Gabriel Crainic, Teodor Gabriel Crainic

Contracting with carriers or third-party logistics firms is a way to secure transportation or warehousing capacity for the next planning period. However, contracts are concluded under uncertainty regarding the demand of loads to be transported, the availability of contracted capacity and of the extra one if needed. The question is how much to contract of each type of capacity to minimize the costs of the contract and of ad-hoc future actions to redress an unfavorable situation. We model this planning problem by extending the Stochastic Variable Cost and Size Bin Packing Problem. Extensive numerical experiments are conducted considering the case of an express courier in a City Logistics environment.

2 - A Learning-based Matheuristic for Stochastic Network Design

Teodor Gabriel Crainic, Université du Quebec à Montreal, School of Management, Department of Management & Technology, QC, H3C 3P8, Canada, TeodorGabriel.Crainic@cirrelt.net, Walter Rei, Fatemeh Sarayloo

We consider the two-stage stochastic programming formulation of the fixed charge multicommodity capacitated network design problem with uncertain demands. We aim to identify promising design decision variables, common to high-quality solutions. We propose a learning mechanism that systematically extracts such information when scenarios are gradually considered. This mechanism and the information it provides are the core elements of a variable-fixing-based matheuristic. Extensive computational experiment show the efficiently of proposed approach in obtaining high-quality solutions in reasonable computational times, particularly as the instance dimensions increase.

3 - Meso-parametric Value Function Approximation for Dynamic Customer Acceptance

Barrett Thomas, University of Iowa, W272 PBB, Iowa City, IA, 52242-1000, United States, barrett-thomas@uiowa.edu, Marlin W. Ulmer

We consider a problem in which a dispatcher decides whether to accept delivery requests given resource constraints and the possibility of additional future requests. To solve the problem, we present a novel method of approximate dynamic programming, the offline, meso-parametric value function approximation (VFA). This method combines parametric and non-parametric VFA to estimate future rewards. We compare the approach with the individual VFAs and online rollout algorithms. For a variety of instance settings, we show that the presented method combines the advantages and alleviates the shortcomings of parametric and non-parametric VFAs.

4 - Service Network Design at the Polish Post
Maciek A.Nowak, Loyola University Chicago, Department of Information Systems, Graduate School of Business, Chicago, IL, 60611, United States, mnowak4@luc.edu, Mike Hewitt, Bogumil Kaminski, Michal Pliszka

Solving the Service Network Design (SND) problem assists a freight transportation firm by prescribing the choice of paths for shipments and the services or resources necessary to execute them, while achieving the economic and service-quality targets of the carrier. This research presents an algorithm that applies SND to assist the Polish Post in developing a more efficient and effective network. The algorithm extends previous research in this area through the consideration of a heterogeneous vehicle fleet and driver pool, providing insight into the large scale, stochastic network operated by the largest employer in Poland.

■ MD66

371A

Resource Allocation in Port Operations I

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Xi Xiang, Tsinghua University, Hai Dian, Beijing, 100084, China, xiangx16@mails.tsinghua.edu.cn

1 - A Decomposition Approach for the Continuous Berth Allocation Problem
Ramez Kian, Istanbul Bilgi University, Department of Industrial Engineering,, Istanbul Bilgi University, Istanbul, Turkey, ramezk@bilkent.edu.tr

Berth allocation problems arise in the maritime logistics which address the schedule and the location of berthing for vessels in many container terminals. This class of problems is shown to be NP-hard in the literature and usually, are dealt with heuristics. In this work, I propose a decomposition approach to providing a relatively fast solution approach for the real moderate-sized problem instances. A numerical computation analysis is provided to compare the efficiency of the solution algorithms.

2 - Assignment and Scheduling of Disrupted Barges
Liliana Delgado Hidalgo, Doctoral Candidate, University of Arkansas and Universidad del Valle, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States, ld002@uark.edu, Heather Nachtmann, Chase Rainwater

We study the assignment and scheduling of disrupted barges to inland ports to minimize the value loss during inland waterway disruptions. Initially, we formulated our problem as a vehicle routing problem with time windows (VRPTW) and then reformulated the VRPTW via Dantzig-Wolfe decomposition method (DW), which yields better linear-relaxation bounds. The DW reformulation decomposes the problem into an upper level master problem and a lower level subproblem that is more tractable to solve. The subproblem corresponds to an elementary shortest path problem with resources constraints (ESPPRC). A case example is presented to illustrate a ESPPRC solution technique.

3 - Port Pilotage Discrete Event Simulation with GIS in Anylogic
Weihang Zhu, Associate Professor, Lamar University, PO Box 10032, Beaumont, TX, 77710, United States, weihang.zhu@lamar.edu, Mohammed Altayeb

Port pilotage is an important step in vessels arrival or departure process. For pilotage, a local pilot boards a vessel and navigates it through the water channels. This talk presents a simulation model on the process of vessel arrival, waiting for the pilot to be boarded, and navigating through waterway to certain docks for port operation. This model is created in AnyLogic with Geographical Information System (GIS) support and user interface. It helps the port management and decision making based on the simulation results.

4 - Pilot and Chemical Tanker Scheduling Problem in a Port
Berna Tokgoz, Assistant Professor, Lamar University 4400 MLK Blvd. P.O. Box 10009, Beaumont, TX, 77705, United States, btokgoz@lamar.edu, Burak Cankaya, Ezra Wari

Chemical tankers differ from many other types of vessels by carrying up to 30-40 different types of liquid loads to different terminals in a port. One of the constraints in port scheduling in canal type of ports is Pilot Scheduling. It is a sequence dependent pre-setup time. Another one of the parameters in scheduling chemical vessels is the tank-cleaning time after each operation. Which is the sequence-dependent post-setup times. The research problem setting in this study contributes to the job shop scheduling and transportation scheduling literature with an open-shop scheduling problem with sequence-dependent pre and post-setup times for vessels.

5 - A Bi-objective Robust Model for Berth Allocation Scheduling under Uncertainty
Xi Xiang, Dr., Tsinghua University, Tsinghua University,Hai Dian, Beijing, Beijing, 100084, China, xiangx16@mails.tsinghua.edu.cn

This paper examines a berth allocation problem with consideration of uncertainty factors, mainly including arrival and operation time of the calling vessels, and formulates a bi-objective robust berth model which focuses on economic performance and customer satisfaction. The model aims to optimize the robustness of berth allocation policy for the two objectives. An adaptive grey wolf optimizer algorithm is developed to solve the proposed model. Finally, the performance of the heuristic is evaluated by a large number of random generated instances and the experimental results show that the proposed heuristic has good solution quality and calculation efficiency.

■ MD67

371B

Design for Resilience in Emerging Complex Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Zhaojun Li, Western New England University, Springfield, MA, 01119, United States, zhaojun.li@wne.edu

Co-Chair: Tongdan Jin, Texas State University, San Marcos, TX, 78666, United States, tj17@txstate.edu

1 - A General Framework for Evaluating Supply Chain Resilience
Xi Chen, University of Michigan-Dearborn, 2290 Engineering Complex, 4901 Evergreen Rd, Dearborn, MI, 48128, United States, xichenxi@umich.edu, Zhimin Xi, Pengyuan Jing

As the complexity of supply chain structures and the frequency of their disruptions rise, businesses are increasingly recognizing the value of supply chain reliability and resilience (SCRR). A number of efforts have been devoted to define SCRR or to develop risk mitigation strategies for their improvement. However, a key question remaining to be answered is how SCRR should be quantified. This work aims to fill this gap by proposing a unified framework for evaluating SCRR that internalizes design inputs and is flexible to varying degrees of data availability.

2 - Enhancing Resilience of Distribution Grids via Intermittent Renewable Power
Tongdan Jin, Texas State University, 601 University Drive, Ingram School of Engineering, San Marcos, TX, 78666, United States, tj17@txstate.edu, Honggang Wang

Reliability and resilience are the key to designing and operating complex power systems. We propose to integrate distributed wind and solar power to achieve four objectives: (1) bidirectional power flow; (2) customized service reliability; (3) high resilience against extreme weather; and (4) (2) zero-carbon emissions. A 13-node distribution network is used to illustrate the conceptual idea and the preliminary findings are also discussed.

3 - Physical Unclonable Function Based Implementation and Application for Securing IoT Devices
Ruolin Zhou, Assistant Professor, Western New England University, 1215 Wilbraham Rd, Springfield, MA, 01119, United States, ruolin.zhou@wne.edu, Jed Briones, Yuan Liu, Zhaojun Li

To defend against threats of bitstream decoding and hijacking the system, we encrypt the bitstream to enhance the security of FPGA (Field Programmable Gate Array) based IoT (Internet of Things) devices. FPGAs can enable vastly growing IoT applications since they can interface with the outside world easily with low power, low latency, high determinism with re-programmable and re-configurable capabilities. A completely unique key for encryption through a physical unclonable function (PUF) is implemented on an IoT device. Such an implementation leverages the intrinsic physical characteristics of the FPGA in order to generate a secure, reliable, and unclonable encryption key.

■ MD68

371C

Data Analytics for System Improvement I

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Xiaochen Xian, UW-Madison, Madison, WI, 53705, United States, xxian@wisc.edu

Co-Chair: Kaibo Liu, UW-Madison, Madison, WI, 53706, UW-Madison, United States, jacoblkb@gmail.com

1 - Improving Food Assistance System Service by Considering Measurement Error

Haomiao Yang, University of Arizona, Tucson, AZ, United States, haomiaoyang@email.arizona.edu, Daoqin Tong, Jian Liu

Generalized linear regression models are usually used to model the service quality of food assistance systems. Conventional estimation methods are based on the assumption that the model covariates are free of errors. In this research, a new algorithm is proposed to explicitly consider two type of errors associated with regression covariates and improve model estimation accuracy. The case study shows the effectiveness.

2 - A Multimodality Factor Mixture Model with Hierarchically-structured Sparsity for Disease Subtype Discovery

Bing Si, Arizona State University, Tempe, AZ, 85287, United States, bingsi@asu.edu, Jing Li

Medical imaging technology has revolutionized health care and plays a pivotal role in Precision Medicine (PM). Disease subtype discovery paves the way toward PM by stratifying patients into subgroups with similar clinical characteristics, prognostics, or/and treatment response. To enable subtype discovery from multimodality imaging data, we propose a Multimodality Factor Mixture Model with a double-L21 penalty to achieve hierarchical selection of informative modalities and features and adopt an efficient Group-wise Majorization Descent algorithm for model estimation. Its performance is demonstrated by both simulation studies and a dataset collected by 2 U.S. medical institutions.

3 - Multifractal and Lacunarity Analysis of Image Profile from UW-Madison, **Ultra-precision Machining**

Farhad Imani, PhD Student, Pennsylvania State University, 233, Leonhard Building, 310 S.Barnard St, University Park, PA, 16802, United States, fxi1@psu.edu, Hui Yang

In this research, we developed a novel method of multifractal and lacunarity analysis which can capture the defects from the in-situ image of ultra-precision machining. Multifractal measures the variation in a layer of image and lacunarity measures heterogeneity to complement multifractal analysis and work together these statistical quantities can characterize patterns extracted from images and very precisely detect the existence of an underlying multiplicative process. The multifractal and lacunarity analysis have shown to have strong potential to be generally applicable as new process monitoring and control tool in a variety of domains such as bioengineering and nanoengineering.

4 - Online Monitoring Big Data Streams: A Rank-based UW-Madison, **Sampling Algorithm**

Xiaochen Xian, UW-Madison, 936 Eagle Heights Apt. C, Madison, WI, 53705, United States, xxian@wisc.edu, Kaibo Liu

With the rapid advancement of sensor technology, a huge amount of data is generated in modern engineering applications, which poses new and unique challenges for Statistical Process Control (SPC). In this paper, we propose an online sampling strategy to online monitor big data streams in the context of limited resources, where only partial observations are available at each acquisition time. Both simulations and case studies are conducted under different scenarios to illustrate and evaluate the performance of the proposed method.

■ MD69

371D

Optimizing Water Resources

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Alexandra M Newman, Colorado School of Mines, Golden, CO, 80401, United States, anewman@mines.edu

1 - Designing River Basin Storage using Optimization

Andy Burrow, MS, Colorado School of Mines, Golden, CO, 80401, United States, aburrow@mymail.mines.edu

The ways in which a growing population increases hydrologic demand are often evaluated using simulation models. This research uses data produced by the State of Colorado's Stream Simulation Model as input to an optimization model to determine the flow of unappropriated water so as to minimize the cost of water shortage mitigation while adhering to constraints that force the physical and topographical structures of the river. Solutions combine upstream pumping and new storage in existing reservoirs, as well as storage in new surface and subsurface reservoirs, and provide prescriptive, rather than descriptive, information.

2 - Coordinated Long-term Planning of Interdependent Energy and Water Systems

Shanshan Hou, University Of Arizona, 1670 N.Forgeus Avenue, Tucson, AZ, 85716, United States, shanshanh@email.arizona.edu, Neng Fan

Water is an important player for decisions in energy system, and energy network supply power for water distribution and extraction. These two infrastructure systems could be modeled as interdependent network. We consider both their operations, and planning period, which analyzes building the possible facilities, adding generators and transmission lines. As long-term planning and real-time operations have mutual and conflicting impacts in their decision making, we propose optimization model to simulate the coordinated system. The objective is to save money for planning and operations. We test the model in the example of IEEE 6-Bus and EPANet 1-Tank, as well as IEEE RTS-96 and EPANet 3-Tank.

3 - Data-Driven Distributionally Robust Water Allocation under Climate Uncertainty

Jangho Park, The Ohio State University, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, park.1814@osu.edu, David Love, Guzin Bayraksan

We apply data-driven distributionally robust stochastic optimization to a real-world water resources allocation model. We allocate Colorado River water to different users by considering possible extreme water shortages and construction of additional water treatment infrastructures until 2050. The system has two main uncertainties, future water demand, and supply. They are interconnected with other uncertain factors such as population growth and climate variability. We provide a statistical framework to predict the future uncertainties. Our data-driven decision provides a cost-benefit analysis for the government to make the long-term city plans and introduce new infrastructures.

4 - A Methodology to Assess the Energy-water Nexus in the UW-Madison, **United States**

Roshi Nategh, PhD, Purdue, West Lafayette, IN, United States, Rnateghi@purdue.edu

Despite the high level of interdependency in energy-water systems, they have been designed, managed and operated by separate entities, and researched independently. However, ensuring the reliability and resiliency of both resources commands knowledge of their interconnectedness. While many research endeavors have focused on addressing the energy-water nexus on the supply side, there is a scant body of knowledge on energy-water demand. In this talk, we present a multivariate, nonparametric technique - leveraging data from various publicly available sources such as the EIA, USGS and US Census - to assess the energy-water nexus in the U.S.

■ MD70

371E

Data Mining

Contributed Session

Chair: Jilei Zhou, Guanghua School of Management, Peking University, Beijing, China, 1501110963@pku.edu.cn

1 - Sustainable Transportation Planning

Mohammad Ali Asudegi, UTK, 525 John D. Tickle Building, 851 Neyland Drive, Knoxville, TN, 37996-2315, United States, masudegi@vols.utk.edu, Rapinder Sawhney

A new perspective of sustainable transportation planning is introduced to help with expanding acceptance of green transportation solutions.

2 - Mining Consumer Shopping Patterns with Mobility and Social Network Data

Sharon Xu, Massachusetts Institute of Technology, UW-Madison, 235 Albany Street, #3023A, Cambridge, MA, 02139, United States, sharon_x@mit.edu, Marta C.Gonzalez

The majority of work in matrix factorization has focused on factorizing a single matrix, making it difficult to exploit the numerous data sources often available. In this talk, we present a collective factorization approach to predict shopping behavior through the addition of consumer mobility and network data. We model how shopping preferences change temporally, jointly factorizing the monthly user-purchase matrix (UVT), user-location matrix (UWT) and social network (UZT) with a shared user latent feature space U. Through this approach, we improve upon single matrix factorization while connecting multiple perspectives of user factors to better understand consumer lifestyles.

3 - Employee or Contractor: A Study of Courts' Misclassification Decisions

Mohammad Javad Feizollahi, Assistant Professor, UW-Madison, Georgia State University, Atlanta, GA, 30303, United States, mfeizollahi@gsu.edu, Charlotte Alexander

In this research, we study federal district court decisions in worker misclassification cases, 2008-2016. Independent contractors lack the benefits and protections available to employees. They may file suit, seeking "employee" classification, but the law poorly defines the two categories. Moreover, judges' classification opinions have never been studied systematically. We use text mining and analytical tools to understand how courts distinguish between employees and independent contractors and the factors that influence their decisions.

4 - Margin-based Pattern Selection for Support Vector Machines

Dongil Kim, Korea Institute of Industrial Technology, 89 Yangdaegiro-gil, Ipjang-myeon, Seobuk-gu, Cheonan, Korea, Republic of, dikim01@kitech.re.kr, Seokho Kang, Sungzoon Cho

Support Vector Machines (SVM) is a widely used training algorithm in data mining and machine learning. However, as the size of the dataset increases, the training complexity of the SVM has become a limit to apply SVM to real applications. In this paper, we propose a margin-based pattern selection method for SVM. Margin of each training pattern is estimated from multiple SVMs trained with smaller sample sets. Based on the estimated margin, the proposed method selects patterns that are likely to be support vectors. Experiments conducted on various datasets show that the proposed method has good generalization performance.

5 - Data Mining for Individual Consumer Credit Default Prediction under E-commence Context: A Comparative Study

Jilei Zhou, Guanghua School of Management, Peking University, No.5 Yiheyuan Road Haidian District, Beijing, 100871, China, 1501110963@pku.edu.cn

This paper explored the relative effectiveness of alternative classifiers (decision tree, logistic regression, random forests and extreme gradient boosting) to estimate how likely an applicant is to default in individual consumer credit services offered by e-commerce platform. Specifically, our work contributes to the following research questions: (i) What kind of features should be introduced in the new context of e-commence? Which features plays important roles in credit scoring model? (ii) How to tuning classification algorithms to avoid model inefficiency? (iii) Do ensemble classifiers real improve classification ability? Data used came from an financial services platform in China.

■ MD71

371F

Mixed-Integer Polynomial Optimization

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Akshay Gupte, Clemson University, Clemson, SC, 29634-0975, United States, agupte@clemson.edu

1 - Outer-product-free Sets for Polynomial Optimization and Oracle-based Cuts

Chen Chen, Columbia University, chen.chen@columbia.edu, Daniel Bienstock, Gonzalo Munoz

We consider valid inequalities for the intersection of a closed set S with a polyhedron P. Given an oracle providing the distance to S we propose a pure cutting plane algorithm; if the initial relaxation is a polytope, the algorithm converges. Cuts are generated from convex forbidden zones, or S-free sets derived from the oracle. A special case is polynomial optimization represented with a symmetric matrix of decision variables. In this lifted representation we let S be the set of real, symmetric outer products, and accordingly develop a theory of outer-product-free sets. We identify two families of maximal outer-product-free sets; associated intersection cuts can be generated in polynomial time.

2 - On Branching-point Selection for Triple Products in Spatial Branch-and-bound: the Hull Relaxation

Emily Speakman, University of Michigan, 2222 Fuller Court, Apt 702A, Ann Arbor, MI, 48105, United States, eespeakm@umich.edu, Jon Lee

Having three or more expressions multiplied together occurs frequently in factorable global-optimization models. For these triple products, we present some analytic results regarding the choice of branching variable and branching point in the context of sBB for factorable formulations. Following the approach we previously introduced to compare various common relaxations associated with trilinear monomials, we use 4-dimensional volume as a comparison measure to evaluate the sBB choice of branching variable and branching point in this context. For branching-point selection, we also compare our results to common practice in software.

3 - Computational Approaches to Mixed Integer Second Order Cone Optimization

Aykut Bulut, Lehigh University, Bethlehem, PA, United States, aykut@lehigh.edu, Ted Ralphs

We introduce a framework for solving Mixed Integer Second Order Cone optimization Problems (MISOCP). We present solver DisCO implemented within COIN-OR's CHiPPS framework. DisCO is a flexible library that implements different algorithms to solve MISOCP.

4 - Cutting Plane Techniques via Decision Diagrams

Danial Davarnia, Carnegie Mellon University, ddavarni@andrew.cmu.edu, Willem-Jan Van Hoeve

We develop cutting plane techniques for certain classes of discrete problems based on their decision diagram formulation. For linear IPs, these cutting planes provide a natural generalization of Gomory and intersection cuts. For convex IPs, they dominate the linearized cuts used in the outer approximation schemes. These cutting planes can also be derived for nonconvex IPs which allows for an adaptation of outer approximation algorithms. Computational experiments show significant gap improvement upon the traditional cutting plane methods.

■ MD72

372A

Networks and Supply Chains

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Anna B Nagurney, University of Massachusetts-Amherst, University of Massachusetts-Amherst, Amherst, MA, 01003, United States, nagurney@isenberg.umass.edu

1 - A Closed-loop Supply Chain Equilibrium Model with Random and Price-sensitive Demand and Return

Qiang Qiang, Penn State, Management Division, 30 E Swedesford Rd, Malvern, PA, 19355, United States, qzq10@psu.edu, Younes Hamdouch

This paper proposes a decentralized closed-loop supply chain network model consisting of raw material suppliers, manufacturers, retailers, and recovery centers. The demands for the product and the corresponding returns are random and price-sensitive. Retailers and recovery centers face penalties associated with shortage demand and supply, respectively.The optimality conditions of the various decision-makers are derived. The governing equilibrium conditions can be formulated as a finite-dimensional variational inequality problem. The qualitative properties of the solution to the variational inequality are discussed. Numerical examples are provided for illustration purpose.

2 - Supply Chain Network Capacity Competition with Outsourcing: A Variational Equilibrium Framework

Deniz Besik, Master's, Isenberg School of Management, University of Massachusetts Amherst, Amherst, MA, 01003, United States, dbesik@som.umass.edu, Anna Nagurney, Min Yu

This paper develops a supply chain network game theory framework with multiple manufacturers/producers, with multiple manufacturing plants, who own distribution centers, which are distinguished by brands, to demand markets, while maximizing profits and competing noncooperatively. The manufacturers avail themselves of external distribution centers for storing their products and freight service provision. We impose capacities on the links. We utilize a special case of the Generalized Nash Equilibrium problem, known as a variational equilibrium. A case study on apple farmers in Massachusetts is provided to illustrate the potential benefits of outsourcing in this sector.

3 - Mergers and Acquisitions in Blood Banking Systems: A Supply Chain Network Approach

Amir H. Masoumi, Assistant Professor of Management, Manhattan College, School of Business, De La Salle Hall 508, Riverdale, NY, 10471, United States, amir.masoumi@manhattan.edu, Min Yu, Anna B.Nagurney

We develop a methodological framework for the assessment of total cost efficiency (synergy) associated with a merger or acquisition in the blood banking industry, which is experiencing a volatile environment. The network optimization pre- and post-merger models handle perishability of the life-saving product of blood, include both operational and discarding costs of waste, capture the uncertainty associated with the demand points, as well as the expected total blood supply shortage cost and the total discarding cost at demand points. The models incorporate capacities on the links and their solution yields the optimal link flows plus frequencies of activities throughout the blood supply chain.

4 - Consumer Learning of Product Quality with Time Delay: Insights from Spatial Price Equilibrium Models with Differentiated Products

Dong Li, Arkansas State University Jonesboro-College of Business, P.O. Box 59, State University, AR, 72467, United States, dli@astate.edu, Anna B. Nagurney, Min Yu

We present spatial price equilibrium network models with differentiated products under perfect quality information for producers and consumers and under quality information asymmetry with consumer learning of product quality with a time delay. In addition, we provide measures of consumer welfare under perfect quality information and under information asymmetry as well as the value of perfect quality information for consumers. The models are especially relevant to agricultural products where spatial price equilibrium models have found wide application. We also present several numerical examples with insights provided.

■ MD73

372B

Underground Mine Planning

Sponsored: Energy, Natural Res & the Environment, Natural Resources Mining

Sponsored Session

Chair: Alexandra M Newman, Colorado School of Mines, Golden, CO, 80401, United States, anewman@mines.edu

1 - Optimally Locating Support Pillars in an Underground Mine

Levente Sipeki, 8805 W. Geddes Pl, Littleton, CO, 80128, United States, levente.sipeki@gmail.com, Alexandra M.Newman, Candace Arai Yano

In underground mining, specifically, in top-down, open-stope retreat operations, blocks are designated as pillars (and left in situ) or stopes (and extracted and processed) so as to maximize profit. Safety is ensured by abiding by geotechnicalrestrictions on (i) the hydraulic radius of a stope, (ii) the length-to-width ratio of a pillar, (iii) the ratio between adjacent pillar and stope lengths, and (iv) the proximity between veins. We present a methodology consisting of (i) preprocessing, (ii) solving an optimization model,and (iii) employing a heuristic to determine structurally stable pillars locations.

2 - Production Scheduling in Underground Mining Operations Incorporating Heat Loads

Oluwaseun Babatunde Ogunmodede, MS, Colorado School of Mines, Golden, CO, 80401, United States, setotravel@gmail.com, Andrea Brickey, Levente Sipeki, Gregory Bogin, Alexandra M. Newman

A problem in the mining industry is production scheduling, or determining when, if ever, notional three-dimensional blocks of ore should be mined. Often lacking in underground production scheduling models are heat limitations, driven largely by the equipment used for underground activities such as development, extraction, and backfilling. To correct this, we attribute a specific heat load to each mining activity owing to equipment use, auto compression, broken rock and strata rock. We incorporate heat into a knapsack constraint in an integer programming model that produces more realistic schedules; adhering to them could increase revenue by lowering refrigeration costs for the mine.

3 - Production and Construction Optimization in Underground Mining

Nelson Morales, DIMIN.& AMTC, Av Tupper 2069, Santiago, Chile, nmorales@ing.uchile.cl

The planning and design of underground mines is a very complex task that requires to balance multiple considerations like economical value and geotechnical constraints in order to generate an extraction and a construction plan. Due to this complexity, the problem is solved in different stages and scopes, which lead to suboptimal solutions or even infeasibilities. In this work we present a MIP model which aims to optimize mine plans in underground mines. We show how this model can then be coupled with other models in order to generate more comprehensive plans that integrate aspects like geomechanics or operational uncertainty.

4 - Optimizing the Cutoff Grade at an Underground Mine

Alexandra Newman, Colorado School of Mines, Golden, CO, 80401, United States, anewman@mines.edu, Barry kING

An important strategic decision for any operational mine is the differentiation between ore and waste material, referred to as the cutoff grade. Our mixed-integer programming optimization framework determines the cutoff grades in three different, predetermined zones for a soon-to-be-operational underground mine by exploiting an underlying mathematical structure; current industry practice would produce solutions with lower net present value, would require six to eight weeks, and would preclude scenario analysis.

■ MD74

372C

Multistage Optimization Models and Applications

Sponsored: Computing

Sponsored Session

Chair: Jorge A Sefair, Arizona State Univerity, Tempe, AZ, 85287-8809, United States, jorge.sefair@asu.edu

1 - Supervalid Inequalities for Network Interdiction Problems

Ningji Wei, 4303, Chestnut Ridge Rd., Buffalo, NY, 14228, United States, ningjiwe@buffalo.edu, Jose Luis Walteros

We focus on attacker-defender network interdiction problems in which: 1) the objective minimizes the attacker's cost of achieving a fixed disruption level over the defender's problem; 2) the defender's problem is to select an optimal graph structure (e.g., a shortest path, a spanning tree) over the residual graph; 3) the attacker strategies are defined over the same ground set of the graph structures. e.g., if the structures are defined over the edges, the attacker also interdicts edges. We develop a cut-generating framework that produces a general class of supervalid inequalities that remove non-trivial suboptimal solutions. We show how to addapt our framwework to tackle a wide variety of problems.

2 - On the Impact of Decentralization in Interdependent Network Restoration Scheduling

Thomas Sharkey, sharkt@rpi.edu, Hongtan Sun

We consider the problem of restoring disrupted services across multiple interdependent networks after extreme events. We consider integer programming approaches to determine the equilibrium (stable) solutions for this decentralized scheduling system. These approaches help to calculate the price of anarchy and the price of stability as well as allocate incentives to improve the loss from the centralized objective.

3 - Bi-level Optimization Model for Assortment Planning under Worst-case Customer Order of Preferences

Saharnaz Mehrani, Arizona State University, 1500 E Broadway Road, Apt B2128, Tempe, AZ, 85282, United States, smehrani@asu.edu, Jorge A.Sefair

One of the main challenges in assortment planning is to capture the customer choice behavior for substitutable products. We model customer behavior using a general ranking-based choice approach with a modified multinomial logit model to incorporate the effect of product unavailability on customer decisions. We present a bi-level optimization approach to maximize the expected revenue and protect it against the worst possible customer preferences. Our solution approach includes a single-level reformulation, which we tighten using problem-specific properties, and then solve using a cutting plane algorithm.

4 - Robust Location of Transparent Interdictions on a Shortest Path Network

Nail Orkun Baycik, Rensselaer Polytechnic Institute, Troy, NY, United States, baycin@rpi.edu, Kelly Sullivan

We study a shortest path network interdiction problem in which the follower seeks to find a path of minimum length on a network and the leader seeks to maximize the follower's path length by interdicting arcs. We consider placement of interdictions that are not visible to the follower; however, we seek to locate interdictions in a manner that is robust against the possibility that some information about the interdictions becomes known to the follower. We formulate the problem as a bi-level program, and apply a Benders decomposition approach to optimally solve it. We derive supervalid inequalities to improve the performance of the algorithm and test the algorithm on randomly generated grid networks.

■ MD75

372D

Methods for Large-scale Convex Optimization

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Paul Grigas, pgrigas@berkeley.edu

1 - Variants of the ADMM for Block Optimization

Xiang Gao, University of Minnesota, 609 Oak Street, Apt 1-11, Minneapolis, MN, 55403, United States, gaoxx460@umn.edu

In this talk we present a suite of first-order algorithms which can be characterized as variants of the ADMM. In terms of the informational structure, we propose several ADMM-type methods that are applicable on a much broader class of problems where only noisy estimations of the gradient or the function values are accessible. For problems involve multi-block and non-separable objective with linear constraint, both deterministic and randomized ADMM variants are introduced. Under different conditions, sublinear convergence rates of all the aforementioned variants will be presented.

2 - Globally Convergent Algorithms for Two Layer Neural Network Problems

Digvijay Boob, Georgia Institute of Technology, digvijaybb40@gatech.edu, Guanghui Lan

Neural network can be trained with stochastic gradient descent to achieve good performance in many applications. Central problem in their training involves optimizing a nonconvex loss function whose theoretical analysis is hard. In this work, we give an algorithm to converge to global optimal solution with high probability under some assumptions about activation functions, distribution of the data and width of neural network.

3 - A Convex Gradient-based Approach for Profit Optimization in Online Advertising Demand-side Platforms

Paul Grigas, UC Berkeley, 4177 Etcheverry Hall, University of California, Berkeley, CA, 94720-1777, United States, pgrigas@berkeley.edu, Alfonso Lobos, Zheng Wen, Kuang-chih Lee

We develop an optimization model for the management of a demand-side platform (DSP), whereby the DSP aims to maximize its own profit while acquiring valuable impressions for its advertiser clients in a real-time bidding environment. We use convex relaxation to develop a tractable convex dual problem, which, due to the properties of second-price auctions, may be solved efficiently with non-smooth stochastic gradient methods. We propose a two-phase solution procedure and demonstrate evidence of strong performance guarantees.

4 - Approximation Algorithms for Bilevel Programming

Saeed Ghadimi, Princeton University, Princeton, NJ, United States, sghadimi@princeton.edu, Mengdi Wang

In this talk, we consider the classical setting for bilevel programming where the objective function of the outer problem depends on the optimal solution of inner one. We present gradient type algorithms for solving this class of problems and obtain an optimal iteration complexity for the outer problem and (nearly) optimal one for the inner problem. We also discuss convergence of stochastic approximation algorithms for solving this class of problems under stochastic setting.

■ MD76

372E

Integrated Methods and Decomposition Approaches

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Joris Kinable, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, jkinable@cs.cmu.edu

1 - Discrete Nonlinear Optimization by State-Space Decomposition

David Bergman, McKinsey & Company, 4106 Stearns HIll Road, Waltham, MA, 02451, United States, david.bergman@business.uconn.edu

In recent years the use of decision diagrams for discrete optimization has grown in popularity, with a focus on linear integer optimization. In this talk, an expansion to nonlinear objective functions will be discussed. The work proposes the use of decision diagrams to model the objective function, which are then linked together through a network flow linearization. Experimental results on problems arising in revenue management, portfolio optimization, and healthcare exhibit orders-of-magnitude improvement in solution times compared with state-of-the-art nonlinear solvers.

2 - Dynamic Programming Bounds from Decision Diagrams

John Hooker, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, 15213, United States, jh38@andrew.cmu.edu

We investigate the potential of relaxed decision diagrams to provide bounds on the optimal value of dynamic programming formulations. We prove general conditions under which a node merger operation in the diagram yields a valid relaxation. We then focus on job sequencing problems with state-dependent processing times, because no useful bounding mechanism currently exists for these problems. Computational experiments show that, surprisingly, relaxed diagrams prove the optimal value when their size is only a small fraction of the size of an exact diagram.

3 - Integer and Constraint Programming for Batch Annealing Process Planning

Willem-Jan Van Hoeve, Carnegie Mellon University, Tepper School of Business, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, vanhoeve@andrew.cmu.edu, Sridhar R.Tayur

We describe an optimization application in the context of steel manufacturing, to design and schedule batches for annealing furnaces. Our solution approach uses a two-phase decomposition. The first phase groups together orders into batches using a mixed-integer linear programming model. The second phase assigns the batches to furnaces and schedules them over time, using constraint programming. Our solution has been developed for operational use in two plants of a steel manufacturer in North America.

4 - A Unified Decomposition Matheuristic for Assembly, Production and Inventory Routing

Jean-Francois Cordeau, HEC Montreal, 3000 Cote-Sainte-Catherine, Montreal, QC, H3T.2A7, Canada, jean-francois.cordeau@hec.ca, Masoud Chitsaz, Raf Jans

We introduce a decomposition-based heuristic for the assembly-routing problem and two related problems: the production-routing problem (PRP) and the inventory-routing problem (IRP). The heuristic relies on the iterative solution of different subproblems. The first phase determines a setup schedule while the second phase optimizes production quantities, supplier visit schedules and shipment quantities. The third phase solves a vehicle routing problem for each period in the planning horizon. Using the same parameter setting for all problems and instances, we obtained 818 new best known solutions out of 2,628 standard IRP and PRP test instances.

5 - Vehicle Routing Problems with Synchronized Visits and Stochastic Travel or Service Times: Applications in Healthcare

Louis-Martin Rousseau, Polythechnique Montreal, Cp 6079 Succ Centre-Ville, Montreal, QC, H3C 3A7, Canada, louis-martin.rousseau@polymtl.ca, Seyed Hossein Hashemi Doulabi, Gilles Pesant

We study the vehicle routing problems with synchronized visits (VRPS) where travel and service times are stochastic or time-dependent. We formulate VRPS as a two-stage stochastic programming model with integer variables in both stages. An advantage of the proposed model is that it does not have any big-M constraints. We consider applications in home-health care scheduling problem, as well as operating room scheduling with stochastic durations. We prove that the integrality constraints on second-stage variables are trivial, and therefore we can apply the L-shaped algorithm and its branch-and-cut implementation to solve the problem.

■ MD77

372F

Joint session OPT/Practice: Applications of Conic Optimization for Energy Systems

Sponsored: Optimization, Linear and Conic Optimization

Sponsored Session

Chair: Ramtin Madani, The University of Texas at Arlington, Arlington, TX, 76015, United States, ramtin.madani@uta.edu

1 - Polynomial Optimization, Interpolation, and its Application to Power Systems

Cédric Josz, ERC Postdoctoral Fellow, Laboratory for Analysis and Architecture of Systems LAAS.CNRS, 7 Avenue du Colonel Roche, Toulouse, 31400, France, cedric.josz@gmail.com

Polynomial optimization in complex numbers is used to model oscillatory phenomena in various applications such as electric power systems, imaging science, signal processing, and quantum mechanics. We propose a hierarchy of complex semidefinite programs as well as a semidefinite programming solver in complex numbers to find global solutions with reduced computational burden. We apply these to large-scale sections of the European HV electricity grid. We also propose an algorithm for extracting global solutions once optimality has been reached, and show that it provides a variant to Prony's method, which is used for instance to determine inter-area oscillations from phasor measurement units.

2 - Power System State Estimation Problem: Optimal Sensor Placement

Salar Fattahi, PhD Candidate, University of California-Berkeley, Berkeley, CA, United States, fattahi@berkeley.edu, Javad Lavaei

This talk is concerned with the power system state estimation (PSSE) problem. Given a set of noisy measurements, PSSE aims at estimating the complex voltages at all buses of the network. Recently, we have shown that a conic optimization problem could effectively estimate the state of the system. In this talk, we use the notion of weighted algebraic connectivity to devise a sparsity-promoting technique that would determine where to place the sensors so that the estimation error associated with the conic formulation of PSSE is minimized.

3 - A Massively Scalable Approach to Power System Scheduling

Ramtin Madani, Assistant Professor, The University of Texas at Arlington, 3004 Franciscan Dr, Apt 1835, Arlington, TX, 76015, United States, ramtin.madani@uta.edu, Alper Atamturk, Ali Davoudi

A computational method is introduced, which is capable of approaching power system scheduling problems with a considerably large number of binary variables, while handling nonlinear equations that govern the flow of electricity. We design a family of linear and conic inequalities to form a polynomial-time solvable surrogate, with the aim of finding a near globally optimal point for the original problem. The proposed method is demonstrated on large-scale problems based on real-world European grid data, for which feasible decisions are obtained within provably small gaps from global optimality.

4 - On the Identification of Optimal Partition for Second Order Cone Optimization

Tamás Terlaky, Lehigh University, 200 W. Packer Ave, Bethlehem, PA, 18015, United States, terlaky@lehigh.edu, Ali Mohammad-Nezhad

The concept of optimal partition was originally introduced for LO and LCP and subsequently extended to SDO. Terlaky and Wang specialized the concept for SOCO. In this paper, we present a fast iterative procedure, which uses the optimal partition information to generate a pair of maximally complementary optimal solutions. We are interested in the local convergence of the iterative procedure near the optimal set. In this regard, we show that, under the primal and dual nondegeneracy conditions, the iterative procedure is quadratically convergent to a maximally complementary optimal solution when starting from a strictly interior pair of solutions close to the optimal set.

■ MD78

381A

Electricity Markets

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Todd Levin, Argonne National Laboratory, 9700 S. Cass Ave, Bldg 202, Lemont, IL, 60439, United States, tlevin@anl.gov

1 - A Multistage Stochastic Dynamic Programme for Major Consumers' Demand Response in Electricity Markets

Mahbubeh Habibian, University of Auckland, 439-325, 70 Symonds, Auckland, 1010, New Zealand, mhab735@aucklanduni.ac.nz, Golbon Zakeri, Anthony Downward

We optimize the bidding policy for a major consumer of energy in an energy and reserve co-optimized electricity market. In our model, the major consumer has dispatchable demand, and it is able to offer interruptible load reserve. The large consumer is a strategic player, maximizing its profit, while meeting its required level of consumption over a long-time horizon. By reformulating the equilibrium constraints, we present a multi-stage stochastic dynamic programming. In order to solve our mixed integer program in an adequate time-frame we use heuristics while utilizing the intuition of stochastic dual dynamic programming.

2 - Demand Response to Electricity Prices in Flexible Manufacturing

Kazem Abbaszadeh, The University of Auckland, Room F, level 1,11 Mount St, Auckland, 1010, New Zealand, kabb955@aucklanduni.ac.nz, Golbon Zakeri, Geoffrey Pritchard

Large manufacturers are often also large users of electricity. This includes Aluminium and Steel manufacturers as well as paper and dairy processing plants in New Zealand. We consider a major consumer of electricity whose decision to contract for production could depend on electricity prices. We describe our stochastic dynamic programming approach for a steel mill in New Zealand with some flexibility in their operations, and utilize this flexibility to provide an optimal production plan. As a part of this model, we need to develop electricity price models over the short and medium time horizon. We will describe these models as well.

3 - Key Drivers of Prices for Ancillary Services

Todd Levin, Energy Systems Engineer, Argonne National Laboratory, 9700 S. Cass Ave, Bldg 362, Lemont, IL, 60439, United States, tlevin@anl.gov

We apply AURORAxmp, a commercial power systems model, to forecast how prices for ancillary services (AS) in PJM are affected under various future scenarios. We find that doubling the natural gas price increases the average frequency regulation price by 41% and decreases the average price for synchronized and primary reserves by 75% and 23% respectively. Increasing wind generation capacity by a factor of 15 decreases average AS prices by 8%, 25% and 90% for regulation, synchronized and primary reserves. Several additional sensitivities including increased AS requirements, unit retirements and natural gas supply constraints are also considered and revenue sufficiency implications are discussed.

■ MD78B

380B

CS and OR Interface

Contributed Session

Chair: Hesam Shams, University of Tennessee, Knoxville, TN, United States, hesam@utk.edu

1 - Bias in Balance Optimization Subset Selection

Hee Youn Kwon, PhD Student, University of Illinois at Urbana-Champaign, 104 S.Mathews Avenue, Transportation Building, Urbana, IL, 61801, United States, hkwon14@illinois.edu, Jason Sauppe, Sheldon H. Jacobson

When estimating a treatment effect from observational data, researchers encounter bias regardless of estimation methods. By focusing on a particular method of estimation called Balance Optimization Subset Selection (BOSS), we investigate all the possible cases that may lead to bias in the context of BOSS and try to mitigate the bias. While doing so, we define a balance hierarchy and a correct imbalance measure which corresponds to a functional form of the responses.

2 - Service Placement Optimization in Mobile Edge Computing

Hossein Badri, Graduate Teaching Assistant, Wayne State University, 4185 4th Street, Manufacturing Building, Detroit, MI, 48202, United States, fq2529@wayne.edu, Kai Yang

Service placement is a very important and at the same time a super complex problem in Mobile Edge Computing (MEC). Dynamisms of users' location and uncertainties in their demands are the main source of complexity in this problem. In this research, we develop a stochastic programming model for the service problem in MEC and conduct an extensive computational analysis to evaluate the performance of the proposed approach.

3 - Two-stage Stochastic Mathematical Model for Inventory Management of Red Blood Cells Accounting for Age-differentiated Demand

Bayan Hamdan, Masdar Institute, Abu Dhabi, United Arab Emirates, bhamdan@masdar.ac.ae, Ali Diabat

Blood Supply Chain inventory management has recently become one of the most important fields in operations research due to the perishability of blood. This paper forms a mathematical model that determines an optimal inventory ordering policy for red blood cells (RBCs). The model accounts for the perishability of the red blood cells and the age-differentiation and stochasticity of the demand. This paper proposes an (R,S) inventory policy where R is the review frequency and S is the target level, to minimize system outdate, shortage, substitution and holding costs.

4 - Surrogate Modeling Recommendations

Reza Alizadeh, Graduate Research Assistant, University of Oklahoma, Norman, OK, 73019, United States, reza.alizadeh-2@ou.edu, Janet K. Allen, Farrokh Mistree

Models describing engineering systems are often simplified, thus creating uncertainty. Surrogate models with their reduced computational costs allow us to manage uncertainty by substantially reducing computational expense. Much has been done to compare different methods; however, there is a gap in providing guidance for the choice of appropriate surrogate modeling methods. We ask these questions: 1) What are the critical characteristics of a model to be approximated? 2) What are desirable characteristics of the DOE, surrogate model and model fitting methods to achieve useful surrogate models? Answering these questions leads to a toolbox to choose appropriate surrogate modeling methods.

5 - Enhancing Optimization Algorithm via Machine Learning

Hesam Shams, University of Tennessee, 851 Neyland Drive, 525 John D. Tickle Engineering Building, Knoxville, TN, 37996, United States, hesam@utk.edu, Oleg Shylo

We explore an application of classification techniques to binary optimization. Given a set of solutions and the corresponding objective values, the goal is to classify each solution component either as zero or one. We implement statistical models based on random forests, convolutional neural networks, and logistic regression and compare their performance on a set of scheduling problems. A learning module based on an efficient logistic regression model is embedded into the tabu search method. The comparison with standard tabu algorithm implementations reveals significant gains in efficiency.

■ MD79

381B

Computational Challenges in RTO Markets

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Yonghong Chen, Midwest ISO, Carmel, IN, 46032, United States, ychen@misoenergy.org

1 - Computational Challenges in RTO Markets

Yonghong Chen, Midwest ISO, 720 City Center Drive, Carmel, IN, 46032, United States, ychen@misoenergy.org

Optimization techniques and algorithms are at the core of electricity market operations with the goal of minimizing system operation cost while ensuring system security. The industry evolution has posed unprecedented challenges to the existing optimization and computation techniques. This panel will discuss the latest advances in formulating optimization problems and developing new algorithm and solution techniques. It includes the development of tighter Mixed Integer Programming (MIP) models and exploration of novel algorithms in solving MIP problems on traditional hardware as well as with distributed and high performance computers.

2 - Tight Formulation and Pricing in Day-ahead Electricity Markets
Bowen Hua, University of Texas at Austin, Austin, TX, United States, bhua@utexas.edu

3 - Combined Cycle Units Modeling and Computational Performance in MISO Day-ahead Market
Fengyu Wang, Midcontinent Independent System Operator, 429 Thornberry Dr., Carmel, IN, 46032, United States, fwang@misoenergy.org

4 - Coordination Schemes for the Integration of Transmission and Distribution System Operations
Anthony Papavasiliou, Université Catholique de Louvain, Center for Operations Research and Econometri, Voie du Roman Pays 34, Louvain la Neuve, 1348, Belgium, anthony.papavasiliou@uclouvain.be

5 - Hippo - Solving Security Constrained Unit Commitment Problem
Feng Pan, Pacific Northwest National Laboratory, 1100 Dexter Ave N, BSRC-379, Seattle, WA, 98109, United States, feng.pan@pnnl.gov

6 - Panelist
Robert E. Bixby, Gurobi Optimization, Inc., 3733-1 Westheimer Road, Box 1001, Houston, TX, 77027, United States, bixby@gurobi.com

■ MD80

381C

Evolution of the Power Grid

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Erin Baker, Univerxity of Massachusetts-Amherst, Amherst, MA, 01003, United States, edbaker@ecs.umass.edu

Co-Chair: Destenie Nock, destenienock5@gmail.com

1 - Long Term Generation and Transmission Co-optimization: Infrastructure Planning to Accommodate Renewables
Patrick Maloney, Iowa State University, 2405 Aspen Road, # 210, Ames, IA, 50010, United States, patrickm@iastate.edu, Ping Liu, James McCalley

This work investigates deterministic and stochastic long term planning models for the Pacific Northwest using a 300 bus reduced model of a WECC TEPPC dataset. NREL toolkit profiles and resource capacities are used to model realistic wind and PV candidate generation. To compete remote renewable resources against traditional generation near load centers, the model co-optimizes generation and transmission. A major thrust of the tools developed for this work is to enable energy decision makers to explore the decisions that allow them to adapt systems to the future; especially in response to increasing interest in and competiveness from renewable technologies.

2 - Pricing Wind: A Revenue Adequate, Cost Recovering Market Clearing Mechanism to Facilitate Volatile Renewables
Golbon Zakeri, University of Auckland, Dept of Eng Science, Private Bag 92019, Auckland, New Zealand, g.zakeri@auckland.ac.nz, Geoffrey Pritchard, Endre Bjorndal, Mette Bjorndal

With the increasing penetration of volatile renewable energy into the power grid, it is imperative to ensure sufficient, economical regulation is available to compensate for any excess or short fall of electricity generated from renewables. To this end, we have developed a stochastic programming market mechanism that is an improved version of Pritchard et al's 2010 model. In this talk we will discuss the properties of our model, that include revenue adequacy in each scenario and expected cost recovery. We have implemented our model on the New Zealand system. Will provide the numerical results that we have obtained thus far.

3 - Effects of Grid-scale Electricity Storage on System Carbon Dioxide Emissions as a Power System Decarbonizes
Michael Craig, Carnegie Mellon University, Pittsburgh, PA, United States, mtcraig@andrew.cmu.edu, Paulina Jaramillo, Bri-Mathias Hodge

While grid-scale electricity storage may be crucial for decarbonizing the electric power system, studies find it would currently increase net carbon dioxide (CO_2) emissions across the U.S. We quantify the effect of storage participating in reserve and/or energy markets on net CO_2 emissions as a power system decarbonizes. To do so, we use two optimization models: a capacity expansion model to forecast generator fleet changes and a unit commitment model to quantify net CO_2 emissions with and without storage. We preliminarily find that storage reduces net CO_2 emissions well before full decarbonization and that storage affects net CO_2 emissions more when participating in reserve than in energy markets.

4 - Evaluation of Generation Portfolios for the New England Power System
Destenie Supreece Nock, University of MA-Amherst, 132 Middle Street, Unit 3, Hadley, MA, 01035, United States, dnock@umass.edu, Erin Baker

As power systems evolve there has been a shift towards sourcing electricity from more sustainable generation sources. This push combined with the need to ensure the system can reliably supply electricity throughout the year makes the generation capacity planning question more complex. In this paper we propose a method for evaluating a portfolio of generation technologies in terms of their sustainability and a pre-integration metric for reliability. Preference scenarios for sustainability are defined in terms of economical, technological, societal, and environmental factors.

■ MD81

382A

Distributional Robust Optimization with Marginals

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Karthik Natarajan, Singapore, 439959, Singapore, karthik_natarajan@sutd.edu.sg

1 - Using Marginal Distribution Choice Models in Traffic Equilibrium
Selin D. Ahipasaolgu, Assistant Professor, Singapore University of Technology and Design, Singapore, Singapore, ahipasaoglu@sutd.edu.sg, Ugur Arikan, Karthik Natarajan

Traffic equilibrium models are fundamental to the analysis of transportation systems. We develop a new user equilibrium model, the MDM-SUE model, that uses the marginal distribution model (MDM) for the underlying route choice. In MDM, the marginal distributions of the path utilities are specified but the joint distribution is not. We show that MDM-SUE exists, is unique under mild assumptions, has a convex optimization formulation, and can be computed efficiently. The MDM-SUE model can be used to recreate logit SUE and weibit SUE. Moreover, the model is flexible as it can capture perception variance scaling at the route level and allows for modeling with skewed and heavy tailed distributions.

2 - Distributionally Robust Markovian Traffic Equilibrium
Ugur Arikan, Singapore University of Technology and Design, Singapore, Singapore, ugur_arikan@sutd.edu.sg

A class of link based models under a Markovian assumption has been proposed to deal with the drawbacks of route based models in traffic assignment. However, the application has been thus far restricted to the multinomial logit model. We propose a distributionally robust Markovian traffic equilibrium model assuming that marginal distributions of link utilities are known but the joint distribution is unknown. We develop a convex optimization formulation and propose an efficient algorithm to compute equilibrium flows. Our formulation is completely link based, relaxes the assumption of independence and identical distributions, and provides modeling flexibility and computational tractability.

3 - Scenario Reduction Revisited: Fundamental Limits and Guarantees
Napat Rujeerapaiboon, Ecole Polytechnique Federale de Lausanne, EPFL.CDM.MTE I.RAO, ODY 1 19 (Odyssea), Station 5, Lausanne, 1015, Switzerland, napat.rujeerapaiboon@epfl.ch, Kilian Schindler, Daniel Kuhn, Wolfram Wiesemann

The goal of scenario reduction is to approximate a discrete distribution with another discrete distribution that has fewer atoms. We distinguish continuous scenario reduction, where the new atoms may be chosen freely, and discrete scenario reduction, where the new atoms are chosen from among the existing ones. Using Wasserstein distance to measure proximity between distributions, we analyze the added benefit of continuous over discrete scenario reduction. We also propose polynomial-time constant-factor approximations and exponential-time exact algorithms for both types of scenario reduction.

4 - Revisiting the Marginal Distribution Model for Discrete Optimization: Extensions and Generalizations
Louis L. Chen, Massachusetts Institute of Technology, Cambridge, MA, United States, llchen@mit.edu, Karthik Natarajan, David Simchi-Levi

Building on previous work which incorporated the Marginal Distribution Model to examine the persistency problem for discrete optimization, we provide extensions in two ways. Firstly, we extend the distributionally robust problem to now incorporate completely arbitrary marginal distributions, and we find a dual optimization problem that not only points the way to tractable cases but also presents a basic multi-marginal transport problem with a story not unlike that found in the assignment game from mathematical economics. Secondly, we investigate the role of the discrete constraint set's structure in tractability. As well, we consider how the results generalize/unify some other works.

■ MD82

382B

Optimizing Network Robustness under Uncertainty

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Tanveer Hossain Bhuiyan, tb2038@msstate.edu

1 - Chance Constrained Distributional Robust Optimization for Capacity Expansion of Wind Generation

Wei Wang, Doctoral Student, University of Pittsburgh, 1025 Benedum Hall, Pittsburgh, PA, 15261, United States, w.wei@pitt.edu, Bo Zeng

To handle uncertainties in wind energy generation in capacity expansion, a chance-constrained distributional robust optimization model is developed and solved. Numerical results will be reported.

2 - Algorithm for a Stochastic Bilevel Optimization

Chaosheng Dong, University of Pittsburgh, 4200 Fifth Avenue, Pittsburgh, PA, 15260, United States, chaosheng@pitt.edu, Bo Zeng

For a bilevel optimization problem with multiple lower level problem, we analyze its property and develop a distributed computational algorithm. Numerical results will be presented.

3 - Network Design and Facility Protection when the Effect of Protection is Uncertain

Tanveer Hossain Bhuiyan, Mississippi State University, P.O. Box 5227, Room 321, Starkville, MS, 39762, United States, tb2038@msstate.edu, Hugh Medal

We study a facility location and network design problem that involves protecting facilities subject to random disruptions where the protection is imperfect, multi-level, and the effect of disruption is imperfect. The goal of our study is to optimally allocate protection resources to the facilities, and construct links in the network to minimize the expected total transportation cost. We model the problem as a two-stage stochastic programming with decision dependent uncertainty where the post-disruption capacity states of the facilities depends probabilistically on the resource allocation decision and the disruption intensity. We implement an L-shaped algorithm to solve the model.

4 - Two-stage Robust Optimization for Single-commodity Network Design with Potential Edge Failures

Logan R. Matthews, Princeton University, Princeton, NJ, United States, loganm@princeton.edu, Yannis G. Kevrekidis, Chrysanthos E. Gounaris

The single-commodity network design problem with potential edge failures is formalized as a two-stage robust optimization problem with an uncertainty set of binary random variables representing uncertain edge failures. A column-and-constraint generation algorithm is tailored to this application and implemented to gain minimum cost networks which remain feasible for a given number of simultaneous edge failures. Problems adapted from the Survivable Network Design Library are solved to measure the cost increases and computational efforts required due to various levels of robustness.

■ MD83

382C

Stochastic Optimization with Learning

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Daniel Jiang, University of Pittsburgh, University of Pittsburgh, Pittsburgh, PA, 15261, United States, drjiang@pitt.edu

1 - Optimal Online Learning for Nonlinear Belief Models with Physical State Information

Weidong Han, Princeton University, 35 Olden Street, Sherrerd Hall, Princeton, NJ, 08544, United States, whan@princeton.edu, Warren Powell

We consider an optimal learning problem with nonlinear belief models and physical state information such as a finite budget or resource. We assume the parameter vector in the belief model follows a discrete prior distribution. We formulate the problem into a dynamic program, and propose a lookahead policy called the OC-correction that is shown to be optimal for two-stage problems. We prove asymptotic convergence properties of the proposed policy for infinite-horizon problems. Adopting this framework, we find an approach to the real-time bidding problem for online advertising.

2 - Statistical Optimality and Model Assessment for SP in Learning Enabled Optimization (LEO)

Yunxiao Deng, PhD Student, University of Southern California, Los Angeles, CA, 90089, United States, yunxiaod@usc.edu

For Learning Enabled Optimization problems, we can obtain solutions with statistical guarantees using concepts of statistical optimality. Model assessment and selection are also critical parts of the modeling process. We present a collection of hypothesis tests, metrics and comparisons between alternative LEO models to assess solution quality.

3 - Ensemble Bayesian Optimization for Partially Controllable Sequential Information Processes

Yingfei Wang, Princeton University, Department of Computer Science,, Princeton University, 35 Olden Street,, Princeton, NJ, 08540-5233, United States, yingfei@princeton.edu, Warren B.Powell

An important element in sequential decision making problems is stochastic models of the environment and proper statistical models and inferences to represent our changing beliefs about the environment as new information is collected. We design an ensemble optimal learning method to respond quickly and robustly to complex data streams. In our ensemble system, multiple models, such as classifiers, are strategically generated and combined to minimize the incorrect selection of a particularly poorly performing statistical model. Similar to the idea of online boosting, we use Bayesian learning with expert advice as the belief model, aiming to spend the limited measurement budget more wisely.

4 - Learning Rare-event Probabilities and Applications to Automated Vehicle Testing

Zhiyuan Huang, University of Michigan, Ann Arbor, MI, 48109, United States, zhyhuang@umich.edu, Henry Lam, Ding Zhao

This talk discusses the estimation of rare-event probabilities where learning takes place in the measurement of the hitting set of interest. Because of the rare-event nature, the estimation requires the use of variance reduction techniques that are sequentially optimized. This problem arises from the safety testing of automated vehicles using simulation-based estimation of critical events such as crashes or conflicts, where the vehicles' behaviors are analytically intractable or not fully observable.

■ MD84

General Assembly A

Markov Lecture

Invited Session

1 - Methods for Model Approximation and Optimization in the Presence of Model Uncertainty using Information Divergences

Guodong Pang, Penn State University, University Park, PA

Tuesday, 7:30 - 9:00AM

■ TA01

310A

Modeling, Decisions, and Sensitivity

Sponsored: Decision Analysis

Sponsored Session

Chair: Emanuele Borgonovo, Bocconi University, Milano, 20136, Italy, emanueleborgonovo@unibocconi.it

Co-Chair: Alessandra Cillo, Bocconi University, Milan, 20136, Italy, alessandra.cillo@unibocconi.it

1 - Multinomial Logit Processes and Preference Discovery

Fabio Maccheroni, Università Bocconi, Milan, Italy, fabio.maccheroni@unibocconi.it, Simone Cerreia-Vioglio, Massimo Marinacci, Aldo Rustichini

We study and axiomatically characterize the dependence of choice probabilities of an agent on the time available to decide by means of a Multinomial Logit Model with time independent (systematic component of the) utility and time dependent scale parameter. This is the most widely used model of preference discovery in all fields of decision making from Quantal Response Equilibrium theory to Discrete Choice Analysis, from Psychophysics to Combinatorial Optimization. Our axiomatic characterization permits, on the one hand, to understand its conceptual underpinnings as a theory of agents behavior, on the other to empirically test its descriptive validity.

2 - Domain Dependent Attitudes
Veronica Roberta Cappelli, PhD Student, HEC Paris, Jouy en Josas, France, veronica.cappelli@hec.edu

Many everyday decisions can be framed as choices between streams of multicriteria alternatives. At the same time, there is by now substantial evidence that decision makers may have domain-specific attitudes toward outcomes. In particular, different categories of outcomes may be discounted differently and associated with different levels of risk aversion. This work aims at providing an axiomatized model of choice between streams of multicriteria alternatives. Our objective is to allow for an evaluation functional that takes into account the fact that, not only utility, but also discounting may be attribute, or domain, dependent.

3 - Accelerated Kriging for Global Sensitivity Analysis
Xuefei Lu, Bocconi University, Via Sarfatti 25, Milan, 20136, Italy, xuefei.lu@phd.unibocconi.it, Emanuele Borgonovo, Lorenzo Andrea Rosasco, Alessandro Rudi

In global sensitivity analysis, kriging is commonly applied as a metamodeling technique, especially when the analyst is dealing with time-consuming computer codes. We study an improved kriging improving estimation with an acceleration procedure coming from Machine Learning. We apply this method to global sensitivity analysis and compare the results with standard kriging.

4 - Information Density in Decision and Sensitivity Analysis
Emanuele Borgonovo, Bocconi University, Bocconi University, Via Sarfatti 25, Milano, 20136, Italy, emanueleborgonovo@unibocconi.it, Gordon B. Hazen, Victor Richmond R.Jose

This work discusses the use of the notion of information density in decision and sensitivity analysis.

5 - On the Relationship Between Safety and Decision Significance
Alessandra Cillo, Bocconi University, Via Roentgen 1, Milan, 20136, Italy, alessandra.cillo@unibocconi.it, Emanuele Borgonovo, Curtis L. Smith

Risk analysts are often concerned with identifying key safety drivers, i.e., the systems, structures and components (SSCs) that matter the most to safety. SSCs importance is assessed both in the design phase and in the implementation phase using the same importance measures. However, in a design phase it would be necessary to appreciate whether, the failure/success of a given SSC can cause the overall decision to change from accept to reject. This work addresses the search for the conditions under which SSCs which are safety significant are also decision significant. To address this issue, the work proposes the notion of teta-importance measure.

■ TA02

310B

Behavioral Issues in Counter-Terrorism Decisions

Sponsored: Decision Analysis

Sponsored Session

Chair: Heather Rosoff, University of Southern California, Los Angeles, CA, 90024, United States, rosoff@usc.edu

Co-Chair: Gilberto Montibeller, Loughborough University, Loughborough University, Loughborough, LE11 3TU, United Kingdom, g.montibeller@lboro.ac.uk

1 - Modeling Multi-target Defender-attacker Games with Quantal Response Attack Strategies
Jun Zhuang, University at Buffalo, SUNY, 317 Bell Hall, Buffalo, NY, 14260, United States, jzhuang@buffalo.edu, Jing Zhang

Due to the growing interest in incorporating behavior models within thedefender-attacker game literature, the perfect rationality assumption of adversary has been relaxed. We study four multi-target defensive resource allocation in defender-attacker games by using quantal response model, in which the attacker might be bounded rational. We compare the our model results with the traditional game theoretic model where the attacker behaves rationally. We studied the impacts of the attacker's rationality level on the defender's optimal defense strategies. This paper provides some novel insights to defensive resource allocation when considering the attacker's bounded rationality.

2 - A Roadmap for OR Research in Homeland Security
Detlof von Winterfeldt, USC, 3710 McClintock Ave, RTH 316A, Los Angeles, CA, 90089-3926, United States, detlof@aol.com

On the occasion of 15th anniversary of 9/11, we will summarize the evolvement and analyze strengths and weaknesses of OR methods in homeland security, in particular in decision and risk analysis, optimization, game theory as well as in simulation and stochastic methods. On the other hand, we will identify in a survey the needs of current key decision makers in homeland security. Finally, we will bring the status quo in theory and the practical needs together in order to develop a roadmap for research on OR methods in counterterrorism in the future.

3 - Public Response to the Security Threat to Aviation
Richard S. John, University of Southern California, Dept of Psychology MC 1061, Los Angeles, CA, 90089-1061, United States, richardj@usc.edu, Heather Rosoff

Important to the effectiveness of airport security measures is public response to the implemented policies. We will present three studies that have assessed public reaction to varying aspects of the security threat to aviation. The first is a longitudinal study looking at the psychological effects of the events of 9/11 over 5 years. The second study examines how travelers value the principle of equal protection by quantifying their willingness to sacrifice to avoid different screening procedures. The third study looks at public perception of traditional airport security schedules that search everyone versus randomized security schedules that randomly deploy security measures.

4 - Understanding Terrorist Attacks with Learning Models
Gilberto Montibeller, Loughborough University, School of Business & Economics, Loughborough, LE11 3TU, United Kingdom, g.montibeller@lboro.ac.uk, Johannes Jaspersen

In this paper we adopt the perspective of the terrorist group as an economic agent learning from reinforcement and calibrate different learning models to study the target selection of terrorists using empirical data. Terrorists display the power law of learning and discount prior information, but show no tendency to have an aspiration level or reference point. Our results show learning models from laboratory experiments in behavioral economics to be applicable to naturally occurring human conflicts and let us draw implications for counterterrorism strategies.

5 - A Hybrid Spatio-temporal Model for Wildlife Poaching Prediction Evaluated through a Controlled Field Test
Shahrzad Gholami, PhD Student, University of Southern California, Los Angeles, CA, 90089, United States, sgholami@usc.edu, Milind Tambe

Worldwide, conservation agencies employ rangers to protect conservation areas from poachers. However, agencies lack the manpower to have rangers effectively patrol these vast areas frequently. While past work has modeled poachers' behavior so as to aid rangers in planning future patrols, those models' predictions were not validated by extensive field tests. We present a hybrid spatio-temporal model that predicts poaching threat levels and results from a five-month field test of our model in Uganda's Queen Elizabeth Park.

■ TA03

310C

Dynamic Ridesharing

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, 77204, United States, jopeng@Central.uh.edu

Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Dynamic Ridesharing
Fernando Ordonez, DII, Univeridad de Chile, Santiago, Chile, fordon@dii.uchile.cl, Maged M.Dessouky

Recent technological developments such as GPS, mobile devices and increases in data storage and computation capacity have greatly enhanced the communication capabilities of travelers, facilitating ridesharing in real-time. This opportunity has created a new ridesharing industry built on making use of the unused vehicle capacity moving about on the roads. There are however still important barriers for widespread dynamic ridesharing adoption. It therefore becomes important to better understand the problems and challenges of ridesharing, creating the need for novel research that explicitly takes into account dynamic ridesharing. In this tutorial we review recent research on new vehicle routing models, cost sharing mechanisms, and planning models that incorporate ridesharing.

■ TA03A

Grand Ballroom A

Energy in Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Bert Zwart, Eindhoven, 5629RD, Netherlands, Bert.Zwart@cwi.nl

1 - Estimating Line Failure Probability in Power Grids under Uncertainty
Tommaso Nesti, CWI, Amsterdam, Netherlands, TNesti@cwi.nl

The advent of renewable energy has huge implications for the control of power

grids. Due to increasing uncertainty, traditional reliability constraints must be replaced by probabilistic guarantees. We investigate the probability of line current overloads assuming stochastic power injections, using techniques from large deviations theory and concentration inequalities, both in a static and in a dynamic scenario. We derive analytic expressions for the set of admissible power injections profiles such that line overloads are sufficiently rare events, and we show how enforcing constraints on line temperature, rather than on current, can lead to capacity gains.

2 - Learning to Price in Demand Response Programs

Kia Khezeli, Cornell University, Ithaca, NY, 14853, United States, kk839@cornell.edu, Eilyan Bitar

Electric power utilities offer demand response (DR) programs where consumers are paid to curtail their electricity consumption when electricity is scarce and expensive. The most basic challenge that a utility faces in implementing DR programs is the prediction of how customers will adjust their demand in response to different prices. In this talk, we'll discuss the role of adaptive control in guiding the design of DR pricing polices that effectively balance the tradeoff between the utility's need to learn the unknown customer response model and the need to minimize its expenditure over time.

3 - Estimation of Stochastic Process Parameters Implied by Financial Transmission Rights

Boris Defourny, Lehigh University, 200 W Packer Ave, Bethlehem, PA, 18015, United States, defourny@lehigh.edu

This work hypothesizes that Financial Transmission Right (FTR) prices in electricity markets express the assessment by market participants of the grid congestion risk, as determined by parameters of stochastic processes such as load levels, generation and transmission grid state driving the underlying day-ahead hourly price differences. We propose a methodology to infer parameters consistent with FTR contract prices, based on a relation between state occupation measures and the contract value. More broadly, this work is concerned with the inverse mapping from occupation measures to stochastic processes, and the stability of the estimates.

4 - Random Graph Models for Power System Controllability

Linqi Guo, California Institute of Technology, Pasadena, CA, United States, lguo@caltech.edu, Steven H.Low

We give a full characterization in terms of spectral graph theory for the controllability of the swing and power flow dynamics when we can only inject control signals to a subset of the buses. In particular, we show the controllability of the system depends on two orthogonal conditions: 1) intrinsic structure of the system graph 2) algebraic coverage of buses with controllable loads. Both conditions can be verified using the eigenvalue and eigenvectors of the graph Laplacian matrix. We then employ random graph models and uncertainty principle to explain why in practice we only need sporadic controllers for full controllability.

■ TA03C

Grand Ballroom C

Economic Models on Markets, Firms and Information

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Shuya Yin, University of California-Irvine, shuya.yin@uci.edu

1 - When Does a Supply Chain Member Benefit from Vendor Managed Inventory?

Ruixia Shi, University of San Diego, San Diego, CA, United States, rshi@sandiego.edu, Jun Ru, Jun Zhang

This paper studies the effects of VMI on a supply chain consisting of one manufacturer and one retailer. We show that whether the two supply chain members benefit from VMI depends on how the holding or shortage cost increment from the manufacturer to retailer compares with two corresponding critical values. We then develop comparative statics results on how these critical values change with respect to different parameters. Interestingly, the retailer is more likely to benefit from the adoption of VMI when its inventory holding cost is low, and the manufacturer is more likely to benefit from VMI adoption when its inventory holding cost is high, contradicting what our intuitions would suggest.

2 - Inventory Allocation in the Presence of Store Switching Caused by Stock Outs

Elcin Ergin, McGill, 3465 Hutchison Street, Apt 905, Montreal, QC, H2X 2G3, Canada, elcin.ergin@mail.mcgill.ca, Mehmet Gumus

In this study, we focus on inventory allocation of fast fashion products between the stores of the firm when there is an evidence of store switching behaviour of customers in the case of stock outs. Examining an extensive dataset taken from a fast fashion retailer company which has more than 300 stores showed that some of the customers visit other stores to find the product they look for. We present an inventory allocation model considering this behavior. We analyze how this behavior would affect the total sales and accordingly how a firm should shape the initial allocation decisions under this model.

3 - Strategic Inventories when Competing Manufacturers Sell through a Common Retailer

Abhishek Roy, University of Texas-Austin, 2110 Speedway Stop B6500, Austin, TX, 78712-1277, United States, abhishek.roy@utexas.edu, Stephen M. Gilbert, Guoming Lai

Although the effects of strategic inventory in dynamic contracts on supply chain agents are well known, most existing research on strategic inventory focuses on bilateral monopolies. When the partially substitutable products of different manufacturers are sold through a common retailer, we find that those effects are altered in significant ways. Among other things, the retailer's and the manufacturers' preferences between commitment and dynamic contracts can be reversed.

4 - Distribution Channel Entry Strategies with Intra-and Inter-channel Demand Learning

Shuya Yin, University of California-Irvine, Paul Merage School of Business, Irvine, CA, 92697-3125, United States, shuya.yin@uci.edu, Jing Hu, Christopher S.Tang

When a rm introduces a new product to market, making it available in multiple channels can achieve higher market coverage and learn market uncertainty better so as to improve subsequent decisions, while selling it in a single channel exclusively can save slotting fees and avoid channel cannibalization. This paper considers a model where a rm needs to determine its distribution channel entry strategy on whether to sell its product in one or two channels over a two-period time.

5 - Incentives for Information Transparency under Vertical Information Asymmetry

Sammi Tang, Associate Professor, University of Miami, Miami, FL, 33146, United States, ytang@miami.edu, He Huang, Hongyan Xu

This paper studies the incentives for horizontal information transparency between competing downstream firms when upstream suppliers possess private information. Information is modeled along two dimensions: vertical information on suppliers' reliability level and horizontal information on suppliers' production cost. Our findings provide novel insights for managers to handle two-dimensional information asymmetry.

■ TA04

320A

Sustainable Operations

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Greys Sosic, University of Southern California, Los Angeles, CA, 90089-0809, United States, sosic@marshall.usc.edu

Co-Chair: Hailong Cui, University of Southern California, Los Angeles, CA, 90089-0809, United States, Hailong.Cui.2019@marshall.usc.edu

1 - Lemons, Trade-ins and Remanufacturing

Ximin Huang, Assistant Professor, University of Minnesota, 321 19th Ave S, Ste 3-150, Minneapolis, MN, 55455, United States, huangx@umn.edu, Atalay Atasu, Beril L.Toktay

Trade-in programs have been shown to partially mitigate the lemons problem in secondary markets. We show when and how remanufacturing traded-in products can further improve the efficiency in secondary markets.

2 - Complementary Product Design and Process Technology Choices in Recycling

Luyi Gui, The Paul Merage School of Business, University of California-Irvine, Irvine, CA, 92697-3125, United States, luyig@uci.edu, Morvarid Rahmani, Atalay Atasu

Motivated by the Japanese implementation of the Home Appliance Recycling Law, we study the complementarity between product design and technology choices for recycling. We evaluate the environmental benefit of recycling capacity sharing between producers and of producers' investment in recycling facilities.

3 - Choice of E-waste Recycling Standard under Recovery Channel Competition

Gokce Esenduran, Ohio State University, 2100 Neil Avenue, 656 Fisher Hall, Columbus, OH, 43210, United States, esenduran@gmail.com, Yen-Ting (Daniel) Lin, Wenli Xiao, Minyue Jin

There are two recycling standards for e-waste recyclers that are different in stringency: E-stewards and R2. E-stewards is more stringent and costlier but attracts more e-waste from environmentally conscious donors. We model the competition between recovery channels and examine how secondary market sales and economies of scale affect recyclers' choice. We find that a recycler may choose e-Stewards only when facing competition. Our results also show that recyclers with strong scale economies in e-waste processing choose e-Stewards only when incurring processing costs significantly higher than R2 would require.

4 - To Recycle or Not: An Analysis of the Environmental and Financial Impact of Recycling

Hailong Cui, University of Southern California, Marshall School of Business, Data Sciences and Operations, Los Angeles, CA, 90089-0809, United States, Hailong.Cui.2019@marshall.usc.edu, Greys Sosic

We evaluate the conditions under which recycling of simple products (made of common materials) has positive impact across three dimensions: GHG emissions, operational costs, and societal costs. Our study contains both an analytical model and empirical validation of our results. We then consider different decision makers when decision variables are collection and yield rates: we start with centralized models wherein a single entity (local government, manufacturer, or independent recycler) determines both values, and then we move to decentralized models in which collection and yield rates are chosen by two different parties. We also discuss incentive mechanisms for achieving social optima.

■ TA05

320B

Behavioral, Incentive and Policy Issues in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21202, United States, dai@jhu.edu

Co-Chair: Song-Hee Kim, University of Southern California, Los Angeles, CA, 90089, United States, songheek@marshall.usc.edu

1 - Search Among Queues under Quality Differentiation

Luyi Yang, Johns Hopkins University, Baltimore, MD, United States, luyi.yang@jhu.edu, Laurens G.Debo, Varun Gupta

We examine a setting in which customers looking for service providers face search frictions and service providers vary in quality and availability. We find that reducing either the search cost or customer arrival rate may strictly increase the average waiting time in the system as customers substitute toward high-quality service providers. We discuss policy implications of our results in the context of public surgical waits.

2 - Upcoding in Medicare Reimbursement for Hospital-acquired Infections

Joel Goh, Harvard Business School, Morgan Hall 420C, Soldiers Field Road, Boston, MA, 02163, United States, jgoh@hbs.edu, Hamsa Sridhar Bastani, Mohsen Bayati

Since 2008, Medicare has levied financial penalties to providers for hospital-acquired infections (HAIs). However, Medicare relies on providers' self reported HAIs to assess these penalties. Consequently, providers may upcode, i.e., mis-report HAIs in a manner that increases reimbursement. One form of upcoding involves incorrectly classifying HAI conditions as being present-on-admission (POA). In this empirical study, we use nationally-representative claims data to investigate the whether such POA upcoding occurs. Our results suggest that the level of state-level regulation and enforcement is an important determinant of POA upcoding.

3 - Designing Response Supply Chain Against Bioattacks

Peter Yun Zhang, Massachusetts Institute of Technology, Cambridge, MA, United States, pyzhang@mit.edu, David Simchi-Levi, Nikolaos Trichakis

We study the problem of designing supply chain against bioattacks. We propose a model that integrates key facets of the problem in a way not done before, with decision variables spanning medical countermeasure stock level, capacity, shipment, and dispensing. We also explicitly capture the interaction between defender and attacker. We present a tractable and provably strong heuristic capable of solving large networks with high fidelity (100,000s nodes). Compiling data on supply, population, lead times, health effects, and costs, we analyze the design of a comprehensive biodefense supply chain in the United States and generate new policy insights.

4 - A Contract Mechanism for the Opioid Prescription Epidemic

Alireza Boloori, Arizona State University, 505 W. Baseline Rd, Apt 2158, Tempe, AZ, 85283, United States, alireza.boloori@asu.edu, Soroush Saghafian, Stephen J. Traub

Hospital EDs are in part responsible for the overprescription of opioid painkillers. To analyze the impact of different contracts (between an insurer (e.g., Medicare and a hospital) on the opioid prescription in EDs, we propose a principal-agent model where pharmaceutical incentives from opioid manufacturers cause asymmetric information (i.e., adverse selection) in the model. Utilizing data from Mayo Clinic, we establish a data-driven contracting approach to not only alleviate the negative consequences of opioids, but also address patients who really need these medications. We also provide implications for healthcare policy makers.

■ TA06

320C

Healthcare Decision Making under Uncertainty

Sponsored: Health Applications

Sponsored Session

Chair: Hadi El-Amine, George Mason University, George Mason University, Fairfax, VA, 22030, United States, helamine@gmu.edu

1 - Adaptive Risk-based Pooling in Public Health Screening

Hrayer Y. Aprahamian, Virginia Tech, 1145 Perry Street, Blacksburg, VA, 24060, United States, ahrayer@vt.edu, Ebru Korular Bish, Douglas R.Bish

Pooled testing is commonly used in public health screening for classifying subjects in a large population as positive or negative for an infectious or genetic disease. Pooling is especially useful when screening for low prevalence diseases under limited resources. We propose and study an adaptive risk-based pooling scheme, which considers important test and population level characteristics often overlooked in the literature. We characterize important structural properties of optimal subject assignment policies, and provide key insights. Our case study demonstrates the effectiveness of the proposed pooling scheme, with false classifications reduced substantially over current policies.

2 - Multi-objective Two-stage Stochastic Programming for Adaptive Interdisciplinary Pain Management with PLN Transition Models

Jay Michael Rosenberger, University of Texas-Arlington, Arlington, TX, 76010, United States, jrosenbe@uta.edu, Gazi Md Daud Iqbal, Victoria Chen, Robert Gatchel

This research uses a two-stage stochastic programming approach to optimize personal adaptive treatment strategies for pain management. The goal is to generate adaptive treatment strategies using statistics based optimization approaches that can be used by physicians to prescribe treatment to the patients. Five pain outcomes has been considered in objective function. This research uses Piecewise Linear Networks (PLN) to represent transition models. A mixed integer linear program is developed to integrate those PLN transition models into an optimization problem.

3 - Comparative Effectiveness of Incorporating a Hypothetical DCIS Prognostic Marker into Breast Cancer Screening

Mehmet Ergun, University of Wisconsin, 7429 Old Sauk Road, Madison, WI, 53717, United States, mergun@wisc.edu, Oguzhan Alagoz, Amy Trentham-Dietz, Ronald E. Gangnon, Natasha Stout, John M.Hampton, Kim Dittus, Ted A. James, Pamela M. Vacek, Sally Herschorn, Elizabeth S. Burnside, Anna N. Tosteson, Donald L. Weaver, Brian L. Sprague

Due to the lack of a reliable test to identify a non-progressive disease, most of the ductal carcinoma in situ (DCIS) cases are treated with similar treatment regimens to localized invasive breast cancers. Thus, most of the patients with a non-progressive disease receive unnecessary treatments that result in decrements in their quality of life as well as an extra financial burden. To assess the potential impact of a hypothetical test that identifies non-progressive DCIS cases, we used the University of Wisconsin Breast Cancer Simulation model. Our results show that a perfect test would reduce the treatment costs as much as 40% and lead to a modest increase in discounted quality-adjusted life years.

4 - Robust Post-donation Blood Screening under Prevalence Rate Uncertainty

Hadi El-Amine, George Mason University, 4310 Cotswolds hill ln, Fairfax, VA, 22030, United States, helamine@gmu.edu, Ebru Korular Bish, Douglas R. Bish

Blood product safety, in terms of being free of transfusion-transmittable infections, is crucial. Under prevalence rate uncertainty, various objective functions, including minimization of a mean-variance objective and minimization of the maximum regret, were considered in order to determine a "robust" post-donation blood screening strategy that minimizes the risk of releasing an infected unit of blood into the blood supply. Efficient and exact algorithms are provided.

■ TA07

322A

New Scheduling and Capacity Management Approaches to Improve Patient Access to Medical Services

Sponsored: Health Applications

Sponsored Session

Chair: Mustafa Y Sir, Mayo Clinic, Rochester, MN, 55905, United States, sir.mustafa@mayo.edu

1 - Acuity Based Demand Management

Bjorn Berg, Mayo Clinic, KPSL 21, 200 First Street SW, Rochester, MN, 55905, United States, berg.bjorn@mayo.edu, Brian Klute, Tarun Mohan Lal

Outpatient specialty practices, notably at large medical centers, face a matrix of uncertainties and objectives when making planning and operational decisions. Uncertainties include requests for new appointments, the mix of services required, and patient preferences. The effects of these uncertainties need to be managed to pursue criteria such as ensuring that the right patients are provided care based on their acuity and needs, the time patients must wait for an appointment, and utilization rates of provider calendars. We present a series of predictive analyses, capacity management models, and simulation-based approaches used to manage demand at an outpatient quaternary care practice.

2 - Online Surgery Reservation to Optimize Surgical Day Utilization

Maria Martinez, Mayo Clinic, Rochester, MN, United States, Martinez.Maria@mayo.edu, Alexander Mafusalov, Mustafa Y. Sir, Kalyan Pasupathy

This paper proposes a novel surgical scheduling optimization method within the general framework of a resource allocation problem. In the clinical setting, a patient enters the department with a diagnosis, which, after a clinical consultation, is linked to a specific surgical procedure. Surgery time slot is reserved upon arrival, when the procedure information is not available. The paper studies the long-run allocation policies, based on the demand in diagnoses, the stochastic relationship linking a diagnosis to a procedure, and on the surgical capacity. The objective is to minimize the surgeons' overtime hours. Numerical experiments on real data illustrate the effectiveness of the methods.

3 - Improving Patient Access of Back Pain Patients

Derya Kilinc, Arizona State University, 1975 E University Dr, Apt 162, Tempe, AZ, 85281, United States, dkilinc@asu.edu, Esma S.Gel, Bernard Bendok

Back pain is one of the leading health problems that affect a significant portion of the population. Identifying the patients that needs a surgical intervention and improving the access of those patients to right providers are crucial in healthcare delivery. We present our results on improving patient access based on of our year-long study in a neurosurgery clinic. Our results suggest that by prioritizing the patients need surgery and managing the capacity, we can achieve improvements in patient access.

4 - A Decision-support Tool for Capacity Management of Two-step Service Calendar

Phichet Wutthisirisart, Mayo Clinic, 200 First Street SW, Rochester, MN, 55905, United States, Wutthisirisart.Phichet@mayo.edu, Maria Gabriela Martinez, Kalyan Pasupathy, Mustafa Y. Sir

This works assess the performance of clinical and surgical calendars in an elective surgical practice. A simulation-based approach is proposed to score the efficiency of calendar with respect to the length of the planning horizon. Our approach generates key performance metrics to assists the identification of potential inefficiencies in the calendar.

■ TA08

322B

System Dynamics in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Nasim Sabounchi, State University of New York at Binghamton, Systems Science and Industrial Engineering, Binghamton, NY, 13902, United States, sabounchi@binghamton.edu

1 - Medicaid Access to Primary Care in Broome County, NY – A Combination of GIS and System Dynamics Methodology

Nasim S. Sabounchi, State University of New York at Binghamton, 4400 Vestal Parkway East, P.O. Box 6000, Systems Science and Industrial Engineering, Binghamton, NY, 13902, United States, sabounchi@binghamton.edu, Nasser Sharareh, Serdar Atav

The effect of Medicaid expansion on primary care access is studied from the spatial aspect. We built a system dynamics model using the constructs of the Health Belief Model to explain the dynamics of primary care access that captures the different stages of getting qualified, enrolling in Medicaid, seeking primary care services, and utilizing preventative care. Finally, the results of simulation model were applied to create a dynamic GIS map which shows the growth of Medicaid enrollees throughout the County, and the distance of patients to primary care providers will be investigated.

2 - Analyzing Optimal Screening Policies for Post-traumatic Stress Disorder in the Presence of Social Stigma

Mohammad S. Jalali, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States, jalali@mit.edu, Navid Ghaffarzadegan, Richard C. Larson

Post-traumatic stress disorder (PTSD) stands out as a major mental illness and screening policies have played a critical role in mitigating the effects of PTSD. However, little agreement exists on the optimal cutoff value—a threshold above which screening scores should be considered as PTSD positive. We develop a simulation model of PTSD screening which includes social forces that inhibit accurate screening. Our analysis shows that with the presence of public stigma, current dichotomous screening policies are not effective to minimize the number of false positive and false negative.

3 - Combination of System Dynamics Modeling and Social Marketing for Increasing Colorectal Cancer Screening

Brian Biroscak, PhD, MS, MA, Yale School of Medicine, New Haven, CT, 06519, United States, brian.biroscak@yale.edu, Peter Hovmand

Human learning in and about complex systems is a feedback process. Yet in the world of social action, feedback processes often do not operate well. We will present our experience using a social marketing approach as one potential means for overcoming the implementation challenge in system dynamics modeling, within the context of an initiative to increase colorectal cancer (CRC) screening. We applied a modeling approach called 'community based system dynamics'. The primary purpose of the model (Stella ArchitectTM; Stella OnlineTM) is to help this academic-community partnership design a social marketing strategy for implementing evidence-based interventions that will increase CRC screening.

4 - Towards Optimal Antibiotic Prescribing for Acute Respiratory Tract Infections in Ambulatory Settings by Applying System Dynamics Modeling

Hamed Kianmehr, State Univerity of New York, Binghamton, NY, 13905, United States, hkianme1@binghamton.edu, Nasim S. Sabounchi, Leon E. Cosler, KarenBeth H. Bohan

Antibiotic resistance is a growing public health concern. There are several conditions for which antibiotics are prescribed excessively including acute respiratory tract infections (ARTIs). The goal of this study is to find key factors that lead to excessive antibiotic prescriptions among ARTI patients. We developed a system dynamics model to reproduce antibiotic prescriptions for ARTI, from the National Ambulatory Medical Care Survey (NAMCS), 1993-2014. The best-fit model captures the relationship between patient and physician decision making properly. The simulation results indicate that patient expectation has a strong effect on physician intention for prescribing antibiotics.

■ TA09

330A

Structural Modeling and Estimation in Operations Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Jun Li, Ross School of Business, University of Michigan, Ann Arbor, MI, 48109, United States, junwli@umich.edu

Co-Chair: Yixin Wang, University of Michigan, Ann Arbor, MI, 48104, United States, iriswang@umich.edu

1 - Manufacturing and Regulatory Barriers to Generic Drug Competition: A Structural Model Approach

Yixin Wang, University of Michigan, 701 Tappan Street R4323, Ross School of Business, Ann Arbor, MI, 48104, United States, iriswang@umich.edu, Jun Li, Ravi Anupindi

Understanding the drivers of market concentration in the generic pharmaceutical industry is essential to guarantee the accessibility of low-cost generics. In this paper, we develop a structural model to capture the determinants of manufacturers' entry decisions and estimate the model using data collated from six disparate sources. In particular, this study focuses on the impact of production cost and regulatory barrier. We find that production complexity, as reflected for example in the administration route, significantly reduces the likelihood of generic entries. An increase in the processing time of production applications due to government capacity issue also deters firms from entering.

2 - Route Preferences in Bike-sharing Systems
Pu He, Columbia University, Uris Hall, Cub 4H, New York, NY, 10027, United States, phe19@gsb.columbia.edu, Fanyin Zheng, Elena Belavina, Karan Girotra

Over 300 cities have implemented large scale bike-share systems, including London, Paris and New York city. Using transaction-level trip and bike-availability data from London's bike sharing system, we construct a structural model of commuters' preferences over different routes that captures the effects of two components of route-length: the biking and the walking distances, along with the service-levels experienced at both ends. We illustrate the use of our estimates for system design, e.g. to choose between adding stations to increase station density in existing coverage areas or to expand the coverage area, to compare a docking station model with a dock-less model, etc.

3 - Managing Flexibility and Relationships in an Online Marketplace: Experiment and Prescriptions for Pricing and Matching
Ken Moon, The Wharton School, Philadelphia, PA, 19104, United States, kenmoon@wharton.upenn.edu, Elena Belavina, Karan Girotra

Exploiting the recent introduction of relationship-specific pricing by the largest online intermediary connecting freelancers to jobs, we present empirical evidence relating the operational performance of the platform's pricing and matching regimes to a simple market characteristic: whether clients derive greater relative value (A) by pursuing repeat relationships with trusted freelancers or (B) by exploiting the platform as an intermediary to flexibly hire different freelancers. We discuss how platforms can follow intuitive rules to tailor their pricing and matching policies based on how participants value relationships and flexibility, respectively.

4 - A Structural Estimation Approach to Study Agent Attrition
Seyedmorteza Emadi, University of North Carolina at Chapel Hill, 221 Tremont Cir, Chapel Hill, NC, 27516, United States, seyed_emadi@kenan-flagler.unc.edu, Bradley R.Staats

We use a structural estimation approach to investigate involuntary and voluntary attrition decisions of agents in a call center. We estimate different parameters of agents including their sensitivity to salary and their degree of forward looking behavior.

■ TA10

330B

Personnel Scheduling

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Rachid Hassani, Polytechnique Montreal/Gerad, rachid.hassani@gerad.ca

Co-Chair: Dalia Attia, Gerad, 1, Montreal, QC, Canada, dalia.attia@gerad.ca

1 - Employee Scheduling with Inter Departments Transfers
Dalia Attia, Polytechnique Montreal & GERAD, Montreal, QC, Canada, dalia.attia@gerad.ca, Guy Desaulniers, Francois Soumis

Employee scheduling with inter-department transfers integer program is intractable for large instances. We propose a three-phase heuristic, each phase solves a small integer program. The first phase is a pre-processing phase which identifies probable inter-departments transfers needs. The second phase creates for each department apart, employee schedules using previously gathered information. The third phase, globally fulfills any remaining demand. Several variations for each phase are implemented and compared showing promissing results along with quick execution time.

2 - Real-time Personnel Re-scheduling After a Minor Disruption
Rachid Hassani, Polytechnique Montreal & GERAD, Montreal, QC, Canada, rachid.hassani@gerad.ca, Issmail El Hallaoui, Guy Desaulniers

This talk is about a real-time optimization method to adapt a pre-set schedule after a small disruption that can result from delay or absence of employees. The method provides schedule's rectification choices to the decision-maker taking into account the immediate and a deterministic future costs. This method considers five types of decision and is based on the dual values of the linear relaxation of the personnel scheduling problem . We also propose a procedure exploiting a multivariate adaptive regression splines method for updating the dual values after each disruption when several ones occur in the same week.

■ TA11

332A

Empirical Studies in Service Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Carri Chan, Columbia Business School, New York, NY, 10027, United States, cwchan@columbia.edu

Co-Chair: Fanyin Zheng, Columbia University, New York, NY, 10027, United States, fz2225@gsb.columbia.edu

1 - Why do Automakers Initiate Recalls?
Robert Louis Bray, 830 Hinman Ave., 2s, Evanston, IL, 60202, United States, robertlbray@gmail.com, Ahmet Colak

Are automakers averse to consumer complaints or to the government recalls they attract? We study this question with 8,439 manufacturer recalls, 5,685 government recalls, and 976,062 defect reports submitted to the government. We model the agents' joint recall decisions as an asymmetric dynamic discrete choice game. Our estimates suggest (i) there is a little overlap in the sets of products the agents recall and in the types of complaints they respond to, (ii) the cost of a recall does not depend on who initiates it, and (iii) auto manufacturers recall faulty products to avoid receiving defect reports but not to preempt anticipated government recalls.

2 - Estimating Dynamic ICU Admission Decision
Fanyin Zheng, Columbia University, Columbia Business School, 412 Uris Hall, New York, NY, 10027, United States, fz2225@gsb.columbia.edu, Carri Chan

We study physician's ICU admission decisions using structural estimation methods.

3 - Understanding the Impact of Remote Patient Monitoring in the Hospital ICU: An Empirical Study
Lesley Meng, The Wharton School, University of Pennsylvania, 3730 Walnut Street, Suite 500 JMHH, Philadelphia, PA, 19104, United States, lmeng@wharton.upenn.edu, Christian Terwiesch

Innovation in healthcare technology has led to new healthcare delivery methods such as the addition of remote patient monitoring in the hospital intensive care unit. We utilize data on patient vitals to study the effect of remote monitoring on provider responsiveness to adverse patient health states in the ICU.

4 - Forecasting Product Life Cycle Curves: Practical Approach and Empirical Analysis
Jan A. Van Mieghem, Northwestern University, Kellogg School of Mgmt (MEDS.Dept), Leverone Hall 2001 Sheridan Rd, Evanston, IL, 60208-2009, United States, vanmieghem@northwestern.edu, Kejia Hu, Jason Acimovic, Francisco Erize, Douglas Thomas

We present an approach to forecast customer orders of ready-to-launch new products that are similar to past products. The approach fits product life cycle (PLC) curves to historical customer order data, clusters the curves of similar products, and uses the representative curve of the new product's cluster to generate its forecast. We propose three families of curves to fit and forecast the PLC: Bass diffusion curves, polynomial curves and simple piecewise-linear curves (triangles and trapezoids). We evaluate our approach using a large data set of customer orders for 4,037,826 units of 170 Dell computer, representing several billion dollars in revenue.

■ TA12

332B

Field Experiments in Service and Retail Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Qiuping Yu, Kelley School of Business, Indiana University, Bloomington, IN, 47405-1701, United States, qiupyu@indiana.edu

1 - The Reference Effect of Delay Announcements: A Field Experiment

Qiuping Yu, Kelley School of Business, Indiana University, 1309 E. Tenth Street, Bloomington, IN, 47405-1701, United States, qiupyu@indiana.edu, Gad Allon, Achal Bassamboo

We explore whether customers are loss averse in time and how the amount of delay information available may impact such reference-dependent behavior by conducting a field experiment at a call center. Our results show that customers exhibit loss averse regardless of the availability or accuracy of the delay information. While delay announcements may not alter the fact that customers are loss averse, they do seem to impact the reference points customers use when the announcements are accurate. However, when those announcements are not accurate, customers may completely disregard them.

2 - Low-acuity Patients Delay High-acuity Patients in the ED

Danqi Luo, Stanford University, Stanford, CA, United States, dluo@stanford.edu, Sara Kwasnick, Mohsen Bayati, Erica Plambeck

Causal analysis of data from 4 different hospitals shows that an additional low-acuity patient in the ED significantly increases the wait time to start of treatment for a high-acuity patient. Through a pseudo-randomized experiment at 1 hospital, we estimate that arrival of a low-acuity patient increases the aggregated wait time for high-acuity patients by 55 minutes on average. We identify 2 mechanisms by which low-acuity patients delay high-acuity patients, analyze a novel model of a priority queue with transition delays, and recommend ways to mitigate delays for high-acuity patients.

3 - Setting Retail Staffing Levels: Methodology and Implementation

Serguei Netessine, University of Pennsylvania, Philadelphia, PA, United States, netessin@wharton.upenn.edu, Marshall L.Fisher, Santiago Gallino

We describe a three-step process that a retailer can use in setting retail store sales staff level. First, use historical data on revenue and planned and actual staffing levels by store to estimate how revenue varies with staffing level at each store. We disentangle the endogeneity between revenue and staffing levels by focusing on randomly occurring deviations between planned and actual labor. Second, using historical analysis as a guide, validate these results by changing the staffing levels in a few test stores. Finally, implement the results chain-wide and measure the impact. We describe the successful deployment of this process with a large specialty retailer.

4 - Stable Schedules for Retail Associates: Field Experiment at the Gap

Saravanan Kesavan, University of North Carolina-Chapel Hill, Kenan-Flagler Business School, Cb 3490 Mccoll Building, Chapel Hill, NC, 27599-3490, United States, skesavan@unc.edu, Susan Lambert, Joan Williams

Employer scheduling practices are an important source of employment instability that can limit earnings, impede worker performance, and create stress and work-life interferences that undermine worker health and well-being. Widespread acknowledgement of the impact of these challenges on thousands of working class households has triggered several policy debates regarding the need for more stable schedules across a variety of industries. In this study, we ran a field experiment in 30 stores of the Gap to improve stability in workers' schedules without affecting the store performance.

■ TA13

332C

Game Theory

Contributed Session

Chair: Xiaojun (Gene) Shan, UHCL, Houston, TX, United States, shan@uhcl.edu

1 - Cost Allocation Mechanisms in a Peer-to-peer Network

Basak Altan, Ozyegin University, Istanbul, Turkey, basak.altan@ozyegin.edu.tr, Okan Orsan Ozener

We consider a P2P network where the service provider broadcasts the content across the network and the users collaborate to seed the content to a subset of users in the network. The objective of the service provider is to determine the minimum cost network solution and to allocate this joint-cost fairly among the users. The minimum cost network solution can be determined by solving a minimum cost Steiner Tree problem. We propose four cost allocation mechanisms: a dual linear programming based mechanism, an approximation mechanism to the Shapley Value, a partition-based mechanism, and an approximation mechanism to the nucleolus.

2 - Safe and Nested Subgame Solving for Imperfect-Information Games

Tuomas W. Sandholm, Professor, Carnegie Mellon University, Gates Center for Computer Science, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, sandholm@cs.cmu.edu, Noam Brown

Unlike perfect-information games, imperfect-information games cannot be solved by solving subgames independently: decisions must consider the strategy for the whole game. Yet one can improve strategies by solving subgames. We introduce subgame-solving techniques that outperform prior methods in theory and practice. We also adapt them to respond to opponent actions that are outside the action abstraction; this significantly outperforms the prior state of the art, action translation. Finally, we show that subgame solving can be repeated as the game progresses down the tree, leading to lower exploitability. These techniques are key components of Libratus, the first AI to beat top humans in no-limit poker.

3 - Tiered Cloud Storage Pricing via Two-stage, Latency-aware Bidding

Vaneet Aggarwal, Purdue University, 315 N Grant St., West Lafayette, IN, 47906, United States, vaneet@purdue.edu, Yang Zhang, Arnob Ghosh, Lan Tian

In this paper, we wish to maximize the overall profit of the Cloud Service Providers (CSPs) that utilize a tiered storage architecture (with hot and cold storage tiers) with file placement and access request scheduling flexibilities. To this end, we propose a scheme where the CSP offers a two-stage auction process for (a) requesting storage capacity, and (b) requesting accesses with latency requirements. Our two-stage bidding scheme provides a hybrid storage and access optimization framework with the objective of maximizing the CSP's total net profit over four dimensions: file acceptance decision, placement of accepted files, file access decision and access request scheduling policy.

4 - Empirical Study on Effects of Defense Resource Allocations

Xiaojun (Gene) Shan, UHCL, Houston, TX, United States, shan@uhcl.edu, Jun Zhuang

In this paper, we use the method of statistical analysis based on data from Global Terrorism Database, which is available at National Consortium for the Study of Terrorism and Responses to Terrorism (START) and the Urban Area Security Initiative (UASI) grant allocations from FY 2004 to FY 2012 to study the effects of defense resource allocations. We conclude that ingeneral, effects of defense resources onreducing success probability of attack are mixed due to scarcity of terrorism data.

■ TA14

332D

Personalized Medicine

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: John Silberholz, University of Michigan, josilber@mit.edu

1 - Personalized Medicine in Cost-effective Management of Diffuse Large B-cell Lymphoma

Qiushi Chen, Massachusetts General Hospital, 101 Merrimac St., 10th FL, Boston, MA, 02114, United States, qchen@mgh-ita.org, Turgay Ayer, Christopher Flowers

Diffuse large B cell lymphoma (DLBCL) is the most common type of aggressive lymphoma. There are various treatment options available, and evidence shows that patients with DLBCL experience widely divergent outcomes. Recent findings imply that treatment tailored by biological subtypes represents a promising treatment strategy for DLBCL patients. In this study we assess the potential benefit of personalized treatment based on subtype with respect to health and cost outcomes, and compare with the one-size-fits-all treatment strategies.

2 - Personalized Treatments for Breast Cancer Patients

Emma L.Gibson, MIT, 60 Woodsworth Street, Cambridge, MA, 02142, United States, emgibson@mit.edu

There are many treatment options available to breast cancer patients, but it is often difficult to predict how successful these treatments will be for individual cases. We have developed a personalized treatment algorithm to select and evaluate treatment options based on individual diagnostic factors and existing medical conditions. When applied to cases in the SEER-Medicare dataset, our algorithm recommended alternative treatment options for approximately 10% of test subjects, resulting in an average estimated increase in survival time of 8 months within the first 8 years after diagnosis.

3 - The Price of Simplicity in Personalized Prostate Cancer Screening Strategies

John M.Silberholz, Assistant Professor, University of Michigan, 701 Tappan Street R5468, Ann Arbor, MI, 48109, United States, josilber@umich.edu

Patient preferences for different health states can significantly impact their best course of action in screening for diseases like prostate cancer. Patients with a relatively small disutility for treatment side effects might benefit from aggressive screening, while others might benefit from less aggressive screening or no screening at all. In this work, we use a mathematical model to quantify the benefit of fully personalized prostate cancer screening versus a one-size-fits-all strategy. Further, we identify simpler, more interpretable personalized screening strategies that could be easier to implement in practice, and we quantify the price of this simplicity in strategies.

4 - Personalised Treatment for Coronary Heart Disease Patients using Electronic Medical Records and Machine Learning

Agni Orfanoudaki, MIT, 77 Massachusetts Avenue, Cambridge, MA, United States, agniorf@mit.edu

Coronary Heart Disease is the most common type of heart disease and the leading cause of death in the United States. However, a common approach to determine which treatment to prescribe to which patient has not yet been established. On that basis, we recognized the substantial benefit that machine learning and algorithmic approaches could bring to this field. We developed a personalized prescriptive algorithm that uses EMR to maximize the expected time to an adverse event from the time diagnosis. Overall, we achieve 15,2% improvement for the overall population, performing particularly well in the female (17,5% improvement) and in the Hispanic subpopulation (24,8% improvement).

■ TA15

332E

Operations-Finance Interface

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: S. Alex Yang, London Business School, London, NW1 4SA, United Kingdom, sayang@london.edu

1 - Crowdfunding via Revenue-sharing Contracts

Soraya Fatehi, University of Washington, 5215 15th Avenue, Apt 15, 15, Seattle, WA, 98105, United States, sfatehi@uw.edu, Michael R.Wagner

We present a new model of crowdfunding where a platform acts as a matchmaker between a firm needing funds and a crowd of investors willing to provide capital. Once the firm is funded, it pays back the investors using revenue sharing contracts. The firm determines its optimal contract parameters to maximize its expected net present value, subject to investor participation constraints and platform fees. We use approximate firm solutions in a game-theoretic setting to analyze the platform's problem, which sets its optimal pricing structure, in the form of origination and servicing fees, to maximize its net present value, subject to firm participation constraints.

2 - Guarantor Financing in a Three-stage Supply Chain

Gangshu Cai, Santa Clara University, Department of OMIS, 216n Lucas Hall, Santa Clara, CA, 95053, United States, gcai@scu.edu, Weihua Zhou, Tiantian Lin

Based on a supply chain model with a manufacturer, a capital-constrained retailer, a third-party logistics (3PL) firm, and a bank, this paper investigates two types of guarantor financing, manufacturer guarantor and 3PL guarantor, and compares them to traditional bank financing.

3 - Inventory Risk and Financing Frictions for SME Suppliers

Fasheng Xu, Washington University in St. Louis, Saint Louis, MO, 63130, United States, fasheng.xu@wustl.edu, Panos Kouvelis, Wenhui Zhao

Most of the financing initiatives revolve around post-shipment approved-invoice financing. But SME suppliers would have cash flow difficulty financing production activities upfront. To fill this gap, we study a pull-structure supply chain with a large retailer and a SME supplier. The bank offers a fairly-priced loan for relevant operational risks and failure of loan repayment leads to costly bankruptcy. We identify the Stackelberg equilibrium and find the supplier's riskiness always dampen the retailer's profit, however may benefit the supplier itself. Interestingly, the supplier's riskiness may benefit the system and increase the supply chain's expected profit.

4 - Financial Pooling in a Supply Chain

S. Alex Yang, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, sayang@london.edu, Qu Qian, Ming Hu

We study a supply chain in which the buyer uses trade credit to purchase from the supplier. The embedded stretch option of trade credit allows supply chain partners to pool their liquidity buffers. Due to this pooling effect, even as the supplier's financing costs are higher than the buyer's, trade credit can be more effcient than cash on delivery when the supplier's cost for collecting trade credit is low or when the supplier does not have access to a low-cost financing channel when facing liquidity shocks. The benefit of pooling increases as the buyer has a more diversified supplier portfolio. As an innovative financing scheme, reverse factoring further enhances the effciency of this pooling effect.

■ TA16

332F

Operations Management

Contributed Session

Chair: Li Haiyan, Harbin Engineering University, Harbin, China, 643076746@qq.com

1 - Innovation Opportunities Emerging from Responsiveness and Co-located Manufacturing

Lauri Saarinen, University of Lausanne, Bâtiment Anthropole 3016, Lausanne, CH-1015, Switzerland, lauri.saarinen@unil.ch

Co-locating manufacturing with either the market or with R&D encourages innovation: Customer ideas are more easily communicated, and product and process innovations are more rapidly tested. We develop a system dynamics model of the interaction between responsiveness and innovation. We demonstrate that the real options created when responsiveness makes it possible to postpone the decision about what will be produced until demand information is available also generate follow-on options through innovation.

2 - Antecedents of New Venture Financing

Thomas Zehren, Assistant Lecturer and PhD Candidate, Technical University of Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, Thomas.Zehren@udo.edu

It is widely acknowledged that traditional capital market theories do not apply to the initial capital structure of new ventures. However, empirical evidence on the actual behavior is very limited. Drawing on a novel sample of over 4,000 new business owners, this paper examines the influence of founder- and venture-related characteristics on the initial capital structure. Our central contribution is that the provision of personal assets by the owner represents a central element of start-up financing. Additionally, we demonstrate that the access of external capital sources is mainly related to venture and not - as one would expect - to founder-related characteristics.

3 - Difficulties of Nascent Entrepreneurs: What Prevents Individuals from Starting a New Venture?
Jessica Moser, Assistant Lecturer and PhD Candidate, Technical University of Dortmund, Vogelpothsweg 87, Dortmund, 44227, Germany, Jessica.Moser@udo.edu

This research analyzes the influences of multiple barriers nascent entrepreneurs (NEs) encounter on their outcome status - still trying, disengaged or started - and on their start-up intention after disengaging. Drawing upon a novel and recent sample of 872 NEs, this paper finds that recently disengaged individuals have faced significantly more barriers than other NEs. A deeper analysis displays that financing difficulties and especially personal barriers hinder a venture creation. In addition, barriers beyond a NE's own control are identified to be lethal for the continuance of the intention to create a new business. Major implications for NEs and policymakers regarding barriers are derived.

4 - Dimension of VC-E Trust Based on the "Guanxi" Culture in China
li haiyan, Harbin Engineering University, Harbin, 000451, China, 643076746@qq.com, Yang hongtao

The dimension of VC - E trust is divided into three aspects: computational trust, knowledgeable trust and relational trust. The results show that relationship trust is particularly important to the performance of start-ups in China. VC and E can share resources in the phase of relational trust.Acknowledgement: This paper is funded by the International Exchange Program of Harbin Engineering University for Innovation-oriented Talents Cultivation.

■ TA17

340A

Random Graphs and Learning in Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Jiaming Xu, Purdue University, West Lafayette, IN, 47907, United States, xu972@purdue.edu

1 - The Lovasz Theta Function of Random Graphs and Community Detection in the Hard Regime
Cris Moore, Santa Fe Institute, Santa Fe, NM, United States, moore@santafe.edu

Community detection and graph coloring is believed to have a hard regime, in between an informational threshold and a computational one, where inference is possible but exponentially hard. In particular, in this range it should be hard to refute the existence of a community structure in a null random graph model. We confirm this for refutations that use the Lovasz theta function, or equivalently degree-two sum-of-squares proofs. This is joint work with Jess Banks and Robert Kleinberg.

2 - Estimating the Number of Connected Components of Large Graphs Based on Subgraph Sampling
Yihong Wu, Yale University, yihong.wu@yale.edu, Jason Klusowski

Learning properties of large graphs from samples is an important problem in statistical network analysis. We revisit the problem of Frank '78 of estimating the numbers of connected components based on subgraph sampling, where a subgraph induced by vertices drawn uniformly at random is observed. The key question is whether accurate estimation is possible if we only sample a vanishing fraction of the vertices. We show that this is impossible if the graph contains high-degree vertices or long induced cycles; otherwise, it is possible by accessing only sublinear number of vertices. Optimal sample complexity are obtained for several classes of graphs including forests, cliques and chordal graphs.

3 - Optimal Community Recovery on the Weighted Stochastic Block Model
Varun Jog, University of Wiscconsin-Madison, vjog@wisc.edu

The Stochastic Block Model (SBM), which is one of the most well-studied statistical models for community detection, has an important limitation: it assumes that each network edge is drawn from a Bernoulli distribution. This is rather restrictive, since weighted edges are ubiquitous in scientific applications, and disregarding edge weights results in a loss of information. In this talk, we study a weighted generalization of the SBM. We propose and analyze a novel algorithm for community estimation and show that it is optimal in terms of its rate of convergence.

4 - On the Local Minima of Nonconvex Matrix Completion with Arbitrary Condition Numbers and General Sampling Patterns
Xiaodong Li, University of California, Davis, CA, United States, xdgli@ucdavis.edu, Ji Chen

In recent years much progress has been made in the theory of nonconvex matrix completion. However, strong conditions are usually required for the condition numbers and sampling patterns. In this work, we study the properties of local minima of nonconvex matrix completion with general sampling patterns and arbitrary condition numbers. We apply this general framework to some specific random graph-based sampling patterns to obtain novel approximate recovery results for all local minima. As a byproduct, we also improve the state-of-the-art no-spurious-local-minima results in the literature under strong conditions of the condition numbers and sampling patterns.

■ TA18

340B

Joint Session MSOM/APS: Supply Chain and Inventory in Applied Probability II

Sponsored: Applied Probability

Sponsored Session

Chair: Xiting Gong, The Chinese University of Hong Kong, Hong Kong, xtgong@se.cuhk.edu.hk

Co-Chair: Xiuli Chao, University of Michigan, Ann Arbor, MI, 48109, United States, xchao@umich.edu

1 - Asymptotic Optimality of Constant Order Policies for Lost Sales Inventory Models with General Supply Functions
Jinzhi Bu, The Chinese University of Hong Kong, Hong Kong, njujzhbu@gmail.com, Xiting Gong, Dacheng Yao

In this paper, we study the constant-order policies (COP) for the lost-sales inventory system with positive lead times and general supply functions. Besides analyzing the asymptotic properties of the best COP with large lead times and large penalty costs, we construct a simple while asymptotically optimal heuristic COP and carry out extensive numerical studies to investigate the COP's performances.

2 - Joint Assortment and Pricing Optimization with Demand Learning
Sentao Miao, University of Michigan, Ann Arbor, MI, 48104, United States, semiao@umich.edu, Xiuli Chao

We study a joint assortment and pricing optimization problem where customers arrive sequentially and make purchasing decisions based on a multi-nomial logit (MNL) model. Without prior information about customers' demand for products, the retailer selects subset of products for display and set their prices through learning customer behavior to maximize its expected total profit over a finite selling horizon. By a special structure of the MNL model, we design an algorithm that estimates the consumer's demand and sets the assortment and price for each period. The algorithm balances the trade-o ff between learning the demand and maximizing the revenue, and is shown to be asymptotically optimal.

3 - Optimality of Order-up-to Policies for Serial Inventory Systems with Lost Sales
Woonghee Tim Huh, University of British Columbia, Sauder School of Business, Operations and Logistics Division, Vancouver, BC, V6T.1Z2, Canada, tim.huh@sauder.ubc.ca, Marco Bijvank, Ganesh Janakiraman

We study how to manage a serial inventory system under periodic review when excess demand at the most downstream stage is lost. First, we show that there is an echelon order-up-to policy that is asymptotically optimal as the lost-sales penalty cost parameter grows large. We also show that this asymptotic optimality result is robust in the sense that there is a large family of order-up-to policies such that it continues to hold. Next, we propose a heuristic rule to set the order-up-to levels based on the algorithm of Clark and Scarf where the resulting policy performs close to the best order-up-to policy even when the penalty cost is not large. Finally, we extend the optimality results to (R,nQ) policies.

4 - Performance Bounds and Asymptotic Optimality of Modified (R,Q) Policies for Stochastic Distribution Inventory Systems
Frank Y. Chen, City University of Hong Kong, Dept of Management Sciences, AC1, Tat Chee Avenue, Hong Kong, youhchen@cityu.edu.hk, Han Zhu, Ming Hu, Yi Yang

We study a classic one-warehouse multi-retailer distribution system, in which any inventory replenishment at each location incurs a fixed-plus-variable cost and takes a constant lead time. The optimal policy is unknown. We identify an easy-to-compute heuristic policy within the class of modified echelon (r, Q) policies that does not require an integer-ratio property or a synchronized, nested ordering property, yet has easily computable performance bounds. The proposed heuristic policy is asymptotically optimal.

■ TA19

342A

General OM-Finance Interface

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Yuqian Xu, New York University, 44 West 4th Street, New York, NY, 10012, United States, yxu@stern.nyu.edu

Co-Chair: Mike Pinedo, New York University, 44 West 4th Street, New York, NY, 10012, United States, mpinedo@stern.nyu.edu

1 - Cash Conversion Systems in Corporate Subsidiaries

Weiwei Chen, Rutgers Business School - Newark and New Brunswick, Piscataway, NJ, United States, wchen@business.rutgers.edu, Benjamin Melamed, Ben Sopranzetti, Oleg Sokolinskiy

This paper models a cash conversion system in a subsidiary of a parent company, where there is an active internal capital market, but otherwise the subsidiary has no access to additional external funds. The cash conversion system implements a perpetual flow cycle, where funds convert to product and back to funds. We model this system as a discrete-state continuous-time Markov process, and compute statistics of the equilibrium cash conversion cycle. We further optimize the financial and operational designs of the system, so as to maximize its financial rate metrics. Finally, we study numerically the impact of friction in such parent-subsidiary relationship.

2 - Dynamic Financial Hedging and Inventory Management for a Storable Commodity

Zhan Pang, City University of Hong Kong, Hong Kong, zhan.pang@cityu.edu.hk

Managing demand and price risks for commodity inventory remains a major challenge for firms facing volatile raw material prices. Consider a firm purchasing a raw material from a spot market with the access to a financial derivative market where derivative contracts can be used to hedge the price risk. We formulate this problem as a dynamic program in the Markowitz mean-variance framework. Recognizing the time-inconsistency of the mean-variance objective, we analyze a class of time-consistent policies and identify the market conditions under which an optimal time-consistent policy can be optimal. The roles and relationship of inventory and derivatives in hedging are discussed.

3 - On a Firm's Optimal Response to Pressure for Gender Pay Equity

David Anderson, Baruch College, City University of New York, 55 Lexington Ave, Office 9-251, New York, NY, 10010, United States, DavidRybergAnderson@gmail.com, Margret V. Bjarnadottir, Cristian Dezsö, David Gaddis Ross

We present a theory of how a firm would rationally respond to pressure for gender pay equity. We show that (a) employees in low-paying jobs and whose job-related traits typify men at the firm are most likely to get raises; (b) counterintuitively, some men may get raises and giving raises to certain women would increase the pay gap; (c) a firm can reduce the gender pay gap as measured by a much larger percentage than the overall increase in pay to women at the firm; and (d) "ghettoizing" women in select jobs can help a firm reduce its pay gap.

4 - Operational Risk Management of Commercial Institutions

Yuanqiao Chen, Nanjing University, Nanjing City, China, ccyykalcc@163.com, Michael L.Pinedo

Operational risk is the risk of losses caused by failed internal processes, people, systems or external events. We propose a process-based model to help organizations predict potential operational losses and determine capital reserves. The model enables us to use available data to predict via a probabilistic network based on process.

■ TA20

342B

Product and Manufacturing Process Development and Innovation in Healthcare

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Zhili Tian, Florida International University, Weston, FL, 33327-2444, United States, ztian99@gmail.com

1 - An Empirical Analysis of the Effects of Personnel Scheduling on Hospital Performance

Bogdan C. Bichescu, The University of Tennessee, 229 Stokely Management Center, 916 Volunteer Blvd, Knoxville, TN, 37996-0525, United States, bbichescu@utk.edu, Randy V. Bradley, John E. Bell, Joonwhan In, Wei Wu

Despite efforts to improve scheduling and resource allocation via the adoption of disparate technologies in hospitals, there is still a lack of empirical evidence that indicates where, and if, the value proposition of such investments exists. We employ regression modeling to analyze a panel of 268 hospitals. Our findings suggest which scheduling applications impact which specific measures of hospital performance. This study offers several theoretical and managerial implications, which contribute to a better understanding of the potential benefits of the use of technology applications for personnel scheduling.

2 - Optimal Investment in Support of Current Drug and Development of New Drug

Zhili Tian, Florida International University, Miam, FL, 33139, United States, ztian99@gmail.com

The marketing spending on the drugs is often equal to or even higher than that for developing a new drug. Despite so much investment in the new drug development, only around twenty new drugs are approved every year for the entire pharmaceutical industry. To boost their revenues, firms often emphasize marketing of the current drugs at the expense of developing new drugs. However, the source for the two competing investments is from the revenues of the existing drugs. Hence we develop models to address the investment in the existing drugs and development of new drugs. Our methods optimally allocate the fund between marketing communication and new drug development for the following three scenarios.

3 - Outsourcing Strategy for Intermediate Production Steps

Yang Wang, University of California-Berkeley, Berkeley, CA, United States, yangwang0803@gmail.com, Philip Kaminsky

Biopharmaceutical firms often outsource their final filling, labeling and packing operations to a third party outsourcer, leaving these firms susceptible to long and variable lead time due to queuing at the outsourcer. To address this issue, a so-called capacity reservation policy is proposed, in which means the firm reserves some fixed capacity at the outsourcer at given intervals to guarantee short and less variable lead time. We show the benefit of such a policy compared to the traditional polices when the lead time is intrinsically random, and conclude that the policy not only reduces the inventory and ordering cost at the firm, but also increases the profit of the outsourcer.

■ TA21

342C

Joint Session PSOR/Natural Hazards: Humanitarian Assistance and Disaster Relief

Invited: InvitedNatural Hazard Planning

Invited Session

Chair: Erica L. Gralla, Washington, DC, 20052, United States, egralla@gwu.edu

Co-Chair: Keziban Rukiye Tasci, Northeastern University, MA, 02115, United States, tasci.k@husky.neu.edu

Co-Chair: Ozlem Ergun, Northeastern University, Boston, MA, 02115, United States, o.ergun@neu.edu

1 - Modeling the Values of Private Sector Agents in Humanitarian Supply Chains

Jarrod D. Goentzel, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E38-650, Cambridge, MA, 02139, United States, goentzel@mit.edu, Corinne Carland, Gilberto Montibeller

Humanitarian organizations (HOs) increasingly engage the private sector to achieve their goals but must understand the different objectives and priorities of such agents to be effective. To develop such knowledge, we formalize an approach based on multi-attribute value analysis and apply it with agents across a multi-echelon health supply chain in Uganda, with a focus on malaria rapid diagnostic tests. Our findings show that objectives are not aligned in this supply chain, but also reveal how our approach can improve private sector engagement, which may be crucial for humanitarian outcomes.

2 - The Post-disaster Debris Clearance Problem with Resource Allocation and Learning

Seyma Guven-Kocak, Georgia Institute of Technology, 1235 Parkway Circle N, Atlanta, GA, 30340, United States, seymaguven@gatech.edu, Pinar Keskinocak

In the aftermath of a disaster, debris blocks roads and hampers critical response operations such as search-and-rescue and relief transportation, so that it needs to be cleared quickly and efficiently. However, debris management is expensive and complicated. This work, motivated by the debris clearance operations in a post-disaster situation, addresses a problem of establishing connectivity between the nodes on a disrupted network with inherent uncertainty and learning. We explore structural results on various special networks, which provide insight for the problem on more general networks.

3 - A Variational Equilibrium Network Framework for Humanitarian Organizations in Disaster Relief: Effective Product Delivery under Competition for Financial Funds

Anna B. Nagurney, University of Massachusetts Amherst, Isenberg School of Management, Dept of Operations & Information Mgmt, Amherst, MA, 01003, United States, nagurney@isenberg.umass.edu, Patrizia Daniele, Emilio Alvarez Flores, Valeria Caruso

In this paper, we present a new Generalized Nash Equilibrium (GNE) model for post-disaster humanitarian relief that captures competition and with novel financial funding and altruism functions. The common shared constraints associated with the relief item deliveries at points of need are imposed by an upper level humanitarian organization or regulatory body and consist of lower and upper bounds to ensure the effective delivery of the estimated volumes of supplies to the victims of the disaster. We formulate the variational equilibrium and illustrate the game theory model through a case study focused on tornadoes hitting western Massachusetts, a highly unusual event that occurred in 2011.

4 - Practice-based Heuristics for Humanitarian Transportation Planning

Erica L. Gralla, George Washington University, 800 22nd st NW, Rm 2680, Washington, DC, 20052, United States, egralla@gwu.edu

Transportation is a critical challenge in humanitarian response, but adoption of optimization-based decision support has been limited due to the difficulty of implementation. We evaluate the performance of heuristics based on current planning practices, identify key weaknesses, and suggest ways to improve planning while maintaining implementability.

5 - Supply Chain Modeling of Large Scale Humanitarian Food Aid Operations with Different Transfer Modalities

Keziban Rukiye Tasci, Northeastern University, 77 Westland Avenue #5, Boston, MA, 02115, United States, tasci.k@husky.neu.edu, Ozlem Ergun

Large humanitarian organizations strive to serve millions of beneficiaries spread around the globe by delivering many different commodities and services on time while abiding by organizational and governmental regulations. This study describes a time expanded network model that determines the cost-effective ways to supply pre-decided basket of commodities via using traditional food delivery and cash & voucher modalities for one of the largest humanitarian aid agencies in the world. Through these models and analysis of historic procurement data we identify significant improvement opportunities for the organization's supply chain operations.

■ TA22

342D

Applications of Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Maxime Cohen, maxccohen@gmail.com

1 - Price and Availability Discrimination, Exclusive Goods and Social Networks

Ruslan Momot, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, ruslan.momot@insead.edu, Elena Belavina, Karan Girotra

We study the value of price and availability discrimination when selling goods whose value derives from exclusive ownership in a social network. We build a stylized model of socially interacting customers who differ in their network position (degree) and their proclivity for social comparisons (conspicuity). We find that firm's optimal strategy is to set price proportional to product of customer's degree and conspicuity and exclusively offer the product to only high conspicuity customers with sufficiently low degree. We find that price and availability discrimination are substitutes. While availability is useful instrument on its own, it has limited values when price discrimination is possible

2 - Pricing and Assortment Strategies with Product Exchanges

Laura Wagner, IESE Business School, Calabria, Barcelona, Spain, LWagner@iese.edu, Victor Martinez de Albeniz

Return policies enable consumers to return or exchange products they are unsatisfied with. We develop a search framework where consumers sequentially learn about products' true value and decide whether to keep, exchange or return them. We show that when pricing is not a decision, the assortment problem is NP-complete. When pricing is endogenous, the optimization becomes tractable and it is not necessarily optimal to set all products at equal margins. Finally, we find that retailers prefer to pass all return costs on to the consumers, and that this decision can also be beneficial to consumers.

3 - Earning and Learning with Varying Cost

Ying Zhong, City University of Hong Kong, Kowloon Tong, Hong Kong, yzhong4-c@my.cityu.edu.hk, Jeff Hong, Guangwu Liu

The earning-and-learning problem refers to the profit maximization problem where one optimizes the profit by choosing a price and learns the demand at the same time. Traditionally, the cost is fixed and the problem may be formulated as a multi armed bandit problem, which is known to have an O(logT) lower bound on the expected regret, where T is the number of periods. In this paper, we consider the case where the cost changes over periods. Then, the optimal pricing decision becomes a function of the cost. We propose an upper-confidence-bound type of algorithm to solve the problem. We find that, surprisingly, the expected regret may be bounded by a constant under certain conditions.

4 - Forecasting and Price Optimization for a Beverage Company: Theoretical Questions Arising from Practice

Will Ma, Massachusetts Institute of Technology, 71 School Street, Cambridge, MA, 02139, United States, willma353@gmail.com, Hanwei Li, David Simchi-Levi, Jinglong Zhao

We discuss our experience conducting demand forecasting and price optimization at a global beverage company, which controls its pricing through multiple retailers. We discuss many different substitution patterns observed in the data: internally within the company's products, externally with competitors' products, over time, and between different retailers. The business contstraints on pricing also give rise to various unsolved theoretical questions.

■ TA23

342E

Revenue Management for Marketing and Service Systems

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: John G Turner, University of California-Irvine, Irvine, CA, 92697-3125, United States, john.turner@uci.edu

1 - Optimal Signaling Mechanisms in Unobservable Queues with Strategic Customers

David Lingenbrink, Cornell University, Ithaca, NY, United States, dal299@cornell.edu, Krishnamurthy Iyer

We consider an unobservable M/M/1 queue offering a service at a fixed price to a Poisson arrival of delay-sensitive customers. The service provider can observe the queue, and may share information about the queue with arriving customers. The customers incorporate this information into their prior beliefs before making the decision to join or balk. We pose the following question: which signaling mechanism and what price should the service provider select to maximize her revenue? We formulate this problem as an instance of dynamic Bayesian persuasion, characterize the structure of the optimal signaling mechanism, and compare its revenue with that of the optimal state-dependent pricing mechanism.

2 - Price Discrimination over Quality via Aggregate Rebate Programs

Amir Ajorlou, Massachusetts Institute of Technology, 32 Vassar Street, 32-D569, Cambridge, MA, 02139, United States, ajorlou@mit.edu, Ali Jadbabaie, David Simchi-Levi

Firms selling network goods can enjoy a marginal gain in profit due to the network effect. Early adopters improve the social value of the product and firm can raise the price when the product becomes more popular. Motivated by this observation, we pose the question as to whether it is beneficial to a firm selling a product with no network effect to artificially inject externality? To this end, we propose an aggregate reward program where the reward paid to the consumers is a function of the sales volume. By analyzing the equilibria of the induced global game among consumers, we show that the optimal reward program pays back the buyers a fixed rebate, if the product fails to reach certain level of popularity.

3 - Waterfall Yield Optimization for Online Advertising

Dmitri Arkhipov, University of California, 23 Bethany Drive, Irvine, CA, 92603, United States, darkhipo@ics.uci.edu, John G. Turner, Michael Dillencourt, Ameila C. Regan

In programmatic advertising, advertisements are matched to users. Quality matches may take time to compute, time being a scarce resource particularly for publishers who would like their webpages to load quickly. Policies for ad placement must execute very quickly; this necessitates policies are either simple or are pre-computed offline. The order in which advertisers are offered ad spaces as these become available is referred to as a waterfall and the process of finding a good or optimal such ordering is referred to as yield optimization. We formulate a stochastic optimization problem to solve a publisher's waterfall yield optimization problem.

■ TA24

342F

Mean Field Approaches and Applications

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Gabriel Weintraub, Stanford Graduate School of Business, Stanford, CA, 94304, United States, gweintra@stanford.edu

1 - Pairwise Comparisons for Online Reputation Systems

Nikhil Garg, 825 Menlo Avenue, Apt G, Menlo Park, CA, 94025, United States, nkgarg@stanford.edu, Ramesh Johari

Modern online marketplaces rely on reputation systems to assess participants, and enable search and matching. Typically, these systems rely on cardinal ratings — e.g., the ubiquitous five star rating system. Inspired by a number of issues that these systems have encountered in practice, we suggest an alternative: reputation systems based on pairwise comparisons. We use a mean field model to compare and contrast such a rating system with cardinal ratings, and present theoretical results, simulations, and empirical analysis that suggest that such rankings can be significantly more informative than cardinals ratings.

2 - An Empirical Framework for Sequential Assignment Allocating Deceased Donor Kidneys

Itai Ashlagi, Stanford University, Department of Management Sci. and Engr., Stanford, CA, 94305, United States, iashlagi@stanford.edu

We provide an empirical framework for designing the allocation of cadaver organs.

3 - Transitional Market Dynamics in Complex Environments

Gabriel Weintraub, Stanford Graduate School of Business, Knight Management Center, Stanford University, 655 Knight Way, E364, Stanford, CA, 94304, United States, gweintra@stanford.edu, Lanier Benkard, Przemek Jeziorski

Recent work in dynamic oligopoly models uses mean-field approaches to approximate long-run Markov perfect industry dynamics. In several applications though, one is interested in the short-run dynamic behavior of an industry after a policy or environmental change. We introduce a mean-field approach for these settings and show that a "resolving" version provides accurate approximations even in concentrated industries. We illustrate our methods with several dynamic oligopoly models relevant to IO and also in a model of network effects.

4 - On Matching in Ridesharing Systems

Amy R. Ward, University of Southern California, Marshall School of Business, Bridge Hall BR.I.401H, Los Angeles, CA, 90089-0809, United States, amyward@marshall.usc.edu, Erhun Ozkan

In a ridesharing system such as Uber or Lyft, arriving customers must be matched with available drivers. These decisions affect the overall number of customers matched, because they impact whether or not future available drivers will be close to the locations of arriving customers. A common policy used in practice is the closest driver policy that offers an arriving customer the closest driver. This is an attractive policy because it is simple and easy to implement. However, we expect that a forward-looking parameter-based policy can achieve better performance. We prove asymptotic optimality of a matching policy based on a continuous linear program in a large market regime

■ TA25

350A

Recent Advances in Oil and Gas I

Invited: Energy Systems Management

Invited Session

Chair: Leah Kaffine, GE Energy Consulting, 16100 W 62nd Dr, Arvada, CO, 80403, United States, leah.kaffine@ge.com

1 - Integrated Gas Electric Modeling with GE MAPS and RBAC GPCM

Leah Kaffine, GE Energy Consulting, 16100 W. 62nd Dr, Arvada, CO, 80403, United States, leah.kaffine@ge.com

Examine the importance of a time varying price elasticity assumption of natural gas demand for power in RBAC's GPCM model. By default, these assumptions are homogenous and independent of time. Coal retirements, renewables and increased gas fired generation are impacting the ability to respond to price signals.

2 - Economic and Environmentally Conscious Supply Chain Network Optimization for Determination of Potential Infrastructure and Production of Biogas

Yong Shin Park, North Dakota State University/UGPTI, 1940 Dakota Drive N, Apt 203, Fargo, ND, 58102, United States, yong.park@ndsu.edu, Joseph Szmerekovsky

Supply chain network design for the animal waste including biogas facility have not been addressed in the previous research. In response, we develop economic and environmentally conscious supply chain design of cattle manure to energy by incorporating carbon policy including carbon tax and cap and trade scheme. Mixed Integer Linear Programming (MILP) approach identify the optimal location of biogas plants and capacities to treat cattle waste from farm, and investigate the impact of the carbon policy on tactical and strategic supply chain decisions. A case study of North Dakota is adopted where there is high potential for biogas production based on number of cattle inventory.

3 - Black Carbon Projection in Energy Model

Cheng (Marshal) Wang, Economist, Environment and Climate Change Canada, 200 Sacré-Coeur Blvd., Office 1053, Gatineau, QC, J8X 4C6, Canada, cheng.uot@gmail.com

Black Carbon is both a short-lived climate pollutant and an air pollutant linked to adverse health effects. Canada, as a member of an Arctic Council, so far has submitted black carbon inventories for 2013 and 2014 in the last two years to the Arctic Council following Convention on Long Range Transboundary Air Pollution guidelines. The objective of this presentation is to provide background information on black carbon and its relationship to climate change, explain the new BC reporting requirements, and provide a progress report on the development of black carbon projections, collective BC target and challenges.

4 - The Causality between Prices and Operating-equipment Costs in the Oil and Gas Industries

Sergio Cabrales, Visiting Professor, Universidad de los Andes, Calle 19 A.no 1-37 Este, ML-758, Bogota, 111711, Colombia, s-cabral@uniandes.edu.co, Laura Herrera, Jesús Godoy

Is there a bidirectional causal relationship between prices and costs in oil and gas markets? This paper studies the causality between prices and operating and equipment costs in oil and gas industries, using annual indexes (1976—2009). In oil market, we find a bidirectional Granger causality relationship between prices and operating costs. By contrast, in gas market, we observe the Granger causality only in one direction, indicating a causality of operating costs on gas prices. Finally, in contrast to operating costs, we do not find Granger causal relationship between prices and equipment costs in oil and gas industries.

■ TA26

350B

Operational Implications of 3D Printing

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Lingxiu Dong, Washington University, Saint Louis, MO, 63130-4899, United States, dong@wustl.edu

Co-Chair: Duo Shi, Olin Business School, Washington University-St Louis, St. Louis, MO, 63130, United States, dshi@wustl.edu

1 - Stock or Print? Impact of 3D Printing on Spare Parts Logistics

Yue Zhang, Duke University, 5507 Butterfly Ln Apt 207, Durham, NC, 27707, United States, yueyue.zhang@duke.edu, Jing-Sheng Jeannette Song

We present a general framework to analyze and quantify the impact of 3D printing on spare parts logistics. We consider multiple parts facing stochastic demands. To minimize long-run average system cost, our model determines which parts should be printed and which should be stocked and the corresponding base-stock levels. We derive various structural properties and characterize the optimal policy for several special systems, which lead to efficient near-optimal heuristic solutions for the general system. We demonstrate that adopting 3D technology can yield significant cost savings and this impact increases in part variety.

2 - Personal Fabrication as an Operational Strategy: Value of Delegating Production to Customer

Nagarajan Sethuraman, PhD Candidate, University of North Carolina, Campus Box 3490, McColl Building, Chapel Hill, NC, 27599, United States, Nagarajan_Sethuraman@kenan-flagler.unc.edu, Ali Kemal Parlakturk, Jayashankar M.Swaminathan

In this paper, we study an operational strategy enabled by 3D printing—- Personal Fabrication (PF) —-in which a firm focuses on product's design and delegates its production to customers. We characterize the conditions under which, such a strategy benefits the firm. We study the implications of various roadblocks for such a strategy: high production costs of 3D printing, intellectual property concerns and product liability issues.

3 - Evaluating the Potential of Additive Manufacturing for Spare Parts Supply

Rob Basten, Eindhoven University of Technology, P.O. Box 513, IE&IS.- OPAC, Eindhoven, 5600 MB, Netherlands, r.basten@utwente.nl, Bram Westerweel, Geert-Jan Van Houtum

We investigate the decision of whether or not to replace a regularly produced spare part with an alternative produced via additive manufacturing (AM), also called 3D printing. Such a transition requires a one-time investment and changes characteristics such as procurement lead time, production costs and component reliability. We consider the entire product lifecycle and take into account performance benefits and design, inventory, maintenance and downtime costs. We derive analytical properties of the required reliability and production costs of the AM part such that its lifecycle costs break even with that of its regular counterpart.

4 - 3D Printing vs. Traditional Flexible Technology: Implications for Operations Strategy

Duo Shi, Olin Business School, Washington University-St Louis, K.H.401, Olin Business School, 1 Brookings Drive, St. Louis, MO, 63130, United States, dshi@wustl.edu, Lingxiu Dong, Fuqiang Zhang

We study a firm's operational strategy under two types of flexible production technologies: the traditional flexible technology and 3D printing. Under the traditional flexible technology, capacity becomes more expensive as it handles more product variants; under 3D printing, however, capacity cost is independent of the number of product variants processed. The firm possesses a dedicated technology and may additionally adopt one or both of the two types of flexible technologies. Our results demonstrate that the rising 3D printing has significantly different implications for firms' assortment and production strategy than the traditional flexible technology.

■ TA27

350C

Network Analysis with Social Media Data

Invited: Social Media Analytics

Invited Session

Chair: Alexander Nikolaev, University at Buffalo, Buffalo, NY, 14260-2050, United States, anikolae@buffalo.edu

1 - Explaining the Emergence of Power Laws in Online Social Networks

Rakesh Nagi, SUNY- Buffalo, Buffalo, NY, United States, nagi@illinois.edu, Sushant Khopkar, Alexander Nikolaev

We present a method for parameterizing a network formation model that explains how the information about "socially contagious" individuals/items propagates into the masses, and the power law in degree emerges as these individuals/items reach new followers. We report the inferred model parameter values for several real-world social media datasets.

2 - Clustering of Ordered Restaurant Rankings on Yelp.com

Alexander Semenov, University of Jyväskylä, Jyväskylä, Finland, alexander.v.semenov@jyu.fi, Alexander Nikolaev

The ease of posting anonymous reviews online has created many opportunities for people to express their opinions about products and services in social media sites. The difference in opinions may or may not imply malicious behavior; in any case, identifying multiple groups of users, sharing different distinct views on how the evaluated items fair against each other, may help us better understand the diversity in tastes. We present a method to identify distinct user groups based on how they rank restaurants on Yelp.com, and interpret the results.

3 - Network Analysis of Social Media Portal VK.com

Vladimir Boginski, University of Central Florida, Orlando, FL, 32541, United States, Vladimir.Boginski@ucf.edu, Alexander Nikolaev, Alexander Veremyev, Eduardo Pasiliao, Alexander Semenov

The "post-Soviet space" includes a group of countries with a substantial fraction of the world's population and spans multiple time zones and cultures, creating a unique geopolitical mixture. We present the study of the social network of VK.com (also known as VKontakte), which is the largest European (mainly Eastern-European) social portal, with over 300 million nodes. We analyze several aspects of the VK network structure, including its global connectivity patterns and community composition and draw conclusions about the "social media landscape" of the post-Soviet space.

4 - Engagement-based Predictive Analyses of the Growth of Online Health

Rahul Gopalsamy, University at Buffalo, 409 Bell Hall, Buffalo, NY, 14260-2050, United States, rahulgop@buffalo.edu, Alexander Nikolaev, Scott McIntosh, Alexander Semenov, Eduardo Pasiliao

The research on nurturing the growth of online communities posits that it is in part attributed to the network externality effects. This study uses the data of a large online portal to show that user engagement - measurable using the recently introduced metric "engagement capacity" - has a positive causal effect on online health community growth, opening the door to exploiting network externality effects in calculated ways.

■ TA28

350D

Behavioral Models in Auctions

Invited: Auctions

Invited Session

Chair: Kyle Woodward, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599-3305, United States, kyle.woodward@unc.edu

1 - Auctions with Max-min Players

Kyle Woodward, University of North Carolina at Chapel Hill, Department of Economics, Gardner Hall, CB #3305, Chapel Hill, NC, 27599-3305, United States, kyle.woodward@unc.edu, Marek Pycia

Multi-unit auctions are commonly used to allocate government debt and electricity generation, but little is known about equilibrium strategies under private information. We show that when bidders have max-min beliefs over opponents' information, equilibrium is analytically tractable; our results apply to both private- and interdependent-values models. We define a natural equilibrium selection, upside dominance, implying equilibrium uniqueness; we show upside dominance to be equivalent to limiting forms of risk and ambiguity aversion. In upside-dominant equilibrium pay-as-bid auctions revenue-dominate uniform-price auctions, offering novel evidence favoring pay-as-bid auctions.

2 - Declining Prices Across Second-price Reverse Auction Formats

Marion Ott, RWTH Aachen University, Templergraben 64/V, Aachen, 52062, Germany, marion.ott@rwth-aachen.de, Karl-Martin Ehrhart

In four experimental reverse second-price auction formats for procuring a good for which bidders have uncertain private values, we find declining auction prices across the four formats. Pseudo-endowment effect arguments on psychological ownership, detachment, and willingness-to-pay/willingness-to-accept disparity predict the order of the declining prices. We conclude that auctions that foster detachment from an item may lead to lower payments.

3 - Empirical Relevance of Ambiguity in First-price Auctions

Gaurab Aryal, University of Virginia, VA, United States, aryalg@virginia.edu

We study the identification and estimation of the first-price auction model with IPV when risk averse bidders face ambiguity about the value distribution and have maxmin expected utility. We use variation in the number of bidders to nonparametrically identify the true value distribution and the lower envelope in the bidders' set of priors. We propose a flexible Bayesian estimation method based on Bernstein polynomials. MC experiments show that our method estimates parameters precisely and chooses the reserve prices with (nearly) maximal revenues. We apply our method to U.S. timber auctions and find evidence of ambiguity in auctions from the Pacific Northwest region.

4 - Threshold Problems in Ascending Combinatorial Auctions

Bart Vangerven, KU. Leuven, Naamsestraat 69, Leuven, 3000, Belgium, bart.vangerven@kuleuven.be, Dries Goossens, Frits C.Spieksma

We experimentally study bidding behavior in ascending combinatorial auctions with threshold problems, using human bidders. We vary feedback from very basic information about provisional allocations, to more advanced concepts as winning/deadness levels, and even coalitional feedback, aimed at helping bidders to overcome threshold problems. The main question we address is the following: `Does additional feedback help bidders overcome threshold problems in ascending combinatorial auctions?' We test this in different auction environments, investigating the effects on economic efficiency, auction revenues, duration, etc.

■ TA29

350E

Artificial Intelligence Problems in Real World

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Jiaheng Xie, University of Arizona, 1130 E Helen Street, Tucson, AZ, 85721, United States, xiej@email.arizona.edu

1 - Genetic Algorithms for Electrical Harness Routing During Satellite Conception

Eliott Roynette, PhD Student, Airbus Defence and Space, 31 Rue des Cosmonautes, Toulouse, 31400, France, eliott.roynette@gmail.com, Cedric Pralet, Vincent Vidal, Bertrand Cabon

In the space industry, every satellite is unique and customized for its mission. In this presentation, we introduce a multi-criteria genetic algorithm for helping in the conception of the 3D routing of the electrical harness, which is responsible for establishing physical connections between several thousands of devices of the satellite. This algorithm is used for obtaining a tradeoff between the total weight of the harness and the complexity of its manufacturing. In the end, we show how using OR tools brings a strong advantage to space engineers both for speeding and optimizing the conception process of real satellites.

2 - Forecasting Crude Oil Price: A Novel Decompose-ensemble Methodology with AIC-ANN Approach

Yishan Ding, Shanghai Jiaotong University, Huashan Road 1954, Xuhui District, Shanghai Jiaotong University, Zhongyuan, Shanghai, 200030, China, dys90@163.com

Forecasting international crude oil is a well-known issue. Hybrid methodology has been widely used in current research. In this study, a novel decompose-ensemble prediction process is proposed. This method, adds the decompose-ensemble to the single AI model to further improve the predicting accuracy. It has been confirmed that "decompose-ensemble" models are better than the normal hybrid one, in terms of prediction accuracy (both level and directional measurement) and Diebold-Mariano test. What's more, the EEMD-based one outperforms the empirical mode decomposition(EMD) one. At last but not the least, AIC gives us reasonable and convincing statement about determining the value of lag.

3 - Advantages of the Parameter Control Strategy Over the Parameter Tuning: A Case Study for the Berth Scheduling Problem at Marine Container Terminals

Maxim A.Dulebenets, Florida A&M.University-Florida State University, 2300 Bluff Oak Way, Apt. 8408, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Eren Erman Ozguven, Ren Moses, Thobias Sando

This study proposes a novel Evolutionary Algorithm to assist with berth scheduling at marine container terminals, which unlike published to date studies on berth scheduling applies a parameter control strategy. Specifically, an adaptive mechanism is developed for the mutation operator, where the mutation rate is altered based on feedback from the search. A set of numerical experiments are conducted to assess performance of the developed algorithm based on a comparison against a typical Evolutionary Algorithm that relies on the parameter tuning analysis.

4 - Path Planning for Multiple UAVs in Dynamic Environment Considering Uncertainty of Threats

Mengqi Hu, University of Illinois at Chicago, 842 W. Taylor Street, MC 251, 3023 ERF, Chicago, IL, 60607, United States, mhu@uic.edu, Di Wang

Path planning for multiple interconnected unmanned aerial vehicles (UAVs) especially for fixed-wing UAVs in dynamic environment has attracted great attention. Considering motion characteristics of dynamic artificial and natural threats, a probability predictive method based on Bayesian theory is presented to modify cost functions. A non-cooperative game model is formulated in which UAVs are modeled as Homo Egualis agents that aim at predicting a sequence of future actions and then a novel reinforcement learning method is proposed to solve the game model to converge to a Nash equilibrium. Finally, the feasibility and effectiveness of the proposed approach is evaluated using simulations.

■ TA30

350F

Topics in Social Media Analytics II

Invited: Social Media Analytics

Invited Session

Chair: Fouad H. Mirzaei, Santa Clara University, Santa Clara, CA, 95050, United States, fhmirzaei@scu.edu

1 - Attracting Investors in Equity Crowdfunding Campaigns

Anna Lukkarinen, Aalto University, Helsinki, 00100, Finland, anna.lukkarinen@aalto.fi, Jyrki Wallenius, Hannele Elina Wallenius, Tomi Seppälä

While many equity crowdfunding campaigns succeed in reaching their funding goals, many also fail. Using campaign and investor level data, we aim to build an understanding of what attracts the crowd to invest. We find that campaign characteristics and networks are more important for success than traditional factors. Furthermore, investors form distinct clusters that differ in their motivations and decision criteria. Donors and supporters place importance on personal acquaintance, while pure investors look at the target company and campaign features. The findings can assist crowdfunding platforms and entrepreneurs in selecting and targeting relevant segments of potential investors.

2 - Social Media Competitiveness

Fouad H. Mirzaei, Santa Clara University, Unit 3, 559 Alviso St, Santa Clara, CA, 95050, United States, fhmirzaei@scu.edu

In this study, we investigate what factors are vital in the short term and the long term success of social media networks.

3 - Do Financial Incentives Induce More Online Participatory Behaviors?

Lini Kuang, Beijing Institute of Technology, 5TH, Zhongguan Street, Haidian District, Beij, Beijing, 100081, China, 3120160689@bit.edu.cn, Zhijun Yan, Han Yang, Yan Liu

Online community-based Question and Answer (Q&A) websites is popular in recent years. The main challenge for Q&A websites is how to motivate users' participation. Using a natural experimental dataset collected from a Chinese Q&A site, we apply difference-in-differences model with propensity score matching to evaluate the impact of paid knowledge sharing activity on free knowledge sharing behaviors and social activities in Q&A sites. Our results show that the paid activity induces more free knowledge sharing and social ties in the site. The results suggest that the financial incentive can increase users' participatory behaviors significantly.

■ TA31

351A

Finance

Contributed Session

Chair: Yen-Ju Chiang, National Cheng Kung University, Tainan, Taiwan, r48031016@mail.ncku.edu.tw

1 - Corporate Bankruptcy Prediction a Penalized Semiparametric Index Hazard Model Approach

Shaobo Li, PhD Student, University of Cincinnati, 5470 Erie Station Lane, Apt.51, Cincinnati, OH, 45227, United States, lis6@mail.uc.edu, Shaonan Tian, Yan Yu

We introduce a parsimonious yet flexible double-index hazard model for corporate bankruptcy prediction under a semiparametric modeling framework. The two indices are naturally constructed by market and accounting based variables respectively. Penalized estimation is considered variable selection. Our empirical results demonstrate the existence of nonlinearity between predictors and default risk, and improvement of predictive power comparing to Shumway's hazard model. Furthermore, we find that the variables in each index vary as the prediction horizon changes. The proposed model framework sheds new light on modeling flexibility and sparsity in various financial applications.

2 - Efficient Hybrid Candlestick Technical Analysis Model for Stock Market Timing on the Basis of the Support Vector Machine and Heuristic Algorithms

Milad Jasemi, Wayne State University, 4815 4th Street, Detroit, MI, 48201, United States, milad@wayne.edu, Leslie Monplaisir, Elham Ahmadi

Here, two hybrid models are used for timing of stock markets based on the technical analysis of Japanese Candlestick by Support Vector Machine (SVM) and Heuristic Algorithms of Imperialist Competition and Genetic. In the first model, ICA is used to optimize the SVM parameters'. In the second model, Genetic Algorithm is used for feature selection in addition to SVM parameters' optimization. To generate the input data, the Raw-based and Signal-based standard approaches of the literature are applied. According to the Hit Rate for periods of 1-6 day, SVM-ICA prevails them all.

3 - Steel B2b Electronic Market in China: Does it Really Matter?

Wen Fang, PhD, Lecturer, Xidian University, Mailbox 106,No.266, Xifeng Road, Xi'an 710126, PR China, Xi'an, 710126, China, Ph.D.,az-moju@163.com

China steel industry has emerged a typical market, which is B2B electronic market, while other countries usually have only steel futures market and spot market. Many commodities prices fluctuating followed by steel price changes. The development of steel markets plays an important role in the development of China's commodity market as well as global commodity market. Steel electronic market is in the process of vigorous development. There are three kinds of steel price signals: forward transaction price from electronic market, futures price and spot price. Research on price discovery in steel markets has important theoretical significance and practical application value.

4 - Game Theory and Weighted Cash-to-cash Metric: Optimizing Economic Value of Seller-buyer Transaction

Mazen Hammady, PhD, University of North Texas, 201 Inman St, Apt# 6305, Denton, TX, 76205, United States, mazen.hammadybrho@unt.edu, Aaron Glassburner, PhD, Wesley Randall, David Nowicki, Brian Sauser

The use of joint metrics between a seller and buyer allows differences in inventory carrying cost and capital costs to be sources of economic value added (EVA). This research models seller-buyer transactions as a collaborative game with a joint weighted cash-to-cash metric as the payoff function. The model uses strategies of shifting inventory and payment to increase firm and supply chain EVA, thus it is posited as a collaboration decision tool. Also, the developed model optimizes operation and finance functions, lowers trading risk, and increases profitability without additional investment.

5 - Can We Understand the Macroscopic Behavior of the Equity Markets?

Abdullah AlShelahi, University of Michigan, 2410 Leslie Circle, Ann Arbor, MI, 48105, United States, shelahi@umich.edu, Romesh Saigal

In this research, we aim to build a market-based framework from the viewpoint of fluid dynamics and its physics. We seek to develop physical sensors made up of an algorithm in the markets that alerts regulators to unusual activities in the flow of stocks. The fluid flow in physics will be used to measure the irregularities found in the behavior of the financial markets. This marriage between physics and finance will bring greater clarity to those who run the stock markets, as well as regular investors who will no longer worry that they are trading in a losing or rigged game.

6 - Market Anomalies of Credit Rating

Yen-Ju Chiang, Student, National Cheng Kung University, No.1, University Road, Tainan, 701, Taiwan, r48031016@mail.ncku.edu.tw, Shuang-Shi Chuang

Our aims to examine the market anomalie of credit rating in Taiwan stock market. we test whether investors can get abnormal returns by different credit rating or not. Especially, we contribute with new knowledge about how investors choice undervalue stocks by credit rating in many situations. Furthermore, our sample includes listed firms on the Taiwan Stock Exchange during 1th of January 2000 to 31th of December 2016. Our regression model is Fama- French Five factor Model, consisting overall market, size, value, profitability and investment factor can predict future stock price. we found creding rating could predict stock return.

■ TA32

351B

Operations/Finance Interface

Contributed Session

Chair: Houcai Shen, Nanjing University, Nanjing, China, hcshen@nju.edu.cn

1 - Price Delegation or Not? the Effect of Heterogenous Sales Agents under Asymmetric Information

Hongyan Xu, Chongqing University, School of Economics & Business Admin, Chongqing, 400030, China, xuhongyan@cqu.edu.cn, Jian Chen, Liming Liu

This study examines the impact of heterogeneous sales agents with private information about type-dependent reservation on price delegation decision. The firm prefers centralized pricing when the reservation difference is small or large, and prefers delegated pricing with moderate reservation difference. Specially, when only equilibrium pooling can be offered for two pricing schemes, delegation outperforms centralization, due to the fact that the benefit from pricing flexibility by delegation dominates the hurt from less effort incentive.

2 - Seeding Strategies for New Product Launch in the Presence of Negative WOM

Fang Cui, Xi'an Jiaotong Univercity, Xi'an, China, cuifang2011@stu.xjtu.edu.cn

Taking negative WOM into account, this paper examines the impact of seeding programs on firm profit and market penetration and explores the optimal seeding targets. We use the agent-based modeling method to explore performances of three seeding targets: early adopters, hubs and randomly chosen consumers and the influences of three factors, mean and variance of the probability of consumers spreading negative WOM, and consumer homophily, which represents the similarity of adjacent consumers. The findings suggest that in the presence of negative WOM, on average, seeding early adopters can generate highest profit and largest market penetration, followed by seeding hubs and then by randomly seeding.

3 - Warranty Pricing with Consumer Learning

Yong Lei, Southwestern University of Finance and Economics, IELM Dept, Chengdu, 611130, China, leiyong@swufe.edu.cn, Qian Liu, Stephen Shum

We consider a problem in which a firm dynamically prices a product and its warranty service over time. Consumers can learn about the reliability of products based on warranty prices. We find that warranty sales will not generate profits directly. However, offering a modest warranty still benefits the firm's overall profits. We also show that consumers' beliefs and the firm's warranty policy converge in the long run. In a steady state, either a fraction of consumers will purchase a warranty or no consumer will purchase a warranty. Lastly, we note a firm benefits from consumer learning by hiding the information about the true product reliability only when the true product failure rate is relatively high.

4 - The Market Entry Strategy of Contract Manufacturers

Houcai Shen, Professor, Nanjing University, Department of Management Science, and Engineering, Nanjing, 210093, China, hcshen@nju.edu.cn, Jiahui Zhou

In this paper, we consider a supply chain consists of an original equipment manufacturer (OEM) who outsources its production process to a contact manufacturer (CM). The main issues we address are, should the CM enter the market with vertical differential product where the OEM sells products to. We develop two game theoretical models when CM entry the market or not, and then make comparative analysis of the equilibrium outcomes.

■ TA33

351C

Airline Schedule Design

Sponsored: Aviation Applications

Sponsored Session

Chair: Vikrant Vaze, Dartmouth College, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu

1 - An Approximate Dynamic Programming Approach for Aircraft Maintenance Scheduling

Qichen Deng, Delft University of Technology, Delft, Netherlands, Q.Deng@tudelft.nl

An approximate dynamic programming (ADP) approach is proposed to optimize the aircraft A-check and C-check schedule. It aims at minimizing the total unused flight hours of a fleet considering aircraft type, status and operational constraints. For each calendar day, the ADP approach evaluates all possible actions (no check, A-check or C-check etc.) and find the best one. This study is one of the few works optimizing both A-check and C-check schedule at the same time and presents the first application of ADP on aircraft maintenance planning. It also shows that ADP makes large scale application feasible and produces promising results in terms of computational time and solutions quality.

2 - Robust Airport Stand Allocation

Bert Dijk, Beontra, Karlsruhe, Germany, dijk.bert@gmail.com, Bruno F.Santos, João P. Pita

This paper presents an innovative approach to the tactical planning of aircraft remote and contact stands allocation at airports. We use the concept of recoverable robustness to test the robustness of the plans and to select the most robust allocation plan, without compromising its efficiency. This is the first work to discuss airport commercial revenues as a metric for the stand allocation problem. Six days of operations at the Guarulhos Airport (Sao Paulo) are used to test the approach. The solutions obtained show that the proposed approach outperform the solutions of a traditional robust approach.

3 - Integrated Timetable Development and Fleet Assignment Model Incorporating Passenger Choice

Vikrant Vaze, Dartmouth College, 14 Engineering Drive, Murdough Center, Hanover, NH, 03755, United States, vikrant.s.vaze@dartmouth.edu, Keji Wei, Alex Jacquillat

We present a mixed-integer linear programming model for integrated timetable development and fleet assignment, where the passenger itinerary flows are modeled using a multinomial logit model. Even for small to moderate network sizes, this is a very challenging problem to solve and has never been addressed in prior literature. We develop multiple exact and heuristic solution approaches and test their performance against the performance of a state-of-the-art off-the-shelf commercial solver. Our computational results using real-world airline networks provide several new insights into the structure of highly profitable airline timetables.

4 - Multi-stage Airline Scheduling Problem with Stochastic Passenger Demand and Non-cruise Times

Ozge Safak, Bilkent University, Department of Industrial Engineering, Ankara, 06800, Turkey, ozge.safak@bilkent.edu.tr, Ozlem Cavus, Selim Akturk

We introduce an airline scheduling problem that determines flight timing, fleeting and routing decisions while considering the randomness of demand and non-cruise times. We assign aircraft by considering not only flight timing and demand but also fuel and emission costs associated with cruise speed adjustments. We propose a mixed-integer multi-stage stochastic programming model with nonlinear fuel cost function, where the nonlinearity is handled by MISOCP. We employ a scenario group-wise decomposition algorithm to obtain lower and upper bounds for the optimal value of the proposed model. We suggest a cutting plane algorithm for solving group subproblems. Supported by TUBITAK [Grant 116M542].

■ TA34

351D

Internally- and Coalition-focused Military Applications

Sponsored: Military Applications

Sponsored Session

Chair: Brian J Lunday, Air Force Institute of Technology, Air Force Institute of Technology, WPAFB, OH, 45433, United States, brian.lunday@afit.edu

1 - On Truthful, Stable and Proportionate International Alliance Burden Sharing

William Caballero, Air Force Institute of Technology, WPAFB, OH, 45433, United States, William.Caballero@afit.edu, Brian J. Lunday, Darryl K. Ahner

We propose cost sharing mechanisms for an international alliance such that burden shares are allocated based on declarations of the alliance's worth, probabilistic inspection efforts, and deception penalties. We develop a set of multiobjective nonlinear optimization problem formulations that are budget balanced, proportional and in the core. Any feasible solution to these problems corresponds to a single-stage Bayesian stochastic game wherein a collectively honest declaration corresponds to varying forms of Nash Equilibria, but the optimal solution considers the alliance's central authority preferences between inspection and penalization.

2 - Automating Mission Essential Task List Crosswalks with Data Science

Dan Koban, United States Military Academy, donald.koban@usma.edu, Michael S. Scioletti

A Mission Essential Task List (METL) crosswalk is a unit's primary analysis tool to plan training; however, it is often improperly executed. We contend improper execution is not a function of training, but rather an unreasonable expectation to solve a difficult problem by hand. By modeling task relationships as a network, we are able to automated the crosswalk and provide descriptive measures of the payoff and complexity associated with tasks included in a Unit Task List (UTL). These measures can then be used to assist commanders with selecting and prioritizing tasks when developing a Unit Training Plan (UTP). We demonstrate the effectiveness of our method by applying it to an infantry company.

3 - Air Force Comprehensive Core Capability RiskAssessment Framework (C3RAF)

Charles Glaze, Headquarters US.Air Force Pentagon, Washington, DC, charles.b.glaze.mil@mail.mil, Shane N. Hall, John R. Lepird, Robert Henson, Donald Allen

This paper examines risk within the United States Air Force (AF) by modeling the AF as a network of core capabilities. This model provides a better understanding of what factors drive risk across the AF and its overall contribution to the United States' ability to win wars. This decision framework provides key insights on strategic investment decisions by linking core capability risk with budgeting decisions on military systems. Application of this effort is utilized to provide repeatable, defendable results informing budget decisions over a 30 year, $3 trillion resource allocation plan.

■ TA35

351E

Supply Chain Management

Contributed Session

Chair: Naser Nikandish, California State University-Fullerton, Fullerton, CA, United States, n.nikandish@gmail.com

1 - Value of Information-sharing in a Supply Chain under a Revenue-sharing Contract

Tal Avinadav, Bar-Ilan University, Webb 1, Ramat-Gan, Israel, tal.avinadav@biu.ac.il, Tatyana Chernonog, Yael Perlman

We investigate the value of vertical information-sharing in a supply chain whose members interact via a revenue-sharing contract. Demand is uncertain, and both the manufacturer and the retailer receive signals about the demand, which are correlated. We analyze the value of information-sharing in this supply chain under the assumption of truth telling. We show that (i) to obtain equilibrium, the leader has to disclose the signal he received or his lack of information; (ii) the leader does not derive any benefit from the information that has been signaled to him, or from knowing what has been signaled to the follower; (iii) the leader does benefit when the follower has knowledge of both signals.

2 - Supply Chain Integration, Advanced Manufacturing Technology, and Operational Performance

Birasnav Muthuraj, New York Institute of Technology, Northern Boulevard, Old Westbury, NY, 11568, United States, bmuthura@nyit.edu, Disha Nair

This study examines the relationship between supply chain integration, implementation of advanced manufacturing technology, and operational performance. Data were collected from Indian manufacturing industries to understand the relationships among the studying variables.

3 - The Influence of Network Resources and Absorptive Capacity on Productive Efficiency

Hung-Chung Su, University of Michigan-Dearborn, Dearborn, MI, 48126, United States, hcsu@umich.edu, Ta-Wei Kao

This study considers the relationships between network resources, exploitative absorptive capacity, and a firm's productive efficiency. This research examines the effects of network positions that relate to three types of informational resources obtained from the network: information volume, information velocity, and information diversity on a firm's productive efficiency. Furthermore, we examine the moderating role of absorptive capacity on the relationship between network resources and productive efficiency.

4 - Evaluation of End-to-end Strategies with Omnichannel Retailing: A Model and Application for Apparel Supply Chains

Shardul Phadnis, Malaysia Institute for Supply Chain Innovation, 2A, Persiaran Tebar Layar, Seksyen U8, Shah Alam, 40150, Malaysia, sphadnis@misi.edu.my

We advance an extant model of end-to-end supply chain to omnichannel retailing to evaluate sourcing and sales strategies as components of one supply chain strategy. We develop demand models for two omnichannel settings—Buy-Online-Pickup-in-Store, and Try-in-Store-Buy-Online. We develop conditions for optimal inventory placement, and evaluate four end-to-end strategies, combinations of two omnichannel settings with offshore and nearshore sourcing to describe the conditions in which each strategy outperforms the others. We test the model using a computer simulation and describe how the optimum end-to-end strategies of omnichannel merchants differ from those of single channel merchants.

5 - Occurrence of Bullwhip Effect in Pricing in the Case of a Revenue-sharing Contract

Ertunga Ozelkan, University of North Carolina-Charlotte, 9201 University City Boulevard, Charlotte, NC, 28223, United States, ecozelka@uncc.edu, Ziaul Haq Adnan

Bullwhip effect in pricing (BP) refers to the amplified variation in pricing. We analyze the occurrence of BP in the case of a revenue-sharing contract with both the deterministic and the stochastic demand. We model the deterministic case as a Stackelberg game, and the stochastic model as a Newsvendor problem with both an additive and a multiplicative uncertainty in demand. The results show that the ratio of the standard deviations of the retail and the wholesale prices (i.e. BP ratio) is inversely proportional to the retailer's profit share. We also discuss the cost-pass-through rates in the case of a revenue-sharing contract with a stochastic demand under a linear and an isoelastic demand form.

6 - Capacity Planning Analysis for Amazon.com Lockers
Naser Nikandish, Assistant Professor, California State University, Fullerton, 800 North State College Boulevard, Fullerton, CA, 92831, United States, n.nikandish@gmail.com, Lawrence W. Robinson

Amazon.com's lockers are this company's innovation to control their increasing fulfillment costs by decreasing last-mile distribution costs and to improve their shoppers' experience by bringing convenience and safety to the package delivery process. In this project, we investigate online shoppers' package retrieval behavior from an Amazon.com locker location and research its impact on capacity decisions at the Amazon.com locker locations.

■ TA36

351F

Recent Progress in Efficient Algorithms in Convex Optimization

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Qihang Lin, University of Iowa, Iowa City, IA, 52245, United States, qihang-lin@uiowa.edu

1 - New Results for Sparse Methods for Logistic Regression and Related Classification Problems
Robert Michael Freund, MIT, MIT Building E62-567, 77 Massachusetts Ave., Cambridge, MA, 02139, United States, rfreund@mit.edu, Paul Grigas, Rahul Mazumder

We propose and analyze methods in logistic regression that induce sparse solutions. We introduce a novel condition number associated with the data for logistic regression that measures the degree of non-separability of the data, and that naturally enters the analysis and the computational properties of methods. We take advantage of very recent new results in first-order methods for convex optimization due to Bach and others, to present new computational guarantees for the performance of methods for logistic regression. In the high-dimensional regime in particular, these guarantees precisely characterize how the methods impart both data-fidelity and implicit regularization, for any dataset.

2 - Sliding Techniques for Large-scale Optimization
Guanghui (George) Lan, Georgia Institute of Tehnology, Newberry, FL, 32669, United States, george.lan@isye.gatech.edu

We provide an overview of gradient/operator sliding techniques which lead to signifiant improvement on optimization algorithms. This includes savings on gradient computation, accesses to dataset and communication costs etc.

3 - Feasible Level Set Method for Constrained Convex Optimization Problems
Negar Soheili Azad, University of Illinois-Chicago, 601 S.Morgan Street, University Hall 2416, Chicago, IL, 60607, United States, nazad@uic.edu, Qihang Lin, Selvaprabu Nadarajah

First order methods have emerged as an effective solution strategy for tackling large scale convex optimization problems. The success of these methods has been greatest for such problems with simple feasible sets. We propose a novel feasible level set method that extends the applicability of these methods to convex optimization problems with potentially complicated constraint sets.

4 - Searching the Growth Rate: Adaptive SVRG Methods under Error Bound Conditions
Qihang Lin, University of Iowa, Iowa City, IA, 52245, United States, qihang-lin@uiowa.edu, Yi Xu, Tianbao Yang

Error bound condition (EBC), an intrinsic property of an optimization problem, can be exploited for developing algorithms with surprisingly fast global convergence. However, many existing approaches utilizing EBC requires knowing a growth parameter in the statement of EBC, which is usually very difficult to estimate, leading to a gap between the theoretical convergence and practical implementation. To address this issue, we propose a variance reduced stochastic gradient method that automatically searches for this unknown parameter on the fly of optimization, while still maintaining almost the same convergence rate just as the parameter is known.

■ TA37

352B

Design and Operation of Interdependent Infrastructure Systems

Sponsored: Service Science

Sponsored Session

Chair: Ann Suhaimi, Northeastern University, Somerville, MA, 02145, United States, nmsuhaimi@gmail.com

Co-Chair: Jacqueline Griffin, Northeastern University, Boston, MA, 02115, United States, jacqueline.griffin@gmail.com

1 - Effect of Constructing Utility Tunnels on Interdependent Critical Infrastructure Resilience to Malicious Attacks
Min Ouyang, Huazhong University of Science and Technology, Wuhan, China, min.ouyang@hust.edu.cn, Min Xu, Liu Hong

We propose a bilevel attacker-defender model to analyze the effect of constructing utility tunnels on interdependent critical infrastructure resilience under the worst-case malicious attack. Results show that designing utility tunnels may largely reduce system resilience to the worst-case malicious attack. But if the utility tunnels are designed with sufficient redundancy or well hardened, interdependent system resilience could be well improved.

2 - An Interdiction-based Approach to Identify Damage in Interdependent Critical Infrastructures
N. Orkun Baycik, PhD Student, Rensselaer Polytechnic Institute, 110 8th Street Center for Industrial Innovation, Suite 5015, Troy, NY, 12180, United States, baycin@rpi.edu, Thomas Sharkey

We study the problem of determining the damage in multiple interdependent infrastructures given outage reports from the customers (or service receivers). Demand nodes within these infrastructure networks may have an outage either from damage that occurred within its infrastructure or due to cascading failures across infrastructures. We present a network interdiction based approach to identify the order in which components should be inspected in order to determine the damage within these networks based on the outages reported by customers.

3 - Employing a Mixed-strategy for Effective Response to Vulnerable Populations in Short-notice Disasters
Rana Azghandi, Northeastern University, 360 Huntington Avenue, Boston, MA, 02115, United States, rana.azghandi@gmail.com, Jacqueline Griffin

A mixed integer programming model is developed for applying a mixed-strategy framework to respond to needs of vulnerable populations in short-notice disasters. The mixed-strategy approach focuses on the joint deployment of resources for sheltering-in-place and evacuation assistance. Moreover, social features, such as the physical and emotional needs of target population, and physical features, such as infrastructure systems, will affect the optimal strategy. We examine the effect of these features on the effectiveness of the mixed strategy policy.

4 - Emergency Response Operations Accounting for Interdependent Infrastructures
Ann Suhaimi, Northeastern University, 30 Adams St, Apt 7, Boston, MA, 02145, United States, nmsuhaimi@gmail.com, Jacqueline Griffin

Demand for emergency response personnel is tightly coupled with the operation of other infrastructures, including power and communication systems, as well as the behaviors of citizens, particularly with respect to evacuation. Additionally, the demand for these services changes dynamically throughout an extreme event (e.g. snowstorm, hurricane, etc.). Using MIP model, we examine effects of coordinated decision making across infrastructures on the efficiency and effectiveness EMS deployment, accounting for the dynamics of demand for services.

5 - Optimizing the Resilience of Interdependent Infrastructure Networks under Pre-and Post-event Uncertainty
Andres David Gonzalez, Assistant Professor, The University of Oklahoma, Norman, OK, 73071, United States, andres.gonzalez@ou.edu, Leonardo Dueñas-Osorio, Andres L. Medaglia, Mauricio Sánchez-Silva, Andrew J. Schaefer

Optimizing the resilience of any given infrastructure system requires optimizing decisions for pre-event enhancement and damage mitigation, as well as for post-event efficient recovery. Moreover, it is imperative to consider the multiple interdependencies that these infrastructure systems depict, which directly impact their vulnerability and recoverability. In this work, we present a comprehensive optimization framework that allows optimizing both pre- and post-event decisions, based on the stochastic Interdependent Network Design Problem (sINDP), while taking into account diverse sources of uncertainty, associated with the failure of components and the demands and costs involved.

■ TA38

352C

Multi-Criteria Decision Making: Can we Always Know that we have Made the Right Decision?

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Evangelos Triantaphyllou, Louisiana State University, Baton Rouge, LA, 70803, United States, etriantaphyllou@yahoo.com

Co-Chair: Juri Yanase, Complete Decisions, LLC, Baton Rouge, LA, 70810, United States, jurijuriy@aol.com

1 - How to (and not) Apply Multi-Criteria Decision Analysis (MCDA) to Medical Decisions

Edouard Kujawski, 1159 Miller Ave., Berkeley, CA, 94708, United States, edkuj@comcast.net

MCDA is increasingly being implemented in shared medical decision-making. Medical professionals and patients face a quagmire of deceitfully attractive methods that can substantially impact alternative rankings. Medical decision-making is often a problem under uncertainty: tests provide imperfect information and outcomes are probabilistic. A significant effort is required to develop realistic and mathematically valid models for making reliable life-critical medical decisions.

2 - Some Important Issues Regarding the use of a Number of Well-known MCDM Methods

Fujun Hou, Beijing Institute of Technology, No.5 South Street Zhongguancun, Haidian, Beijing, 100081, China, houfj@bit.edu.cn

Recent findings on the way some popular MCDM methods rank and prioritize alternatives, raise questions on the validity of their results. We examine these issues comprehensibly. We consider three types of preference data for MCDM problems and identify some isomorphic relations. We use these results to design some appealing approaches for dealing with the problems that face current MCDM methods.

3 - Can We Always Determine the Best MCDM Method?

Evangelos Triantaphyllou, Louisiana State University, Dept of Computer Science, 298 Coates Hall, Baton Rouge, LA, 70803, United States, etriantaphyllou@yahoo.com, Juri Yanase

The reason there is more than one method to solve a given MCDM problem is the fact that sometimes such methods may yield different results for exactly the same input data. Thus, a critical question is to identify the best MCDM method. This problem may be intractable. We discuss a number of intriguing issues related to this fundamental MCDM question.

■ TA39

352D

Young Researchers

Sponsored: Analytics

Sponsored Session

Chair: Aaron Burciaga, Accenture, Global Analytics Executive, 4305 Majestic Lane, Fairfax, VA, 22033, United States, adburciaga@gmail.com

1 - A Decision Support Prototype for Blood Donation Management

Deepti Bahel, Proxima Analytics, West Lafayette, IN, 47906, United States, baheldeepti@gmail.com, Matthew Lanham

We study the performance of machine learning algorithms that have not been previously investigated to support the problem of blood donation prediction. We build models on clustered data sets using k-means clustering and not using clustering to see if performance can be significantly improved. The motivation for this research is that blood demand is gradually increasing by the day due to needed transfusions due to accidents, surgeries, diseases etc. Accurate prediction of the number of blood donors can help medical professionals know the future supply of blood and plan accordingly to entice voluntary blood donors to meet demand. In addition to predicting demand accurately, we show how to incorporate the costs of targeting a potential donor or not, which provides novel decision support to blood centers in how they can manage their donation efforts.

2 - A Balanced k-Means Clustering Algorithm to Support the Division III Men's Wresting Conference Alignment Problem

Amar Iyengar, Purdue University, West Lafayette, IN, United States, iyengara@purdue.edu, Matthew Lanham

We develop a balanced k-means clustering algorithm that allows the modeler to specify a range of how many observations the modeler would like within each generated cluster. The traditional k-means clustering algorithm is one of the most well-known clustering algorithms used by practitioners today. Unfortunately, it often leads to the generation of groups that have a diverse number of observations in each group. Such scenarios regularly lead to cluster formations that violate the problem context and requirements. Since the k-means algorithm is so intuitive, we modify how the algorithm forms clusters so that cluster formations tend to have a similar number of observations in each group. We apply our algorithm to an industry problem posed by division III men's wresting where they were seeking to form new conference regions that we more competitively and geospatially balanced. We show our algorithm improves their current region assignments. Lastly, we identify additional potential avenues this clustering algorithm could be implemented.

■ TA41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Aditya Jain, Baruch College, Zicklin School of Business, New York, NY, United States, aditya.jain@baruch.cuny.edu

1 - Evaluating Cardiac Mortality Rates: An Alternative to the RAMR

Christine Pitocco, Research Professor, Stony Brook University, 333 Harriman Hall, Stony Brook, NY, 11794-3775, United States, christine.pitocco@stonybrook.edu, Acsah Joseph, Thomas Sexton

The risk adjusted mortality rate (RAMR) measures the mortality performance of health care providers such as hospitals and physicians. It is used by health care consumers in selecting providers and policy makers evaluating their mortality performance. However, the RAMR has several serious flaws. We propose an alternative measure and demonstrate its use in measuring performance of cardiac surgeons and hospitals.

2 - Graph Regularized EEG Inverse Program with Total Variation Priors

Feng Liu, UT.Arlington, 19251 Preston Rd, Apt 1214, Dallas, TX, 75252, United States, liufengchaos@gmail.com

As EEG sensors measure electrical potentials on the scalp instead of directly measuring activities of brain sources, many approaches were proposed to infer brain source activation pattern. We propose that by leveraging label information, the task related discriminative sources can be much better retrieved among strong spontaneous background signals. A novel supervised EEG source imaging model was proposed which aims to explicitly extract the discriminative source extents by implicitly coding the label information into the graph regularization term. An ADMM optimization algorithm is given to solve the problem. Numerical results show the effectiveness of our proposed framework.

3 - Modeling the Pre-clinical Phase for Ovarian Cancer using a Conditionally Stationary Markov Process

Jing Voon Chen, University of Southern California, Los Angeles, CA, 90089, United States, jingvooc@usc.edu, Julia L. Higle

Creating a nonstationary natural history (NH) model can overwhelm parameter search methods and exacerbate the problems surrounding calibration uncertainty, especially when data is scarce. We present a conditionally stationary Markov model (CSMM) that decomposes the overall NH into two components: a stationary Markov chain governing the disease progression and a nonstationary process for competing risk mortality. We investigate the window of opportunity for ovarian cancer using a CSMM.

4 - Creating Thickness in Kidney Exchange Markets

Shayan Oveis Gharan, Stanford University, 475 Via Ortega,, Huang Engineering Center, 314K, Stanford, CA, 94305, United States, shayan@stanford.edu, Shengwu Li

We study a dynamic model of kidney exchange in which patient-donor pairs arrive and depart continuously and the composition of the market depends on the matching algorithm. We discuss the role of thickness and information in designing optimal policies.

5 - The Effect of Flexible Service Rates in Appointment Scheduling System

Aditya Jain, Baruch College, Zicklin School of Business, 55 Lexington Ave, Suite 9-240, New York, NY, 10010, United States, aditya.jain@baruch.cuny.edu, William P.Millhiser

Recent empirical evidence suggests that ambulatory care healthcare workers intentionally vary service rates in response to two factors: time of day and queue length, where workers choose work speeds to balance their own overtime and the patient's wait. We explore a theoretical justification of this behavior and show that workers speed up if the cost of patient waiting is relatively small compared to workers' overtime cost. We analyze the implications of such worker behavior on various performance metrics for established appointment systems, and how appointment systems should be adapted.

■ TA42

360A

Nano Manufacturing

Invited: Advanced Manufacturing

Invited Session

Chair: Chiwoo Park, Florida State University, Tallahassee, FL, 32310-6046, United States, cpark5@fsu.edu

1 - Quantifying Nanoparticle Mixing State to Account for Both Location and Size Effects

Yanjun Qian, Texas A&M.University, 1501 Harvey Rd, Apt 806, College Station, TX, 77840, United States, qianyanjun09@gmail.com, Ling Dong, Xiaodong Li, Dan Yu, Hui Zhang, Zhong Zhang, Yu Ding

Ripley's K function is a favored tool in quantifying the homogeneity of the nanoparticles mixing state, a parameter is of close relevance to certain properties of the nanomaterial. Ripley's K function assumes that the spatial points are dimensionless, however the nanoparticles form clusters or agglomerates of various sizes and shapes. Our analysis shows that using the original K function falls short of ranking the homogeneity of nanoparticle mixing. We therefore propose to revise the K function to account for both particle location and size effects. The analysis on electron microscopy images of material samples shows that the revised function is a better index to quantify the mixing states.

2 - Tensor Mixed Effects Model with Applications in Nanomanufacturing Inspection

Xiaowei Yue, Georgia Institute of Technology, 755 Ferst Drive NW, ISYE, Atlanta, GA, 30332, United States, xwy@gatech.edu, Jin Gyu Park, Zhiyong Liang, Jianjun Shi

Raman mapping technique has been used to do quality inspection of nanomanufacturing process. Massive high dimensional data with mixed effects are generated. The existing tensor decomposition methods cannot separate mixed effects, and mixed effects model can only handle matrix data instead of tensor data. We propose a tensor mixed effects (TME) model to handle high dimensional data with complex structure. The TME model can (i) separate fixed effects and random effects in a tensor domain; (ii) exploit the correlations along different dimensions; and (iii) realize efficient parameter estimation by a double Flip-Flop method. Simulation and case study demonstrate the efficiency and accuracy.

3 - Structural Sparsity Regularization for Inference of Lattice Structure

Xin Li, Florida State University, 2525 Pottsdamer St, Building A, Suite A231, Tallahassee, FL, 32310, United States, xl12d@my.fsu.edu, Alex Belianinov, Ondrej Dyck, Stephen Jesse, Chiwoo Park

We presents a regularized regression model with a two-level structural sparsity penalty applied to locate individual atoms in a noisy scanning transmission electron microscopy image (STEM). The applicability of the algorithm on determination of atom structures and identification of imaging distortions and atomic defects was demonstrated using real STEM images. We believe this is an important step toward automatic phase identification and assignment with the advent of genomic databases for materials.

■ TA43

360B

Last Mile Aid Operations

Sponsored: Public Sector OR

Sponsored Session

Chair: Feyza Guliz Sahinyazan, McGill University, Montreal, QC, H3A 1G5, Canada, feyza.sahinyazan@mail.mcgill.ca

1 - Community Healthcare Network in Underserved Areas: Design, Mathematical Models, and Analysis

Marie-Ève Rancourt, HEC Montreal, Montreal, QC, H3T.2A7, Canada, marie-eve.rancourt@hec.ca, Marilène Cherkesly, Karen Smilowitz

In this presentation, we design community healthcare networks in underserved areas. The problem consists of determining the number of community health workers and supervisors, as well as the routing and scheduling of the supervisors. We propose four set-partitioning mathematical models. Computational results are presented for a real-life case study.

2 - Food Assistance Modality Selection Problem: In Kind, Cash or Voucher?

Feyza Guliz Sahinyazan, McGill University, Desautels Faculty of Management, Bronfman Building, 1001 Rue Sherbrooke O, Montreal, QC, H3A 1G5, Canada, feyza.sahinyazan@mail.mcgill.ca, Marie-Ève Rancourt, Vedat Verter

There is a vast empirical literature suggesting that providing food aid in cash or vouchers is significantly more effective compared to in-kind. Yet, ours is the first study that mathematically models the aid modality selection and provides a methodology that can respond the dynamics of the environments requiring food assistance.

3 - On the Cost and Effectiveness of Packaging as a New Lever in Food Aid Supply Chain Design

Mark Brennan, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E38-649, Cambridge, MA, 02139, United States, mbrenn1129@gmail.com, Jarrod D. Goentzel, Prithvi Sundar, Dan Frey

Recent legislation has changed from where and when US food aid can be sourced, and how it can be shipped, affecting the timeless and cost-effectiveness of relief efforts. Using data collected from a $1.7 million US food aid procurement in which new packaging types were piloted, this study shares results of the cost and effectiveness of changing in which packaging food aid is shipped. This study demonstrates how packaging can be a lever of supply chain design, and presents the advantages and limitations of including another "lever" in the US food aid supply chain.

■ TA44

360C

Military Applications

Contributed Session

Chair: Laura Freeman, IDA, Alexandria, VA, United States, lfreeman@ida.org

1 - Model Predictive Control for the Flow Field in an Intermittent Transonic Wind Tunnel

Jian Zhang, City University of Hong Kong, Hong Kong, jzhang398-c@my.cityu.edu.hk

This study aims to design a controller to quickly reject various disturbances for the varying Angle of Attack (AoA) tests in an Intermittent Transonic Wind Tunnel (ITWT). A novel AoA model (i.e., Hammerstein model) with corresponding modeling approach is developed to characterize the influence of varying AoA on the static pressure. Finally, the flow field controller is formed as a simple Quadratic Programming (QP) problem, and the feedforward strategy is employed to compensate for the varying AoA disturbance. Simulation results and practical wind tunnel tests prove that the proposed controller can improve test precision and reduce test costs.

2 - Assessing Risk in a Military Logistics Network

Brandon McConnell, North Carolina State University, 1631 Carywood Drive, Apt 1631, Cary, NC, 27513, United States, bmmcconn@ncsu.edu

The U.S. Army's adoption of an enterprise resource planning (ERP) system provides an opportunity to develop automated decision-support tools and other analytical models designed to use logistical data. This research presents a tool that runs in near-real time to assess risk while conducting capacity planning and performance analysis for a military logistics network. A goal-seeking adaptive simulation is combined with recent advances in transient queue analysis to both account for uncertainty and assess residual risk.

3 - Simulation of a Readiness Based Sparing Optimization

Javier Salmeron, Naval Postgraduate School, 1411 Cunningham Road, Monterey, CA, 93943, United States, jsalmero@nps.edu, Wray John, Arnold H. Buss

We develop a simulation to complement a new optimization tool that establishes inventory levels for aviation weapon systems (WS) in the U.S. Navy. We seek cost minimization while achieving required readiness for hundreds of WS, each comprising thousands of indentured parts. We employ the Vari-Metric model and a variant of a greedy heuristic algorithm. On average, the optimization slightly overestimates availability. Also, 57 of 64 WS simulated yield results within 8% difference, with a worst-case under 11%. We identify factors correlated to these differences. We test another legacy optimization tool currently in use by the Navy and find it has a larger difference in expected readiness.

4 - Robust Allocation of Resources in Reliability Growth Testing

Mohammadhossein Heydari, University of Arkansas, 1898 Caton Dr, Fayetteville, AR, 72704, United States, mhheydar@uark.edu, Kelly Sullivan

Reliability growth testing seeks to identify and remove failure modes in order to improve the reliability of a system. In this study, we consider the robust allocation of testing resources across the components of series and series-parallel systems. We assume that the failures of each component occur according to the AMSAA model (Crow, 1974) with uncertain parameters within a bounded uncertainty set. We develop and analyze exact solution approaches for this problem based on a cutting plane algorithm. A simulation approach is used to compare solutions from our model with solutions from an analogous deterministic optimization model.

5 - Statistical Techniques for Modeling and Simulation Validation
Laura Freeman, IDA, 4850 Mark Center Drive, Alexandria, VA, 22311, United States, lfreeman@ida.org, Kelly Avery

Modeling and simulation (M&S) can augment live testing to provide a more complete evaluation of system performance. It is essential that the usefulness and limitations of the M&S are well characterized, and uncertainty quantified. This talk highlights statistical techniques to compare M&S output with live test data. We will show how design for computer experiments can be used to efficiently cover the simulation domain and inform live testing. A simulation study shows that regression analysis is the most powerful method when paired with experimental design techniques. A Defense system case study shows highlight real world implications.

■ TA45

360D

Revenue Management, Pricing

Contributed Session

Chair: Tulay Flamand, Colorado School of Mines, Golden, CO, United States, tflamand@mines.edu

1 - Tell Me What I Want: A Study of Personalized Assortment Planning for Learning Consumers
Yulia Vorotyntseva, University of Texas at Dallas, 2200 Waterview Parkway, Apt 1627, Richardson, TX, 75080, United States, yxv120230@utdallas.edu, Canan Ulu, Dorothee Honhon

We model the retailer's and consumer's simultaneous learning about the consumer's idiosyncratic preferences in a given product category. In each period the retailer chooses the assortment of products to offer learns about the consumer's preferences by observing her choice. The consumer picks at most one product, gets a noisy signal about its utility and updates her beliefs on her own preferences in Bayesian fashion. We derive structural properties of the firm's optimal assortment policy and quantify the value of information about the consumer's experience, such as feedback surveys.

2 - Novel Ways to Leverage Consumer Choices through Optimization
James Farmer, President of The Harvest Group, 5500 West JB Hunt Drive, Suite 720, Rogers, AR, 72758, United States, jfarmer@harvestgroup.com

Organizations struggle with how to determine appropriate spend. This dynamic reinforces the behavior of beginning with the "what did we do last year" approach - that reduces optimal results. By taking a different perspective that begins bottom-up and ends with practical engineering, brands and retailers can discover more growth. Data driven feedback loops provide executives with an ability to optimize past results based on predictive analytics. This dynamic re-allocation of resources guides managers and executives toward focusing investment where business can improve.

3 - Designing a Centralized Distribution System for Omnichannel Retailing
Jia Guo, the University of Alabama, 311 Reed Street, Apt 8, Tuscaloosa, AL, 35401, United States, jguo23@crimson.ua.edu, Burcu B.Keskin

Shifts in consumer spending toward services and experiences as well as the competition from discounters and online stores force the traditional retailers to reconsider their supply chain designs. We consider a two-stage stochastic integer programming model for designing an omnichannel network integrating brick-and-mortar stores with an online channel by filling online orders through shipping from nearby stores; by offering their customers the option to buy online and pick up in-store or curbside. Using a single period model, we evaluate the effectiveness of these cross-channel strategies for improving profitability, moving store inventory and avoiding markdowns.

4 - Simulation and Analysis of a Grocery Store Layout
Jessica Peggy Dorismond, University at Buffalo, 17DA Creekside Village, Buffalo, NY, 14212, United States, jpdorism@buffalo.edu, Jose Walteros, Rajan Batta

The purpose of this research is to utilize optimization and simulation modeling to yield an optimal supermarket layout. This study focuses on how to optimize the layout of a supermarket in order to increase its gross profit via the maximization of impulse sales. In most supermarkets many items often get unnoticed because on average customers only walk one-third of the store. Since customers use tangible products as a memory cues, increasing the visibility of certain items will prompt customers to purchase items that are not included on their shopping list.

5 - Sales Assistance Search and Purchase Decisions an Analysis using Retail Video Data
Aditya Jain, Baruch College, Zicklin School of Business, 55 Lexington Ave, Suite 9-240, New York, NY, 10010, United States, aditya.jain@baruch.cuny.edu, Nils Rudi, Sanjog Misra

We investigate the roles of sales assistance and search in driving customer's purchase decision using unique observational video data from retail stores. Our analysis reveals that both sales assistance and search play substantial roles which differ based on the context of specific decisions—search has a more dominant role in purchase incidence, whereas the latter in conditional expenditure.

6 - Retail Analytics on Store-wide Shelf Space Allocation
Tulay Flamand, Colorado School of Mines, Engineering Hall 816 15th Street Office #313, Golden, CO, 80401, United States, tflamand@mines.edu, Ahmed Ghoniem, Bacel Maddah

We investigate how to optimize the store-wide shelf space allocation of retailers in a way that guides in-store traffic and induces impulse buying. A predictive model for in-store traffic is formulated based on our data analysis and is embedded into an optimization model that prescribes shelf space allocation solutions.

■ TA46

360E

Scheduling in Operations Management

Invited: Project Management and Scheduling

Invited Session

Chair: Chelliah Sriskandarajah, Texas A&M University, College Station, TX, 77843-4217, United States, chelliah@mays.tamu.edu

Co-Chair: Yunxia Zhu, Rider University, Pennington, NJ, 08534, United States, yuzhu@rider.edu

1 - Outpatient Appointment Block Scheduling under Patient Heterogeneity and Patient No-shows
Yunxia Zhu, Rider University, 101 tuxford ct, Pennington, NJ, 08534, United States, yuzhu@rider.edu, Seung Jun Lee, Gregory R. Heim, Chelliah Sriskandarajah

We study outpatient appointment block scheduling policies for single providers under conditions of patient heterogeneity in service times and patient no-shows. The objective is to find daily appointment schedules that minimize a weighted sum of patients' waiting time, the physician's idle time, and the physician's overtime. We contribute by suggesting new effective sequential block scheduling procedures motivated by actual outpatient clinic practices across the globe and grounded in the successful Toyota Production System load smoothing approach.

2 - Lateral Transshipment Strategy with Customer Switching
Ying Li, Texas A&M.University, College Station, TX, 77843, United States, yli@mays.tamu.edu, Wenjing Shen, Xinxin Hu, Yi Liao

We consider inventory replenishment and transshipment decisions at two retail locations in a single-period setting while allowing the possibility of customers not staying with their initial retail location. Our research identifies the optimal replenishment and transshipment policy. In particular, we show that the surplus retailer should reserve part of its inventory for switching demand, as opposed to satisfy all transshipment demand. Through numerical studies, we examine the impact of random customer switching on profitability and demand fill rate, as well as the value of the optimal transshipment policy.

3 - Network Seeding on Social Media
Rakesh Reddy Mallipeddi, Texas A&M.University, 320 Wehner - 4217, Mays Business School, Dept of Info&Operations, College Station, TX, 77843-4217, United States, rmallipeddi@mays.tamu.edu, Subodha Kumar, Yunxia Zhu, Chelliah Sriskandarajah

With explosive growth in number of users, marketers have embraced social media as a preferred platform to diffuse and advertise their products. In this study, we propose analytical models to identify influencers (or network seeders) to maximize the reach and effect of an advertisement (or seed) on social media platforms.

4 - A Framework for Analyzing the U.S. Coin Supply Chain
Yunxia Zhu, Rider University, 101 Tuxford Ct, Pennington, NJ, 08534, United States, yuzhu@rider.edu, Yiwei Huang, Subodha Kumar, Chelliah Sriskandarajah, Bala Shetty

This study addresses operational issues within a Coin Supply Chain (CSC) and provides an optimal/near-optimal operating policy for the Federal Reserve System and Depository Institutions to increase their efficiency and cost-effectiveness in ordering, producing, packaging, distributing, and managing inventory of coins. We treat the U.S. CSC as a closed-loop supply chain from both supply and demand side perspectives. We devise and perform an extensive computational study to answer managerially relevant questions in the context of improving the efficiency of the U.S. CSC.

■ TA47

360F

Ebusiness and Social networks

Sponsored: EBusiness

Sponsored Session

Chair: Jie Zhang, University of Texas, Arlington, TX, 76019, United States, jiezhang@uta.edu

1 - On the Spillover Effects of User-generated Reviews on Purchases: Evidence from Clickstream Data

Gene Moo Lee, University of Texas at Arlington, 6746 Deseo #112B, Arlington, TX, 75039, United States, gmlee7@gmail.com, Young Kwark, Paul Pavlou, Liangfei Qiu

We analyze the spillover effect of the online reviews of related products on the purchases of a focal product using clickstream data from a large retailer by investigating (a) whether the related, co-visited products are complementary or substitutive; (b) whether the related products are from the same or a different brand, and (c) the choice of media channel (mobile or PC) used. The result shows that the mean rating of the online reviews of substitutive products has a negative effect on the purchasing of the focal product, while the mean rating of complementary products has a positive effect.

2 - Social Processes and Earnings Management: Evidence from Employee Reviews

Feng Mai, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States, feng.mai@stevens.edu, Xinyan Yan

We study the link between corporate culture and earnings management. Using data from a leading employee review site, we show that the use of discretionary accruals to manipulate reported earnings is more pronounced at those firms having stronger social affiliation among employees. Our results suggest that employee reviews can provide pertinent information about corporate ethics.

3 - Augment Reality Game's Spillover

Jie Zhang, University of Texas at Arlington, Arlington, TX, 76011, United States, jie.zhang2@mavs.uta.edu, Yuan Zhang

This study empirically examined how the introduction of augmented reality games, such as Pokemon Go affects the reputation of local businesses.

4 - Social Learning and Early Purchase under Product Fit Uncertainty and Price Uncertainty

Xuying Zhao, University of Notre Dame, 361 Mendoza College Of Business, Notre Dame, IN, 46556, United States, xzhao1@nd.edu, Zhan Pang, Jie Zhang

The first period buyers make purchase decisions under future price uncertainty. Social learning increases this uncertainty because the second period price may depend on the review valence then, which is uncertain in the first period. So social learning has the increasing-price-uncertainty effect, which changes early buyers' waiting incentives and may hurt or benefit the firm in different scenarios.

5 - Competitive Poaching in Search Advertising: A Randomized Field Experiment

Siddharth Bhattacharya, Temple University, Philadelphia, PA, United States, tug79848@temple.edu, Jing Gong, Sunil Wattal

A key strategy firm's are following in search advertising is to generate traffic by bidding on not only their own keywords but also competitors' keywords. This strategy, known as competitive poaching, is prevalent in multiple industries. However, little research has empirically examined the effectiveness of competitive poaching. The objective of this research is to examine the effect of ad copy variations with respect to competitor keywords on driving click-through and conversion. We further expect this relationship to be moderated by quality and location of competitor. We run a 4-month randomized field experiment in collaboration with a business school.Managerial implications are discussed.

■ TA48

361A

Empirical Behavioral Operations

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Dennis Zhang, University City, MO, 63124, United States, denniszhang@wustl.edu

1 - Learning from Inventory Availability Information: Field Evidence from Amazon

Ruomeng Cui, Goizueta Business School, Emory University, 1300 Clifton Rd, Atlanta, GA, 30322, United States, ruomeng.cui@gmail.com, Dennis Zhang, Achal Bassamboo

Many online retailers provide real-time inventory availability information. Customers can learn from the inventory level and update their beliefs about product quality. Based on a unique setting from Amazon lightning deals, which displays the percentage of inventory consumed in real time, we explore whether and how consumers learn from inventory availability information. We run randomized field experiments on Amazon and run a panel data analysis. We find evidence of consumer learning from inventory information: a decrease in product availability causally attracts more sales in the future; in particular, a 10% increase in past sales leads to a 2.08% increase in cart add-ins in the next hour.

2 - When You Work with a Super Man, Will You Also Fly? An Empirical Study of the Impact of the Coworkers on Workers' Performance

Fangyun Tan, Southern Methodist University, 6212 Bishop Blvd, Dallas, TX, 75275, United States, ttan@cox.smu.edu, Serguei Netessine

We examine a large operational data set in a casual restaurant setting to study how coworkers' sales ability level affects other workers' sales performance. We find that waiters react non-linearly to their coworkers' ability. Our empirical findings imply that to maximize sales, managers should mix waiters with heterogeneous ability levels during the same shift.

3 - Last Place Aversion in Queues

Ryan Buell, Harvard Business School, Morgan Hall 429, Boston, MA, 02163, United States, rbuell@hbs.edu, Michael Norton, Jay Chakraborty

Waiting in queues is an all-too-common source of customer frustration, disrupting the customer experience and - when queues or waits are sufficiently long - causing customers to switch queues, or forgo the experience altogether by reneging. While the number of people in front of a customer in a queue logically predicts such behaviors - the more people, the longer the wait - we examine an underexplored trigger of frustration: how many people are behind the customer in the queue. In particular, in a series of lab and field experiments, we explore whether being in or near last place in a queue predicts switching and reneging, independent of how many people are ahead in the queue.

4 - Fixed or Random Supplier? Evidence from an Order Allocation Game

Chao Xue, Tsinghua University, Beijing, 100084, China, xuec15@mails.tsinghua.edu.cn, Xiaobo Zhao, Jinghuo Chen

We present an experimental study to investigate the impact of fairness concerns on supplier selection strategies. In the game, a manufacturer needs to allocate its orders to two identical suppliers, and the relationships are established through either fixed or random pairings. It is observed that order allocations over time by the manufacturer follow a U-shaped curve under the fixed matching. To capture such learning dynamics, we propose a behavioral model in which the manufacturer updates his belief about the supplier's fairness preferences through repeated interactions. Our results provides useful insights for how to adopt supplier selection strategies appropriately.

■ TA49

361B

Practice/eBusiness I

Contributed Session

Chair: Rajiv Misra, XLRI-Xavier School of Management, C H Area (East), Jamshedpur, 831001, India, rajiv@xlri.ac.in

1 - How to Compare Two Products? A Framework to Make a Better Decision for Consumers Based on Online Word-of-mouth Information

Song Gao, Tongji University, 1 Zhangwu Road, Tongji Block A, Shanghai, 200092, China, hardygao@outlook.com, Hongwei Wang

It is an essential part for consumers to make a purchase decision by comparing different products. And online WOM can guide consumers to judge which one is better. This paper proposes a framework to compare two products based on three comparison types. The first one is comparing two products using the direct comparison opinions presented by other consumers. If they have no direct relation, we construct stable comparison relation by introducing a common comparison object, which has the direct relation with them respectively. The third type focuses on two products, which have no direct relation and no common object. We compare them using the comparison between consumer's opinion and past experience.

2 - Effects of Certificates on Buyers' Order Cancellations in E-marketplaces

Sang Won Kim, Assistant Professor, CUHK.Business School, The Chinese University of Hong Kong, Shatin NT, Hong Kong, skim@cuhk.edu.hk, Youngsok Bang, Yiying Zhang

Despite a plethora of previous studies on the role of seller certificates in e-marketplaces, we have a limited understanding of their effects in post-order stage where buyers can reverse their purchase decisions. Based on the psychological contract violation theory, we propose hypotheses about potential negative effects of certificates and test them using transaction data from a leading e-marketplace in Korea. Our results suggest that, given the time elapsed from the order, buyers are more likely to cancel their orders from "quick" sellers, whereas the impact is reversed for "quality" or "quantity" sellers. We also examine how the results vary over different product types and purchase channels.

3 - Online Retailer Competition with an Option of Referral Services

Kihoon Kim, Associate Professor, Korea University, Korea Univeristy Business School, LG-POSCO.#316, Anam-dong, Seongbuk-gu, Seoul, 136701, Korea, Republic of, kihoon@korea.ac.kr

We investigate whether two competing online retailers can be better off by adopting a referral service. When they adopt the referral service, a referral-offering online retailer faces a trade-off between generating additional revenues from referral fees and the risk of exposing its loyal consumers to the price of its referred online retailer. We show that the proportion of strongly loyal consumers of the referral-offering retailer among all its (potential) consumers mainly determines the degree to which the referral service will improve the retailers' profits.

4 - Domestic Expansion Strategies for Online Grocery Retailers: Case Study from Emerging Economy

Rajiv Misra, Professor, XLRI-Xavier School of Management, C. H. Area (East), Jamshedpur, 831001, India, rajiv@xlri.ac.in, Sayan Mukherjee, Alok Baveja, Atanu Ghosh

This is a study on the strategies that an Online Grocery Store can consider for expansion in the domestic market. Our overarching research questions are: 1.What strategic options does an online grocery store have when it considers expansion? 2. What factors affect the choice of an expansion strategy? By conducting literature review and by evaluating cases from an emerging economy, we first try to explore the strategic options available for expansion and the factors that affect the choice of each option. Taking the case of a leading online grocery retailer in India, we next longitudinally evaluate the decisions taken by the retailer while expanding into several locations in the domestic market.

■ TA50

361C

Advances in Urban Transportation

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Qie He, University of Minnesota, Minneapolis, MN, 55455, United States, qhe@umn.edu

1 - Real Options Switching Strategies in Dynamic Transportation Operations

Joseph Y.J. Chow, New York University, 2 Washington Square Village, Apt. 10i, New York, NY, 10012, United States, joseph.chow@nyu.edu, Qianwen Guo, Paul M. Schonfeld

With increasing ubiquity of real time data in urban transportation, there is a need for dynamic decision-making to switch operational mode based on an underlying stochastic process. Examples include flexible transit that switch between fixed route and on-demand operations; autonomous vehicle fleet management; and taxi surge pricing. We present an analytical optimal policy model based on market entry-exit real options to identify such switching thresholds. The model assumes an Ornstein-Uhlenbeck stochastic process and can reduce up to 72% of the excess cost of a myopic policy. Test cases are presented to illustrate the model.

2 - Continuous Approximation on the Vehicle Routing Problem with Unpaired Pickup and Delivery

Chao Lei, Ph. D., University of Illinois at Urbana–Champaign, 205 N Mathews Ave, Urbana, IL, 61801, United States, chaolei@illinois.edu, Yanfeng Ouyang

We propose a hybrid modeling framework for the vehicle routing problem with unpaired pickup and delivery (VRPPD) of a commodity. Continuum approximation (CA) is used to model internal pickup and delivery within each of multiple subregions, while matching of net excess or deficit of the commodity out of these subregions is addressed in a discrete model. A Lagrangian relaxation algorithm is developed to solve the hybrid model for large-scale VRPPD instances.

3 - Analysis of Two Hybrid Route Choice Models in Stochastic Assignment Paradox

Zhanhong Cheng, Harbin Institute of Technology, Harbin, China, 18369181837@163.com, Jia Yao

This paper compares the stochastic assignment paradoxes of the multiplicative hybrid model and the linear combinatorial hybrid model, both of which can overcome the drawbacks of the multinomial logit/weibit model, in three typical networks (two links, independent links, and three routes with an overlapping link).

4 - Traffic Assignment Paradox Incorporating Congestion and Stochastic Perceived Error

Jia Yao, Harbin Institute of Technology, Harbin, China, yaojia@hit.edu.cn

This paper analyzes how congestion and stochastic perceived error affect traffic assignment paradox simultaneously. The paradox corresponding to the travel cost and the perceived travel cost for marginal improving and adding a link and information paradox in which a higher stochastic perceived error decrease the travel cost are analyzed respectively.

■ TA51

361D

Online Markets

Sponsored: Information Systems

Sponsored Session

Chair: Wei Chen, Tucson, AZ, 85718, United States, weichen@email.arizona.edu

1 - Value of Diversity in Online Equity Crowdfunding

Mingfeng Lin, University of Arizona, 1130 E.Helen St, Tucson, AZ, 85721, United States, mingfeng@eller.arizona.edu

This talk discusses the role and value of diversity in predicting business performance using an extremely detailed proprietary dataset from online equity crowdfunding. Results have implications for investors, entrepreneurs, and policy makers.

2 - The Impact of Store Opening on Customers' Spending in Online Retailing Platform with A Hybrid Model of Reselling and Marketplace

Ling Xue, Georgia State University, Department of Computer Information Systems, J. Mack Robinson College of Business, Atlanta, GA, 30302, United States, lxue5@gsu.edu, Peijian Song, Yanran Liu, Arun Rai

In this study, we examine how the offline channel of the retailer influence the sales in the hybrid online channel with both the reselling section and the marketplace section. We use the opening of offline stores as a research setting to draw causal inferences. Our findings show how the offline channel generates differential impacts on the reselling section and the marketplace section of the online channel. Our study extends the existing understanding of online-offline interaction by bringing the marketplace model into consideration.

3 - Market Segmentation and Software Security: Pricing Patching Rights

Duy Dao, University of Calgary, Calgary, AB, Canada, Duy.Dao@rady.ucsd.edu

The patching approach to security in the software industry has been less effective than desired. A critical issue is that the ability for a consumer to choose whether security updates are applied lacks the incentive structure to induce better security-related decisions. In this paper, we establish how vendors can differentiate their products based on the provision of patching rights and how optimally pricing this right can segment the market in a manner that leads to both greater security for consumers and greater profitability for vendors.

■ TA52

361E

Energy

Contributed Session

Chair: Jose-Ignacio Munoz-Hernandez, University of Castilla-La Mancha, Ciudad Real, Spain, joseignacio.munoz@uclm.es

1 - Allocating Distributed Generators for Resilient Distribution System under Uncertain Probability Distribution of Natural Disasters

Sadra Babaei, Oklahoma State University, 322 Engineering North, Industrial Engineering & Mgmt, Stillwater, OK, 74078, United States, sadra.babaei@okstate.edu

A new distributionally robust defender-attacker-defender model is proposed for the planning of line hardening and allocating distributed generators, to hedge against the risk of disruptions caused by natural disasters. We consider the case that the true probability distribution of extreme weather is ambiguous, and minimize the load shedding with the worst-case scenario of weather distribution. Unlike traditional robust models, our approach takes advantage of moment information of the weather distribution that is learned from historical data. We reformulate the proposed model as a tractable two-stage robust optimization and employ a column-and-constraint generation algorithm to solve it.

2 - Decision Criteria for Wave Energy Extraction Characterizing its Temporal and Spatial Variability

Francisco Haces Fernandez, Texas A&M.University-Kingsville, Kingsville, TX, United States, fr.haces@gmail.com, Hua Li, David Ramirez

Wave energy is one of the most promising renewable energy resources. However, its commercial development has been slow and is facing important challenges. Understanding its high temporal and spatial variability will significantly improve its extraction. This research is able to identify how wave energy behaves as a two temporal estate system, with high and low energy periods. Energy Events have distinctive characteristics, allowing them to be identifiable on calendar periods, by its seasonal frequencies and on energy content. This study provides decision criteria for the installation of wave energy extraction equipment that provides the optimal fit for each location.

3 - Improving the Efficiency and Performance of Genetic Algorithm Based Layout Optimization Method on Irregular Shape Wind Farms

Hua Li, Associate Professor, Texas A&M University-Kingsville, 700 University Blvd MSC 191, Kingsville, TX, 78363-8202, United States, hua.li@tamuk.edu, Yan Xu

Layout optimization has become a one of the critical tools to help increase the power output or decrease the cost of a wind farm. Most of the existing layout optimization algorithms are based on regular shape wind farms, while most commercial wind farms have irregular shapes. A layout optimization algorithm that can be applied on different irregular shape wind farm with consideration of different commercial wind turbine models and hub heights is needed to help improve the efficiency and performance of commercial wind farms. This study develops and improves a genetic algorithm based wind farm layout optimization method for irregular shape wind farms with real world parameters.

4 - Optimal Use of the Storage Capacity of a Pool of Electrical Vehicles, Connected to a Micro Grid or a Virtual Power Plant

Jose-Ignacio Munoz-Hernandez, University of Castilla - La Mancha, Edifico Politecnico - UCLM, Avda Camilo Jose Cela, S/N, Ciudad Real, 13071, Spain, joseignacio.munoz@uclm.es, Pablo Diaz-Cachinero, Javier Contreras

Micro grids and Virtual Power Plants consist of several types of generation resources to meet their demand necessities. Electrical vehicles are mobile demands that can plug into the network at different sites but, at the same time, they also can be used as power reservoirs or sources. Due to the increasing penetration of renewable energy sources, electric vehicles, and storage units, the associated uncertainty needs to be properly characterized. This work develops a new approach to optimize the use of this sort of resources in a micro grid and in a virtual power plant.

■ TA53

361F

Improving Energy Efficiency of Personal Transportation

Sponsored Session

Chair: Hesham Rakha, PhD, P. Eng., Virginia Tech Transportation Institute, 3500 Transportation Research Plaza,, Blacksburg, VA, 24061, United States, hrakha@vt.edu

1 - A Web Based Personal Driving Assistant using Real Time Data and a Dynamic Programming Model

Mohammad Ali Alamdar Yazdi, PhD Student, Auburn University, 516 E. Glenn Ave, Apt 128, Auburn, AL, 36830, United States, mza0052@auburn.edu, Fadel Mounir Megahed, Alexander Vinel

This talk presents a web based Eco-Driving Assistance System to improve a vehicle's miles per gallon (mpg) fuel-economy performance. More specifically, a dynamic programming model is constructed to dynamically optimize the current speed, gear, and route based on forthcoming route conditions (weather, traffic, elevation, etc.) collected from different web APIs.

2 - An Algorithm for Incentive Allocation Problem as a Part of Smart Mobility Solutions

Mehrdad Shahabi, University of Michigan, 2350 Hayward St, 205, Ann Arbor, MI, 48109, United States, mshahabi@umich.edu, Yafeng Yin, Chenfeng Xiong, Lei Zhang

Recently, there has been a surge of interest in transportation demand management tools involving incentive provision in order to manage the growing congestion problems in transportation networks. With the goal of decreasing the energy consumption on the system level, our focus in this work is to design a framework through which a number of travelers are offered incentives on some travel alternatives different from their original travel option. The results confirm significant savings in energy consumption as a result of changing travel behavior.

3 - Multi-scale and Multi-modal Agent-based Modeling of Network-wide Energy/Fuel use of Travel Incentive Strategies

Hesham Rakha, Samuel Reynolds, Pritchard Professor of Engineering, Virginia Tech, Blacksburg, VA, 24060, United States, hrakha@vt.edu, Ahmed Elbery, Filip Dvorak, Matthew Klenk, Jinghui Wang, Ahmed Ghanem

The need to objectively and systematically evaluate the network-wide impacts of travel incentive strategies necessitates the development of multi-scale multi-modal agent-based modeling tools. This presentation describes the various building blocks of the proposed modeling tool, namely: (a) traveler behavior modeling; (b) modeling of train dynamics; (c) modeling driver and vehicle longitudinal and lateral movement; (d) modeling of multi-modal energy/fuel consumption (gasoline, electric, and plugin hybrid electric vehicles, CNG buses, and electric trains); (e) integration of microscopic and mesoscopic modeling into a fully-integrated multi-scale multi-modal agent-based modeler.

■ TA54

362A

Operations Research in Plant Breeding

Invited: Agricultural Analytics

Invited Session

Chair: Lizhi Wang, Iowa State University, Ames, IA, 50011, United States, lzwang@iastate.edu

1 - The Extended Predicted Cross Value for Genetic Introgression of Multiple Alleles with Multiple Individuals

Ye Han, Iowa State University, Black Engineering, Room 0076, Ames, IA, 50014, United States, yeh@iastate.edu, Lizhi Wang, William D. Beavis, John N. Cameron

In our recent research, we applied operations research approaches to optimize introgression of multiple alleles from a donor to a recipient genome. We designed a novel metric called the Predicted Cross Value (PCV) for selecting breeding parents. The PCV has been proved to bring in significantly advantages over the existing approaches by simulations. In this research, according to the practical breeding requirements, we extend the PCV idea to introgression process for multiple individuals. The updated metric is referred as PCV for multiple individuals or NPCV. We examine the NPCV in different case studies compared with the PCV or existing approach and demonstrate the results by simulations.

2 - New Genomic Selection Approaches
Lizhi Wang, Iowa State University, IMSE and ECPE, Ames, IA, 50011, United States, lzwang@iastate.edu

Genomic selection is among the most impactful decisions that plant and animal breeders make. It also presents an incredibly complex mathematical challenge: how to select the right breeding parents to produce the next generation of progeny to achieve maximal genetic gains? We will review previously proposed genomic selection approaches, present a new one, and discuss future research directions.

3 - Mathematical Programming Based Training Set Optimization for Genomic Selection
Shiyang Huang, Iowa State University, 0076 Black Engineering, Ames, IA, 50011, United States, shuang@iastate.edu, Guiping Hu

A new method of optimized training set (TRS) selection was proposed for genomic selection. A quadratic optimization model with binary variables is formulated and and solved with a specially designed algorithm to select individuals forming the TRS from a calibration set. A ridge regression best linear unbiased predictor (rrBLUP) model was trained based on selected TRS to calculate genomic-estimated breeding value (GEBV) and predict the corresponding trait. The proposed method significantly outperformed common existing TRS selection methods, and suggested a criterion based on individuals' Identify-By- State (IBS) distances to evaluate training sets.

4 - Optimizing the Size of Training Data for Genomic Prediction
Reka Howard, University of Nebraska-Lincoln, 342B Hardin Hall, Lincoln, NE, 68583, United States, rekahoward@unl.edu

Genomic prediction (GP) is a technique in plant breeding where plants' genotypic and phenotypic information - called training set - are used to predict plant's phenotypic performance for which only marker information is available, also known as testing set. In GP the size, genetic architecture and quality of phenotypic data influence predictability. Herein an algorithm based on genetic similarities that avoids the use of phenotypic data for choosing the optimal training set for GP using a soybean data set containing information for 5600 individuals is presented.

■ TA55

362B

Robust Portfolio Selection

Sponsored: Financial Services

Sponsored Session

Chair: Victor DeMiguel, London Business School, London, NW1 4SA, United Kingdom, avmiguel@london.edu

1 - Long-term Asset Allocation under Time-varying Investment Opportunities: Optimal Portfolios with Parameter and Model Uncertainty
Alex Weissensteiner, Free University of Bolzano Bozen, Universitÿtsplatz 1, Bolzano, 39100, Italy, alex.weissensteiner@unibz.it, Thomas Dangl

We study the implications of predictability on the optimal asset allocation of ambiguity averse long-term investors in a VAR model. While over short periods the model-implied conditional covariance structure of asset-class returns determines the optimal allocation, over longer horizons the optimal asset allocation is significantly influenced by the covariance structure induced by estimation errors. As a consequence, the ambiguity averse long-term investor tilts her portfolio not simply toward the global minimum-variance portfolio but shrinks portfolio weights toward a seemingly inefficient portfolio which shows maximum robustness against estimation errors.

2 - A Portfolio Perspective on the Multitude of Firm Characteristics
Victor DeMiguel, London Business School, Management Science and Operations, Regents Park, London, NW1 4SA, United Kingdom, avmiguel@london.edu

We investigate which characteristics matter jointly for an investor who cares not only about average returns but also about portfolio risk, transaction costs, and out-of-sample performance. We find only a small number of characteristics—six—are significant without transaction costs. With transaction costs, the number of significant characteristics increases to 15 because the trades in the underlying stocks required to rebalance different characteristics often net out. We show investors can identify combinations of characteristics with abnormal out-of-sample returns net of transaction costs that are not fully explained by the Fama and French (2015) and Hou, Xue, and Zhang (2014) factors.

3 - Risk-adjusted Returns and Leverage Efficiency under Market Impact
Chanaka Edirisinghe, Rensselaer Polytechnic Institute, Lally School of Management, Pittsburgh 2118, Troy, NY, 12180-3590, United States, edirin@rpi.edu, Jingnan Chen, Jaehwan Jeong

We model the Pareto-efficient set between portfolio's Sharpe and leverage under risk-aversion in continuous-time trading under market impact. We derive analytical properties for Sharpe-Leverage tradeoff and show the departures from the standard theory that ignores trading costs. We also obtain the minimum variance portfolio and provide empirical testing under market impact. Disregarding market impact leads to severe performance shortfall.

4 - Portfolio Construction by Mitigating Error Amplification: The Bounded-noise Portfolio
Long Zhao, UT.McCombs Business School, 2110 Speedway Stop B6500, CBA 5.334 B, Austin, TX, 78712-1277, United States, longzhao@utexas.edu

This paper focuses on the problem of poor portfolio performance when a minimum-variance portfolio is constructed using the sample estimates. Estimation errors are mostly blamed for this problem. However, we argue that even small unbiased estimation errors can lead to bad performance because the optimization step amplies errors. Instead of trying to independently improve the estimation step or fix the optimization step for robustness, we disentangle the well-estimated aspects from the poorly estimated aspects of the covariance matrix and handle them differently and appropriately. Using a single constant parameter, our method achieves excellent performance in both simulation and real data.

■ TA56

362C

Emerging Topics in Machine Learning: Methodology and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Tong Wang, University of Iowa, Iowa City, IA, 52245, United States, tong-wang@uiowa.edu

1 - Big Data is Small Data
Jessica Clark, University of Maryland Smith School of Business, College Park, MD, 20742, United States, jclark@stern.nyu.edu, Foster Provost

The goal of this work is to explore the ways in which big data and small data are similar in a binary classification setting. We define big data sets as those that represent human behaviors selected from a large set of options, and are therefore not only large in quantity but are also sparse. Conversely, small data sets are dense and comprise few instances and few features. We propose a model for big (and small) data generation and use it to generate sample data sets. We find two key similarities between big and small data. First, models trained on big data generate learning curves that continue to improve as more instances are added. Second, models trained on sparse data tend not to overfit, even with many features.

2 - New Algorithms for Inference in Dynamic Stochastic Block Models
Theja Tulabandhula, UIC, Chicago, IL, United States, tt@theja.org, Mehrnaz Amjadi

Although the computational and statistical trade-offs for modeling single graphs are relatively well understood, extending such results to sequences of graphs is difficult. In this work, we propose two models for such sequences that capture: (a) link persistence between nodes across time, and (b) community persistence of each node across time. In the first model, we assume that the latent community of each node does not change, and in the second model we relax this assumption. For both models, we propose computationally efficient inference algorithms, which leverage community detection methods that work on single graphs. We provide simulation results validating their performance.

3 - Causal Rule Sets for Identifying Subgroups with Enhanced Peer Influence
Tong Wang, University of Iowa, Pappajohn Business Build, 21 East Market Street, Iowa City, IA, 52245, United States, tong-wang@uiowa.edu, Cynthia Rudin, Shan Huang, Haojun Wu

Peer influence is of central importance in social science. The goal of this paper is to identify subgroups where peer influence exerts enhanced effect on users' responses to social advertisements. Our model characterizes such a subgroup using a set of interpretable rules, constructed from information regarding a user (susceptibility), his/her friend (influence), and their relationship. For this study, we partnered with a world leading mobile social network platform, WeChat, and conducted a large-scale randomized controlled field experiment on WeChat Moments on more than 28 million users across 99 ads. Our model showed competitive performance on different types of product ads.

4 - Cost-effective Interpretable Treatment Regimes
Cynthia Rudin, Duke University, Durham, NC, 27708, United States, cynthia@cs.duke.edu, Himabindu Lakkaraju

I will present work on cost-effective interpretable treatment regimes. This is a policy design problem that involves estimating counterfactuals and using tools from interpretable machine learning.

■ TA57

362D

Simulation Optimization and Ranking and Selection

Sponsored: Simulation

Sponsored Session

Chair: Demet Batur, University of Nebraska-Lincoln, dbatur@unl.edu

1 - Ranking and Selection as Stochastic Control
Yijie Peng, George Mason University, Fairfax, VA, United States, ypeng10@gmu.edu, Edwin P.Chong, Chun-Hung Chen, Michael Fu

We propose a new framework for ranking and selection (R&S). The speaker shows an unexpected phenomenon that many popular methods in R&S decrease the probability of correct selection (PCS), which is caused by the imperfect theoretical foundation of these methods. To address the problem, R&S is formulated as a stochastic control problem and efficiently solved in an approximate dynamic programming (ADP) paradigm. Two ADP approaches are provided. One using a single feature of the value function sequentially achieves an asymptotically optimal sampling ratio that cannot be achieved by the many existing methods. Another ADP approach using two features avoids the non-monotonicity of the PCS.

2 - Quantile Based Selection
Demet Batur, University of Nebraska-Lincoln, Department of Management, CBA 209, Lincoln, NE, 68588-0491, United States, dbatur@unl.edu, Fred Choobineh

We study comparison of stochastic simulated systems based on a quantile performance measure. An indifference-zone quantile selection procedure is presented.

3 - Tractable Sampling Strategies for Ordinal Optimization
Dongwook Shin, Hong Kong University of Science and Technology, Kowloon, Hong Kong, dwshin@ust.hk
Dongwook Shin, Columbia University, New York, NY, 10027, United States, dwshin@ust.hk, Mark Nathan Broadie, Assaf Zeevi

We consider a problem of ordinal optimization when the objective is selecting the best of several competing alternatives ("systems"), where probability distributions governing each system's performance are not known, but can be learned via sampling. The objective is to dynamically allocate a finite sampling budget to minimize the probability of selecting a system that is not the best. The aforementioned objective does not possess an analytically tractable solution. We introduce a family of practically implementable sampling policies and show that the performance exhibits (asymptotically) near-optimal performance.

■ TA58

362E

Shipping and Port Operations of the Future

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Amir Gharehgozli, Texas A&M University at Galveston, Galveston, TX, 77553, United States, gharehga@tamug.edu

1 - Integrated Planning of Ship Waterway Traversals and Berthing at Maritime Ports using Resource-constrained Project Scheduling
Alessandro Hill, Universidad Adolfo Ibanez, Santiago, Chile, alessandro.hill@uai.cl, Marcos Goycoolea, Eduardo Lalla-Ruiz, Stefan Voss

We consider short-term scheduling of ship traversals of waterways that connect the seacoast with the actual port area in accordance with arrival and departure times. Side constraints arising from the port's geographical situation, traffic and the influence of the tides make this problem challenging when minimizing the total ships' turnaround times. We extend this problem for including ship berthing operations, which have to be completed within pre-assigned time windows, and we show that this problem can be expressed as a multi-mode resource-constrained project scheduling problem. Using mathematical programming, we improve previous results for real-world instances.

2 - A Junction Traffic Coordination in the Large Scale Act Network
Ek Peng Chew, National University of Singapore, 10 Kent Ridge Crescent, Dept of Industrial and Systems Engineering, Singapore, 119260, Singapore, isecep@nus.edu.sg

In the mega transshipment automated container terminal (ACT), there are many potential conflicts and congestion occur in the junctions because of interactions among traffic flows from different direction. We present a scheme for control of AGV traffic flow and coordination of junctions to improve the operation performance in terms of container throughput.

3 - Module Based AGV Routing Algorithms for Automated Container Terminal
Loo Hay Lee, National University of Singapore, 10 Kent Ridge Cresent, Industrial and Systems Engineering, Singapore, 119260, Singapore, iseleelh@nus.edu.sg, Ek Peng Chew, Qitong Zhao

In this talk, we will present a module based routing algorithms for AGV for Automated Container Terminal. This routing algorithm consists of two level planning. The high level planning will determine the rough routing for each AGV by considering congestion, while the low level planning looks into the inner module control which avoids the deadlock for a small section of road.

4 - Developing Reshuffling Free Container Stacking Operations
Amir Gharehgozli, Texas A.& M.University, P.O. Box 1675, Galveston, TX, 77553, United States, gharehga@tamug.edu, Nima Zaerpour

This paper addresses a highly-researched area, the reshuffling problem in container terminals. Container stacking and reshuffling operations can cause ship delays and additional risk. In deep-sea terminals, outbound containers are tightly stacked according to the retrieval sequence. Due to lack of space, terminals stack containers in multiple tiers. This means any delay in the arrival of a ship can impose extra handlings and reshuffling of containers delaying future cargo handling. To address this issue, this study proposes an alternative stacking policy allowing different container types to share the same pile. At the same time, we avoid reshuffling. We aim to minimize the total retrieval time.

■ TA59

362F

Joint Session RAS/Practice: Passenger and High Density Railway Corridor OR/MS

Sponsored: Railway Applications

Sponsored Session

Chair: Shane Wu, National Railroad Passenger Corporation (Amtrak), Washington, DC, 20002, United States, SWu@alumni.pitt.edu

Co-Chair: Steven Harrod, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark, stehar@dtu.dk

1 - CO2REOPT: Real-time Train Dispatching on the Iron Ore Line
Lukas Bach, SINTEF, Forskningsveien 1, 0314 Oslo, Oslo, 0314, Norway, lukas_bach@hotmail.com, Carlo Mannino

On a congested critical railway corridor, the Iron Ore line between Narvik (Norway) and Lluleå (Sweden), we investigate if optimized train dispatching can increase the capacity of the corridor such that more trains can be operated while reducing delays. This is achieved by applying an exact mathematical model as real-time decision support to the dispatchers, given a railway infrastructure and its status, a set of trains and their current position, we find a route for every train from its current position to the destination and a disposition timetable to minimize the cost function.

2 - CO2REOPT: Integrated Planning for Multimodal Networks with Stochastic Demand and Customer Service Requirements
Ioannis Fragkos, Assistant Professor, Rotterdam School of Management, Kralingse Plaslaan 120 bgg, Rottredam, Netherlands, Fragkos@rsm.nl, Joris Wagenaar, Rob A. Zuidwijk

Multimodal networks use multiple modes of transport to carry freight from its origin to its destination. Such networks are more cost efficient than their single-mode counterparts, but their planning is more challenging, as resources have to be coordinated across several modes of transport. Motivated by the operations of a Dutch provider, we integrate strategic, tactical and operational decisions in a single framework, which, on its original form, is intractable. By utilizing a careful reformulation, we develop decomposition heuristics and lower bounding procedures. Our experiments demonstrate that good solutions for realistic instances can be obtained within reasonable time.

3 - A Rapid Modeling Method for High-speed Railway Terminal Simulation

Guangyuan Zhang, Southwest Jiaotong University, Chengdu, Sichuan, 32202, China, gyzhang@swjtu.cn, Yuan Wang

Each railway terminal has many specific features like rail network topology, connectivity structure and route conflicts conditions etc., which makes modeling process complicated and time consuming. This talk will demonstrate a rapid way of modeling the railway terminal simulation, including following procedures: 1) terminal railway network modeling; 2) routes and track connectivity recognition; 3) simulation preprocessing; 4) route conflicts detection; 5) timetable simulation; 6) rapid animation modeling; 7) statistics calculation.

■ TA60

370A

OR/MS Education for MBAs Around the World

Sponsored: INFORMEd

Sponsored Session

Chair: Nilakantan Sundara Raman Narasinganallur, K.J. Somaiya Institute of Management Studies & Research, K.J. Somaiya Institute of Management Studies & Rese, Mumbai, 400082, India, nilakantan@somaiya.edu

1 - A Game of Thrones Optimization Game for Teaching Linear Programming

Jeroen Belien, KU. Leuven, Warmoesberg 26, Brussel, 1000, Belgium, jeroen.belien@kuleuven.be

This paper presents an educational game for teaching LP modeling built entirely around the popular HBO series Game of Thrones. The student takes on the role of a miner's son and encounters various important leading characters from the television series. Every encounter involves formulating and solving a linear programming problem correctly before being allowed to move on to the next one. The game has been used successfully in an introductory course of linear programming for Business Engineering students at KU Leuven (Belgium) in the academic years 2015-2016 and 2016-2017.

2 - O.R./MS Education for MBAS- in India and Around the World

Nilakantan Sundara Raman Narasinganallur, K.J. Somaiya Institute of Management Studies & Research, B.602 Tulip Rachna Garden, Mulund Colony, Mumbai, 400082, India, nilakantan@somaiya.edu

In the modern world, businesses are complex and their study requires quantitative analysis to predict an outcome or prescribe a decision. Operations Research (Management Science) breaks down the problems into a mathematical form and provides optimal or near optimal solutions. All managers are expected to have a good understanding of the OR techniques since such understanding assists in their mastery of the decision-making process. The presentation describes the experiences of researchers in India and around the World and identifies useful tips to deliver the knowledge base and skillsets of Operations Research to MBA students, who are aspiring to be managers in the real world.

3 - Introducing Web-based Spreadsheet Modeling in the MBA Classroom

Neil Desnoyers, Saint Joseph's University, 133 Green Valley Rd, Upper Darby, PA, 19082, United States, ndesnoye@sju.edu

Web-based spreadsheets are different from computer-based spreadsheets. We explore several implications for teaching.

4 - Intelligent Tutoring Systems Driven Management Education

Mark W. Chun, Pepperdine University, 6100 Center Drive, Los Angeles, CA, 90045, United States, mark.chun@pepperdine.edu, Owen P. Hall

Business schools are under growing pressure to engage in significant programmatic reforms in light of the business community's call for web-savvy, problem solving graduates. Some specific benefits for adopting intelligent tutoring systems throughout schools of business include:1) improve learning outcomes; 2) approach Bloom's two-sigma learning goal; and 3) enhance employment opportunities. The purpose of this presentation is to highlight best practices in the use of intelligent tutoring systems throughout the management education universe.

■ TA61

370B

Sports Analytics I

Sponsored: SpORts

Sponsored Session

Chair: Keith A Willoughby, University of Saskatchewan, Saskatoon, SK, S7N 5A7, Canada, willoughby@edwards.usask.ca

1 - 2 Players, 5 Rocks, 8 Ends: Exploring the Analytics of Mixed Doubles Curling

Keith A.Willoughby, University of Saskatchewan, Department of Finance and Mangement Science, Saskatoon, SK, S7N.5A7, Canada, willoughby@edwards.usask.ca, Kent J.Kostuk

As a variant of traditional curling, mixed doubles curling features teams of two players. Each team plays five rocks during an eight-end game. The inclusion of mixed doubles curling in the 2018 Winter Olympics has precipitated an increase in the sport's popularity. The decision-making environment within mixed doubles curling offers significant differences from that observed in traditional curling. We apply quantitative analysis to explore various decisions made during a mixed doubles game.

2 - What Does it Take to Win Consistently in Daily Fantasy Sports?

Ryan Elmore, University of Denver, Denver, CO, United States, Ryan.Elmore@du.edu

Daily fantasy sports (DFS) contests, or fantasy sports contests in general, are at their core a problem of choosing a set of players, or team, that will hopefully outperform the team chosen by one's opponent(s). Individual team construction serves as the basis for variation within games and, hence, a player's team choice is critically important in not going bankrupt. In this talk, we will present several mathematical results related to team choice, DFS player ability, and how good a particular player must be relative to his/her opponents in order to create a positive expected value. We will illustrate our work via a Monte Carlo experiment using hypothetical DFS contests from the 2016-7 NBA season.

3 - Teamwork in e-Sports: Evidence from League of Legends

David Mendonca, RPI, Troy, NY, United States, mendod@gmail.com, W. Gray, M. Sangster, J. Eaton

This talk explores prospects for understanding antecedents and consequences of teamwork through the analysis of data from e-sports: that is, online games that—because they may attract millions of dedicated teams worldwide—produce data of scale and scope that dwarf those of conventional sports. This talk explains how data from one such e-sport, League of Legends, are being used to explore how changes in the membership of teams over fairly long time scales can affect team processes (such as collaboration) and team outcomes (such as winning). Implications for research on conventional sports are also addressed.

4 - Working with Sports Media

James Cochran, University of Alabama, Auburn, AL, United States, jcochran@cba.ua.edu

Members of the various sports media often rely on support from experts for their stories and articles, and as the use of analytics has become more prevalent academics who work in sports analytics have been called on more frequently to provide such support. There are many benefits to providing such support, and one could argue that we are obliged to do so, but this can be daunting the first few (or perhaps several) times you are asked to do so. In this talk we provide guidelines punctuated with discussion of the speaker's experiences.

5 - UFC PPV Buys and the Value of Celebrity Fighters

Thomas Robbins, East Carolina University, 3212 Bate Building, Greenville, NC, 27858, United States, robbinst@ecu.edu

In 2016 the Ultimate Fighting Championship was sold for a reported price of $4 billion, the highest price ever paid for a sports franchise. This was a remarkable turn-around for a promotion that 15 years earlier was saved from bankruptcy by a $2 million buyout. This turnaround was driven by the UFC's ability to mainstream the promotion and the sport while establishing reliable revenue streams through television contracts and massive pay per view events. In this paper we analyze the pay per view record of the UFC and analyze the extent to which it is driven by high profile celebrity fighters with broad crossover appeal. We assess the economic value they generate for the UFC.

■ TA62

370C

Statistical Methods for Degradation Data Analysis

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Qingyu Yang, Wayne State University, Detroit, MI, 48202, United States, qyang@wayne.edu

Co-Chair: Yong Chen, University of Iowa, Iowa City, IA, 52242-1527, United States, yong-chen@uiowa.edu

1 - Physical-statistical Modeling and Quantification of Degradation Rate for Corroding Aluminum Alloy

Xuxue Sun, University of South Florida, 5005 Excellence Blvd 435C, Tampa, FL, 33617, United States, xuxuesun@mail.usf.edu, Mraied Hesham, Wenjun Cai, Guoyuan Liang, Mingyang Li

Corrosion-induced degradation of aluminum alloy is a key causing factor for structure failure of many mission critical systems, such as aircrafts. Successful evaluation of degradation performance is important yet challenging since the degradation rate is not directly measurable. We propose a physical-statistical modeling approach in evaluating the alloy degradation rate. Specifically, the latent degradation rate is first characterized via fractional order system dynamics. Bayesian inference is then carried out to address both data uncertainty and population variability due to the limited data samples. A real case study is further provided to illustrate of the proposed work.

2 - Degradation Analysis of High Strength Dual-phase Steel by using Microstructure Images

Wujun Si, Wayne State University, 4500 Cass Avenue, Apt 1001, Detroit, MI, 48201, United States, fk9456@wayne.edu, Qingyu Yang, Xin Wu

The microstructure of high strength dual-phase steel strongly impacts steel degradation and failure. In this paper, we conduct degradation based reliability analysis of the dual-phase steel by utilizing its microstructure images. A novel functional covariate degradation model is proposed for the analysis. A penalized least square estimation method is developed for the model parameter estimation. Simulation and real case studies are conducted to demonstrate the proposed model. Results show that the failure prediction is more precise by utilizing the microstructure images.

3 - An Integrated Method for Pipeline Fatigue Crack Growth Prediction

Mingjiang Xie, University of Alberta, Edmonton, AB, Canada, mingjian@ualberta.ca, Zhigang Will Tian

Managing fatigue cracks has been a huge challenge in pipeline industry. An integrated method is proposed for predicting pipeline fatigue crack growth considering large defect sizing uncertainty, which can be used for remaining useful life prediction. Stress analysis models, crack propagation models and in-line inspection (ILI) data are fused in this approach. Model parameters are updated based on ILI data through Bayesian approach to achieve a more accurate crack growth prediction. The proposed method is compared with existing physics-based methods.

4 - A Prognostic Framework for Complex Engineering Systems with Multiple Failure Modes

Liexiao Ding, Georgia Institute of Technology, Atlanta, GA, United States, nagi.gebraeel@isye.gatech.edu, Nagi Gebraeel, Xiaolei feng

Complex engineering equipment typically undergoes multifaceted degradation processes. The use of multiple sensors potentially allows the capture of different aspects of such complicated degradation processes, which sometimes exhibit different failure modes. In this talk, we present a statistical prognostic framework for multi-failure modes applications. Specifically, a penalized functional data clustering methodology is first built to select the informative sensor signals corresponding to each failure modes. Next, a prognostic model is built by using the informative sensor signals selected earlier. Numerical studies are used to evaluate the performance of our model.

■ TA64

370E

Causal Data Mining

Sponsored: Data Mining

Sponsored Session

Chair: Michael Lash, University of Iowa, Iowa City, IA, 52242, United States, michael-lash@uiowa.edu

1 - Building Recommenders and Search Engines using Causal Data Mining

Adith Swaminathan, Microsoft, One Microsoft Way, Redmond, WA, 98052, United States, adswamin@microsoft.com

Interactive systems like search engines, recommender systems, and ad placement platforms are ubiquitous. Evaluating and optimizing these systems is hard – users' feedback governs system performance, and gathering their feedback in randomized experiments is costly. Can we re-use logs collected from deployed systems to reliably perform offline evaluation and learning? I will outline two projects (Viewing Recommendations as Treatments, ICML'16 and De-biasing Learning to Rank, WSDM'17) that advance the state of the art for these problems.

2 - Large-scale Model Validation with Negative Controls

Robert Moakler, rmoakler@stern.nyu.edu

Causal models are essential for drawing real-world inferences about cause and effect relationships. Therefore, validating these models is crucial, but unfortunately very difficult. Negative control testing, a method typically employed at small-scales, shows promise when applied to large-scale digital applications. In this work, we build a framework for applying negative control testing and argue that the full potential of negative control testing is only realized when companies and organizations are collecting data for many events they observe. We apply this framework to assess and compare RCTs and observational models built for real-world examples in online advertising.

3 - Prophit: Inverse Classification via Causal Deep Learning

Michael Lash, University of Iowa, 2 West Washington Street, B4 MacLean Hall, Iowa City, IA, 52242, United States, michael-lash@uiowa.edu, Qihang Lin, Nick Street

Past work in the area inverse classification, the process of obtaining instance-specific feature-value updates (recommendations) that optimally improve the probability of a desired classification, focuses on eliciting real-world recommendations, optimization methodology, and classifier inclusion. Ultimately, however, the problem is causal in nature, yet methodologically unexplored. Therefore, we propose Prophit, a deep neural network architecture augmented with causal properties, to solve the inverse classification problem.

4 - Generalized Random Forests

Susan Athey, Stanford University, Stanford, CA, United States, athey@susanathey.com, Stefan Wager

We propose a method based on random forests (Breiman, 2001) can be used to fit any quantity of interest identified as the solution to a set of local moment equations. Our method operates in covariate space by considering a weighted set of nearby examples. We propose a computationally efficient algorithm for growing generalized random forests, develop a sample theory for our method that shows our estimates are consistent and asymptotically Gaussian and provide an estimator for asymptotic variance. Our approach to develop estimators: non-parametric quantile regression, conditional average partial effect estimation, & heterogeneous treatment effect estimation via instrumental variables.

■ TA65

370F

Planning Logistics Systems Under Uncertainty II

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Mike Hewitt, Loyola University Chicago, Glen Ellyn, IL, 60137, United States, mhewitt3@luc.edu

1 - Covering Path Problem on Grid with an Application to School Bus Routing

Liwei Zeng, Northwestern University, 2145 Sheridan Road, IEMS.Department, Evanston, IL, 60208, United States, liweizeng2015@u.northwestern.edu, Karen Smilowitz, Sunil Chopra

We will present work from a collaboration with a large public school district, related to bus transportation to reduce budget pressure. We focus on bus stop selection and route design, two key components of the School Bus Routing Problem identified in the literature. We model the joint problem as a covering path problem. We further exploit the underlying grid-like structure of the road network and obtain robust and easy-to-implement solutions.

2 - Anticipatory Synchromodal Transportation Planning

Martijn Mes, University of Twente, Building Ravelijn, P.O. Box 217, Enschede, 7500 AE, Netherlands, m.r.k.mes@utwente.nl, Arturo E. Pérez Rivera

We study the problem of selecting transport modes and transfers in a synchromodal network over a multi-period horizon. Freights with different characteristics become known over time. Using probabilistic knowledge of freight arrivals, the planner balances current and future costs at each period. We model this problem as a Markov Decision Process (MDP) and solve it using Approximate Dynamic Programming (ADP) in combination with various exploration strategies. Using different problem settings, we show that our look-ahead approach has significant benefits compared to benchmark heuristics.

3 - Approximate Dynamic Programming for the Multi-Period Technician Scheduling with Experience-based Service Times and Stochastic Customers (MTSP-ESTSC)

Xi Chen, Beijing Foreign Studies University, Beijing, China, chenxi0109@bfsu.edu.cn, Barrett Thomas, Mike Hewitt

In this work, we explore the value of integrating future information into the current period decision-making process for the MTSP-ESTSC. We propose an approxi- mate dynamic programming solution approach that uses a basis function to reduce the dimensionality of the state. We benchmark the performance of the ADP solution ap- proach with the basis function against a one-day lookahead approach that minimizes the recent two periods' costs. Our computational results demonstrate the value of proposed approach.

4 - A Benders Decomposition Method for Two-stage Stochastic Network Design Problems

Walter Rei, University of Quebec-Montreal, 10673 Larose, Montreal, QC, H2B 3C4, Canada, rei.walter@uqam.ca, Ragheb Rahmaniani, Teodor Gabriel Crainic, Michel Gendreau

In this presentation, we describe a Benders decomposition algorithm capable of efficiently solving large-scale instances of the multi-commodity capacitated network design problem with demand uncertainty. This problem is relevant to a wide gamut of real-world applications in the telecommunications, transportation and logistics fields. To obtain a state of the art Benders method, we propose various acceleration techniques, including the use of cutting planes, partial decomposition, heuristics, stronger cuts, reduction and warm-start strategies. Extensive computational experiments conducted on benchmark instances confirm the superiority of the proposed algorithm over existing ones.

■ TA66

371A

Network Design in Freight Logistics

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Lokesh Kalahasthi, Rensselaer Polytechnic Institute, Troy, NY, United States, kalahl@rpi.edu

1 - Scheduling Optimization of Local Farmers

Sefakor Fianu, North Carolina A&T.State University, 1601 .Market St, Greensboro, NC, 27401, United States, sfianu@aggies.ncat.edu, Lauren Berrings Davis

Local farmers face challenges such as; seasonality, transportation, food safety, and packaging requirements that prevent them from meeting the demand of institutions like universities. This research is part of the University Food Systems project aimed at connecting local farmers and universities in North Carolina. We solve the transportation problem by developing weekly schedules that minimizes the distance traveled by farmers to drop off their produce at crossdocking facilities. The schedules addresses capacity, collection frequency and food spoilage constraints.

2 - The Dynamic Shortest Covering Path Problem

Jimena Pascual, Pontificia Universidad Catolica de Valparaiso, Av Brasil 2241, Casilla 4059, Valparaiso, 2362807, Chile, jimena.pascual@pucv.cl, Andrea Leticia Arias, Dario Canut De Bon, Ricardo Gatica, Timothy I. Matis

We consider a variant of the Shortest Covering Path Problem (SCPP) in which the arc costs change over time due to dynamic environmental conditions. In this problem, the aim is to determine a minimum cost path from a starting to an ending position, such that all the nodes in the network are covered by at least one node selected to be in the path. We present an integer programming formulation for the Dynamic SCPP and explore solution methodologies.

3 - Freight Demand Synthesis with Mode Choice; A Combined Estimation Procedure

Lokesh Kumar Kalahasthi, Rensselaer Polytechnic Institute, 22, College Ave,, Troy, NY, 12180, United States, kalahl@rpi.edu, Jose Holguin-Veras, John E.Mitchell

This research develops a combined model for freight demand synthesis (FDS) that incorporates the estimation of modal split between rail and truck. A gravity model is adopted for the estimation of trip distribution; a binary logit model for modal split between rail and truck; and Noortman and van E's model is used for empty trips. It is assumed that the total productions and attractions, the network data, and the link flows by both modes are available. Application on a sample network shows that, the model provides reasonably good estimates for O-D table and modal split. This research serves as a potential tool for transportation planners in evaluating various policy outcomes.

■ TA67

371B

High-dimension Spatio-Temporal Analysis II

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Shyam Ranganathan, Virginia Tech, shyam81@vt.edu

Co-Chair: Jian Liu, University of Arizona, Tucson, AZ, 85721, United States, jianliu@email.arizona.edu

1 - A Class of Bayesian Hierarchical Models with Conjugate Full-conditional Distributions for Dependent Data

Jonathan Bradley, Florida State University, Tallahassee, FL, United States, bradley@stat.fsu.edu

We introduce a class of models for Bayesian analysis of high-dimensional dependent data. In particular, we introduce something we call the "conjugate multivariate distribution." Furthermore, we provide substantial theoretical and methodological development including: results regarding conditional distributions, an asymptotic relationship with the multivariate normal distribution, conjugate prior distributions, and full-conditional distributions for a Gibbs sampler. The results in this manuscript are extremely general, and can be adapted to many different settings. We demonstrate the methodology through several illustrations.

2 - Estimation of Sparse Vector Autoregressive Moving Averages

Ines Wilms, KU. Leuven, Naamsestraat 69, Leuven, 3000, Belgium, Ines.Wilms@kuleuven.be, Sumanta Basu, Jacob Bien, David Matteson

The Vector Autoregressive Moving Average (VARMA) model is a fundamental tool for modeling multivariate time series. However, as the number of time series increases, the VARMA model becomes heavily overparameterized. For such high-dimensional VARMA models, estimation is generally considered intractable, leading people to favor simpler approaches such as Vector Autoregressive (VAR) models. We propose a new framework for learning parsimonious VARMA models in high-dimensional settings and show that it has good forecast accuracy both in simulation and in various application domains.

3 - A Statistical Modeling Approach for Large-scale Spatio-temporal Data

Xiao Liu, Assistant Professor, University of Arkansas, Department of Industrial Engineering, 4207 Bell Engineering Center, 1 University of Arkansas, Fayetteville, AR, 72701, United States, liuxiao314923@gmail.com

The research presents a statistical modeling approach for large-scale spatio-temporal data. In particular, we show the connection of the statistical model to physical models which are given by Stochastic Partial Differential Equations.

■ TA68

371C

Manufacturing Data Analytics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Hongyue Sun, University at Buffalo, Buffalo, NY, 1, United States, hongyues@buffalo.edu

1 - Heterogeneous Recurrence Monitoring of Dynamic Transients in Ultraprecision Machining Processes

Chen Kan, Pennsylvania State University, University Park, PA, United States, cjk5654@psu.edu, Changqing Cheng, Hui Yang

In-situ monitoring and control of process variations are important for quality assurance in ultraprecision machining (UPM) processes. However, conventional approaches are limited in their ability to address the complex dynamics in the nonlinear and nonstationary processes. This paper presents a heterogeneous recurrence monitoring approach to detect dynamic transients in UPM processes. Experimental results showed that the proposed approach effectively detects transitions with a small magnitude in the Lorenz system, and identifies the shift from stable cutting to unstable cutting in the real-world study of UPM processes.

2 - Sensor Fusion and on-line Monitoring of Friction Stir Blind Riveting for Lightweight Materials Manufacturing

Weihong Guo, Rutgers, The State University of New Jersey, 96 Frelinghuysen Rd, CoRE Rm 220, Piscataway, NJ, 08854, United States, wg152@rutgers.edu, Zhe Gao

Friction stir blind riveting (FSBR) is a recently developed manufacturing technique for joining lightweight materials for wider adoption in the automotive sector. Using FSBR to join carbon fiber-reinforced polymer (CFRP) composite and aluminum alloy sheets has been studied experimentally, however, the quantitative relationship between FSBR and joint quality remains unclear. To gain a better understanding of FSBR lightweight materials manufacturing, the proposed method effectively models this relationship by integrating data de-noising, dimension reduction, feature extraction, feature selection, and classifier fusion. The proposed method is demonstrated with real data from FSBR.

3 - Remaining Useful Life Prediction Based on Model Integration for Broaching Tools

Wenmeng Tian, Virginia Tech, 415 New Kent RD, Blacksburg, VA, 24060-6507, United States, tian0414@vt.edu, Lee J. Wells, Jaime Camelio

Remaining useful life prediction is a critical task for various multi-edged machining processes such as broaching. Tool wear occurs when cutting edge and machining surface rub each other, leading to material loss from the cutting edge. A system-level health index and the parametric form of its degradation path are derived simultaneously based on the physical process model. Then the degradation path is used for remaining useful life prediction. A Bayesian update framework is used to combine in-situ observations of a testing sample and historical degradation model parameter distributions considering possible correlation between the degradation path parameters and the random failure threshold.

4 - Online Monitoring of Line Resistance in Aerosol Jet Printing Process

Rao Prahalada, University of Nebraska-Lincoln, Lincoln, NE, 68588, United States, rao@unl.edu, Roozbeh Salary, Mark Poliks, Jack Lombardi

The goal of this research is online monitoring of functional electrical properties, e.g., resistance, of electronic devices made using aerosol jet printing (AJP) additive manufacturing (AM) process. In pursuit of this goal, the objective is to recover the cross-sectional profile of AJP-deposited electronic traces (called lines) through shape-from-shading (SfS) analysis of their online images. The aim is to use the SfS-derived cross-sectional profiles to predict the electrical resistance of the lines.

■ TA69

371D

OR Application in Policy Study and Environment Analysis

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Yihsu Chen, University of California Santa Cruz, 1156 High Street, M/S SOE3, Santa Cruz, CA, 95060, United States, yihsuchen@ucsc.edu

Co-Chair: Ryuta Takashima, Tokyo University of Science, Tokyo, Japan, takashima@rs.tus.ac.jp

1 - Optimizing Water Pollution Monitoring Systems: Regulation Policy Guideline for Curbing Nutrient Pollution

Michael K. Lim, Univ of Illinois Urbana-Champaign, Champaign, IL, United States, mlim@illinois.edu, Xin Chen

We examine regulatory guidelines of surface water quality to curb nutrient pollution resulting from various farming activities. We formulate an optimization model that captures the government's regulation decision taking into account farmers' moral hazard issue. We obtain policy insights and guidelines, along with a solution method for the problem.

2 - Theoretical and Simulation Analysis of Electricity Market for Integrative Evaluation of Renewable Energy Policies from Social Welfare Aspect

Masaaki Suzuki, Tokyo University of Science, 2641 Yamazaki, Noda-shi, Chiba, Japan, m-suzuki@rs.tus.ac.jp, Mari Ito, Ryuta Takashima

Governments have introduced various policies for promoting renewable energy technologies such as feed-in tariff and renewable portfolio standard. Our purpose is to clarify how the relationships among policy, market power, and number of producers impact social welfare. In this work, multi-agent system is constructed for integrative evaluation of renewable energy policies. Multi-agent simulations enable us to evaluate more realistic market and to observe emergent processes of equilibrium states. By comparing the results obtained from the simulation and the equilibrium analysis, we comprehensively examine the policies from both bottom-up and top-down viewpoints.

3 - Analysis of Climate-induced Vulnerability of Northern California Natural Gas System

Sepehr Ramyar, University of California-Santa Cruz, 1156 High Street, Santa Cruz, CA, 95064, United States, sramyar@ucsc.edu, Yihsu Chen, Andrew Lu Liu

This talk will discuss an ongoing project that analyzes the vulnerability of the Northern California natural gas system, considering delivery contracts and engineering aspects. The study is formulated as an optimization problem that minimizes the operational and contractual energy delivery costs while at the same time accounting for the physical characteristics of the network to guarantee reliable delivery of natural gas to customers. The model will be coupled with the downscaled outputs from climate change models to evaluate its vulnerability and identify possible resilience options.

4 - When Agents Trade in Electricity Attributes, Who Benefits?

Janiele Custodio, George Washington University, Washington, DC, United States, janiele@gwu.edu, Ekundayo Shittu

The integration of RPS programs has been suggested as a way to accomplish renewable goals at low cost. However, issues such as market power and overlapping regulatory mechanisms are critical to the performance of such systems. The purpose of this research is to explore the viability and the implications of integrated markets for renewable certificates. We formulate a series of MPECs to analyze how imperfect competition and redundant renewable policies would affect the economics of an inter-regional market. Lastly, we estimate aggregate supply and demand curves using data from existing RPS programs to explore the viability of an integrated market for renewable certificates.

■ TA70

371E

Data Mining

Contributed Session

Chair: Samuel Davis, Northeastern University, Boston, MA, United States, davis.sam@husky.neu.edu

1 - A Data Mining Approach to Identify Third Party Subrogation in the Health Insurance Industry

Naveen Kumaresan, Data Mining Analyst, West Corporation, 11808 Miracle Hills Drive, Omaha, NE, 68154, United States, nkumaresan@west.com, Shruti Palasamudram Ramesh

Every year, health insurance companies pay billions of dollars in excess to medical providers. An average of up to 5% of medical claims paid by insurers are the responsibility of other payers which leads to subrogation. Subrogation is the recovery of an insurance claim from a third party that was originally paid by a patient's medical plan. Traditional subrogation process is laborious and time consuming. This paper discusses how WEST Corporation's Center for Data Science utilized predictive analytics to predict the probability of a claim to be third party liable (TPL) with highest recovery chances. The predictive model has increased the identification of TPL claims by 5 times.

2 - Analyzing Patterns of Multiple Chronic Conditions and Their Associated Behavior in Temporal Direction using Multi-level Temporal Bayesian Network

Syed Hasib Akhter Faruqui, Graduate Research Assistant, The University of Texas at San Antonio, One UTSA Circle, San Antonio, TX, 78249, United States, syed-hasib-akhter.faruqui@utsa.edu, Adel Alaeddini, Mary Jo Pugh, Jaramillo Carlos

The rising prevalence of multi-morbidity raises the complexity of health care management, Medicaid co-ordination and treatment planning. The domain knowledge of underlying pattern among the Multiple Chronic Conditions (MCC) from the existing longitudinal co-morbid patient dataset can be used for building a decision support system. Multi-Level Temporal Bayesian Networks can be used to reveal and analyze hidden patterns present in co-occurring MCC and any risk factor associated with it along the temporal abstraction. This study describes the prevalence of and patterns of co-morbidity among patients of different age groups receiving Medicaid assistance.

3 - A Semi-markov Mixture Model Clustering Method for Multi-state Partially Censored Data

Geet Lahoti, Graduate Research Assistant, Georgia Tech, 1038 Mcmillan St. NW, Atlanta, GA, 30318, United States, glahoti6@gatech.edu, Chitta Ranjan, Zih Huei Wang, Zhen Qian, Chuck Zhang, Ben Wang

Semi-Markov model is used to model the state transition dynamics in spatio-temporal data widely found in the web, marketing, reliability, and healthcare. The main challenge in modeling this data is the underlying (unobserved) heterogeneity with respect to the behaviors in the transition dynamics. We propose a semi-Markov mixture model based methodology and develop an EM algorithm that stratifies the partially censored data into homogeneous groups. The transition dynamics of all the subjects within a stratified group will be similar; thus, a predictive model built for a group will have a better accuracy. We demonstrate the validation and application on synthetic and real data sets.

4 - Using an Integrated System Approach in Finding the Optimal Simulation Model Based on Healthcare Case Study

Tannaz Khaleghi, Wayne State University, Detroit, MI, 48202, United States, fj6710@wayne.edu, Alper E. Murat

Nowadays predicting the system architecture and its corresponding core attributes at a specific time slice is valued the most. Simulation experts usually simulate the system based on the data they receive and observing some processes. However, in many cases one may not be able to gather prior information about the system design. In this study the attempt is to propose 3-stage analysis namely, process mining, dynamic Bayesian network and discrete event simulation, to discover the best system design model which is not only exclusively grantees infinitesimal deviation from the real model, but also reduces the time complexity of finding the optimal model significantly for large systems.

5 - Data Analytics & Modeling in Medical Imaging Analysis & Decision Making

Shouyi Wang, Assistant Professor, University of Texas-Arlington, 500 West First Street, Woolf Hall 420, Arlington, TX, 76019, United States, shouyiw@uta.edu, Feng Liu, Kin Ming Puk, Rahilsadat Hosseini

The advances in computing and advanced data analytics techniques have led to powerful and promising data-driven tools to solve complex healthcare and medical decision making problems based on increasingly large amounts of data. This session provides a collection of talks in the field to present several most recent research studies that develop data-driven approaches and machine learning techniques for comprehensive decision modeling in medical imaging analysis and decision making.

6 - Application of Conditional Binary Decision Tree to Develop Improved Hospital Length of Stay Prediction

Samuel Davis, PhD Candidate, Northeastern University, Boston, MA, United States, davis.sam@husky.neu.edu

Managing the variable demand and relatively fixed supply of hospital bed and nurse resources is critical for maintaining safe and efficient operations. Level-loading daily patient census requires a firm understanding of patient arrival and length of stay (LOS) patterns. This work shows that traditional LOS prediction methods are less accurate at the individual and aggregate level than the proposed method, and does so by using a novel conditional binary decision tree. Predictions are produced and validated using data from a large Boston metro area hospital. Aggregate demand predictions are created from the individual patient predictions and are shown to be accurate and rigorous.

■ TA71

371F

7:30 - 8:15 Syncopation /8:15 - 9:30 Mathworks

Invited: Vendor Tutorial

Invited Session

1 - DPL Portfolio and DPMX(tm): A Decision Analysis based System for Better Portfolio Decisions

Chris Dalton, Syncopation Software, Inc, Bangor, ME, United States, cdalton@syncopation.com

This demonstration will show how the DPMX(tm) System can improve portfolio decision quality by bringing better analytics and data management to your portfolio analysis process. We'll start with an overview of DPL Professional, a widely used modelling environment for decision analysis, risk analysis and Monte Carlo simulation. Next, we'll cover DPL Portfolio, the platform for portfolio analysis, visualization and prioritization. Finally we'll show DPMX, a web-based based system for managing project data and presenting portfolio results in attractive, management-ready reports. The motivating examples will be drawn from the prioritization of an R&D portfolio.

2 - Data Analytics with MATLAB

Mary C.Fenelon, MathWorks, 3 Apple Hill Dr., Natick, MA, 01760-2098, United States, mary.fenelon@mathworks.com

Join us to see how MATLAB can help you explore data, develop predictive and prescriptive models, and integrate analytics into enterprise applications. We'll illustrate this through a load forecasting and unit commitment demo on Big Data following this workflow. Merge historical demand and weather data into a time series. Explore machine learning models interactively to find the best model to predict demand. Prescribe how to satisfy demand by formulating and a solving mixed-integer linear program. Deploy an application to the web or enterprise systems to empower business analysts.

■ TA72

372A

Network Dynamics and Inference

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Chris Quinn, Purdue University, Purdue, West Lafayette, IN, United States, cjquinn@purdue.edu

1 - Identification of Peer Effects in Networked Panel Data

Daniel Rock, Massachusetts Institute of Technology, Sloan School of Management, 100 Main Street, Cambridge, MA, 02142, United States, drock@mit.edu, Sinan Aral, Sean J. Taylor

After product adoption, consumers make decisions about product use. These choices can be influenced by peer decisions in networks, but identifying causal peer influence effects is challenging. Extending the work of Bramoullé et al. (2009), we apply proofs of peer effect identification in networks under a set of exogeneity assumptions to the panel data case. With engagement data from simulation and two mobile applications, we estimate usage peer effects, comparing the performance of a variety of regression models under simulated homophily conditions. Though violation of exogeneity assumptions can bias regression estimates, there are contexts where such IV analysis can be usefully applied.

2 - Coevolutionary Latent Feature Processes for Continuous-time User-item Interactions

Le Song, Georgia Institute of Technology, Atlanta, GA, United States, lsong@cc.gatech.edu

Matching users to the right items at the right time is a fundamental task in recommendation systems. Traditional models based on static latent features or discretizing time into epochs become ineffective in capturing the fine-grained and complex temporal dynamics in the time-varying user-item interaction networks. We propose both parametric and nonparametric coevolutionary latent feature process models which accurately captures the coevolving nature of users' and items' features. Extensive experiments on diverse real-world datasets demonstrate significant improvements in user behavior prediction compared to state-of-the-arts.

3 - A Relational Event Approach to Modeling Continuous Network Change

Aaron Schecter, University of Georgia, Athens, GA, United States, aschec@gmail.com, Noshir Contractor

The increasing availability of continuous event data, such as emails or clickstreams, has made interaction processes significantly more visible. These interactions are driven by short-term and long-term patterns of directed events. To analyze this data with traditional network approaches, event data would have to be transformed into static links. However, this process would reduce the sequential and temporal information available. We present a method which directly utilizes this data, the relational event model, to infer the effect of event patterns on network change.

4 - Network Model Selection and Tuning by Cross-validation

Tianxi Li, University of Michigan, Ann Arbot, MI, United States, tianxili@umich.edu

Though many models and methods are now available for network analysis, model selection and tuning remain challenging. Cross-validation, a general tool for these tasks in many settings, is not directly applicable to networks since network splitting destroys some of the network structure. We propose a network cross-validation strategy which avoids losing information and is applicable to a wide range of network problems. We provide a theoretical justification for our method. Numerical results on both simulated and real networks show that our approach performs well for a number of model selection and parameter tuning tasks.

■ TA73

372B

Open Pit Mine Planning

Sponsored: Energy, Natural Res & the Environment, Natural Resources Mining

Sponsored Session

Chair: Alexandra M. Newman, Colorado School of Mines, Golden, CO, 80401, United States, anewman@mines.edu

1 - Scheduling Optimization for a Continuous Steel Caster

Alexandra Newman, Colorado School of Mines, Golden, CO, United States, anewman@mines.edu, Joshua Betz

In continuous steel casting operations, molten steel is batched into heats inside a ladle that is cast into slabs, which are then rolled into coils. We present a mixed integer program to produce a daily casting schedule that is solved using state-of-the art software. This model minimizes penalties incurred by violating plant best practices while strictly adhering to safety and logical constraints. A heuristic produces an initial feasible solution to expedite solutions, which we compare to current plant practice.

2 - A Study of Problem Specific Cutting Planes for the Open Pit Strategic Mine Scheduling Problem

Orlando Rivera Letelier, Universidad Adolfo Ibanez, Santiago, Chile, orlando.rivera@uai.cl

We study four types of problem specific cutting planes for the Open Pit Strategic Mine Scheduling Problem: Cliques, Early Starts, VRHS and Hourglass cuts. Two of them, the Cliques and the Early Start cuts are well-known cuts in the literature for the Precedence Constrained Knapsack Problem, while the other two types, the VRHS and the Hourglass cuts are new cuts developed for this work that make use of the production capacity constraints of the problem. We make computational tests in a set of real mines instances of the production scheduling problem, showing that the root node gap can be improved in average from 9.21% to 0.74%, which allows to solve to near optimallity instances of this problem.

3 - Revisiting Lane's Model: An Optimization Approach

Patricio Lamas, Universidad Adolfo Ibanez, Santiago, Chile, plamas@alumnos.uai.cl, Marcos Goycoolea, Bernardo Kulnig Pagnoncelli, Adriana Piazza

In 1964 Kenneth, Lane proposed an algorithm for optimizing the cutoff grade in an open pit mining project. Lane's algorithm has made their way into multiple commercial software systems. However, the algorithm is regarded as a heuristic since no convergence proof is available in the literature. We present a formal description of Lane's algorithm, and present theoretical results regarding the behavior of the optimal cut-off grade. Moreover, we propose a new mathematical optimization formulation for the problem, and use it as a benchmark to test the performance of Lane's algorithm. Our computational results for real-world mines show that Lane's algorithm finds the optimal solution for all instances.

4 - An Efficient Frontier Analysis to Determine Final Pit under Geological Uncertainty

Enrique Jelvez, PhD, Advanced Mining Technology Center, Santiago, Chile, ejelvez@delphoslab.cl
Enrique Jelvez, PhD, Delphos Mine Planning Lab & Department of Mining Engineering, University of Chile, Santiago, Chile, ejelvez@delphoslab.cl, Nelson Morales, Nelson Morales, Julian Ortiz

The final pit problem consists of finding the set of blocks that maximizes the undiscounted value of exploitation subject to precedence constraints. Although there exist efficient algorithms to compute it in a deterministic setting, the information on which this decision is made is subject to uncertainty. In this work, we present a comparison of several options to calculate final pit, including geological uncertainty given by a number of conditional simulations. In particular, we develop a model that allows us to generate the efficient frontier of final pit alternatives in the expected return-risk context, when the risk is measured in terms of Conditional Value at Risk.

■ TA74

372C

Network Problems with Hop Constraints

Sponsored: Computing

Sponsored Session

Chair: Austin Buchanan, Oklahoma State University, Stillwater, OK, 74078, United States, buchanan@okstate.edu

1 - Why is Maximum Clique Easy on Real-life Graphs?

Jose Luis Walteros, University at Buffalo, SUNY, 413 Bell Hall, Buffalo, NY, 14260, United States, josewalt@buffalo.edu, Austin Buchanan

Recently, researchers have developed algorithms that solve maximum clique rather quickly for real-life graphs despite the computational intractability of the problem. An explanation for the success of these approaches on these graphs is their sparsity, allowing one to delete low-degree vertices in a preprocessing step. We provide an alternative explanation based on the empirically observed proximity of the clique number to the graph's degeneracy d. We develop an algorithm that runs in time polynomial in the graph's size, but exponential in d - . When this difference is a constant, the running time is O(dm) = O(m1.5). Since 70% of common instances have d - ≤ 3, our algorithm is highly competitive.

2 - The Optimal Design of Low Latency Virtual Backbones

Hamidreza Validi, Oklahoma State University, Stillwater, OK, 74078, United States, hamidreza.validi@okstate.edu, Austin Buchanan

In wireless networks, two nodes may not be close enough to communicate directly, necessitating the use of intermediate nodes for relaying information. Often, one seeks a (smallest possible) subset of nodes to serve as designated relay nodes. In this talk, we discuss a hop-constrained variant of this optimization problem and propose an integer programming approach to solve it.

3 - On the 2-club Polytope of Graphs

Foad Mahdavi Pajouh, University of Massachusetts Boston, 100 Morrissey Boulevard, Boston, MA, 02125-3393, United States, foad.mahdavi@umb.edu, Balabhaskar Balasundaram, Illya V. Hicks

A k-club in a graph is a subset of its vertices such that the subgraph induced by this set has diameter at most k. Polyhedral study of the k-club model is a challenging task as this property is not hereditary. This talk presents a new class of facets for the 2-club polytope that contains all known nontrivial facets as special cases. Computational results addressing the effectiveness of these new inequalities will also be presented.

4 - Parsimonious Formulations for Low-diameter Clusters

Hosseinali Salemi, Oklahoma State University, 15 North University Place, Apartment Number 2, Stillwater, OK, 74075, United States, hosseinali.salemi@okstate.edu, Austin Buchanan

In the analysis of social and biological networks, one often searches for tightly knit clusters. One property of a "good" cluster is that it have a small diameter, which leads to the concept of a k-club. We propose a new IP formulation for detecting k-clubs and show that a relatively simple implementation of it often outperforms previous approaches.

■ TA75

372D

Nonlinear and Stochastic Optimization

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Albert S Berahas, Northwestern University, Evanston, IL, 60208, United States, albertberahas@u.northwestern.edu

Co-Chair: Jorge Nocedal, Northwestern University, Evanston, IL, 60208-3118, United States, j-nocedal@northwestern.edu

1 - Linear Convergence of Gradient and Proximal-gradient Methods under the Polyak-lojasiewicz Condition

Mark Schmidt, 201 2366 Main Mall, Vancouver, BC, V6T1Z4, Canada, schmidtm@cs.ubc.ca

In 1963, Polyak proposed condition that is sufficient to show gradient descent has a global linear convergence rate, without strong-convexity. We show that this condition is weaker than the main conditions used to relax strong-convexity over the last 25 years. We also it to give new analyses of coordinate descent and stochastic gradient methods. We give a natural generalization of the inequality that applies to proximal-gradient methods for non-smooth optimization, and show this gives a simple linear convergence proof for LASSO and SVMs. Along the way, we give new convergence results for a wide variety of problems in machine learning.

2 - An Optimal Randomized Incremental Gradient Method Independent of Exact Gradient Evaluations

Yi Zhou, Georgia Institute of Technology, 3209 Druid Hills Reserve Dr, Atlanta, GA, 30329, United States, yizhou@gatech.edu, Guanghui Lan

In this talk, we consider a class of finite-sum convex optimization problems whose objective function is given by the average of m smooth components together with a strongly convex term. We first present a deterministic predictive accelerated gradient descent (PAGED) method that achieves the optimal black-box iteration complexity for solving these problems. We then develop a randomized variant, Rand-PAGED method, which needs no exact gradient evaluations and computes the gradient of one randomly selected smooth component iteratively but can possibly achieve better complexity bounds than optimal deterministic first-order methods in terms of the number of gradient evaluations.

3 - On the use of L-BFGS in Derivative-Free Optimization
Albert S.Berahas, Northwestern University, Evanston, IL, 60208, United States, albertberahas@u.northwestern.edu, Jorge Nocedal, Richard Byrd

The efficiency and efficacy of using finite-differencing to estimate derivatives in the Derivative-Free Optimization (DFO) setting still remains an unexplored domain. In this talk, we present a finite-difference quasi-Newton method for minimizing smooth deterministic, and noisy, black-box functions, and illustrate the performance of the method on several test-problems. We argue that popular model-based trust-region methods may not, for certain classes of problems, be more efficient in their use of function information than the finite-difference BFGS method, and that these problems have special identifying characteristics.

■ TA76

372E

Large Scale Optimization

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Samir Elhedhli, University of Waterloo, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, elhedhli@uwaterloo.ca

1 - Benders Decomposition for Uncapacitated Multicommodity Network Design
Carlos Zetina, Concordia University, 1455 De Maisonneuve, Montreal, QC, H2L.4H1, Canada, c_zetina@encs.concordia.ca, Ivan Contreras, Jean-Francois Cordeau

In this study, we present a Benders based exact algorithm to solve the uncapacitated multicommodity network design problem. Our algorithm combines the use of a modified Benders reformulation, lower bound strengthening and upper bound heuristics. We analyze the performance of the algorithm on benchmark instances and compare them with current solution methods

2 - A layer-Based Branch-and-price Approach for 3D Bin Packing
Samir Elhedhli, University of Waterloo, Department of Management Sciences, 2000 University Street West, Waterloo, ON, N2L.3G1, Canada, elhedhli@uwaterloo.ca, Burak Can Yildiz, Fatma Gzara

We propose a new formulation and a branch-and-price solution approach where the subproblems are two dimensional layers, a feature that is highly desirable in practice. The approach allows the inclusion of important practical constraints such as support, family groupings, isle friendliness, and load bearing. We conduct extensive computational experiments and compare against existing approaches. We also use industrial data to train and propose a realistic data set. The proposed approach outperforms the best performing algorithm in the literature and succeeds in solving practical size instances in very reasonable computational times.

3 - Network Planning of Green Telecommunication Networks
Joe Naoum-Sawaya, Ivey Business School, 1255 Western Road, London, ON, N6G 0N1, Canada, jnaoum-sawaya@ivey.ca

We present the network planning problem of an LTE cellular network with switchable base stations, ie. where the configuration of the antennae is dynamic, depending on demand. This is formulated as a two-stage stochastic program under demand uncertainty with integers in both stages. We develop its Dantzig-Wolfe reformulation and solve it using column generation. Preliminary results confirm the efficiency of the approach.

4 - Data Driven Robust Order Batching for Warehouse Management: A Branch and Price Approach
Vedat Bayram, Assistant Professor, TED University, Endustri Muhendisligi Bolumu, Ziya Gokalp Caddesi No:48, Kolej Cankaya, Ankara, 06420, Turkey, vedat.bayram@tedu.edu.tr, Gohram Baloch, Fatma Gzara, Samir Elhedhli

In this presentation, we report on data analytics solutions for a warehouse management and control systems company. We present data driven robust order batching solutions by developing an optimization model and a state of the art branch and price algorithm that employs simultaneous column and row generation procedures.

■ TA77

372F

Conic Reformulation for Integer and Quadratic Programming

Sponsored: Optimization, Linear and Conic Optimization

Sponsored Session

Chair: Ziteng Wang, Northern Illinois Universtiy, DeKalb, IL, 60115, United States, zwang3@niu.edu

1 - Quadratic Programs with Hollows
Boshi Yang, PhD, Clemson University, Clemson, SC, United States, boshiy@clemson.edu, Kurt M.Anstreicher, Samuel Burer

Let F be a quadratically constrained bounded set, and let E1, ... , El denote ellipsoids contained in F with non-intersecting interiors. We prove that minimizing an arbitrary quadratic q() over G := F \ (\cup_{k=1}^l int(Ek)) is no more difficult than minimizing q() over F in the following sense: if a given SDP relaxation for min{ q(x) : x in F } is tight, then the addition of l linear constraints derived from E1, ... , El yields a tight SDP relaxation for min { q(x) : x in G }. Inspired by these results, we resolve a related question in a seemingly unrelated area, mixed integer nonconvex quadratic programming.

2 - A Completely Positive Programming Approach to the Cardinality Constrained Quadratic Programming
Ziting Wang, Northern Illinois University, DeKalb, IL, United States, zwang3@niu.edu, Ye Tian

In this paper, we propose a completely positive programming reformulation of the cardinality constrained portfolio selection problem. By constructing a sequence of computable cones of nonnegative quadratic forms over a union of second-order cones, an -optimal solution of the original problem can be found in nite iterations using semidenite programming techniques. In order to obtain a good lower bound eciently, an adaptive scheme is adopted in our approximation algorithm. The numerical results show that the proposed algorithm can nd better approximate and feasible solutions than other known methods in the literature.

3 - A New Linear Reformulation for Binary Quadratic Programming Problems
Shan Jiang, North Carolina State University, sjiang8@ncsu.edu, Tiantian Nie, Shu-Cherng Fang, Qi An

This paper presents a new 0-1 mixed-integer linear reformulation of a binary quadratic programming (BQP) problem. The proposed $O(n)$-sized linear reformulation is distinguished from other known $O(n)$-sized linear reformulations by a new linearization strategy that simultaneously treats symmetric quadratic terms. Besides the new structure embedded, the proposed reformulation also reduces the number of required continuous variables and linear constraints. Numerical experiments on various BQP instances demonstrate the superior computational efficiency of the proposed reformulation over other state-of-the-art linear reformulations.

■ TA78

381A

Generation and Transmission Capacity-Expansion Planning

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Ramteen Sioshansi, The Ohio State University, 240 Baker Systems Engineering Building, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, sioshansi.1@osu.edu

Co-Chair: Antonio J. Conejo, The Ohio State University, 286 Baker Systems Engineering Building, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, conejonavarro.1@osu.edu

1 - Combining the L-shaped Method and Lagrangian Relaxation for Expansion Planning with Energy Storage Devices and Renewable Portfolio Standard Constraints
Roderick Go, Johns Hopkins University, Baltimore, MD, 21218, United States, rgo1@jhu.edu, Francisco David Munoz, Jean-Paul Watson

We propose a convergent solution algorithm to solve capacity expansion planning problems that co-optimize transmission, generation, and energy storage investment decisions on a transmission network subject to linking policy constraints like Renewable Portfolio Standards. In the proposed algorithm, we introduce a novel hybridization of Lagrangian relaxation and the L-shaped method that allows us to efficiently compute upper and lower bounds on optimal system cost. Additionally, we introduce a heuristic method to accelerate the solution while maintaining bounds. We illustrate the performance of these algorithms using the IEEE 24-bus test case with 52 weeks of hourly data.

2 - Understanding the Decision Making in a Long-term Electric Power Sector Capacity Expansion Models

Kelly Eurek, National Renewable Energy Laboratory, Golden, CO, United States, Kelly.Eurek@nrel.gov

Long-term capacity expansion model are used for exploring the potential evolution of the electric power sector. Often formulated using linear and mixed integer optimization, these models choose the mix of technologies that minimize the cost to reliability balance supply and demand of electricity. This presentation highlights a method for understanding the decision making in NREL's Regional Energy Deployment System (ReEDS) capacity expansion model.

3 - Stochastic Transmission Expansion Planning: Computational Challenges

Mohammad Majidi-Qadikolai, The University of Texas at Austin, 1616 Guadalupe UTA 2.304, Austin, TX, 78701, United States, majidi_mohammad@yahoo.com, Ross Baldick

Increasing uncertainties in future generation generation mix, output of high penetration intermittent resources, contribution of demand response and energy storage capacity significantly increase complexities of transmission expansion planning (TEP), and traditional experienced based methods may not be efficient anymore. Stochastic programming can be used to model and integrate these uncertainties into TEP decision making process. Being computationally expensive is the main drawback of this method. In this work we proposed a generalized decomposition framework that allows us to solve a two-stage stochastic TEP problem with security constraints for real-size problems.

4 - Using Multihorizon Stochastic Programming to Analyze the Potential Trade-off Between Demand Response and Transmission

Asgeir Tomasgard, Norwegian University of Science and Technology, Dept. of industrial economics, Alfred getz vei 3, Trondheim, 7491, Norway, asgeir.tomasgard@iot.ntnu.no, Christian Skar, Hector Maranon-Ledesma

The objective of this work is to analyse to what demand response (DR) can contribute to the transition to an European low emission power system. The capabilities of DR are studied through the multi horizon stochastic programming model EMPIRE, an electricity sector model with a time span of 30 years and hourly market clearing. The model includes uncertainty at the operational level and energy economics dynamics at a strategic level. The investment-operation DR module models several classes of shiftable and curtailable loads in residential, commercial, industrial and transport sectors for 31 European countries.

■ TA78B

380B

Design Engineering

Contributed Session

Chair: Rhythm Wadhwa, NTNU, Gjoevik, Norway, rhythmwadhwa@hotmail.com

1 - Finding Patterns in Pareto Optimal Solutions and its Applications

Abhinav Gaur, Doctoral Candidate, Michigan State University, 428 S Shaw Lane, East Lansing, MI, 48824, United States, gaurabhi@msu.edu, Kalyanmoy Deb

Multi-objective optimization (MOO) problems lend themselves to not one but a set of optimal solutions also called Pareto-optimal (PO) solutions. Such P.O. solutions carry information on patterns that make these solutions concurrently optimal for multiple objectives. Discovering such patterns from the P.O. solutions is called 'Innovization' or innovation through optimization. Some of the uses of carrying out an Innovization exercize are discovering design principles for the MOO design problem, automatically discovering optimization heuristics for a problem and, expediting black box MOO algorithms.

2 - Redundancy Allocation of Standby Components in Repairable K-out-of-N Systems

Hanlin Liu, City University of Hong Kong, Hong Kong, hanlinliu2-c@my.cityu.edu.hk, Rui Peng, Min Xie

In system design process, standby redundancy is a widely-used technique to improve system reliability and availability. In this paper, we investigate the repairable K-out-of-N system with both warm and cold standby redundancy. In the proposed system, each component can be in failure, cold, warm and active states and the components are assumed to be repairable. The systems are modeled by continuous time Markov chain (CTMC) and the system long run availability is derived. Furthermore, optimal number of warm standby is studied by considering system availability and average long run cost. Illustrative examples are also given to show the applications of the proposed model.

3 - An Incentive Mechanism to Improve Engineering Design Process under Requirement Based Engineering Design

Soodabeh Yazdani, PhD Student, George Mason University, 4400 University Dr, Fairfax, VA, 22030, United States, syazdan2@masonlive.gmu.edu, Edward Huang, Daniel Lin

Large-scale complex engineering systems are mostly carried out by requirement based engineering design where project manager at higher levels flow-down requirements and design resources to design teams at lower levels. Under this scheme, incentive alignment and efficient resource allocation are crucial factors in the success of design outcome. This paper explores economics incentives to control and improve the system-level design outcome. A mathematical framework by using mechanism design theory is proposed to analyze the effect of incentives on system wide design outcome.

4 - Determining Decoupling Points in a Network Associated with Different Design Preferences using Exploration of the Solution Space

Lin Guo, Graduate Research Assistant, University of Oklahoma, 202 W. Boyd Street, Room 218, Norman, OK, 73019, United States, lin.guo@ou.edu, Reza Alizadeh, Janet Katherine Allen, Farrokh Mistree

In this paper, we propose an approach using exploration of the solution space of a multi-goal compromise Decision Support Problems model to determine the decoupling points of a three-echelon supply chain. Facing different design preferences of the supply chain, the goals should be satisfied in different degree, and the change of the design preference may take place rapidly, which requires the decoupling points flexible enough to be moved through the supply chain.

5 - Axiomatic Design in Early Product Design a Case of Outdoor Sports Equipment

Rhythm Wadhwa, Professor, NTNU, Teknologiveien 22, Gjoevik, 2821, Norway, rhythmwadhwa@hotmail.com

The paper presents the application of Axiomatic design for the early product development of outdoor sporting equipment. The design parameters were used to decouple the functional and customer requirements. The product developed after multiple iterations and was field tested. The results of the simulation and field trials have been compared and discussed.

■ TA79

381B

JOINT ENRE/Petro/OR Oil: Logistics and Supply Chain Optimization in Petrochemical/Petroleum Industry

Sponsored: Energy, Natural Res & the Environment, Natural Resources Petrochemicals

Sponsored Session

Chair: Arul Sundaramoorthy, BP, BP, Naperville, IL, 60563, United States, arul.sundaramoorthy@bp.com

1 - Batch Scheduling of Multi-Product Pipeline Networks

Sander J. Vlot, ORTEC, Zoetermeer, Netherlands, Sander.Vlot@ortec.com

In this research, we propose a novel method for scheduling pipeline networks. The method consists of a planning and a scheduling phase that are coupled in a hierarchical decomposition scheme. In the planning phase, global transportation volumes are determined for each pipeline. In the scheduling phase, we use the planning output to generate complete schedules. Both phases are based on discrete-time MILP formulations. The method is successfully tested on two case studies involving up to 4 products, 8 pipelines, 8 tank farms, 2 supply locations, and 5 demand locations. The proposed method is flexible in terms of network configurations, supply and demand requirements, and cost structures.

2 - A Mixed-complementarity Approach to Assess the Potential Gain from Intra-regional Electricity Transmission Utilizing the GCC Interconnector

David Wogan, Research Associate, King Abdullah Petroleum Studies and Research Center, P.O. Box 88550, Riyadh, 11672, Saudi Arabia, david.wogan@kapsarc.org

The GCC Interconnector links the electricity systems of the six countries of the Gulf Cooperation Council. Potential economic and technical gains could be realized by utilizing the Interconnector to deliver electricity from lower-cost sources across the region. We formulate a bottom-up mixed-complementarity problem to capture market distortions that arise from subsidized fuel prices for power and water producers. We assess the impact on volume of transmission and marginal costs of supply and demand by considering electricity production for domestic consumption at administered prices and for export to the Interconnector at prices reflecting fuel opportunity costs.

3 - Gas Storage Valuation via Least Squares Monte Carlo and Support Vector Regression

Alexander Malyscheff, University of Oklahoma, 110 W Boyd Street, Devon Energy Hall 150, Norman, OK, 73019-1102, United States, malyscheff@gmail.com, Theodore B.Trafalis

Least squares Monte Carlo (LSMC) approaches represent a computationally efficient method for the valuation of natural gas storage facilities. LSMC methods are computationally tractable while they simultaneously allow for a decoupling of the price path simulation from the optimization of the decision vector. We study the impact of additional pricing information in the form of a forward contract on the value of a gas storage facility. Value function approximation is carried out by employing a kernel-based regression technique in the form of support vector machine regression (SVR).

4 - Optimal Control of Tank Levels with Constrained Chance of Pipeline Shutdown

Tianyuan Zhu, University of Calgary, Scurfield Hall, 2500 University Dr NW, Calgary, AB, T2N.1N4, Canada, zhut@ucalgary.ca

In a petroleum pipeline network, when unexpected power failure or other malfunctions happens during a predetermined shipping and maintenance schedule, the unusual change of pipeline flow rate may lead to excessively high or low inventory level in tank farms, which will result in connecting pipeline shutdowns and network throughput missing. To address this problem, an optimization model is developed to study the optimal tank levels and associated pipeline flow rate adjustment policy with the objective of minimizing the missing throughput, while the chance of pipeline shutdown is bounded. The model is tested on a simplified real-world network owned by a Canadian pipeline company.

■ TA80

381C

Modeling Interdependent Infrastructures

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States, fqiu@anl.gov

Co-Chair: Spada Matteo, Paul Scherrer Institute, Villigen PSI, 5232, Switzerland, matteo.spada@psi.ch

1 - Enhancing Resilience of Powergrid-cyber-transportation Interdependent Infrastructures

Yunhe Hou, University of Hong Kong, CYC Building, Room 522, Hong Kong, Hong Kong, yhhou@eee.hku.hk

This presentation discusses the coordinating strategies for enhancing the resilience of energy systems. The interaction among power network, cyber system, and transportation systems are modeled. Cyber-attack and extreme weather events trigger the disruptive event of a power system. Some sequential resilient operating strategies to absorb the impacts and to restore the system are discussed. Due to the essential interdependent characteristics of three systems and stages after the trigger events, the proposed strategies are constructed based on a multi-level optimization framework. The solution methods are discussed as well.

2 - Resilience Planning and Operations of Energy and Water Systems

Neng Fan, University of Arizona, 1127 E James E. Rogers Way, PO Box 210020, Tucson, AZ, 85721, United States, nfan@email.arizona.edu

In this talk, multilevel optimization model will be constructed to model the interdependency between energy and water systems. To ensure the resilience planning and operations, failure scenarios in both systems will be integrated into the model with their respective planning/operations standards. To solve the complicated model, decomposition based algorithms will be designed and validated on some test cases.

3 - Computable Equilibrium Model Analysis for Energy-water Nexus

Feng Qiu, Argonne National Laboratory, 9700 S Cass Ave, Building 202, Room C205B, Lemont, IL, 60439, United States, fqiu@anl.gov, Andrew Schreiber, Jianhui Wang

Many studies on energy and water are rightfully interested in the interaction of water and energy, and their projected dependence into the future. While many studies are beginning to ask the right questions, the lack of numerical rigor raises questions of concern in conclusions discerned. In this study, we will perform economic analysis using computable general equilibrium models with energy-water interdependencies captured as an important factor. We atempt to answer important and interesting questions in the studies: how can we characterize the economic choice of energy technology adoptions and their implications on water use in the domestic economy.

4 - Modeling Recovery of Interdependent Civil Infrastructure Systems

Eun Jeong Cha, Assistant Professor, University of Illinois at Urbana-Champaign, 205 N.Mathews Ave., Room 2207, Urbana, IL, 61801, United States, ejcha@illlinois.edu, Xian He

Civil infrastructure systems depend on each other for product input and/or information sharing and properly modeling such dependencies is essential in assessing the performance of the civil infrastructure systems during and following a disruptive event, which lays the foundation of assessing the community resilience. This presentation introduces the Dynamic Integrated Network model which has been developed under the NIST's Center for Risk-Based Community Resilience Planning. The model assesses the damage and recovery of a civil infrastructure network consisting of different systems following a disruptive event with considering the facility-level dependencies.

■ TA81

382A

Distributionally Robust Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Grani Hanasusanto, The University of Texas at Austin,grani.hanasusanto@utexas.edu

1 - Two-stage Distributionally Robust Linear Programming Over Wasserstein Balls

Grani Adiwena Hanasusanto, The University of Texas at Austin, ETC 5.120, Austin, TX, 78712, United States, grani.hanasusanto@utexas.edu, Daniel Kuhn

We study two-stage stochastic linear programming problems where the distribution of the uncertain parameters is ambiguous and is only known to belong to a family of all distributions that are close to the empirical distribution with respect to the Wasserstein metric. We derive an exact copositive program for the generic problems and formulate a tractable linear program for instances with only right-hand side uncertainty. We illustrate the effectiveness of our reformulations in numerical experiments and demonstrate their superiority over the classical sample average approximation scheme and the state-of-the-art moment-based model.

2 - Distributionally Robust Mechanism Design

Cagil Kocyigit, Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, cagil.kocyigit@epfl.ch, Garud N. Iyengar, Daniel Kuhn, Wolfram Wiesemann

We study a mechanism design problem for auctioning a single good, where the bidders' values are random variables that may follow any distribution in a commonly known ambiguity set. We assume that the seller is ambiguity averse and the bidders have Knightian preferences. If the bidders' values are independent, then the added value of the optimal mechanism over a simple second price auction is offset by just attracting one extra bidder. If the bidders' values are dependent and characterized through moment bounds, we provide a new class of randomized mechanisms, the highest-bidder-lotteries, whose revenues cannot be matched by any second price auction with a constant number of additional bidders.

3 - From Data to Decisions: Distributionally Robust Optimization is Optimal

Daniel Kuhn, Ecole Polytechnique Federale de Lausanne (EPFL), EPFL.CDM.MTE I.RAO, ODY 1 01 B.(Odyssea), Lausanne, 1015, Switzerland, daniel.kuhn@epfl.ch, Bart Paul Gerard Van Parys, Peyman Mohajerin Esfahani

Data-driven stochastic programming aims to find a procedure that transforms time series data to a near-optimal decision (a prescriptor) and to a prediction of this decision's expected cost under the unknown data-generating distribution (a predictor). We propose a meta-optimization problem to find the least conservative predictors and prescriptors subject to constraints on their out-of-sample disappointment. Leveraging tools from large deviations theory, we prove that the best predictor-prescriptor pair is obtained by solving a distributionally robust optimization problem.

4 - Robust Map Inference in Markov Random Fields

Areesh Mittal, University of Texas at Austin, 1626 West 6th St, Apt F, Austin, TX, 78703, United States, areeshmittal@utexas.edu, Grani Adiwena Hanasusanto

In the maximum a posteriori (MAP) inference on Markov Random Fields (MRFs), we seek for the most likely assignment to the given Markov network. The underlying parameters of the MRFs, however, are typically estimated from data and can be subject to substantial errors. In this work, we introduce a new MAP inference model that endeavors to alleviate these estimation errors by leveraging on techniques from robust optimization. We show that the arising optimization model is amenable to standard integer programming solution schemes, and we assess its effectiveness via numerical experiments.

■ TA82

382B

Joint Session OPT/Practice: Optimizing Power System Operations under Uncertainty

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Bita Analui, Arizona State University, Tempe, AZ, United States, bita.analui@asu.edu

1 - Evaluating Power Plant Operation and Maintenance Policies for Concentrated Solar Power

Alexander Zolan, University of Texas, Austin, TX, United States, na, Jennifer DiCarlo

We simulate maintenance and component failure events (i.e., for a salt-to-heat steam exchanger, three sizes of turbines, water pumps, and a generator) in a Concentrating Solar Power plant, when provided component specifications and hourly dispatch decisions from an independent optimization model; a collection of stochastic realizations of failure, repair and maintenance events, each of which includes intervals of forced plant downtime, characterize the failure events. An iterative approach takes these as inputs to suggest an improved dispatch strategy that mitigates loss of revenue associated with expected downtime, cold starts (and, more generally, cycling), and maintenance.

2 - A Dynamic Multistage Stochastic Unit Commitment Formulation for Intraday Markets

Bita Analui, AZ, United States, bita.analui@asu.edu, Anna Scaglione

As net-load becomes less predictable there is a lot of pressure in changing decision models for power markets such that they account explicitly for future scenarios in making commitment decisions. This paper proposes to make commitment decisions with multiple gate closures. Our proposed model also leverages a state-space formulation for the commitment variables, through which the operational constraints of generation units participating in the market are respected. We also study the problem of constructing scenario tree approximations for both original and residual stochastic processes and evaluate our algorithms on scenario tree libraries derived from real net-load data.

3 - Condition-based Generation Maintenance and Operations Scheduling under the Uncertainty of the Unexpected Failures

Beste Basciftci, Georgia Institute of Technology, Atlanta, GA, United States, beste.basciftci@gatech.edu, Shabbir Ahmed, Nagi Gebraeel

In this study, our aim is to effectively model and solve the integrated condition-based maintenance and operations scheduling problem of a fleet of generators by explicitly considering the unexpected failures. We formulate this problem as a stochastic mixed-integer program and introduce a chance constraint to ensure a reliable maintenance plan. We propose a data-driven approach by explicitly considering the degradation levels of the generators within the optimization model through their estimated remaining life time distributions. Finally, we present computational experiments demonstrating the effectiveness of the proposed approach.

■ TA83

382C

Two-stage Stochastic and Distributionally Robust MIPs: Algorithms and Applications

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24060, United States, bansal@vt.edu

1 - Analysis of Power Grid Attacks

Mauro Escobar, Columbia University, 502 W. 122nd St, Apt 23, New York, NY, 10027, United States, me2533@columbia.edu, Daniel Bienstock

This research project focuses on power grid attacks. The problem setting is as follows: an adversary has the ability of altering the supply/demand of a set S of buses in the network and report a different angle phase of a set T of buses (containing S), while a set R of buses (disjoint of T) responds to the total supply/demand change. This study analyzes the conditions in which the adversary could report phase angles that are consistent with a network flow that satisfies branch capacities and models frequency response, while the real flow would not. So far, the analysis has consisted of DC formulated simulations using cases from 'Matpower.'

2 - New Solution Approaches for the Maximum-reliability Stochastic Network Interdiction Problem

Eli Towle, University of Wisconsin-Madison, Madison, WI, United States, etowle@wisc.edu

We investigate methods to solve the maximum-reliability stochastic network interdiction problem (SNIP). In this problem, a defender interdicts arcs on a directed graph to minimize an attacker's probability of undetected traversal through the network. The attacker's origin and destination unknown to the defender and assumed to be random. We introduce a new extensive formulation that is more compact than the existing extensive formulation. We propose a new path-based formulation of SNIP and a branch-and-cut algorithm to solve it. Computational results demonstrate that both approaches provide a significant improvement over a state-of-the-art implementation of Benders decomposition for SNIP.

3 - On Continuous Mixing Cuts for Two Stage Mean Risk Stochastic Mixed Integer Programs

Hideaki Nakao, University of Michigan, Ann Arbor, MI, United States, nakaoh@umich.edu, Simge Kucukyavuz, Siqian Shen

We study a class of two-stage mean-risk stochastic mixed-integer linear programs (SMILP) which involve mixed-integer variables in the first stage and continuous variables in the second stage. The objective is to minimize the weighted sum of the expected value and the conditional value-at-risk (CVaR) of a random cost function dependent on first-stage decisions and realizations of uncertain parameters. A common approach for solving the two-stage optimization problem is to apply the Benders decomposition algorithm. We show how the CVaR-based Benders cuts lead to a structure that can be used to derive continuous mixing (CMIX) cuts to tighten the relaxed master problem.

4 - Decomposition Algorithms for Two-stage Distributionally Robust Mixed Binary Programs

Manish Bansal, Virginia Tech., 227 Durham Hall, 1145 Perry Street, Blacksburg, VA, 24060, United States, bansal@vt.edu, Kuo-Ling Huang, Sanjay Mehrotra

We present a decomposition algorithm to solve two-stage distributionally robust mixed binary problems (TSDR-MBPs) where the random parameters follow the worst-case distribution belonging to an uncertainty set of probability distributions. We investigate conditions and families of uncertainty set for which our algorithm is finitely convergent. In addition, we present a cutting surface algorithm to solve TSDR-MBPs. We computationally evaluate the performance of our algorithms in solving distributionally robust versions of a few instances from the Stochastic Integer Programming Library, in particular stochastic server location and stochastic multiple binary knapsack problem instances.

Tuesday, 9:30 - 10:30AM

Tuesday Plenary

Hilton-Ballroom of America, Level 2

Plenary

Plenary: How Analytics Powers the Uber Marketplace

Invited Session

1 - How Analytics Powers the Uber Marketplace

Robert Phillips, Director of Data Science, Uber Technologies

Uber – the leading ride-sharing company in the world – faces the challenge of efficiently managing both sides of a two-sided market in which it has no direct control over either demand or supply. The challenges include determining real-time prices for both riders and drivers, matching riders and drivers and providing signals to drivers that incentivize efficient movement. In this talk we describe how Uber uses a wide variety of approaches drawn from operations research, management science, statistics, economics and machine learning to address these challenges in a highly dynamic temporospatial marketplace.

Tuesday, 10:30 - 12:00PM

■ TB01

310A

Portfolio Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: Alec Morton, University of Strathclyde, Glasgow, G1 1XQ, United Kingdom, alec.morton@strath.ac.uk

Co-Chair: Liesio Juuso, juuso.liesio@aalto.fi

1 - Out of Sample Comparison of SSD and Directionally SSD Constrained Portfolio Choice

Nasim Dehghan Hardoroudi, Aalto University School of Business, Runeberginkatu 22-24, Chydenia (4th floor), Helsinki, 00100, Finland, nasim.dehghan.hardoroudi@aalto.fi

In this paper we compare out-of-sample performance of second order stochastic dominance (SSD) and directionally SSD constrained portfolio optimization using stock market data of the US. When the market index is taken as benchmark, out-of-sample tests show that both SSD and DSSD constrained optimization with a variety of objective functions out-perform the benchmark in terms of average return, and DSSD based approach compares favorably against SSD based, given that risk aversion exhibited by the objective function is relatively mild.

2 - Sparse Dynamic Portfolios with Regret-based Selection

David Puelz, University of Texas, 6309 Burns Street, Austin, TX, 78752, United States, david.puelz@utexas.edu

This paper considers portfolio construction in a dynamic setting. We present a new decision theoretic approach based on a loss function comprised of utility and portfolio complexity components. These components are related by an unknown tradeoff parameter, and we develop a novel regret-based criterion for selecting the tradeoff parameter to construct optimal sparse portfolios over time. We demonstrate the procedure under a variety of modeling and preference scenarios using data from exchange traded funds.

3 - Allocation Rules for Global Donors

Alec Morton, University of Strathclyde, Management Science, University of Strathclyde, Glasgow, G1 1XQ, United Kingdom, alec.morton@strath.ac.uk, Ashwin Arulselvan, Ranjeeta Thomas, Peter C. Smith

A vitally important part of ensuring that recent improvements in global health are sustained is financial aid from rich countries to poor ones. Aid donors must also ensure that countries build the financial capacity to deliver healthcare for their own population on a sustainable basis, and the allocation rules used by aid donors must reflect this. We present a game theoretic analysis of the relationship between a donor and a country. The donor has a healthcare related mission and the country cares about healthcare but also about other things. We show how our model produces both insight and operationalisable rules for guiding aid donation.

■ TB02

310B

Multicriteria Decision Making

Sponsored: Decision Analysis

Sponsored Session

Chair: Canan Ulu, Georgetown University, Washington, DC, 20057, United States, cu50@georgetown.edu

1 - An Additive Model of Decision Making under Riskand Ambiguity

Ying He, University of Southern Denmark, Campusvej 55, Odense, M, 5230, Denmark, yinghe@sam.sdu.dk, James S. Dyer, John C. Butler, Jianmin Jia

We develop preference conditions to separate "value', "risk" and "ambiguity" to obtain a descriptive, additive model of decision making under risk and ambiguity. This model explicitly captures the tradeoff between the magnitude of risk and the magnitude of ambiguity when making a choice over ambiguous lotteries. Combining this model with the standard risk-value model, we obtain a value-risk-ambiguity preference model.

2 - Where do We Stand on Multi-objective Decision Making?

Ali E. Abbas, Director, DECIDE Center, University of Southern California, OHE 310R, 3650 McClintock Ave, Los Angeles, CA, 90089, United States, aliabbas@usc.edu

The construction of a representative multi-attribute utility function is is an essential step in the analysis of many decisions. This talk with discuss some advances in the field of multi-attribute utility (including graphical representations and connections with artificial intelligence). The talk will also discuss some misuses of the theory, and some subtleties and approaches that still persist.

3 - An Interactive Bayesian Method for Multicriteria Sorting Problems

Canan Ulu, Georgetown University, McDonough School of Business, Operations and Information Management Area, Washington, DC, 20057, United States, cu50@georgetown.edu, Tom Shively

We build a Bayesian learning model for the multicriteria sorting problem.

4 - Robust Multicriteria Decision Analysis

Fabio Maccheroni, Universita Bocconi, Via Sapfath, 25, Milan, Italy, fabio.maccheroni@unibocconi.it, Veronica Roberta Cappelli, Salvatore Corrente, Salvatore Greco

In MCDA, often an alternative can be represented by a vector of probabilities, its i-th component representing the distribution of scores of attribute i. Typically (Keeney and Raiffa, 1976), alternatives are evaluated by an expected additively separable utility. Yet, in many situations the DM's utility is unknown to the DA: available data only leads to an incomplete ranking of alternatives. We provide necessary and sufficient conditions to represent this ranking by a family of additively separable utility functions, so that an alternative outranks another alternative if and only if its expected utility is greater than that of the other alternative for every utility in the representing family.

■ TB03

310C

Quantitative Imaging System for Cancer Diagnosis and Treatment Planning: An Interdisciplinary Approach

Invited: Tutorial

Invited Session

Chair: Jiming Peng, University of Houston, Houston, TX, 77204, United States, jopeng@Central.uh.edu

Co-Chair: Rajan Batta, University at Buffalo (SUNY), 410 Bell Hall, Buffalo, NY, 14260, United States, batta@buffalo.edu

1 - Quantitative Imaging System for Cancer Diagnosis and Treatment Planning: An Interdisciplinary Approach

Teresa Wu, Arizona State University, Tempe, AZ, United States, Teresa.Wu@asu.edu

During the past decade, with breakthroughs in systems biology, precision medicine has emerged as a novel paradigm that has transformed healthcare. Precision medicine is an approach for disease treatment and prevention that takes into account individual variability where medical imaging is a key component. This tutorial focuses on research investigating the roles of medical imaging in cancer diagnosis and treatment planning. While the cornerstone of the imaging research is mathematical and statistical modeling, the research has to take a multidisciplinary and systematic approach due to the nature of the problem. We offer a comprehensive review and discussion on four important components that form an imaging pipeline: imaging pre-processing, imaging feature extraction, feature dimensionality reduction and classification. To illustrate the clinical relevance, our in-house developed system, the imaging Multi-Texture Disease Diagnosis System (iMT-DDS) is presented with two clinical case studies, one on breast cancer diagnosis using contrast enhanced digital mammography imaging, and the other on cholangiocarcinoma using computed tomography imaging. The future directions of the imaging research are highlighted in the end.

■ TB03A

Grand Ballroom A

Financial Engineering in Applied Probability I

Sponsored: Applied Probability

Sponsored Session

Chair: Tomoyuki Ichiba, University of California-Santa Barbara, Santa Barbara, CA, 93106, United States, ichiba@pstat.ucsb.edu

1 - Systemic Risk in Financial Markets

Andrey Sarantsev, University of California, Santa Barbara, CA, United States, sarantsev@pstat.ucsb.edu

We study behavior of utility-maximizing private banks borrowing from the central bank and investing in risky assets. The central bank is risk-averse, and sets the interest rate to control the amount of risk in the system.

2 - Option Pricing with Delayed Information

Tomoyuki Ichiba, University of California-Santa Barbara, South Hall 5607A, Santa Barbara, CA, 93106, United States, ichiba@pstat.ucsb.edu, Mostafa Mousavi

We study the effects of delayed information on option pricing. First, we discuss absence of arbitrage and super replication problem with delayed information in discrete time, binomial-tree models. For contingent claims with convex payoff we present a closed-form formula. Then we also consider continuous time models as the limit of binomial tree models when the time steps and delay steps go to zero. Finally, we explore how delayed information exagerates the volatility smile.

3 - Pricing Various Swaps

Indranil SenGupta, North Dakota State University, Department of Mathematics, Fargo, ND, 58108-6050, United States, indranil.sengupta@ndsu.edu, William Wilson, William Nganje

One of the major challenges in arbitrage free pricing of swap is to obtain an accurate pricing expression which can be used with good computational accuracy. In this presentation we obtain various approximate expressions for the pricing of volatility, variance and covariance swaps. We show that with the approximate formulas obtained from the Barndorff-Nielsen and Shephard model the error estimation in fitting the delivery price is much less than the existing models with comparable parameters.

4 - Pricing Spread Options using a Variance Gamma Copula Paradigm

Kyle Meerscheidt, University of Houston, 4800 Calhoun Rd, Houston, TX, 77004, United States, kmeerscheidt@gmail.com, Edward Kao

A spread option is a contingent claim whose value depends on the difference between the value of one asset and a constant multiple of the value of a second asset. This paper examines the valuation of a spread call option where the prices of the two assets are driven by a bivariate dependent Lévy process, with a two-dimensional Lévy copula describing the dependence structure. This method can be extended to other bivariate Lévy processes, including those whose marginal (component) processes are not of the same family.

■ TB03C

Grand Ballroom C

Data-Driven Operations Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Adam J Mersereau, University of North Carolina, Chapel Hill, NC, 27599-3490, United States, ajm@unc.edu

Co-Chair: Gah-Yi Ban, London Business School, London, NW1 4SA, United Kingdom, gban@london.edu

1 - Data-driven Percentile Optimization for Multi-class Queueing Systems with Model Ambiguity: Theory and Application

Austin Steven Bren, Arizona State University, 5151 Guadalupe Road, Apt 2061, Phoenix, AZ, 85044, United States, hasbren@gmail.com, Soroush Saghafian

Multi-class queueing systems often experience ambiguity in the form of unknown parameters. To incorporate robustness in the control policies we apply a novel data-driven technique that can express different levels of robustness and utilize incoming data parameter learning. Optimal policies are found to be related to a closed-form priority-based policy, with connections traditional priority policies. We also apply our approach to a hospital Emergency Department (ED) using real-world data, and demonstrate the benefits of using our framework for improving current patient priority policies.

2 - Pricing for Reusable Resources

Yunjie Sun, Columbia University, 500 West 120th Street, 535 S.W. Mudd Building, New York, NY, 10027, United States, ys2888@columbia.edu, Omar Besbes, Adam Elmachtoub

We consider price optimization of reusable resources. We develop results on structural properties of the optimal dynamic pricing policy as well as provably good heuristics for this class of problems. We also discuss initial implementation efforts of a large scale pricing project at an industry partner, Dassault Falcon Jet, for rotable spare parts.

3 - Learning Single-peaked Ranking Preferences from Choice Data

Mohammed Ali Aouad, Massachusetts Institute of Technology, 856 Massachussetts Avenue, Flat 9, Cambridge, MA, 02139, United States, aaouad@mit.edu, Vivek Farias, Retsef Levi

We develop an efficient estimation procedure to learn single-peaked preferences from assortment choice data. The latter choice model assumes that individual ranking preferences form a « peak » according to a central permutation over items. This structure is popular in social choice theory, assortment optimization and matrix completion. While searching over the space of permutations is generally hard, we show that rank aggregation (corresponding to the column generation step in the estimation problem) can be solved in polynomial time under the single-peaked structure. We showcase the relevance of the proposed methodology in experiments on real choice data, in several product categories.

4 - Dynamic Procurement of New Products with Covariate Information: the Residual Tree Method

Adam J. Mersereau, University of North Carolina, Kenan-Flagler Business School, CB 3490, Chapel Hill, NC, 27599-3490, United States, ajm@unc.edu, Gah-Yi Ban, Jeremie Gallien

We study a practice-motivated problem of dynamically procuring a new, short life-cycle product under demand uncertainty. The firm does not know the demand for the new product but has data on demand histories and covariate information for similar products sold in the past. We propose a new data-driven combined forecasting and optimization algorithm called the residual tree method, and we analyze its performance via epi-convergence theory and computations. Numerical validations on realistic data confirm the tractability of the approach and the value of covariate information.

■ TB04

320A

Sustainable Operations and Policy

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Krishnan S. Anand, University of Utah, Salt Lake City, UT, 84112, United States, anand@eccles.utah.edu

1 - Food Wastage in Commercial Kitchens

Varun Karamshetty, INSEAD, Boulevard de Constance, Fontainebleau, 77300, France, Varun.Karamshetty@insead.edu, Elena Belavina

Kitchens are wasting as much on food waste as they make in profits. With an estimated $1 trillion in food being wasted every year, food waste is not only a huge economic loss, but also has a major impact on our environment accounting for nearly 15% of global GHG emissions. We analyze proprietary data to understand key drivers of food wastage in commercial kitchens. We identify the controllable factors, and quantify the impact of each of them. We then propose changes in their operations that minimize wastage while maintaining their service quality and bottom-line.

2 - Are Hazardous Substance Rankings Effective?

Basak Kalkanci, Georgia Institute of Technology, 3151 Stillhouse Creek Dr SE, Apt 25517, Atlanta, GA, 30339, United States, basak.kalkanci@scheller.gatech.edu, Wayne Fu, Ravi Subramanian

We empirically investigate the relationship between changes in the relative assessed hazard levels of chemicals and emissions reductions (including the use of source reduction and end-of-pipe treatment) by facilities that use these chemicals. We also examine the moderating effects of operational leanness - an attribute that prior studies have found to be associated with better environmental performance - in the setting wherein the relative assessed hazard levels of chemicals change over time.

3 - Fairness in Pollution Regulation

Krishnan S. Anand, University of Utah, David Eccles School of Business, Ois Department, University Of Utah, Salt Lake City, UT, 84112, United States, anand@eccles.utah.edu, Francois C. Giraud-Carrier

Fairness in pollution regulation is an important and much-debated question, especially given multiple stake-holders with conflicting objectives, including polluting firms, industry lobby groups, consumers, environmentalists, doctors and the government. While there is a vast literature on the notion of fairness in general, we use the term precisely to mean that the polluter pays for the entire pollution damage it causes, and no more— the so-called 'polluter pays' principle. We develop a novel benchmark-mechanism to implement fairness, and assess the fairness of Cap-and-Trade and Taxes against this benchmark.

■ TB05

320B

Beyond the Unit - Holistic Approach to Demand-Based Staffing in Hospital Systems

Sponsored: Health Applications

Sponsored Session

Chair: Hari Balasubramanian, University of Massachusetts-Amherst, Amherst, MA, 01003, United States, hbalasubraman@ecs.umass.edu

Co-Chair: Ekin Koker, University of Massachusetts, Amherst, MA, 01003, United States, ekoker@umass.edu

1 - Forecasting Demand and Staffing Fluctuations in Hospital Operations

Jeffrey Jung, Navigant Consulting, Inc., jeffrey.jung@navigant.com

A critical component of labor optimization is the ability to predict short and long term forecasts of demand variations as well as the supply /staffing variations. By projecting fluctuations in demand, hospital leaders are equipped to accurately reflect proportional changes to staffing needs. A variety of different algorithms (e.g. vector auto-regression, ARIMA), provide different approaches to minimize the forecasting error. These predictions lead to hiring decisions in anticipation high volume times and flight risk. The forecasted demand complements the optimal staffing plans to enable our clients to plan their future staffing in a dynamic environment with a higher level of precision.

2 - Creating Optimized Hospital Workforce Solutions

Jeffrey Jung, Senior Consultant, Navigant Consulting, Inc., New York, NY, 60606, United States, Jeffrey.jung@navigant.com, Hannan Abdi, Yaqiong Li, Asli Kayaalp

Hospitals are faced with the challenge of staffing to demand; however, the demand is sometimes hard to predict until just before a shift starts. Managers are therefore inclined to staff to capacity, or use expensive resources to fill gaps. These methods are inefficient and costly. Using mixed integer programming, we model the needs of a group of like-units and determine the optimal numbers of core and flexible resources (float pool vs. per diem, overtime, etc.) required to satisfy demand while minimizing cost. The results allow managers to allocate the best mix of resources (core vs. flexible, part-time vs. full-time) and plan schedules to meet the varying demand throughout the day/week.

3 - Sustaining Performance using Workforce Management Tools

Asli Kayaalp, PhD, Navigant Consulting, Inc., Washington, DC, 20036, United States, asli.kayaalp@navigant.com, Vamshi Gunukula, Hannan Abdi, Jeffrey Jung

To achieve and sustain the value of labor optimization, it is critical for hospital operational leaders to use tools and technologies that allows them to measure and track their performance. These tools include a well-defined position control process with mechanisms to track the impact of decision-making, predictive hiring plans and schedule planners all informed by the optimal staffing models. These tools are complemented by standardized productivity reporting analytics across functional areas. We work with the client to assess the optimal utilization of existing management tools and technologies and identify additional tools to supplement those currently available.

■ TB06

320C

Healthcare Operations

Sponsored: Health Applications

Sponsored Session

Chair: Hessam Bavafa, Wisconsin School of Business, Madison, WI, 53706, United States, hbavafa@bus.wisc.edu

1 - The Impact of E-visits on Visit Frequencies and Patient Health: Evidence from Primary Care

Hessam Bavafa, Wisconsin School of Business, 4284C Grainger Hall, 975 University Avenue, Madison, WI, 53706, United States, hbavafa@bus.wisc.edu

Secure messaging, or "e-visits," between patients and providers has increased sharply in recent years, and many hope they will help improve healthcare quality while increasing provider capacity. Using a panel dataset from a large healthcare system in the United States, we find that e-visits trigger about 6% additional office visits, with mixed results on phone visits and patient health. These additional visits come at the sacrifice of new patients: physicians accept 15% fewer new patients each month following e-visit adoption. Our data on nearly 100,000 patients spans from 2008 to 2013, which includes the rollout and diffusion of e-visits in the health system we study.

2 - Black Swans in Patient Costs: Evidence and Implications for Patient Allocation and Reimbursement

Michael Freeman, INSEAD, 1 Ayer Rajah Avenue, 138676, Singapore, mef35@cam.ac.uk, Stefan Scholtes

Using a unique data set of patient-level clinical information and costs, we identify "black swan" events — i.e. the admission to hospital of patients who cost significantly more than expected — and study their distribution across over 50 hospitals in England. We show that while emergency black swans appear to be allocated at random across hospitals, there is evidence that for planned patients the black swans are concentrated in certain hospitals. We estimate the quality and productivity implications of a black swan patient beeing seen at a hospital that rarely treats such patients, and recommend how these patients might be better allocated to hospitals and how to reimburse for them appropriately.

3 - Cherrypicking Kidneys and Patients: Incentives in Transplant Centers

Mazhar Arikan, University of Kansas, 931 Drum Dr, Lawrence, KS, 66049, United States, mazhar@ku.edu, Baris Ata, Rodney P.Parker

The Centers for Medicare and Medicaid Services' (CMS) Conditions of Participation requirements evaluate transplant centers based on one-year risk-adjusted patient and organ survival rates post transplantation. Using actual transplant data, we empirically analyze some potential unintended consequences of these regulations such that more risk averse centers choose healthier patients and higher quality organs to transplant.

4 - Personalized Health Care Outcome Analysis of Cardiovascular Surgical Procedures

Guihua Wang, Ross School of Business, University of Michigan, 1209 McIntyre Drive, Ann Arbor, MI, 48105, United States, guihuaw@umich.edu, Jun Li, Wallace J. Hopp

Using patient-level data from thirty-five hospitals for six cardiovascular surgeries in New York state, we identify patient groups that exhibit significant differences in outcomes with a recently developed instrumental variable tree approach. We find that outcome differences between hospitals are heterogenous across patients. By quantifying these differences, we demonstrate that a large majority of patients can achieve better expected outcomes by selecting providers based on personalized outcome information. We also show how personalized outcome information can help providers to improve their processes and payers to design effective pay-for-performance programs.

■ TB07

322A

Operations Research and Analytics for Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Sharan Srinivas, Penn State University, State College, PA, 16803, United States, sus412@psu.edu

1 - Smart Appointment Scheduling Rules for Outpatient Clinics

Sharan Srinivas, Penn State University, 265 Blue Course Dr, Apt 3E, State College, PA, 16803, United States, sus412@psu.edu, Arunachalam Ravindran

In this research, a new framework that uses a combination of predictive analytics and simulation is proposed for scheduling patients dynamically. Further, new appointment scheduling rules that leverage patient specific no-show values are proposed to improve patient satisfaction and resource utilization of outpatient clinics. A case study with real data from a Family Medicine Clinic is used to compare the effectiveness of the proposed rules with current scheduling practices. The results indicate that the proposed scheduling rules significantly outperform the current practice for all the clinic settings tested.

2 - Guided Undersampling Classification for Automated Radiation Therapy Quality Assurance of Prostate Cancer Treatment

William Eric Brown, Texas A&M.University, 3131 TAMU, College Station, TX, 77843-3131, United States, webrown@tamu.edu, Kisuk Sung, Dionne Aleman, Erick Moreno-Centeno, Thomas Purdie, Chris J. McIntosh

Review of radiation therapy (RT) treatment plans requires ample care and human capital; failure to identify errors can cause sizable patient harm. We cast this issue as imbalanced-data classification and address it with a novel modularized guided undersampling method. A sequence of accepted and erroneous RT plans for low to intermediate risk prostate cancer patients was used for testing. While upholding clinically acceptable false-positive rates (FPR), we identify 100% of flawed plans. Remarkably, our framework correctly identifies error types it was not trained on with an FPR of only 18%.

3 - Optimizing the Emergency Call Taking Process with Machine Learning Methods.

Nikiah Nudell, Dakota State University, 2800 7th St N, St. Cloud, MN, 56303, United States, nnudell@paramedicfoundation.org

Over 7 billion emergency calls are made worldwide to emergency numbers such as 911 each year. For cardiac arrest cases, delays cost lives and the currently used decision tools only achieve about 85% accuracy. This study proposes the first work to optimize the emergency call taking process based on patient outcomes using an adaptive hybrid machine learning method. Our method could be implemented in emergency call centers to improve the accuracy and speed of incident detection for up to 50% improvement in survival benefit. These self-optimizing methods could be deployed across many industries from military to retail, to manufacturing, to customer service upstream of decision support systems.

4 - A Hybridized Machine Learning Framework for Health Risk Ranking

Doug Popken, Senior Vice President, NextHealth Technologies, Denver, CO, United States, doug.popken@nexthealthtechnologies.com, Jeremy Schendel

We have deployed a hybrid predictive modeling system in a production environment to predict different forms of medical utilization. Predictions are used for risk stratification and subsequent targeting of behavior changing interventions. Challenges and ongoing research directions are presented.

■ TB08

322B

OR and IS in Health: Never the Twain Shall Meet?

Sponsored: Health Applications

Sponsored Session

Chair: Sally C. Brailsford, University of Southampton, Southampton, S017 1BJ, United Kingdom, s.c.brailsford@soton.ac.uk

1 - Panelist

Cynthia M.Lerouge, University of South Florida, 1727 Carroll Street, Saint Louis, MO, 63104-3305, United States, lerouge@tampabay.rr.com

2 - Panelist

Fay Cobb Payton, North Carolina State University, COM, Box 7229, Raleigh, NC, 27695, United States, fay_payton@ncsu.edu

3 - Panelist

Paul Harper, Cardiff University, Cardiff, United Kingdom, harper@cardiff.ac.uk

4 - Operations Research and Information Systems: Never the Twain Shall Meet?

Sally C. Brailsford, University of Southampton, School of Management, Southampton, S017 1BJ, United Kingdom, s.c.brailsford@soton.ac.uk

Operations Research and Information Systems are different scientific disciplines, yet they clearly have non-zero intersection. In this panel session, the four Editors-in-Chief of the UK OR Society journal "Health Systems" present their perspectives on the relationship between OR and IS, and how each can inform and enrich the other, especially in the domain of healthcare.

■ TB09

330A

Online Advertising Markets

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Gabriel Weintraub, Stanford Graduate School of Business, Stanford, CA, 94304, United States, gweintra@stanford.edu

1 - Budget Management Strategies in Repeated Auctions

Anthony Kim, Stanford University, 39 Angell Court Apt. 106, Stanford, CA, 94305, United States, tonyekim@stanford.edu, Santiago Balseiro, Mohammad Mahdian, Vahab Mirrokni

One of the most important features advertising platforms often provide is budget management, which allows advertisers to control their cumulative expenditures. We study the "system equilibria" of a range of budget management strategies in terms of the seller's profit, buyers' utility and overall welfare. We show these methods admit a system equilibrium in a rather general asymmetric setting and prove dominance relations between them when buyers are symmetric. We also empirically compare the system equilibria of these strategies using real ad auction data.

2 - Price Discrimination with Ex-post Participation Constraints

Francisco Castro, Columbia University, New York, NY, United States, fcastro19@gsb.columbia.edu, Dirk Bergemann, Gabriel Weintraub

In online display advertising markets, publishers typically use a series of second-price auctions to "waterfall" a given impression, implicitly imposing different priorities and reserve prices over buyers. In addition, business constraints do not allow sellers to charge up-front fees. Thus motivated, we study a sequential screening problem with ex-post participation constraints. Our results shed light on the effectiveness of the series of waterfall auctions as a price discrimination device and on what type of improvements could be implemented in practice.

3 - Boosted Second-price Auctions, Simple Mechanisms to Capture Heterogeneity

Negin Golrezaei, University of Southern California, 812 S Marengo Avenue, Unit 6, Pasadena, CA, 91106, United States, golrezae@usc.edu, Max Lin, Vahab Mirrokni, Hamid Nazerzadeh

We propose a new auction format called boosted second-price auctions that can yield more revenue than widely used second-price auctions. In boosted second-price auctions, for each advertiser, a boosted bid is calculated, where the boosted bid is a linear function of submitted bids. Then, an advertiser with the highest boosted bid wins. We provide theoretical justification as to how new boosted second-price auctions increase revenue over second-price auctions when advertisers are heterogeneous. We further provide practical guidelines to determine boosts. We validate our guidelines theoretically and empirically using Google Ad Exchange data.

4 - Multiplicative Pacing Equilibria in Auction Markets

Christian Kroer, Carnegie Mellon University, Computer Science Department, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, ckroer@cs.cmu.edu, Vincent Conitzer, Eric Sodomka, Nicolas Stier-Moses

Budgets play a significant role in auction markets implemented by Internet companies. To maximize the value provided to auction participants, spending is smoothed across auctions so budgets are used for the best opportunities. We consider a smoothing procedure that relies on pacing multipliers: for each bidder, the platform applies a factor between 0 and 1 that uniformly scales the bids across all auctions. We introduce the notion of pacing equilibrium, and prove that one or more equilibria always exist. Although computing a social welfare or revenue maximizing pacing equilibrium is NP-hard, we develop an integer program that can be used to characterize pacing equilibria and optimize among them.

■ TB10

330B

Data and Information in Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Fuqiang Zhang, Washington University in St. Louis, St. Louis, MO, 63130, United States, zhang@olin.wustl.edu

1 - Trade-off Between Flexibility and Productivity: An Empirical Analysis of Manufacturing Networks

Vivek Choudhary, INSEAD, Singapore, Singapore, Vivek.Choudhary@insead.edu, Sameer Hasija, Serguei Netessine

Manufacturing flexibility has been studied in many contexts and the celebrated "chaining" principle dictates how manufacturing networks should be structured. However, empirical analysis of this principle are non-existent. We analyze the impact of manufacturing network structure on productivity.

2 - Consumer Equilibrium, Pricing, and Efficiency in Group Buying: Theory and Evidence

Tunay Tunca, Unversity of Maryland, 8803 Courts Way, College Park, MD, 20742, United States, ttunca@rhsmith.umd.edu, Liu Ming

We study consumer equilibrium and network effects in group buying mechanisms. We theoretically model dynamic consumer behavior in group buying and derive the continuous time stochastic recursive equilibrium. Utilizing data from a major retail platform, we structurally estimate the model and predict the efficiency gains created by employing the mechanism.

3 - Demand Information Sharing for a Platform

Zekun Liu, Washington University in St. Louis, One Brookings Drive, Campus Box 1156, St. Louis, MO, 63130, United States, liu.zekun@wustl.edu, Fuqiang Zhang, Dennis Zhang

We study the information sharing strategy for a platform on which independent sellers engage in Cournot competitions. The platform possesses superior information than the sellers and may choose to share the information with the sellers. We characterize the optimal sharing strategy for the platform.

4 - Corporate Social Responsibility with Asymmetric Information

Xiaomeng Guo, Hong Kong Polytechnic University, Hong Kong, Hong Kong, xiaomeng.guo@polyu.edu.hk, Guang Xiao, Fuqiang Zhang

We develop a game-theoretic model to analyse the impact of consumers' social-responsibility concerns on a firm's pricing decision and profit. The firm can be either socially responsible or non-responsible, and consumers do not have perfect information about the firm's type. We find that the existence of information asymmetry may have interesting implications for the firm regarding corporate social responsibility.

■ TB11

332A

Empirical Service Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Pnina Feldman, University of California-Berkeley, University of California-Berkeley, Berkeley, CA, 94720, United States, feldman@haas.berkeley.edu

1 - Welfare Implications of Congestion Pricing: Evidence from SF Park

Hsin-Tien Tsai, University of California, Berkeley, CA, 94703, United States, hsintien@berkeley.edu

Congestion pricing offers an appealing solution to urban parking congestion. We find that SFpark increases consumer and social welfare in congested regions but may hurt welfare in uncongested regions. Interestingly, congestion pricing may not surely reduce search traffic, because dispersed prices induce consumers to search for affordable spaces. In such cases, a simpler pricing policy may achieve higher welfare than a complex one. Lastly, congestion pricing increases social welfare compared to capacity rationing. The insights offer important implications for local governments considering regulation vs. market-based approaches for managing parking.

2 - Listen to the Crowd: Network Effects and Online Reviews in Restaurant Sales Forecasting

Shawn Mankad, Cornell University, Ithaca, NY, United States, spm263@cornell.edu, Qiuping Yu, Masha Shunko

Using a comprehensive dataset from a major restaurant franchise, we forecast weekly store sales using classical measures of service quality from internal surveys at focal and neighboring stores, in addition to online ratings. Our results show that higher quality at the neighboring stores leads to higher sales at the focal store. We also find that the accumulation of online reviews reduces the importance of internal quality surveys at focal and neighboring stores as predictors.

3 - The Customer May Not Always be Right: Customer Compatibility and Service Performance

Ryan Buell, Harvard Business School, Morgan Hall 429, Boston, MA, 02163, United States, rbuell@hbs.edu, Dennis Campbell, Frances X. Frei

Leveraging data from a nationwide retail bank, we investigate the extent to which customer satisfaction is explained by differences between customers (versus differences among factors more directly controlled by the firm). We find that differences among customers account for more than 90% of the explainable variation in customer satisfaction, and that although individual customers tend to experience the operation consistently, there are surprisingly large differences in experiences among customers. The presentation will also preview ongoing research that highlights how operational design choices can shape customer selection, and in turn, customer compatibility.

4 - Ratings and Version Updates in the Mobile App Market

Gad Allon, University of Pennsylvania, gadallon@wharton.upenn.edu, Yorgos Askalidis, Randall Berry, Nicole Immorlica, Ken Moon, Amandeep Singh

Mobile apps have become an economy with a projected market size of $77 Billion in 2017. One of the key features that distinguishes mobile apps from other types of digital goods (such as movies, songs or books) is that they have versions. A developer can release an app into a mobile app store, and can then keep adding, removing, or editing features of the app with subsequent version updates. We characterize the optimal strategy for timing such updates and structurally estimate the extent to which developers respond to demand-side incentives in a ratings-sensitive environment. We discuss implications for platforms and developers.

■ TB13

332C

Game Theory

Contributed Session

Chair: Jian Yang, Rutgers University, Newark, NJ, United States, jyang@business.rutgers.edu

1 - Multi-strategy Trust Evolution Dynamics in the Venture Capital Syndicate Network

Heyin Hou, Southeast University, School of Economics and Management, Southeast University, Nanjing, 211189, China, heyinhou@hotmail.com, Jun Yin, Weida Chen

Venture Capital Syndicate Network (VCSN) derives from syndicate investments and relies on trust between venture capitalists (VCs). Based on a Wright-Fisher process, we introduce a general game model of trust evolution dynamics with multi-strategy and protection mechanism in the VCSN. Then, we explore influences of the protection mechanism on evolutionary stability conditions for the two-strategy and the four-strategy game models. Finally, we construct the global profit function for the VCs and adopt simulation experiments to verify the trust evolution dynamics for the two-strategy and the four-strategy game models.

2 - Augmented Probability Simulation Methods for Non-cooperative Games

Tahir Ekin, Assistant Professor of Quantitative Methods, Texas State University, 601 University Dr. Mccoy 451, San Marcos, TX, 78666, United States, t_e18@txstate.edu

We provide an augmented probability simulation framework to solve non-cooperative games, focusing on sequential problems. We include approaches to approximate Nash equilibria under common knowledge conditions, assess such solutions under a robust approach and, finally, approximate adversarial risk analysis solutions when lacking common knowledge. A security example serves as illustration.

3 - Competition for Blood Donations: A Nash Equilibrium Network Framework

Pritha Dutta, Doctoral Candidate, University of Massachusetts-Amherst, 6 H.Brandywine Drive, Amherst, MA, 01002, United States, pdutta@umass.edu, Anna B. Nagurney

In this paper, we develop a game theory model where blood service organizations compete for blood donations at collection sites in different regions based on the quality of their service and seek to maximize their transaction utilities. The governing equilibrium concept is that of Nash Equilibrium. The equilibrium is formulated as a variational inequality problem. An algorithm with nice features for computations is proposed and applied to a case study consisting of examples of increasing complexity. The results demonstrate that enhanced competition can improve the quality service level and that blood service organizations can also benefit from having collection sites in multiple regions.

4 - Column Generation Approach for Patrolling Games

Abdolmajid Yolmeh, Rutgers University, Dept of Industrial & System Engineering, 96 Frelinghuysen Road, Piscataway, NJ, 08854, United States, majid_yolmeh@yahoo.com, Melike Baykal-Gursoy

Most of the studies in the patrolling games area assume that all of the nodes have the same value or their values are fixed throughout time. However, in reality different nodes may have different values and these values may change over time. In this study we consider a patrolling game model on a general graph with different and dynamically changing node values and different attack times. We develop an efficient column generation approach to solve this problem. We also present a lower bound for the value of the game which can be used to terminate the column generation algorithm when a desired solution quality is reached. Computational experiments show the efficiency of the proposed column generation method.

5 - The Cooperative Game with Non-deterministic Payoffs

Jian Yang, Rutgers University, 1 Washington Park Rm 1084, Newark, NJ, 07102, United States, jyang@business.rutgers.edu

We study a non-traditional cooperative game where payoffs from coalitions are non-deterministic. Under various conditions, we show how the game's core can be related to that of a traditionally defined auxiliary. When individuals both contribute to coalitions in additive fashions and share a common mean-deviation utility, we show that increased risk aversion will promote the formation of the grand coalition. Core members can also be identified by solving nonlinear or even linear programs.

■ TB14

332D

Operations Research for Health Systems in Emerging Countries

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Jorge Vera, Pontificia Universidad Catolica de Chile, Santiago, 7820436, Chile, jvera@ing.puc.cl

1 - A Proactive Policy to Manage Critical Inpatient Flow in Hospitals

Juan-Carlos Ferrer, Pontificia Universidad Catolica de Chile, Casilla 306 Correo 22 Stgo, Santiago, Chile, jferrer@ing.puc.cl, Jaime Gonzalez

Critical beds scarcity in Chilean hospitals produce overcrowding in emergency rooms, generating patients being hospitalized in urgency beds leading to large delays in emergency care. A Markov decision process was formulated to study the relation between bed availability and critical patient demand. This model shows a policy to proactively discharge patients from a unit, leaving space for an expected critical patient. The policy was tested in a simulation of a hospital in Santiago. The results show that, with the same amount of resources, both emergency patient waiting time and patient renege were reduced, increasing real capacity of the emergency room.

2 - Age Dependent Optimal Policies for Hepatitis C Treatment

Susana Mondschein, Universidad Adolfo Ibanez, 2640 Diagonal las Torres, Penalolen, Santiago, 7550000, Chile, susana.mondschein@uai.cl, Natalia Yankovic

Highly effective drugs for hep C virus have become available. However, their high prices require a cost effectiveness evaluation, due to the economic constraints most health care systems face. We developed a dynamic programming model with age dependent transitions, to determine optimal timing for the drug. The optimal solution is of a threshold-box type (no-yes-no, as function of the fibrosis stage). Using an age-dependent cohort, we achieved similar performance for the number of transplants, HCV deaths, and QALYs, with less overall expenditure, compared to the current Spanish policy. We also evaluated 3 heuristics, to improve both, life expectancy and expected QALYs, while containing the costs.

3 - Scheduling Operating Rooms under the Uncertainty of Surgery Duration and the Early Cancellation Decision

Guillermo Latorre-Núñez, Pontificia Universidad Católica de Chile, Santiago, Chile, golatorre@uc.cl, Vladimir Marianov, Armin Lüer-Villagra, Jorge Vera, Germán Paredes-Belmar

Operating Rooms (ORs) are among the most expensive resources in a hospital. Poor scheduling of the ORs can generate delays in the schedules, excess of overtime, even cancellation of some surgeries. This directly affects the hospital costs, as well as patient and medical team satisfaction. We solve the daily OR programming problem. It consists on assigning and sequencing the surgeries to the ORs, considering uncertainty in the surgeries' duration and a priori cancellation of surgeries. The objective is to minimize total costs. We use a robust type of approach.

4 - Admission Planning in Real Time for Emergency Services

Jorge Vera, Dept. Industrial and System Engineering, Universidad Catolica de Chile, Santiago, 7820436, Chile, jvera@ing.puc.cl Jorge Vera, Pontifical Catholic University of Chile, Santiago, Chile, jvera@ing.puc.cl, Ana Celeste Batista

Admission Planning Problem (APP) is concerned with deciding which patient to admit. The problem is complex due to service capacity, patient priorities and uncertainty in health care processes, such as patient length of stay. Off-line approaches have been proposed but they assume knowledge of the (uncertain) arrival rate of patients and these models would not be helpful for real-time bed allocation. We study an advance APP to control real-time bed allocation decisions for emergency patients considering on-line optimization. We derive mathematical insights to compare with the existing APP methodologies. We present computational results for a set of benchmarks in a public hospital from Chile.

■ TB15

332E

Topics in Supply Chain Management

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Nikolay Osadchiy, Emory University, Atlanta, GA, 30322, United States, nikolay.osadchiy@emory.edu

1 - The Structure of Grocery Retail Markets and Food Waste

Elena Belavina, University of Chicago Booth School of Business, 5807 S.Woodlawn Ave, Chicago, IL, 60637, United States, elena.belavina@chicagobooth.edu

This paper examines the impact of grocery-store density on food waste using a stylized two-echelon perishable-inventory model. We find that the effects on household and store food waste are opposite, yet household waste dominate. We find that increasing store density reduces household and total food waste, typically achieving around 6% waste reduction for a 10% reduction in the distance between stores, while making groceries more affordable—- policy makers should promote laws that encourage new store openings. Finally, popular store targeted interventions must carefully weigh the intervention's impact on household food waste; otherwise, they might result in overall higher food waste.

2 - The Implications of Visibility on the use of Strategic Inventory in a Supply Chain

Abhishek Roy, Doctoral Student, University of Texas-Austin, 2110 Speedway Stop B6500, Austin, TX, 78712-1277, United States, abhishek.roy@utexas.edu, Stephen M.Gilbert, Guoming Lai

It is now widely accepted that, by holding strategic inventory, a retailer can influence the wholesale price offered by an upstream manufacturer and improve the efficiency of the supply chain. Yet, although it is typically assumed that the manufacturer can observe the retailer's inventory, this is often not the case in practice. We recognize that this inability to observe downstream inventory creates a form of hidden action and investigate the implications upon the use of strategic inventory under both linear and non-linear contracts.

3 - Operational Transparency with Investors

William Schmidt, Cornell University, 314 Sage Hall, Ithaca, NY, 14850, United States, wschmidt@cornell.edu

We use two complementary approaches to tie the impact of operational disruptions to changes in the firm's systematic risk in the aftermath of a disruption. First we show that compared to firms that comply with new transparency requirements, firms that do not comply experience a materially larger decrease in their market value after an operational disruption, even after controlling for the earnings impact of the disruption. Second, we use the change in the volatility of the firm's share price return as a proxy for the change in the firm's systematic risk to show that firms that do not comply experience a materially larger increase in risk after an operational disruption compared to firms that do comply.

4 - Evolution of Supply Networks
Nikolay Osadchiy, Emory University, 1300 Clifton Rd NE, Atlanta, GA, 30322, United States, nikolay.osadchiy@emory.edu, Vishal Gaur, Maximiliano Udenio

Using a large panel of firm-level buyer-supplier relationships, we study evolution of supply networks over time and implications for idiosyncratic and systematic risk.

■ TB16

332F

Operations Management

Contributed Session

Chair: Katsunobu Sasanuma, Stony Brook University, Stony Brook, NY, United States, katsunobu.sasanuma@stonybrook.edu

1 - New Heuristics for the Lost Sales Inventory Problem
Peter L. Berling, Associate Professor, Lund University, Box 118, Lund, SE-22100, Sweden, peter.berling@iml.lth.se, Víctor Martínez-de-Abénis

We develop two heuristics based on the ideas of the "Single-unit decomposition approach" that originates from Axsäter (1990) and have been further developed by Muharremoglu and Tsitsiklis (2008) among others. Both heuristics use the expected cost per demanded unit inked to the next unit to be ordered but there is a difference in how this cost is defined. The best myopic decision, i.e. the one that minimizes the expected cost per demanded unit, can then be determined and implemented in respective heuristic. The resulting policy is a simple state-dependent base-stock policy and the numerical test show an improvement of the performance compared to traditional base-stock or time-phased policies.

2 - The Optimization Model of Inventory Control of Spare Components when Inventory Fails
Liying Cai, Mechanical Technology Institution, Shijiazhuang, China, cailiyingsharon@sina.cn

Properly control of spare components is the core element in optimization of inventory control of spare components. This paper established an optimization model of inventory control of spare components when inventory fails. Firstly, we established a single component system with its spare components' type being irreparable; then analyzed its system lifetime and cost; finally, a case study is carried out, which proved the effectiveness of the proposed optimal model made in this article.

3 - Stochastic Setup Cost Inventory Model with Backorders and Quasiconvex Cost Functions
Yan Liang, Stony Brook University, Department of Applied Mathematics and Statistics, Stony Brook, NY, 11794, United States, yan.liang@stonybrook.edu, Eugene A. Feinberg

This talk is concerned with a periodic-review setup-cost inventory model with backorders and holding/backlog costs satisfying quasiconvexity assumptions. We show that this model satisfies assumptions that imply the validity of optimality equations for discounted and average cost criteria and the family of discounted relative value functions is equicontinuous. We establish two groups of results: (i) optimality of (s,S) policies for infinite-horizon problems under discounted and average cost criteria, and (ii) convergence of optimal discounted lower thresholds s and discounted relative value functions to their average-cost counterparts as the discount factor converges to 1.

4 - Finding Repair Shop Priorities
Ece Zeliha Demirci, Postdoc Researcher, Eindhoven University of Technology, Eindhoven, 5600 MB, Netherlands, e.z.demirci@tue.nl, Joachim Jacob Arts, Geert-Jan van Houtum

We investigate the dynamic scheduling problem of a repair shop with a single server. The problem is to allocate the capacity of the repair shop between spare parts and decide on which part to repair first. Using the MDP formulation of the problem, we show that longest queue policy is optimal if the parts have identical characteristics and controlled with the same or different levels of base stock.

5 - Analysis of Perishable Inventory with Substitution under a Base Stock Policy
Katsunobu Sasanuma, Assistant Professor, Stony Brook University, Harriman Hall, Stony Brook University, Stony Brook, NY, 11794, United States, katsunobu.sasanuma@stonybrook.edu, Mohammad Delasay, Christine Pitocco, Thomas Raymond Sexton, Alan Scheller-Wolf

We study heuristic control policies for perishable inventory systems with substitution. We derive a simple state-dependent base stock policy by approximating the exact optimality condition. We demonstrate its validity by comparing with simulation results.

■ TB17

340A

Robust Optimization and Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Chaithanya Bandi, Northwestern University, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

1 - Beyond Worst-case: A Probabilistic Analysis of Affine Policies in Dynamic Optimization
Omar El Housni, Columbia University, 110 Morningside Drive, Apt 64, New York, NY, 10027, United States, oe2148@columbia.edu, Vineet Goyal

Affine policies are widely used in dynamic optimization where computing an optimal adjustable solution is usually intractable. While the worst case performance of affine policies can be significantly bad, the empirical performance is observed to be near-optimal for a large class of problem instances. In this paper, we aim to address this stark-contrast. In particular, we consider a two-stage dynamic robust optimization problem with linear covering constraints and uncertain right hand side and show that affine policies give a good approximation on random instances generated from a large class of distributions including the commonly used distributions such as uniform and Gaussian.

2 - Learning-based Robust Optimization: Procedures an d Statistical Guarantees
Henry Lam, University of Michigan, 1205 Beal Avenue, Industrial & Operations Engineering, Ann Arbor, MI, 48109, United States, khlam@umich.edu, Jeff Hong, Zhiyuan Huang

We discuss a statistical framework to integrate data into robust optimization (RO) based on prediction set learning and a simple data-splitting validation scheme that achieves finite-sample statistical guarantees on the feasibility of the underlying uncertain constraints. We demonstrate how the framework satisfies a dimension-free sample size requirement on feasibility guarantees and how it provides a platform to integrate machine learning tools into RO driven by convoluted or high-dimensional data.

3 - Distributionally Robust Inventory Control when Demand is a Martingale
Linwei Xin, University of Chicago, Booth School of Business, Chicago, IL, 60637, United States, linwei.xin@chicagobooth.edu, David Goldberg

Independence of random demands across different periods is typically assumed in multi-period inventory models. In this talk, we consider a distributionally robust model in which the sequence of demands must take the form of a martingale with given mean and support. We explicitly compute the optimal policy and worst-case distribution in closed form. We prove that at optimality the worst-case distribution corresponds to the setting in which inventory may become obsolete at a random time, a scenario of practical interest. We also compare to the analogous setting in which demand is independent across periods, and identify interesting differences between these two models.

4 - Tractable Distributionally Robust Optimization with Data
Zhi Chen, National University of Singapore, NUS Business School, PhD B1-02 Biz2 Building, Singapore, 117592, Singapore, chenzhi@u.nus.edu, Melvyn Sim

We present a unified and tractable framework for distributionally robust optimization then encompasses a variety of statistical information including, among others things, expectation constraints, uncertain probabilities of regions and Wasserstein distance. We also introduce a new region based linear decision rule that provides better approximations of adaptive distributionally robust optimization problems and this can also be applied in situations when the recourse variables are discrete.The framework can be incorporated in an algebraic model tool box to facilitate modeling of robust optimization problems.

■ TB18

340B

A/B Testing and Experimentation

Sponsored: Applied Probability

Sponsored Session

Chair: Ramesh Johari, Stanford University, Stanford, CA, 94305-4121, United States, ramesh.johari@stanford.edu

Co-Chair: David Walsh, Stanford University, San Francisco, CA, 94117, United States, dwalsh@stanford.edu

1 - Should A/B Testers Just be Bayesian?
David Walsh, Stanford University, 876 Shotwell Street, San Francisco, CA, 94110, United States, dwalsh@stanford.edu

Any large internet company runs thousands of A/B tests each week, because they provide objective feedback on which ideas work. Progress is incremental, so there are usually strong connections between new experiments and those run before. However, the default Frequentist approaches analyze each A/B test in isolation. A Bayesian framework can easily leverage such prior data, enabling more accurate results with shorter experiments. But we examine how it can also be vulnerable to strategic behavior by the experimenter. This undermines the objective feedback loop and enables the A/B tester simply to get the answer they want.

2 - Improving the Expected Improvement Algorithm
Russo Dan, dan.joseph.russo@gmail.com

The expected improvement (EI) algorithm is a popular strategy for information collection in optimization under uncertainty. To provide rigorous insight into EI, we study its properties in a simple setting where the goal is to choose the best among a finite set of options based on noisy measurements of their quality. In this framework, one can show formally that EI is far from optimal. To overcome this shortcoming, we introduce a simple modification of the expected improvement algorithm. Surprisingly, this simple change results in an algorithm that is asymptotically optimal for problems with Gaussian observation noise, and provably outperforms standard EI by an order of magnitude.

3 - Experimentation and Interference in a Marketplace
Nicholas Chamandy, Lyft, San Francisco, CA, United States, nickchamandy@gmail.com

Simple "random-user" experiment designs fall short in the face of complex dependence structures. These come in the form of large-scale social graphs or, more recently, spatio-temporal network interactions in a two-sided transportation marketplace. Naive designs are susceptible to statistical interference, which can lead to biased estimates of the treatment effect of interest. We consider the implications of interference for the design and analysis of experiments at Lyft. The literature on causal inference for infectious diseases offers some insights; these are briefly discussed. We motivate the use of large-scale simulation to both filter candidate tests and validate design methodology.

4 - A Personalized BDM Mechanism for Efficient Market Intervention Experiments
Imanol Arrieta, Stanford University, Stanford, CA, United States, imanol@stanford.edu

The BDM mechanism employs a second-price auction against a random bidder to elicit a consumer's willingness to pay. It has been recently utilized as a treatment assignment mechanism to evaluate policy interventions while simultaneously measuring the demand for the interventions. We develop a personalized extension of this mechanism using modern machine learning algorithms to predict an individual's willingness to pay and personalize the "random bidder". We show through simulations and a mock experiment on Amazon Mechanical Turk that our personalized BDM mechanism results in lower costs and provides better balance over covariates.

■ TB19

342A

Operations/Innovative Financing Interaction

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: S. Alex Yang, London Business School, London, NW1 4SA, United Kingdom, sayang@london.edu

1 - The Impact of Demand Uncertainty on Business Interruption Insurance
Yuan-Mao Kao, Duke University, Durham, NC, United States, yuan.mao.kao@duke.edu, Kevin Shang, N. Bora Keskin

We consider a firm that faces uncertainty about demand and possible business interruptions in advance of a selling season. In this setting, we formulate an optimal insurance design problem and study how different types of uncertainty affect the insurance offering as well as the firm's operational decisions.

2 - The Benefit of Scale: Crowdfunding Risks and Returns
Mabel Chou, National University of Singapore, 3 60 Pasir Panjang Rd, #01-11, Singapore, 118699, Singapore, mabelchou@nus.edu.sg, Guodong Lyu, Chung-Piaw Teo, Zhichao Zheng, Yuanguang Zhong

With the internet becoming more accessible than ever, entrepreneurs nowadays do not need to ask a few people for big sums of money. Instead, they can use the internet to talk to thousands or even more potential funders that each contribute a small amount. A natural question any potential funder would want to ask is: what are the risks and returns for this investment? To attract more funders, this is a question an entrepreneur needs to address properly. In this talk, we will help the entrepreneurs who are looking for crowdfunding to address this important question based on the new insights obtained from an application of Blackwell's Approachability Theorem.

3 - Signaling to the Crowd: Private Quality Information and Rewards-based Crowdfunding
Soudipta Chakraborty, Duke University, 100 Fuqua Drive, Durham, NC, 27708, United States, sc390@duke.edu, Robert Swinney

We consider the problem faced by a seller designing a rewards-based crowdfunding campaign via a platform like Kickstarter. The seller solicits donations from contributors, and if total contributions exceed a pre-determined threshold the campaign is a success, the seller receives all donations and each contributor receives a reward; otherwise, contributors are refunded their donations and the campaign is a failure. We determine how the seller should design her crowdfunding campaign when contributors know less than the seller about the value of the reward.

4 - Financing through Advance Selling: the Role of Social Ties
S. Alex Yang, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, sayang@london.edu, Shuang Xiao, Yiangos Papanastasiou

Advance selling (the practice of selling a product in advance of its consumption date) has received significant attention in the recent operations literature, and has shown to be beneficial in a variety of industries as a tool for implementing price discrimination, reducing demand uncertainty, and managing capacity more effectively. More recently, start-up companies have been exploring the use of advance selling as a mechanism to help capital-constrained firms secure bank financing. This paper conducts a theoretical investigation into the efficacy of this alternative financing approach.

■ TB20

342B

Topics on Service Design

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Ioannis Bellos, George Mason University, Fairfax, VA, 22030, United States, ibellos@gmu.edu

1 - First Ranked First to Serve: Strategic Agents in Service Contest
Konstantinos Stouras, University of Virginia, Charlottesville, VA, United States, StourasK@darden.virginia.edu, Serguei Netessine, Karan Girotra

Work-from-home contact centers crowdsource demand to a pool of freelance agents, who are ranked in a predetermined number of priority classes based on their sales performance. The agents endogenously decide whether to participate and provide service on-demand. Agents' idle time is not compensated and higher ranked agents are utilized more and earn more. In a markovian queueing model with ex ante random capacity, we show that a coarse partition with two priority classes provide better incentives for agents to participate, maximize firm's profit and asymptotically maximize social welfare.

2 - Balancing Advisory and Service Delivery Efforts in a Nonprofit Organization
Priyank Arora, Georgia Institute of Technology, Atlanta, GA, United States, Priyank.Arora@scheller.gatech.edu, Morvarid Rahmani, Karthik Ramachandran

This paper studies how a nonprofit organization (NPO), which aims to maximize overall utility delivered to its clients, should balance levels of effort between advisory and service delivery stages.

3 - Consumption Decisions in Queues
Sezer Ulku, Georgetown University McDonough School of Business, 594 Rafik B. Hariri Building, Washington, DC, 20057, United States, su8@georgetown.edu, Christopher Hydock, Shiliang Cui

We study how the time spent waiting in line influences consumption decisions. We conduct a series of lab experiments and field studies in a variety of contexts, and observe that people deviate from rational behavior; we find that the longer people wait in line, the larger is their purchase quantity. In our final experiment, we show that two strategies that are used to improve consumer experience in queues can in fact result in lower purchase quantities.

4 - When Should Customers Control Service Delivery? Implications for Service Design
Ioannis Bellos, George Mason University, Enterprise Hall, 4400 University Dr., MS.5F4, Fairfax, VA, 22030, United States, ibellos@gmu.edu, Stylianos Kavadias

What do a Mongolian stir-fry restaurant, a discount broker, and a lab specializing in home-test kits have in common? They are examples of innovative services that base their success on customers' participation in the service delivery. Motivated by these practices we develop an analytical model to determine which parts of a service process should be performed by the service provider and which parts should be delegated to the customers.

■ TB21

342C

Supply Chain Risk and Disruptions

Invited: InvitedNatural Hazard Planning

Invited Session

Chair: Eghbal Rashidi, Clemson University, erashid@clemson.edu

1 - Supply Chain Risk Analysis using Dynamic Fault Tree
Xue Lei, Iowa State University, Ames, IA, 50011, United States, xlei@iastate.edu

Supply chain risk analysis can help supply chain managers assess the risk in their supply chain and identify mitigation strategies. This research applies dynamic fault trees to assess the risk in manufacturing supply chains. Dynamic fault trees were developed to measure the reliability of systems in which the timing of failure for different components impacts total system failure. Applying dynamic fault trees to quantify the risk in a supply chain allows us to analyze how the time at which a primary supplier fails impacts the ability of a backup supplier to meet the delivery schedule. A new dynamic gate is proposed to consider the situation in which a firm relies on two primary suppliers.

2 - Risk Mitigation Models for Low Volume High Value (LVHV) Supply Chains
Michael Daniel Sherwin, Mississippi State University, 1767 Independence Way, Valencia, PA, 16059, United States, mdsherwin@gmail.com, Hugh Medal

Firms that produce low volume high value (LVHV) goods are more susceptible in many ways to delays within their respective supply chains than higher volume, higher value manufacturers. Due to the scarcity of capable suppliers to produce large, complex, highly precise items combined with the cost to develop a new supplier, a large number of LVHV firms have many single or sole source suppliers within their supply chains. We define supplier unreliability as the probability that a given product or service is not delivered on-time and develop a multinomial logistic regression model based on the variables that affect the unreliability of a LVHV supplier.

3 - Simulating Severe Supply Chain Disruptions with Multiple Suppliers and Firms
Cameron MacKenzie, Iowa State University, 3029 Black Engineering, Industrial and Manufacturing Systems Eng, Ames, IA, 50011, United States, camacken@iastate.edu

This presentation discusses a model and simulation of a severe supply chain disruption in which several suppliers suffer from disabled production facilities and firms that purchase goods from those suppliers may suffer a supply shortage. The simulation is applied to a case inspired by the Japanese tsunami.

5 - A Multi Stage Stochastic Programming Model for Semiconductor Supply Chain Risk Management
Eghbal Rashidi, Clemson University, Clemson, SC, United States, erashid@clemson.edu

We propose a three-stage stochastic programming model for a multi-product semiconductor supply chain risk management problem with uncertainty in process yield and product demand. The production processes are considered to follow a push policy in the Front-End, and a pull policy in the Back-End; with the die bank being the decoupling point. Outsourcing of production and process is considered for each process step in this study, at fabrication, sort, assembly and test. Computational results on test case problems show that our proposed stochastic programming model produces solutions that are significantly better than those produced by a deterministic expected value approach.

4 - Effectiveness of Resilience Strategies Against Supply Chain Disruptions: An Empirical Study
Milad Baghersad, Virginia Polytechnic Institute and State, Pamplin Hall, Room 1007, Blacksburg, VA, 24061, United States, mbaghers@vt.edu, Christopher Zobel

In this study, we empirically evaluate the effectiveness of three specific resilience strategies- operational slack, business diversification, and geographical diversification- in reducing the negative impacts of supply chain disruptions on firms' financial performance. Borrowing from the systems resilience literature, we develop four complementary metrics to quantify the negative impacts of supply chain disruptions on firms' performance. By adopting a more comprehensive view of firms' performance, we are able to develop new and expanded inferences about the types of impacts that the different strategies have on firms' performance after supply chain disruptions.

■ TB22

342D

Multi-product Assortment, Pricing and Inventory Control

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Anran Li, Columbia University, New York, NY, United States, al2942@columbia.edu

1 - Complementarity Analysis for Optimal Multi Item Inventory and Partial Price Management
Sang Jo Kim, The Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong, sangjo@ust.hk, Youyi Feng, Jianjun Xu

We study a multi-product joint inventory replenishment and pricing problem, where some pairs of products are economic complements but other pairs are substitutes. The seller periodically replenishes the products and controls the selling price of one of them while the other prices are exogenously determined. We show that there always exists an economic relationship between products that the seller should reflect in the optimal operations, and moreover, such a relationship may not be identical to that from the customers' viewpoint. Further, the optimal decisions should follow a base-stock list-price policy in which there exist a set of ideal values of the inventory levels and the price.

2 - Dynamic Pricing under Consumer's Sequential Search
Sajjad Najafi, University of Michigan, Ann Arbor, MI, United States, snajafi@umich.edu, Sami Najafi Asadolahi, Chi-Guhn Lee, Steven Nahmias

We study a firm offering a line of perishable products with fixed initial inventory over a finite horizon. Consumers arrive randomly and inspect products sequentially until they find a product to purchase (if any). Each consumer incurs a positive cost to inspect a product and hence may stop the sequential search without inspecting all the available items. The firm aims at offering the best sequence of products, as well as the best price for each product at each time. We show that, under some circumstances, (i) it is optimal to present products in a descending order of quality; (ii) surprisingly, the optimal price can increase over time.

3 - Approximation Algorithms for Product Framing and Pricing
Anran Li, Columbia University, Mudd 345, Columbia University, New York, NY, 10027, United States, al2942@columbia.edu, Guillermo Gallego, Van-Anh Truong, Xinshang Wang

We propose one of the first models of "product framing" and pricing. Product framing refers to the way consumer choice is influenced by how the products are framed, or displayed. We present a model where a set of products are displayed into a set of virtual web pages. We assume that consumers consider only products in the top pages, with different consumers willing to see different numbers of pages. Consumers select a product, if any, from these pages following a general choice model. We show that the product framing problem is NP-hard. We derive algorithms with guaranteed performance relative to an optimal algorithm under reasonable assumptions. We also present structural results for the pricing problem under framing effects.

4 - Incentive Issues in the Implementation of Urban Consolidation Centers

Xin Fang, Singapore Management University, 50 Stamford Road, #05-01, Singapore, 178899, Singapore, xfang@smu.edu.sg, Yun Fong Lim

The growth of e-commerce worsens the traffic congestion in cities. An urban consolidation center (UCC) is a potential solution, but many UCC projects have failed due to the reluctance of carriers to cooperate. In this paper, we develop a game-theoretical model that captures carriers' incentives. We find that the price that carriers are willing to pay for UCC's service is too low for UCC to make a profit. We propose that UCC can work as information intermediary among carriers for capacity sharing. In this case, UCC can always make a profit from commissions, and carriers have stronger incentives to cooperate.

■ TB23

342E

Revenue Management in Fashion Retailing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Kris Johnson Ferreira, Harvard Business School, Boston, MA, 02163, United States, kferreira@hbs.edu

1 - Pass-through Constrained Vendor Funds for Promotion Planning

Lennart Baardman, Massachusetts Institute of Technology, Operations Research Center, 77 Mass Ave, Bldg E40-130, Cambridge, MA, 02139-4307, United States, baardman@mit.edu, Georgia Perakis, Kiran Venkata Panchamgam

Pass-through constrained vendor funds are trade deals in which suppliers offer discounts to retailers, encouraging them to promote their products, while demanding pass-through to the customers. First, we analyze the supplier's strategic model about what vendor fund to offer. We show that pass-through constrained vendor funds eliminate forward-buying behavior and coordinate supply chains. Additionally, we model the retailer's operational problem about which vendor funds to select. To solve this model we propose a fast Lagrangian relaxation approach with analytical performance guarantees.

2 - Using Clickstream Data to Improve Flash Sales Effectiveness

Victor Martinez de Albeniz, IESE Business School, Av Pearson 21, Barcelona, 08034, Spain, valbeniz@iese.edu, Arnau Planas, Stefano Nasini

Flash sales retailers organize online campaigns where products are sold for a short period of time at a deep discount. The demand in these events is very uncertain, but clickstream data provides very detailed information about the shopping process. We build a model for shoppers' sequential decisions about visiting a campaign, obtaining product information and placing a purchase, which we validate using a large data set from a leading flash sales firm. Our forecasting model allows flash sales retailers to learn about the performance of new products in a few hours. We use this information to update prices so as to better match supply and demand forecast, and increase profits, on average by 20%.

3 - Assortment Rotation and the Value of Concealment

Kris Johnson Ferreira, Harvard Business School, Morgan Hall 492, Boston, MA, 02163, United States, kferreira@hbs.edu

We study one reason why frequent assortment rotations can be valuable. Namely, by distributing its seasonal catalog of products over many assortments, the retailer conceals a portion of its product catalog from consumers, injecting uncertainty into the consumer's relative product valuations. Rationally acting consumers may respond to this uncertainty by purchasing more products, generating additional sales for the retailer. We refer to this phenomenon as the value of concealment. We develop a consumer choice model and stochastic dynamic program to study the value of concealment.

■ TB24

342F

Topics in Revenue Management & Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: N. Bora Keskin, Duke University, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu

1 - Strategic Experimentation on Networks

Ramandeep Randhawa, University of Southern California, Bri 401p, 3670 Trousdale Pkwy, Los Angeles, CA, 90089, United States, ramandeep.randhawa@marshall.usc.edu, Kimon Drakopoulos

We study a dynamic game with multiple agents who are working to discover the quality (type) of an unknown project. An example is multiple R&D teams experimenting with new technology. At any time, an agent must decide whether to exert costly effort to "experiment" with the unknown project, or to wait in hope to see the outcome from other agents. We study this game in a networked setting, in which agents only have access to information from their neighbors. We find that agents with access to more information free-ride in optimistic scenaria, but work more in pessimistic scenaria.

2 - Learning Customer Preferences through Crowdvoting

Yifan Feng, The University of Chicago, 5807 S.Woodlawn Avenue, Chicago, IL, 60637, United States, yfeng4@chicagobooth.edu, Rene A. Caldentey, Christopher T. Ryan

A firm is launching a new product with multiple potential designs. To pick the design most preferred by customers, the firm invites potential customers to vote for their favorite designs. We study how to dynamically customize each voter's choice set, in order to most efficiently learn overall customer preferences.

3 - Dynamic Pricing for Batch Jobs in the Cloud

Hossein Jahandideh, 3777 Mentone Avenue, Apt 405, Los Angeles, CA, 90034-6473, United States, hs.jahan@gmail.com

A growing model for selling cloud computing services is for the cloud provider to accept batch jobs such as machine learning, classification, large-scale optimization, etc. and commit to finishing the job by a certain deadline. The provider receives service requests and quotes a menu of prices for different completion times, based on the job type and resources required to fulfill the job. This amounts to a dynamic network revenue management problem, for which we propose a dynamic pricing mechanism and demonstrate its effectiveness.

4 - Discontinuous Demand Functions: Estimation and Pricing

N. Bora Keskin, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708-0120, United States, bora.keskin@duke.edu, Arnoud Victor den Boer

Motivated by online price-rankings that create discontinuities in demand functions, we consider a dynamic pricing-and-estimation problem with an unknown and discontinuous demand function. We show that ignoring such discontinuities results in substantial loss of revenues, and construct near-optimal policies that can handle demand discontinuities.

■ TB25

350A

Recent Development in Electricity Markets

Invited: Energy Systems Management

Invited Session

Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States, fqiu@anl.gov

1 - Development of MISO Market to Embrace Current and Future Challenges

Yonghong Chen, Midwest ISO, 720 City Center Drive, Carmel, IN, 46032, United States, ychen@misoenergy.org

This presentation will first give an overview of recent developments at MISO to improve market clearing and market pricing efficiency. It will then discuss new initiatives to embrace future challenges.

2 - Multi-market Settlements and Computational Efficiency in Power System Planning Studies

Clayton Barrows, NREL, Denver, CO, United States, Clayton.Barrows@nrel.gov

The pathway towards modernized grids will consider enhanced coordination between markets and interconnected systems. However, traditional models of power systems represent one of two extremes: centrally-planned and operated models of an entire interconnection, or mostly-isolated market footprint models with little trade between neighboring systems. Neither of these approaches accurately reflects present or future power system operations. This research develops techniques to simulate decentralized coordination of operations and trade between entities while enhancing the computational efficiency of power system planning studies.

3 - A Market for Transactive and Deliverable Flexibility Based on Uncertainty Marginal Price

Hongxing Ye, Cleveland State University, Cleveland, OH, United States, hye9@hawk.iit.edu

The demand of flexibility increases dramatically with rapid growth of variable energy resource. We propose a new concept of transactive flexibility that can be bought and sold at the uncertainty marginal price (UMP). The proposed model positions deliverable flexibility cost-effectively, and its cost is allocated to flexibility consumers respecting a cost-causation principle. With a proposed solution approach, it provides an option to address emerging questions: 1) how to determine the flexibility amount while keeping ISO independent; 2) how to allocate deliverable flexibility to demander cost-effectively; 3) how to handle the high flexibility demand when the flexible resource is scarce.

4 - An Aggragator Business Model for Distribution Level Electricity Market

Shmuel S. Oren, Professor, University of California at Berkeley, 57 Hill Rd, Berkeley, CA, 94720, United States, oren@ieor.berkeley.edu, Clay Campaigne

The Californa ISO has introduced a tariff that recognizes aggragators of distributed resources at the distribution level as wholesale market participants. In this talk I will describe an end to end business model in which aggragators bundle demand response at the distribution level with intermitten renewable energy resources so as to create a firm energy product that is offered into the wholesale market. We describe the contract structure and incentive mechanism offered to customers and the deployment and bidding strategy of the bundled wholesale product.

5 - Modeling of Operating Reserve Demand Curve in ERCOT Electricity Market

Hailong Hui, ERCOT, Taylor, TX, United States, hhui@ercot.com

ERCOT has implemented the Operating Reserve Demand Curve (ORDC) in its Real-Time market since June 1, 2014. The Real-Time prices determined by Security Constraint Economic Dispatch (SCED) would be increased by the Real-Time Reserve Price which is determined based on remaining reserves in the system and a predefined ORDC to reflect the incremental value of scarce operating reserves. This presentation will discuss the current implementation of ORDC and the impact since it went live. Future possible improvement for ORDC in ERCOT market will also be discussed.

■ TB26

350B

Clustering and Social Network Analysis

Sponsored: Telecommunications

Sponsored Session

Chair: Eli Olinick, Southern Methodist University, Dallas, TX, 75275-0123, United States, olinick@lyle.smu.edu

1 - The One Time Period Least Cost Influence Maximization Problem on Social Networks

Rui Zhang, University of Colorado, Boulder, CO, United States, Rui.Zhang@Colorado.edu, S. Raghavan

We consider an influence maximization problem where there is requirement that the diffusion of influence takes place within one time period, which is referred to as the one time period least cost influence problem (1TPLCIP). First, we propose a linear-time algorithm for the 1TPLCIP on trees. More importantly, we present a tight and compact extended formulation for the 1TPLCIP on trees. Then, we project the extended formulation onto the space of the original payment and node selection variables. Finally, we observe that the good formulation for trees is also a valid formulation on general graphs resulting in a stronger formulation for the 1TPLCIP on general graphs and discuss our experiment results.

2 - Finding the Hierarchy of Dense Subgraphs

Ahmet Sariyuce, Sandia National Laboratories, Livermore, CA, United States, asariyu@sandia.gov

Finding dense substructures in a network is a fundamental operation, with applications in social networks, visualization, and cyber-security, to name a few. Current dense subgraph finding algorithms usually optimize some objective, and only find a few such subgraphs without providing any structural relations or distribution over the graph. We define the nucleus decomposition of a graph, which represents the graph as a tree of subgraphs, called nuclei, where smaller cliques are present in many larger cliques. The tree of nuclei consistently gives a global, hierarchical snapshot of dense subgraphs which are higher quality than the state-of-the-art.

3 - Analysis and Comparison of Node Centrality Measures

Eli Olinick, Southern Methodist University, Dept Eng Mgmt Info and Systems, P.O. Box 750123, Dallas, TX, 75275-0123, United States, olinick@lyle.smu.edu

We propose a new clustering algorithm based on hierarchical maximum concurrent flow (HMCF) and its duality relation to the sequence of sparsest cuts, and discuss theoretical properties which make it more accurate and often more robust than many popular algorithms in the literature. We present a new measure of node centrality, determined from the HMCF, called flowthrough centrality, and empirical results comparing its improved stability relative to currently used centrality measurements employed in social network analysis when knowledge of the network topology is incomplete or in transition.

■ TB27

350C

Psychology Neural Cognitive Computing

Invited: Social Media Analytics

Invited Session

Chair: Jiayin Qi, Shanghai University of International Business and Economics, Room 338, Bocui building, 1900th Wenxiang Road, Songjiang District, Shanghai, China, Shanghai, 201620, China, qijiayin@139.com

1 - Braking and Snowballing: The Moderating Roles of Adaptive and Maladaptive Cognitive Emotion Regulation Strategies between Job Stressor and General Health

Charles Deng, PhD, Shanghai University of International Business and Economics, Shanghai, 201620, China, dengsc@live.com

The present study investigated the moderating role of cognitive emotion regulation strategies between job stressor and general health. With the survey data from 495 employees, we found that job stressor was significantly and negatively associated with general health in both males and females with demographics being controlled.

2 - Recognition, Retrieval and Content Analysis for Massive Speech Data

Ji Wu, PhD, Associate Professor, Tsinghua University, Beijing, 100084, China, wuji_ee@tsinghua.edu.cn, Xiangling Fu

In this talk, I will talk about a speech content analysis platform developed at the Multimedia Signal and Intelligence Information Processing Lab at Tsinghua University and iFlytek for call centers in China that integrates ASR, audio indexing and spoken language understanding techniques. Quality inspection of custom service can be automatically achieved through this platform and its analysis results will be of a great help to strategy design and initiative marketing. The platform has been widely used in call centers in twenty provinces in China.

3 - Experimental Techniques for a Novel Neural-network-like System for Image Classification

Lai Xue, Shanghai Xiayun Culture Communication Co., Ltd, Shanghai, China, sheley1998@gmail.com

Artificial neural networks are extremely robust in areas such as image classification and speech recognition due to the fact that they could be trained instead of having to be explicitly programmed. This research presents several experimental non-biologically-inspired techniques for a neural-network-like system. An open-source web based implementation of this system is constructed to evaluate the efficiency of these techniques, provide realtime visualizations, as well as provide an interface for user interaction in order to further experiment with the capability of said system.

4 - Diffusion of Collective Action through Social Media Networks

Rostyslav Korolov, Doctoral Student, Rensselaer Polytechnic Institute, Troy, NY, 12210, United States, korolr@rpi.edu, Molly Renaud, David Mendonca, William A. Wallace

Previous work has shown that social media communications can be used to predict collective responses to certain events in the real world. However, the actual processes that enable this prediction remain unexplained. Considering collective behavior as a diffusion process, we expect the dynamic structural properties of the social network to play a role in the diffusion of collective behavior. We explore the possibility of using structure and dynamics of networks found in social media to predict collective action and identify events that may trigger it.

■ TB28

350D

Algorithmic Game Theory and Data Science

Invited: Auctions

Invited Session

Chair: Vasilis Syrgkanis, Microsoft Research, Cambridge, MA, 02139, United States, vasy@microsoft.com

1 - Oracle-efficient Online Learning and Applications to Auction Design

Nika Haghtalab, Carnegie Mellon University, 5000 Forbes Avenue, CS Department, Pittsburgh, PA, 15213, United States, nhaghtal@cs.cmu.edu, Miroslav Dudik, Haipeng Luo, Robert Schapire, Vasilis Syrgkanis, Jennifer Wortman Vaughan

We consider the fundamental problem of no-regret learning from experts and its applications to auction design. We consider designing computationally efficient no-regret algorithms given access to an oracle that finds the historically best-performing expert. We apply these results to an online auction framework, where the seller's goal is to maximize its revenue by adaptively choosing the auction that is run on an online series of bid profiles. Our algorithms are general-purpose and, by design, can use little overhead to tap into existing tools that optimize auctions over historical data, thereby achieving online no-regret results without the need for building new specialized tools from scratch.

2 - Fairness Incentives for Myopic Agents

Jamie Morgenstern, University of Pennsylvania, Philadelphia, PA, United States, jamiemmt.cs@gmail.com

We consider schemes to incentivize myopic agents (such as Airbnb landlords, who may emphasize short-term profits and property safety) to treat arriving clients fairly, in order to prevent overall discrimination against individuals or groups. Our notion of fairness asks that more qualified individuals are never (probabilistically) preferred over less qualified ones [Joseph et al]. We investigate whether it is possible to design inexpensive (subsidy) or payment schemes for a principal to motivate myopic agents to play fairly in all or almost all rounds. We show both positive and negative results in the classic and linear bandit settings by upper and lower bounding the cost of fair subsidy schemes.

3 - Deep Learning for Predicting Human Strategic Behavior

James R. Wright, Microsoft Research, New York, NY, United States, jrwright@microsoft.com, Jason Hartford, Kevin Leyton-Brown

Predicting the behavior of humans in strategic settings is an important problem in many domains. Most existing work either assumes that participants are perfectly rational, or attempts to directly model each participant's cognitive processes based on insights from cognitive psychology and experimental economics. We present an alternative, a deep learning approach that automatically performs cognitive modeling without relying on such expert knowledge. We introduce a novel architecture that allows a single network to generalize across different input and output dimensions, and show that it significantly outperforms the previous state of the art, which relies on expert-constructed features.

■ TB29

350E

Artificial Intelligence for Social Media Applications

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Sagar Samtani, sagars@email.arizona.edu

1 - Aspect Extraction and Polarity Classification of Reviews Based on Deep Neural Network

Czang Yeob Kim, Korea University, Seoul, Korea, Republic of, czangyeob@korea.ac.kr, Pilsung Kang

Consumers buy products and leave opinions online. Companies need to analyze the voice of consumers online to understand the response of the market. Consumer reviews can be analyzed with sentimental analysis at the aspect-level to gain insights for new products by reflecting the consumer's response to current products' functionality. We propose a deep neural network-based aspect extraction and polarity classification model. The aspect extraction model identifies the product feature the review is referring to, whereas polarity classification determines the review is whether positive or negative to the identified feature. The proposed model is verified based on Amazon's review data.

2 - Semantics in Hacker Forums

Sandeep Suntwal, University of Arizona, Tucson, AZ, United States, sandeepsuntwal@email.arizona.edu

Cyberattacks are a high impact technological risk. Cyber threat intelligence (CTI) is the process of understanding the threats to an organization based on available data points focusing on understanding key threat actors and relevant threat vectors. In this talk, we discuss a framework to model online hacker forums into Heterogeneous Information Networks (HIN) and identify semantically similar hackers. Identifying similar hackers can aid in proactive CTI by providing actionable intelligence.

■ TB30

350F

Social Media Analytics I

Invited: Social Media Analytics

Invited Session

Chair: Shu He, University of Connecticut, Storrs, CT, 06268, United States, shuhe@utexas.edu

1 - Online to Offline: Impact of Social Advertising on Pro-social Behavior

Cenying Yang, ycy_tracy@utexas.edu, Shun-Yang Lee, Andrew B. Whinston

We attempt to link the social advertising to offline pro-social behavior. We launch advertising campaign on Facebook and test its effectiveness on actual pro-social behavior in real world. We run field experiments under the context of political voting, blood donation and HPV vaccine shot. Psychological mechanisms that could potentially drive people to behave pro-socially are explored.

2 - Unraveling the "Social" in Social Norms: the Conditioning Effect of User Connectivity

Che-Wei Liu, University of Maryland, Robert H. Smith School of Business,, College Park, MD, 20742, United States, cwliu@rhsmith.umd.edu, Guodong Gao, Ritu Agarwal

We studied the effect of social norms on users' goal setting and goal attainment behavior. We find that while social influence increases the rate of goal setting, strikingly, we also observe an undesirable effect in that such influence leads to lower rates of goal attainment. Our examination of heterogeneous treatment effects shows that individuals with higher levels of social connectivity are the most susceptible. Further analysis suggests that social norms motivate these runners with high social connectivity to set up a goal beyond their own capabilities, resulting in low goal attainment. Our findings have important implications for the design of interventions in mobile health technologies.

3 - Impacts of Online Diaries on Sales of Credence Goods: Evidence from a Cosmetic Surgery Platform

Hongfei Li, University of Connecticut, School of Business, 2100 Hillside Road, Storrs, CT, 06269, United States, hongfei.li@uconn.edu, Gang Wang, Jing Peng, Xue Bai

Credence goods are defined as products whose quality is difficult to evaluate. While online reviews have found to be effective in driving sales of search and experience goods, little is known about its effectiveness on credence goods. Using data from a cosmetic surgery platform, we investigate the impact of a novel form of online reviews, i.e. diaries, on the sales of credence goods. We also examine how the effects are moderated by the risk of surgeries. We focus on two diary features: number of images and post duration. We find the number of images has a positive impact on sales and the effects are stronger for more risky surgeries. These findings shed some light on the online marketing of credence goods.

■ TB31

351A

Financial Engineering

Contributed Session

Chair: Mingying Song, The University of Hong Kong, Hong Kong, mysong@hku.hk

1 - An Efficient Simulation Method for Normal Stochastic Volatility Model

Jaehyuk Choi, Peking University HSBC Business School, Shenzhen, China, jaehyuk@phbs.pku.edu.cn, Byoung Ki Seo

Normal, as opposed to lognormal, distribution is often suitable for modeling some financial observables which allow negative values. This study concerns a class of normal stochastic volatility model which includes the zero beta case of the popular Stochastic-Alpha-Beta-Rho (SABR) model. We provide an exact one-step simulation method and an efficient integration method for vanilla option pricing. A special case of the class admits a closed-form distribution, which can be used for modeling and simulating leptokurtic distributions.

2 - Structural Pricing of Cocos and Deposit Insurance with Regime Switching and Jumps

Olivier Le Courtois, Professor, EM Lyon Business School, Lyon, 69134, France, lecourtois@em-lyon.com, Xiaoshan Su, Xiaoshan Su

This article constructs a structural model with jumps and regime switching features that is specifically dedicated to the pricing of CoCos and deposit insurance. This model assumes that the assets of a bank evolve as a geometric regime switching double exponential jump diffusion and that debt profiles are of exponential type. The definition of an Esscher transform and the definition and implementation of a related matrix Wiener-Hopf factorization are developed. Then, valuation formulas for the bank equity, debt, deposits, CoCos and deposit insurance are obtained. An illustration concludes the paper and addresses the respective impacts of jumps and regime switching on the viability of a bank.

4 - A New Framework for Pairs Trading without Spread Functions

B. Ross Barmish, Professor, University of Wisconsin, 1415 Engineering Drive, ECE Department, Madison, WI, 53706, United States, barmish@engr.wisc.edu, Atul Deshpande

Pairs-trading methods in the literature largely rely on mean-reverting spread functions defined on the two stock prices under consideration. In this paper, we present a new framework for trading pairs which only requires a weak assumption involving correlation of the returns; i.e., no spread function is used. Within this idealized framework, our main result is a trading algorithm which is proven to guarantee a positive expected profit for the generic case when the expected returns are non-zero. Whereas traditional pairs trading relies on a widening spread function to obtain such a result, in our framework, we obtain such results for new situations.

5 - Investigate the Most Suitable Distance Measurement for Evaluation of Portfolio Composition

HeonBae Jeon, Yonsei University, Yonsei-ro 50, Bld#212, Seoul, 03722, Korea, Republic of, kimsm@yonsei.ac.kr, Hongseon Kim, Seongmoon Kim

This study suggests the portfolio composition evaluation in terms of the distance. Various vector distance measurements are compared to select a method to evaluate the portfolio composition. Through the regression analysis and the symmetry analysis of the distribution, we confirmed that Euclidean distance measurement is suitable to evaluate the portfolio composition. In addition, by comparing the portfolio performance, such as Sharpe ratio and return, with Euclidean distance, we checked the relationship between the portfolio performance and the composition. Therefore, we confirmed that Euclidean distance measurement can be used as a new analysis method for portfolio optimization models.

6 - Resilience Measurement of the Financial System Considering Recovery Solutions

Mingying Song, The University of Hong Kong, Haking Wong Room 824, Hong Kong, 999077, Hong Kong, mysong@hku.hk, Junwei Wang

Resilience is a property of the system, which focuses on the recovery ability of the system after a shock. Financial system plays a key role in our society. Therefore, resilience is especially important for the financial system. In this paper, we present a modified novel model for the risk contagion process of the financial system considering both network effects and market liquidity effects. In addition, we put forward several some recovery solutions. Based on these recovery solutions, we present a measure for resilience in the context of the financial system. A case study considering shocks of different levels is given to illustrate the whole risk contagion and resilience measurement process.

■ TB32

351B

Operations/Finance Interface

Contributed Session

Chair: Philippe Chevalier, UCL, Louvain La Neuve, Belgium, philippe.chevalier@uclouvain.be

1 - Welfare Implication of Reforming Energy Subsidies

Hossein Mirzapour, University of Montreal (HEC School of Business), 920-6275 Northcrest, Montreal, QC, H3S.2N3, Canada, hossein.mirzapour@hec.ca, Michèle Breton

Reforming energy consumption subsidies has been frequently referred to as a quick-win policy to enhance environmental mitigation. One of the most recognized challenges of such reform is "selling" the new energy prices to citizens, particularly those with a more fragile purchasing power. Several studies have prescribed that a direct compensation mechanism may ensure the feasibility of reform. That practice was successful at the beginning in cases like Iran but did not proceed as expected. In this paper, we develop a stylized model to study the feasibility range of a subsidy reform where direct compensation is the instrument proposed to restore consumers' utility against increased energy prices.

2 - Managing Product Innovation in Sourcing

Yunke Mai, Duke University, 4225 Larchmont Road, Durham, NC, 27707, United States, yunke.mai@duke.edu, Sasa Pekec, Bin Hu

We study strategic decisions of an innovator and a competitor-supplier in the presence of spillover risk. The value of innovation is uncertain, and depends on the market acceptance of new product features or the innovative concept. We characterize equilibrium decisions for both firms and show that the innovator's optimal sourcing decision involves making tradeoffs between managing innovation spillover risk and (not-) securing market leadership position. The exact nature of this tradeoff depends on the structure of uncertainty in the product value that the innovation brings.

3 - Pricing and Prioritization in a Duopoly with Self Selecting Heterogeneous Time Sensitive Customers

Arvind Sainathan, Nanyang Business School, S3-B2a-03, Nanyang Business School, 50 Nanyang Avenue, Ntu, Singapore, 639798, Singapore, Asainathan@ntu.edu.sg

Time is often used as a differentiating factor in several service operations contexts by service providers (SPs) who prioritize their customers. We investigate the competition between two SPs involving a three-stage game. In the first stage, the SPs decide whether single service, in which customers are not prioritized, or differentiated service, with two service classes, should be offered. In the second stage, they set their prices. In the third stage, customers self-select and decide which option they should purchase. We consider impatient and patient customers. We use a novel approach to model customer self-selection. We characterize key equilibria and derive insights on when they occur.

4 - Optimal Forecast Disclosure in Ride-sharing Platforms

Hao Sun, Tsinghua University, School of Economics and Management, Tsinghua, Beijing, China, sunh3.13@sem.tsinghua.edu.cn, Peng Shi

We study how much forecast information on future demand should a ride-sharing platform disclose to drivers. We show that there is an interplay between the wage structure and the optimal disclosure policy. We show that when the wage is fixed, or when it is optimized but does not depend on the forecast, there are cases in which the platform should hide the forecast; we solve for the optimal disclosure policy in this case. However, when the wage is optimized and can depend on the forecast, then the platform should share as much forecast information as possible. We support our analytical findings with numerical experiments.

5 - Enterprise Optimal Selling Strategy when Considering Product Quality and Response Time

Guoqing Gao, Student, HUST, Room 328, School of Management, HUST, Wuhan, 430074, China, 1414902387@qq.com

Researching on a company's selling strategy under different conditions. Establishing the revenue function based on customer utility, and solve the problem to get the optimal strategy. The result suggests that firms should increase the product price and product quality, or decrease the response time when the production cost raises, or price sensitivity declines.

6 - Joint Dynamic Pricing and Lot-sizing under Competition

Philippe Chevalier, Professor, UCL, Louvain School of Management - CORE, L1.03.01, Louvain La Neuve, B1348, Belgium, philippe.chevalier@uclouvain.be, Alejandro Lamas

We study the joint dynamic pricing and lot-sizing problem when firms operate in a competitive environment. The pricing strategies of the firms should reach a Nash equilibrium. In order to compute the equilibrium efficiently, we propose a framework to bound solutions a priori. For this we use the fact that, under some conditions, pricing and inventory planning remain stable to marginal variations in competitors' prices. Our approach reduces the computation times by more than an order of magnitude, and we show that dynamic pricing can give significant profit improvements.

■ TB33

351C

Aviation Forecasting

Sponsored: Aviation Applications

Sponsored Session

Chair: Reed Harder, Dartmouth, 14 Engineering Drive, Hanover, NH, 03755, United States, reed.haseltine.harder.TH@dartmouth.edu

1 - Airline Entry and Exit Predictive Modeling: A Structural Econometric Approach Versus Machine Learning

Chia-Mei (Mei) Liu, Federal Aviation Administration, Washington, DC, United States, Chia-Mei.Liu@faa.gov, Peng Wei, Xufang Zheng, Lei Kang

Airline passenger route choice forecast modeling has not been a widely explored area in the airline forecasting community even though it is studied quite often in the airline empirical papers. This paper takes the initiative to build a model to forecast passenger choice between direct and connecting flights. Individual itineraries from 2000 to 2016 are aggregated to the airport-pair level to form our target variable, the percent of passengers flying direct. We compare forecast performance between statistical modeling and machine learning. Our preliminary findings show great promise with machine leaning techniques.

2 - Predicting Performance of Traffic Management Initiatives

Alexander Estes, University of Maryland-College Park, College Park, MD, United States, aestes@math.umd.edu, Michael O. Ball, David J.Lovell

The Federal Aviation Administration uses traffic management initiatives to manage excess demand for resources in the national airspace system. We present methods for estimating the performance that a given traffic management initiative will produce under a given set of weather and traffic conditions. These methods combine a weighting scheme from Geographic Weighted Regression with forest-based regression methods. Estimates of the conditional density can be produced along with standard regression estimates.

3 - Airline Entry and Exiting Predictive Modeling: A Structural Econometric Approach

Kang Hua Cao, Hong Kong Baptist University, WLB 517, 34 Renfrew Road, Kowloon Tong, Hong Kong, kanghuacao@hkbu.edu.hk, Chia-Mei Liu, Vikrant Vaze

Airlines' decisions on entering or exiting a market are interrelated with other airlines' choices of entry and exit. Ignoring such strategic effects in forecasting can lead bias results. In this paper, we develop a discrete game and estimate the structural parameters of the payoff function. Thus, we recover valuable information about how airline makes entry/exit decisions and predict its future outcomes. We apply the structural econometric approach on a rich airline dataset, which features variables signaling the health of the economy such as employment and housing starts, network variables such as the connectivity at the airports, and competition variables such as Herfindahl-Hirschman Index.

4 - Combining Empirical and Game Theoretic Approaches to Airline Frequency Decision Modeling

Reed Harder, Dartmouth, 14 Engineering Drive, Hanover, NH, 03755, United States, reed.haseltine.harder.TH@dartmouth.edu, Vikrant Vaze

Forecasts of air traffic are leveraged by the Federal Aviation Administration in planning and policy making. In practice, airlines allocate capacity across their networks in the face of competition from other airlines on service frequency and price. We present approaches to combining empirical data on airline operations and game theoretic models of airline competition for the purpose of modeling and forecasting airline frequency decisions, and show the potential of behavioral models of airline decision making to augment air traffic forecasts.

■ TB34

351D

Military Decision Making Under Uncertainty

Sponsored: Military Applications

Sponsored Session

Chair: Brian J. Lunday, Air Force Institute of Technology, Air Force Institute of Technology, WPAFB, OH, 45433, United States, brian.lunday@afit.edu

1 - A Military Variant of the Stochastic Inventory Routing Problem

Ethan Salgado, Air Force Institute of Technology, Dayton, OH, United States, ethan.salgado@afit.edu, Matthew J.D. Robbins, Darryl Ahner

Military commanders resupply forward operating bases from a central location within the area of operations mainly via convoys. Commanders must decide when and how much inventory to distribute throughout the area of operations while minimizing soldier risk; we call this problem class the military inventory routing problem (MILIRP). We examine the unique structure of the MILIRP by considering a small problem instance and prove that the optimal policy is monotone when a sufficient penalty is applied. Moreover we show how the unique structure can be exploited by utilizing monotone approximate dynamic programming algorithms.

2 - Analysis of Personnel Policy via Discrete Event Simulation

Lee Evans, University of Louisville, lee.evans@louisville.edu

An effective performance appraisal system is critical in identifying officers with the knowledge, skills, and abilities to lead the future force. This study uses discrete event simulation to analyze the effect of system structure, system dynamics, and human behavior on the performance of the United States Army's officer evaluation system. We demonstrate the efficacy of simulation optimization throughout the model development process, from model validation to model implementation.

3 - Using Markov Decision Processes with Heterogeneous Queueing Systems to Examine Military MEDEVAC Dispatching Policies

Phillip R.Jenkins, Air Force Institute of Technology, WPAFB, OH, 45433, United States, phillip.jenkins@afit.edu, Matthew J.D. Robbins, Brian J. Lunday

The goal of this research is to identify how to dispatch military medical evacuation (MEDEVAC) units to optimize system performance. A Markov decision process (MDP) model is developed to examine the MEDEVAC dispatching problem. A notional planning scenario is utilized to investigate differences between the optimal policy and three practitioner-friendly policies. Results indicate that dispatching the closest available unit is not always optimal. Moreover, an analysis of solution approaches for the MEDEVAC dispatching problem reveals that the policy iteration algorithm substantially outperforms the linear programming algorithms executed by CPLEX 12.6 in regards to computational effort.

■ TB35

351E

Supply Chain Management, Green

Contributed Session

Chair: Samar K Mukhopadhyay, GSB SKK University, 53 Myeongnyung-dong 3-ga, Jongno-gu, Seoul, 110-745, Korezca, Republic of, samar@skku.edu

1 - Severity Assessment of Food Security Impediments in Food Supply Chain

Rachita Gupta, Research Scholar, Indian Institute of Technology Delhi, New Delhi, 110016, India, rachitagupta1987@gmail.com, Ravi Shankar

One of the major challenges worldwide is food security. The study proposes integrated Evidential Reasoning Algorithm to prioritize various food security impediments during logistics and distribution phases of Food Supply Chain. This would enable regulatory authorities to identify the most severe impediment and ensure affordable food security to the masses.

3 - Selection of Online Pickup Facility Networks using Fuzzy AHP

Choonki Min, YonginSongdam College, Yoingin, Korea, zcRepublic of, ckmin@ysc.ac.kr, Byeong-Yun Chang

Online pickup has become one of the most popular omnichannel services. In this study, we categorized the types of online pickup service facilities and analyzed the characteristics of each facility type. Using the fuzzy AHP method, the relative importance of online pickup service selection factors for each type of facility was derived from related experts.

4 - Managing Used Products: Who Should Refurbish?

Narendra Singh, Indian School of Business, Knowledge City, Sector 81, SAS.Nagar, Mohali, 140 306, India, narendra_singh@isb.edu, Ahmed Timoumi

We study a supply chain where a manufacturer sells new products through a retailer and decides whether to refurbish used products itself or to let the retailer refurbish them. We examine whether and when should a manufacturer allow the retailer to refurbish the used products.

5 - Brand Selection in a Supply Chain with Customer Returns

Jing Chen, Professor, Dalhousie University, 6100 University Avenue, Halifax, NS, B3 H.4R2, Canada, JChen@dal.ca, Bintong Chen

A retailer can sell a retailer can sell either or both of two brands, a well-known brand and a new brand, in a market supplied by two manufacturers in a manufacturer Stackelberg supply chain. We identify the conditions under which the retailer should choose one or both of the two manufacturers. We also show that an MBG enhances the profit of the manufacturer with low satisfaction rate, resulting in an increase in both the wholesale price and demand, but it has an opposite impact on the manufacturer with high satisfaction rate. In addition, an MBG enhances the retailer's profit and expands the overall market.

6 - Effect of CSR on Product Differentiation in the Presence of Cost Advantage

Samar K. Mukhopadhyay, Professor, University of Wisconsin-Milwaukee, 3200 N.Maryland Ave., Milwaukee, WI, 53211, United States, samar@uwm.edu, Guangliang Ye, Lu Xu

This paper links a firm's CSR strategy with its product differentiation strategy when it competes within another firm in a Hotelling type product differentiation line. The CSR firm maximizes a convex combination of its profit and a form of utility function, while the non-CSR firm maximizes its profit only. The CSR firm is also assumed to have a technological advantage that reduces its production cost. The interaction of the effects of both the extent of CSR is considered along with a scenario of asymmetric information. Our main results show that the degree of product differentiation is reduced when CSR is practiced. On the other hand, product differentiation increases with production cost advantage.

■ TB36

351F

Diversification

Invited: INFORMS Special Sessions

Invited Session

Chair: Michael P Johnson, University of Massachusetts-Boston, Department of Public Policy & Public Aff, 100 Morrissey Boulevard, Boston, MA, 02125-3393, United States, michael.johnson@umb.edu

Co-Chair: Ruben Proano, Rochester Institute of Technology, Gleason College of Engineering, 81 Lomb Memorial Drive, Rochester, NY, 14623, United States, rpmeie@rit.edu

1 - Strengthening the Profession Through Diversity, Inclusion and Equity: Best Practices and Distinguished Practitioners

Michael P.Johnson, University of Massachusetts-Boston, Department of Public Policy & Public Aff, 100 Morrissey Boulevard, Boston, MA, 02125-3393, United States, michael.johnson@umb.edu

This session will introduce INFORMS conference participants to the mission and goals of the diversity, inclusion and equity committee. Panelists will describe the state of diversity and inclusion at INFORMS and other professional societies; at organizations whose employees and members participate in INFORMS and other professional societies; and the community of practice associated with operations research, management science and analytics, other STEM fields and related disciplines. Speakers and audience members will explore values, strategies and tactics that may enable INFORMS members of diverse backgrounds and experiences to achieve professional success, and that may enable organizations to produce greater social impact through best practices in diversity and inclusion.

2 - Panelist

Ruben Proano, Rochester Institute of Technology, Gleason College of Engineering, 81 Lomb Memorial Drive, Rochester, NY, 14623, United States, rpmeie@rit.edu

3 - Panelist

Deborah H. Urbanski, Director, Office of Equal Opportunity & Diversity, Nasa Johnson Space Center, Houston, TX, United States, deborah.h.urbanksi@nasa.gov

4 - Panelist

Jeffrey Lowe, Co-Chair, Planners of Color Interest Group of the, Texas Southern University, Houston, TX, United States, lowejs@tsu.edu

■ TB37

352B

Service Science Analytics Competition Award

Sponsored: Service Science

Sponsored Session

Chair: Robin Qiu, Pennsylvania State University, 30 E. Swedesford Road, Malvern, PA, 19355, United States, robinqiu@psu.edu

■ TB38

352C

MCDM Challenges in Highly-Constrained Problems

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Stephen Henry, Sandia National Labs, Albuquerque, NM, 87109, United States, smhenry@sandia.gov

1 - Increasing Stakeholder Confidence in Multi-criteria Decision Analysis

Lucas Waddell, Sandia National Laboratories, 6401 Santa Monica Avenue NE, Apt 2085, Albuquerque, NM, 87109-4166, United States, lucas.waddell44@gmail.com

Optimization techniques are increasingly being used to inform high-consequence, national-scale decision making. These problems are typically multi-objective, nonlinear, and highly constrained, necessitating heuristic solution methods. Lack of optimality conditions, simplifying modeling assumptions, and imperfect data often leave stakeholders asking the gut-wrenching question, "How can I be confident that the analysis is leading to well-informed decisions?" This talk will explore practical ways that we have increased analyst and customer confidence in our modeling and optimization techniques.

2 - Addressing Inconsistent Trade-Space Exploration in Constrained Genetic Algorithms

Marissa Ballantine, Sandia National Labs, Albuquerque, NM, United States, mdballa@sandia.gov

The Whole System Trades Analysis Tool (WSTAT) employs a multi-objective genetic algorithm to identify Pareto optimal system designs that also adhere to the physical and operational constraints of the system. Systems with complex constraints can yield solutions that fall into one of several "system architectures" (defined by the manner the constraints are satisfied). Unfortunately, genetic operators can have difficulty jumping from one architecture to another, resulting in solution sets that are inconsistent from run to run. The talk presents research for automatically identifying multiple system architectures and ensuring the genetic algorithm represents each one fairly and consistently.

3 - Integrating System Design and Portfolio Optimization: A Computational Study

Matthew Hoffman, Sandia National Laboratories, 1624 Singletary Dr. NE, Albuquerque, NM, 87112, United States, mjhoffm@sandia.gov, Stephen Henry, Lucas Waddell, Frank Muldoon

Optimal system design should consider the portfolio into which the system will be integrated, but representing portfolio constraints in a multi-objective metaheuristic is typically intractable. We will review previous work that described a method for incorporating multiobjective system design tradeoff information into a mixed-integer portfolio optimization, using a convex hull representation of the system design Pareto set. We will discuss refinements to the method and provide computational results comparing this method versus a typical approach of including all system design Pareto solutions in the portfolio optimization and limiting to a choice of one design via SOS1 constraints.

4- Multi-objective Optimization for Task Mode Selection and Scheduling Utilizing a Genetic Algorithm

Alexander Dessanti, Sandia National Laboratories, P.O. Box 5800, MS.1188, Albuquerque, NM, 87185-1188, United States, adessan@sandia.gov

Schedule Management Optimization (SMO) is a new analytic capability that utilizes a multi-objective genetic algorithm to identify optimal combinations of activities to complete a set of tasks for a project as well as the optimal schedule for each set of selected activities. SMO is flexible and can account for various constraints such as precedence relationships between activities, resource availability, and fixed dates for certain activities. Focus will be on introducing the SMO capability, pros and cons of using a genetic algorithm for this type of problem, and how constraints are handled.

■ TB39

352D

Collaborations in OR Practice

Sponsored: The INFORMS Section on Practice

Sponsored Session

Chair: Michael F. Gorman, University of Dayton, Dayton, OH, 45469, United States, michael.gorman@udayton.edu

1 - Collaborations in OR Practice

Michael F.Gorman, University of Dayton, 300 College Park, Dayton, OH, 45469, United States, michael.gorman@udayton.edu

Practitioners and academics share their best-practices and their mistakes in collaboration between academia and the private sector. The audience should expect to find out how to best structure such relationships. This Session has an open question and answer format.

2 - Panelist

Jeffrey D.Camm, Wake Forest University, School of Business, PO.7897, Winston-Salem, NC, 27109, United States, cammjd@wfu.edu

3 - Panelist

Glenn Wegryn, Executive Director, Center for Business Analytics, University of Cincinnati, Cincinnati, OH, United States, wegryngn@ucmail.uc.edu

4 - Panelist

Pooja Dewan, BNSF Railway, 2650 Lou Menk Drive, #2, Fort Worth, TX, 76131, United States, pooja.dewan@bnsf.com

5 - Panelist

Michael Rappa, North Carolina State University, Raleigh, NC, 27606, United States, mrappa@ncsu.ed

■ TB41

352F

Health Care, Modeling and Optimization

Contributed Session

Chair: Haolin Feng, Sun Yat-sen University, Guangzhou, China, FengHaoL@mail.sysu.edu.cn

1 - Robust Nurse Scheduling

Kjartan Kastet Klyve, PhD Student, Norwegian University of Science and Technology, Prinsens gate 61, Trondheim, 7011, Norway, kjartan.klyve@ntnu.no, Henrik Andersson, Marielle Christiansen, Anders Nordby Gullhav

We present a tactical staff-scheduling problem at the neonatal intensive care unit at a Norwegian hospital, with a planning horizon of 6 months. We expand the scope of the typical tactical scheduling problem by formulating a scheduling model that produces schedules that are robust, i.e. well prepared for operational disruption. A simulation model, simulating staff absence and requirement at the ward, is also developed. We can thus test different strategies for robust scheduling in the scheduling model and evaluate the robustness of them using extensive historical data and the simulation model.

2 - Optimal Elective Surgery Scheduling Subject to Disruptions of Emergent Cases

Xiaoqiang Cai, Chinese University of Hong Kong, Dept of Systems Eng & Eng Management, Shatin NT, Hong Kong, xqcai@se.cuhk.edu.hk, Xianyi Wu, Xian Zhou

We consider the scheduling of elective surgeries in an operation theater that has to treat emergent patients with priority when they arrive (randomly). The problem is to find the optimal policy to determine the sequence of all operations in waiting. Optimal policies are derived based on the theory and techniques of stochastic scheduling and open bandit processes.

3 - Nursing Skill-mix Optimization in Inpatient Care Units using a Queueing Theory Approach

Parisa Eimanzadeh, Wichita State University, 1845 N.Fairmount,, Wichita, KS, 67260-0035, United States, p.eimanzadeh@gmail.com, Ehsan Salari

Hospitals often use nursing staff with different skill levels in inpatient units for cost-saving purposes. Highly trained nurses can perform all types of tasks while lower-skilled staff can only perform limited tasks. Additionally, the care intensity for each patient involves uncertainty and varies depending on their acuity. This research aims at finding optimal skill-mix configurations that minimize staffing costs while ensuring timely delivery of nursing care. A finite-source queueing model with multiple patient classes and server types is developed to analyze the nursing care delivery.

4 - Float Nursing Strategy: An Alternative Short Term Strategy in Hospitals to Minimize Nurse Shortage and Decrease Total Labor Cost

Kamil Ciftci, PhD Candidate, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, 18015, United States, kac208@lehigh.edu

Float nursing strategy has been discussed in literature to reduce labor cost and provide more scheduling flexibility. However, float nursing strategy may decrease service quality because of changing work environment and location and no direct responsibility to assigned department. In this study, we investigate the effects of float nursing strategy using different regular nurse levels. While we find optimal number of nurses need to be hired as a float nurses, we determine how much more than based salary health Network should offer to them in order to decrease total labor cost. A case study with real data from a local hospital is used to prove efficiency of proposed approach.

5 - Adaptive Appointment Scheduling for Patient Centered Medical Homes

Ali Kemal Dogru, University of Alabama, Box 870226, Tuscaloosa, AL, 35487, United States, akdogru@crimson.ua.edu, Sharif Melouk

Incorporating patient centered medical home (PCMH) principles, we develop an adaptive appointment scheduling model for a primary care setting. We propose a simulation optimization approach to sequentially schedule appointments to provide desirable schedules from the perspective of both patients and the medical practice. Our data-driven algorithm is efficient and takes patient preferences into account. We benchmark against myopic and optimal algorithms. Computational results show that the adaptive scheduling approach provides significant value.
Key Words: Appointment Scheduling, Simulation, Patient Centered Medical Home

6 - Sequential Clinical Scheduling with Patient Re-entrant and No-show: the Case with MOHS Micrographic Surgery for Skin Cancer

Haolin Feng, Sun Yat-sen University, Lingnan College, Guangzhou, 510275, China, FengHaoL@mail.sysu.edu.cn, Mark Alan Lawley, Stephen Steidle

Mohs Micrographic Surgery (MMS) is a surgical method for the excision of skin cancers. It repetitively removes one skin layer at a time, with each removed layer sent for pathology examination until a cancer free layer is found. This results in same-day patient re-entrants. Currently patients often experience long in-clinic waiting due to the stochastic nature of layer removals and pathology. To improve patient experience and clinic revenues, we develop a model for MMS clinic scheduling. The model captures the key characteristics of the surgery-pathology and stochastic re-entrants. Theoretical results and numerical study demonstrating the improvement are provided.

■ TB42

360A

Precision Manufacturing

Invited: Invited OR and Advanced Manufacturing

Invited Session

Chair: Prahalad Rao, University of Nebraska-Lincoln, University of Nebraska-Lincoln, Liconoln, NE, 68506, United States, prahalad.k.rao@gmail.com

1 - Quantifying Geometric Accuracy with Unsupervised Machine Learning: using Self-Organizing Map on Fused Filament Fabrication Additive Manufacturing Parts

Mojtaba Khanzadeh, Mississippi State University, Industrial and Systems Engineering Department, P.O. Box 9542, Mississippi State University, MS, 39762, United States, mk1349@msstate.edu, Linkan Bian

Complex geometries are attainable with additive manufacturing (AM), a major barrier preventing its use in mission-critical applications is the lack of geometric accuracy of AM parts. The objective of this work is to quantify the geometric deviations of additively manufactured parts from a large data set of laser-scanned coordinates using an unsupervised machine learning approach called the self-organizing map. The outcomes of this research are: (1) visualizing and quantifying the link between process conditions and geometric accuracy in FFF; and (2) significantly reducing the amount of point cloud data required for characterizing of geometric accuracy.

2 - Data Analytics and Optimization for Efficient E-warehousing
Ugur Yildiz, University of Waterloo, Waterloo, ON, Canada, uyildiz@uwaterloo.ca, Fatma Gzara, Samir Elhedhli

We analyze data from an e-commerce warehouse, characterized by high product variety and small order sizes, to model the order fulfillment process and identify areas of improvement. We focus on the order consolidation process and pose a problem that we call the Wave Sorting Problem. We provide models and solution methodologies based on column generation where the subproblem is solved using dynamic programming.

3 - A Novel, Dynamic Sparse Classification Approach for Online Monitoring of the Functional Properties of Printed Electronics in Aerosol Jet Printing Process
Roozbeh Salary, Ph.D. Candidate and Graduate Research Assistant, State University of New York (SUNY) at Binghamton, 25 Tracy Street, Binghamton, NY, 13905-1841, United States, rsalary1@binghamton.edu, Jack P. Lombardi, Mohammad Samie Tootooni, Darshana L. Weerawarne, Prahalad K. Rao, Mark D. Poliks

The goal of this work is online monitoring (and ultimately, closed-loop control) of the functional properties of aerosol jet-printed electronic devices. In pursuit of this goal, the objective is to develop a multiple-input, single-output (MISO) machine learning model to predict the device functional properties in a real-time fashion as a function of process parameters as well as 2D/3D morphology characteristics. The aim is to use the MISO model for in situ classification and thus, monitoring of line/device resistance in aerosol jet printing (AJP) process. The core hypothesis of the work is that line resistance is predicted (and as a result, monitored) online within 10% of offline measurements.

■ TB43

360B

Matching in Two-Sided Markets with Social Impact

Sponsored: Public Sector OR

Sponsored Session

Chair: Ozlem Ergun, Northeastern University, Boston, MA, 02115, United States, o.ergun@neu.edu

Co-Chair: Tina Rezvanian, Northeastern University, Boston, MA, 02115-4420, United States, rezvanian.t@husky.neu.edu

1 - KUDU: A Mobile Market for Agricultural Trade in Uganda
Neil Newman, University of British Columbia, Vancouver, BC, Canada, newmanne@cs.ubc.ca, Nicole Immorlica, Kevin Leyton-Brown, Brendan Lucier, Richard Ssekibuule, John Quinn

In developing countries such as Uganda, agricultural markets exhibit inefficiencies as rural farmers have poor access to pricing information. Kudu is a two sided market for agricultural produce in Uganda seeking to address this problem using AI. Farmers and traders each submit bids to a centralized system using SMS and USSD (technologies available on non-internet-enabled phones) and a matching algorithm periodically proposes trades. This talk will discuss the challenges we have faced designing a market in this unique setting over the past four seasons of operation.

2 - Effect of Selfish Choices in Deferred Acceptance with Short Lists
Hedyeh Beyhaghi, Cornell University, Ithaca, NY, United States, hedyeh@cs.cornell.edu, Daniela Saban, Eva Tardos

We study the outcome of deferred acceptance when prospective medical residents can only apply to a limited set of hospitals. This limitation requires residents to make a strategic choice about the quality of hospitals they apply to. We study the effect of this strategic choice on the preferences submitted by participants, as well as overall welfare. We find that residents' choices in our model mimic the behavior observed in real systems where individuals apply to a mix of positions consisting mostly of places where they are reasonably likely to get accepted, as well as a few "reach" applications to hospitals of very high quality, and a few "safe" applications to hospitals of lower than their expected level.

3 - Optimal Trading and Shipping of Agricultural Commodities
Nicolas Stier-Moses, Universidad Torcuato Di Tella, Buenos Aires, Argentina, nstier@utdt.edu, Nicolas Merener, Ramiro Moyano, Pablo Watfi

We develop a model for a profit-maximizing firm that provides an intermediation service between commodity producers and end-users. We are motivated by the grain intermediation business at Los Grobo, one of the largest commodity-trading firms in South America. Producers and end-users are distributed over a realistic spatial network, and trade with the firm through contracts for delivery of grain during the marketing season. Under realistic capacities, network structure and shipping costs, we identify the optimal trading, storing and shipping policy for the firm as the solution of a minimum cost flow problem in a time-expanded network that captures both geography and time.

4 - Two-sided Stable Matching with Negotiations in Markets with Multiple Periods
Tina Rezvanian, PhD, Northeastern University, Boston, MA, 02115, United States, rezvanian.t@husky.neu.edu, Ozlem Ergun

It is a well-known fact that the core of match stays the same under any stable algorithms. Stable algorithms in multi-period two-sided markets come at the cost of continuous dissatisfaction for same group of agents, resulting in high turn overs, low overall welfare and ultimately, unsustainability over multiple periods. Many industries demand mechanisms that guarantee sustainability and perfect assignments over all periods. We use labor marker auction models to offer contract-like negotiations to agents, identified through a novel centrality measure that we introduce for two-sided markets. Proposed heuristic relaxes stability only to guarantee sustainability over multiple periods.

■ TB44

360C

Marketing

Contributed Session

Chair: Efstratios Pistikopoulos, Texas A&M University, College Station, TX, United States, stratos@tamu.edu

1 - A Method of Exploration of the Solution Space for Decision Support in Design of a Green Supply Chain
Lin Guo, University of Oklahoma, Norman, OK, United States, lin.guo@ou.edu, Warren Smith, Janet Katherine Allen, Farrokh Mistree

Multi-objective optimization models have been proposed to improve supply chain design, considering social and environmental goals as well as financial goals. However, optimization models search for single optimal solution that is sensitive to variations. In this paper, we propose a multi-goal model built on the construct of compromise Decision Support Problems (cDSP) to output solution space that is relatively insensitive to variations. A method of exploration of the solution space is used to provide us the insight on how to improve the feasibility robustness of the supply chain with multiple conflict goals.

2 - Modoalgos.jl: Computing Approximate and Exact Efficient Frontiers of Multiobjective Mixed Integer Linear Programs in Julia
Aritra Pal, Doctoral Candidate, University of South Florida, 4202 E. Fowler Avenue, Tampa, FL, 33620, United States, aritra1@mail.usf.edu

We introduce Modoalgos.jl (and 2 other related packages), a Julia package capable of computing the exact and approximate frontiers of both Biobjective and Multiobjective Mixed Integer Linear Programs using state of the art algorithms.

3 - B-pop: A Multi-parametric Programming Based Toolbox for the Global Solution of Bi-level Mixed-integer Linear and Quadratic Programming
Efstratios N. Pistikopoulos, Texas A&M.University, College Station, TX, United States, stratos@tamu.edu
Efstratios N. Pistikopoulos, Texas A&M.Energy Institute, College Station, TX, United States, stratos@tamu.edu, Styliani Avraamidou, Styliani Avraamidou, Nikolaos A. Diangelakis

We present a prototype toolbox, B-POP, a MATLAB toolbox for bi-level programming, for the exact, global and parametric solution of different classes of bi-level programming problems. The toolbox features i) bi-level programming solvers for linear and quadratic programming problems and their mixed-integer counter-parts, ii) a versatile problem generator capable of creating random bi-level problems of arbitrary size, and iii) a library of bi-level programming test problems. The toolbox is based on multi-parametric theory and our developed algorithms and software tools. A set of test problems was solved illustrating the computational performance and scalability of the toolbox.

■ TB45

360D

Revenue Management, Pricing

Contributed Session

Chair: Alejandro Lamas, NEOMA Business School, Rouen, France, alejandro.lamas@neoma-bs.fr

1 - Spatial Distribution of Surge Prices under Incentive Compatible Driver Assignment

Shuangyu Wang, Columbia University, Rm 323 SW. Mudd Building, 500W. 120th Street, New York, NY, 10027, United States, sw2756@columbia.edu, Garud N.Iyengar, Vineet Goyal

In our work, we propose a fluid model for computing the optimal spatial distribution of surge prices on ride-sharing platforms in the presence of temporal demand shocks, to manage the mismatch in supply and demand of rides. The goal of surge is to maximize total revenue or throughput over the traffic network and the platform can assign drivers to riders but is constrained to respect driver incentives with respect to assignment deviations. Our main contribution is to show the structural properties of optimal surge prices with an efficient computation of surge prices.

2 - Dynamic Pricing when Customers Learn the Quality of the Product

Ruizhi Shi, University of Minnesota, 2600 University Avenue SE, Apt 413, Minneapolis, MN, 55414, United States, shixx588@umn.edu

In this talk, we consider a revenue management problem when customers give review ratings of the products and take that into account when making purchase decisions. In particular, we consider a seller selling a single product to a sequence of customers. Customers' utilities are based on both the price and other customers' rating. Each time, one customer comes and gives a rating which is drawn from a certain distribution, and the rating of the product will be updated after each customer's purchase. We derive optimal policy on how the seller should change its prices during the time horizon to maximize his revenue. We also derive lower bounds on the best performance of any policy.

3 - Competitive Revenue Management with Sequential Bargaining

Yuanchen Li, Purdue University, 2192 Tortuga Lane, West Lafayette, IN, 47906, United States, li1820@purdue.edu, Qi Feng, J. George Shanthikumar

We study the role of bargaining in competitive revenue management. The seller firms each have some fixed initial stocks and compete to sell to a random arrive stream of potential buyers who are heterogeneous in product valuation. We fully characterize the equilibrium outcome, which depends on the length of the selling season and the initial stock levels. When the selling season is up to three periods, the seller with a lower stock level is weakly preferred by an incoming buyer. When the selling season is longer than three periods, the seller with a higher stock level may win the competition.

4 - Dynamic Pricing for Multi-period Home Delivery

Alejandro Lamas, Assistant Professor, NEOMA Business School, Rouen, 76130, France, alejandro.lamas@neoma-bs.fr

We consider a firm that delivers goods (or provides service) to a set customers. When a customer requests a delivery, the firm charges a price based on the geographical location, the available capacity and the lead-time of the delivery. Since customers and firms agree on the lead-time of the delivery, the problem for the firm consists of setting prices for deliveries in a rolling-horizon. The problem suffers from the "curse of dimensionality", thus we propose heuristic approaches for obtaining efficient solutions.

5 - Optimal Pricing for Selling to a Static Multi-period Newsvendor

Xiao Alison Chen, University of Minnesota, 111 Church Street SE, ME 1101, Minneapolis, MN, 55455, United States, chen2847@umn.edu, Zizhuo Wang, Hongsong Yuan

This paper considers a multi-period supply chain model in which a supplier sells to a multi-period newsvendor. Such a problem is relevant in industries with long production lead times. We study the optimal pricing problem for the supplier. We derive procedures for solving the optimal prices and show that the optimal pricing sequence is decreasing in time. We also show that the optimal prices are increasing in the backorder cost when the cumulative demand functions have increasing generalized failure rates.

6 - Airline Switching Revenue with Price-guarantees

Fouad H. Mirzaei, Santa Clara University, Unit 3, 559 Alviso St, Santa Clara, CA, 95050, United States, fhmirzaei@scu.edu

Many airlines permit passengers to change the time of their flight by paying a switching fee. In this study, we model a firm which delivers two sequential homogeneous services and generates ancillary revenue from customers switching between two services. Without imposing any distributional assumptions, we analyze the firm's revenue function and derive the optimal switching fee. We also investigate the impact of the uncertainty in switching behavior of customers on the ideal switching policy.

■ TB46

360E

Scheduling in Project Environment

Invited: Project Management and Scheduling

Invited Session

1 - Resource-Constrained Dynamic Programming with"Hot-Starting" for the Elementary Shortest Path Problem

Luis Novoa de Oro, The George Washington University, Washington, DC, United States, ljnovoa@gwu.edu, Ahmad I. Jarrah, Jonathan F. Bard, Daniel Chudnov

New hot-starting procedures to significantly improve the efficiency of a dynamic program (DP) for solving the Resource Constrained Elementary Shortest Path Problem are implemented and tested. The DP is integrated with bidirectional extensions, decremental state-space relaxation, 2-cycle elimination and a sharpest-to-date restricted set of unreachable nodes.

2 - Scheduling Public Requests for Proposals

Janne Kettunen, The George Washington University, Department of Decision Sciences, 2201 G.Street NW, Washington, DC, 20052, United States, jkettune@gwu.edu, Young Hoon Kwak

We show that the schedule for contracting public procurements can impact the number of proposals and thereby the cost of procured services or products. We formalize this previously unexplored problem of scheduling procurement contracting and develop an optimization framework to solve it. Furthermore, we develop heuristics that do not require solving optimization problems, such as (i) equal number with mixed cost scheduling heuristic and (ii) equal cost scheduling heuristic. We apply our optimization framework to the Florida Department of Transportation's procurement contracts scheduling problems and show that it yield significant cost savings over the actual schedules employed in practice.

3 - Establishing Actionable Visibility in Project Scheduling under Optimism, Heuristics, and Algorithmic Biases

Byung-Cheol Kim, Penn State, Erie, PA, United States, buk70@psu.edu

Establishing an actionable visibility into the future in terms of effective scheduling is a crucial challenge for successful management of a project. This session presents analytical approaches to establish the actionable visibility required for the project manager to make informed decisions under optimism, heuristics, and algorithmic biases. The presentation starts with illustrative examples of the situations where the project visibility is less actionable with incomplete and often biased information. Then a set of analysis tools is formulated based on best practices and proven techniques in project scheduling, risk analysis, and systematic error controls.

■ TB47

360F

Economics of Online Platforms

Sponsored: EBusiness

Sponsored Session

Chair: Hossein Ghasemkhani, Purdue University, 425 W State Street, West Lafayette, IN, 47907, United States, hossein@purdue.edu

1 - The Advertising Big Picture: Analyzing the Cross Platform Synergies Between TV and Online Advertising

Mohammed S. Alyakoob, Purdue University, 2165 Cushing Drive, West Lafayette, IN, 47906, United States, malyakoo@purdue.edu

The advent of the internet naturally gave rise to digital advertising, which provides a unique and insightful avenue for researchers and practitioners to monitor customers' responses to a multitude of different types of advertisements. This research seeks to utilize this potential in combination with a detailed television advertising data set to gain insights regarding the synergies that exist between television and online advertising platforms and the way these interactions affect customer behavior. We study the relationships between the online and television advertising platforms and the impact these synergies have on a customer's propensity to purchase (convert) in an online setting.

2 - Level Up: Leveraging Skill and Engagement to Maximize Player Retention in Online Video Games

Yan Huang, University of Michigan, 701 Tappan Street, Ann Arbor, MI, 48109, United States, yphuang@umich.edu, Stefanus Jasin, Puneet Manchanda

We propose a novel two-stage data analytic modeling approach, combining statistical methods with optimization techniques to maximize customer retention via matching in the online video game industry. In Stage 1, we build a Hidden Markov Model (HMM) to capture the evolution of gamers' latent engagement state and calibrate the HMM using a longitudinal dataset obtained from a major video game company. We find high-, medium- and low-engagement-state gamers respond differentially to motivations such as achievement and challenge. In Stage 2, we develop a matching algorithm that learns a gamer's current engagement state and exploits that learning to match the gamer to a round to maximize retention.

3 - The Impact of an Augmented Reality Game on Local Businesses: A Study of Pokemon Go on Restaurants

Vandith Pamuru Subramanya Rama, Purdue University, West Lafayette, IN, United States, vandith@purdue.edu, Warut Khern-am-nuai, Karthik Kannan

Pokemon Go, an augmented reality technology based game incentivizes it's user to move in the physical world. Such incentives can have potential externalities to businesses associated with them. Using online reviews of restaurants as a proxy for sales and quality, we study the impact of Pokemon Go on local restaurants. We treat the release of Pokemon Go as a natural experiment and study the post-release impact for the associated restaurants. We find that restaurants that are located near PokeStops indeed observe a higher number of customers compared to restaurants that do not have PokeStops nearby. However, the online quality perception isnt affected due to this effect.

4 - Platform Control and Complementor Performance: Evidence from Mobile Apps

Anparasan Mahalingam, Purdue University, 403 W. State Street, Krannert Building, West Lafayette, IN, 47906, United States, anparasan@purdue.edu

We study how changes in platform control affect the performance of complementors. Leveraging the jailbreak of iOS 10 as a natural experiment, we examine how an exogenous deciency in iOS's gatekeeping policy affects the performance of mobile apps on iOS compared with apps on Android. We also show several boundary conditions shaping the effect of the jailbreak on apps' performance

■ TB48

361A

BOM Working Paper Competition Finalists

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Michael Becker-Peth, University of Cologne, Cologne, 50923, Germany, michael.becker-peth@uni-koeln.de

1 - BOM Working Paper Competition Finalists

Michael Becker-Peth, University of Cologne, Albertus-Magnus-Platz, Supply Chain Management & Man. Sci., Cologne, 50923, Germany, michael.becker-peth@uni-koeln.de

Finalists in the BOM Best working paper competition will present.

2 - Discrimination with Incomplete Information in the Sharing Economy: Evidence from Field Experiments on Airbnb

Ruomeng Cui, Emory University, 1300 Clifton Rd, Atlanta, GA 30322, Atlanta, GA, 30322, United States, ruomeng.cui@gmail.com, Jun Li,, Dennis J Zhang

Recent research has found widespread discrimination by hosts against guests of certain races in online marketplaces, which endangers the very basis of a sharing economy â€" building trust in the communities. In this paper, we explore the root cause of discrimination and how to reduce discrimination. We conducted two randomized field experiments among 1,256 hosts on Airbnb by creating fictitious guest accounts and sending accommodation requests to them. We find that requests from guests with distinctively African American names are 19 percentage points less likely to be accepted than those with distinctively White names. However, a public review posted on a guestâ€™s page mitigates discrimination: when guest accounts receive a positive review, the acceptance rates of guest accounts with distinctively White and African American names are statistically indistinguishable. We further demonstrate that a negative review also significantly reduces discrimination. Our finding is consistent with statistical discrimination: when lacking perfect information, hosts infer the quality of a guest by race and make rental decisions based on the average predicted quality of each racial group when enough information is shared, hosts do not need to infer guestsâ€™ quality from their race, and discrimination is eliminated. Our results offer direct and clear guidance for sharing-economy platforms on how to reduce discrimination. Platform owners should motivate users to write reviews of one another and design a better mechanism to facilitate information sharing â€" especially information that signals guest quality.

3 - Modeling Newsvendor Behavior: A Prospect Theory Approach

Bhavani Shanker Uppari, INSEAD, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, BhavaniShanker.Uppari@insead.edu, Sameer Hasija

Problem definition: Studies have shown that the behavior of subjects in newsvendor experiments is not consistent with expected profit maximization as an assumption that is often made in inventory and supply chain management literature. Although prospect theory has been established as a popular model of behavioral decision making under uncertainty, it was considered to be inconsistent with observed newsvendor behavior (in particular, the pull-to-center effect) until a recent study proposed a prospect theory model that is consistent with the pull-to-center effect however, this model's ability in representing newsvendor behavior compared to other plausible prospect theory models is unexplored in the literature. This paper takes a more comprehensive approach in building several prospect theory-based newsvendor models, and evaluates their competence in representing the observed newsvendor behavior. An important feature of these models is that they are not only consistent with the pull-to-center effect, but they also can accommodate individual level heterogeneity in order quantities. This is in accordance with the findings from recent research that there is remarkable heterogeneity in the order quantities in newsvendor experiments, and that the behavior of a significant proportion of individuals is inconsistent with the pull-to-center effect.

■ TB49

361B

Practice/eBusiness II

Contributed Session

Chair: Xinyi Ren, University of Maryland-College Park, College Park, MD, United States, xinyi.ren@rhsmith.umd.edu

1 - Measuring Consumer Surplus in the On-demand Economy: The Case of Ride Sharing

Meng Liu, Massachusetts Institute of Technology, 100 Main Street, Sloan Room 412, Cambridge, MA, 02142, United States, mengliu@mit.edu

To understand the consumer welfare impact of ride-sharing platforms, we estimate a demand model for rides. Leveraging on the unusually rich taxi, Uber, and Lyft trip records from NYC as well as Uber and Lyft dynamic pricing and wait time, we find substitution patterns that vary by location, time, and demographics. We further provide strong evidence that consumers value time and dislike waiting. The consumer welfare gain mainly comes from two channels: first, the tech-aided ride-sharing platforms represent a more efficient "meeting" technology, causing an overall reduction in wait time; second, the platforms "fill in" the previously under-served communities by taxi.

2 - Neighborhood Selection Methods to Improve Recommendation Diversity

Pelin Atahan, Assistant Professor, Ozyegin University, Nisantepe Mah Orman Sok Cekmekoy, Istanbul, 34794, Turkey, pelin.atahan@ozyegin.edu.tr

Recommendation systems help match users with products in order to ease information overload of users. Recommendation systems are being utilized in many domains such as e-commerce, social networks, entertainment, and apps. While majority of the literature has focused on improving recommendation accuracy, recent studies have focused on other aspects of recommendation quality, such as diversity. However, there is typically a trade-off between recommendation accuracy and diversity. We propose a method that carefully selects neighbors in a way that will help learn the unique tastes of the users in order to improve recommendation diversity, while not compromising recommendation accuracy.

3 - Customer Differentiation with Shipping as an Ancillary Service: Free Service, Prioritization, and Strategic Delay

Arvind Sainathan, Nanyang Business School, S3-B2a-03, Nanyang Business School, 50 Nanyang Avenue, Ntu, Singapore, 639798, Singapore, Asainathan@ntu.edu.sg

A service provider/retailer offers ancillary service (e.g. shipping by an online retailer) to impatient and patient customers, who may be heterogeneous both in their delay sensitivities and service valuations. She can use prioritization and/or strategic delay to differentiate them. We characterize the optimal solutions under both exogenous and endogenous capacities, and find conditions in which these key service delivery features are present: (i) free service, (ii) single/differentiated service, (iii) split of customers, and (iv) strategic delay.

4 - Pricing in the ERA FF Omni-channel Retailing
Nevin Mutlu, Assistant Professor, Eindhoven University of Technology, Eindhoven University of Technology, P.O. Box 513, Eindhoven, 5600 MB, Netherlands, n.r.mutlu@tue.nl

In this research, we develop an analytical model to study an omni-channel retailer's pricing policy across store and online channels, considering that different channels exhibit different cost structures, yet an inconsistent pricing scheme across channels may lead to consumer confusion, resulting in important long-term effects.

5 - It is Hard to Please the Consumers. the Impact of Omnichannel Operation on Firm Performance
Xinyi Ren, PhD Student, University of Maryland-College Park, College Park, MD, 20742, United States, xinyi.ren@rhsmith.umd.edu, Philip Evers

In this paper, we analyze the impact of omnichannel operation on firm performance. In particular, we predict that after a retailer launches the mobile app, it will not only affect the sales from the online platform, but also exert spillover effects to the Brick and Mortar (B&M) channel. In addition, because of the differences in regard to the information delivery mechanism, we propose that there exist distinguished return rate as well as cart abandonment decisions between the PC customers and mobile customers. By adopting econometric models, we empirically investigate the hypotheses using company level data.

■ TB50

361C

Activity-based Modeling and Emerging Mobility Patterns

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Feixiong Liao, f.liao@tue.nl

1 - A Comprehensive Scenario Analysis of Household use of Autonomous Vehicles and On-demand Ride Sharing
Yashar Khayati, State University of New York at Buffalo, Buffalo, NY, United States, yasharkh@buffalo.edu
Yashar Khayati, State University of New York at Buffalo, Buffalo, NY, United States, yasharkh@buffalo.edu, Jee Eun Kang, Mark Karwan, Chase Murray

We define a framework to model and evaluate potential household-level use of Autonomous Vehicles (AVs) and on-demand ridesharing (ODR) systems. We introduce a new formulation, the Household Activity Pattern Problem for AV and ODR, to simulate the travel patterns of people. A comprehensive scenario analysis is designed to assess the impact of various parameters such as parking availability in different urban areas, parking cost, ODR cost, value of travel time, AV operational cost, etc. on travel behavior changes. We define and measure new metrics to suggest new policies on parking locations, AV ownership, ODR coverage.

2 - Representing Carsharing Operators Competition in an Agent-based Simulation of Transport
Milos Balac, ETHZ, Zurich, Switzerland, milos.balac@ivt.baug.ethz.ch, Francesco Ciari

In the past, almost all carsharing services were local monopolies of a sort. However, as carsharing is gaining momentum, competition among different operators in the same area is becoming a reality and research on this issue is required. Therefore, the goal of our ongoing work is twofold: 1) to implement a carsharing framework suitable to incorporate both land use information and socio demographic characteristics of people in the study area and 2) to model the competition of different free-floating carsharing operators. The simulations and analysis conducted will give us an opportunity to draw conclusions on the impacts on all involved parties of having a competing carsharing environment.

3 - Modeling Mode Choice and Parking Service for Commuting Trips in a Corridor: An Inclusion of Self-driving Cars
Cong Zhao, Key Laboratory of Road and Traffic Engineering of the Ministry of Education, Tongji University, 4800 Cao'an Road, Shanghai, China, Shanghai, 201804, China, zhc_tongji@163.com, Feixiong Liao, Yuchuan Du, Xinghua Li

This paper studies multimodal travel patterns in a corridor with the presence of self-driving cars. We focus on the commuting trips along a corridor connecting two CBDs, where commuters are distributed and allowed to use public transit (PT), park-and-ride, and pick-up and drop-off services.. The proposed model integrate choice of mode, paring location and departure time within a dynamic traffic assignment (DTA) simulation system. Computational experiments are conducted to demonstrate the proposed formulations and potential applications for the evaluation of transport and land pricing policies.

4 - Incorporating Free-floating Car Sharing into an Activity-based Dynamic User Equilibrium Model in Multi-state Super Network
Qing Li, Nanjing University of Information Science & Technology, 219 Ningliu Road, Nanjing, 210044, China, liqing_321@hotmail.com, Feixiong Liao, Harry J.P. Timmermans, Haijun Huang, Jing Zhou

Free-floating carsharing (FFC) has recently received increasing attention. Existing studies related to FFC have been rare to model the dynamic choice of free-floating shared cars (SC) in daily multi-modal multi-activity trip chains. This study proposes a tolerance-based multi-class dynamic activity-travel assignment model in an extended multi-state supernetwork representation. Dynamic traffic flows and supply-demand interactions of SC are formulated endogenously. Three numerical examples demonstrate that fleet size, distribution, rental and parking prices of SC significantly influence the choice of activity-travel patterns.

■ TB51

361D

Platform Economics

Sponsored: Information Systems

Sponsored Session

Chair: Rakesh Reddy Mallipeddi, Texas A&M University, College Station, TX, 77843-4217, United States, rmallipeddi@mays.tamu.edu

1 - The Effects of Social Media Sentiment on Engagement
Rakesh Reddy Mallipeddi, Texas A&M.University, 320 Wehner - 4217, Mays Business School, Dept of Info&Operations, College Station, TX, 77843-4217, United States, rmallipeddi@mays.tamu.edu

Individual celebrities or "human brands" from different fields ranging from sports to art to politics use various social media platforms to connect and communicate with their target audience. We empirically analyze the effects of content generated by human brands on the popular social media platform, Twitter, on audience engagement.

2 - How Information Sharing Helps Firms Fight Return Abuse: A Network Perspective
Serkan M. Akturk, Texas A&M.University, 4217 TAMU, Wehner 320 M, College Station, TX, 77843-4217, United States, makturk@mays.tamu.edu

We study a setting where a service provider offers return information exchange (RIE) services, which exhibit network externalities for participating retailers and manufacturers. Firms can participate in the network by paying a subscription fee and benefit from shared databases. The RIE provider can offer customer proling, product tracking, and joint networks. Under different conditions of the network service, we derive the equilibrium subscription fees and the sizes of the customer profiling, product tracking, and joint networks. Our results provide strong managerial insights for retailers, manufacturers, and the RIE provider.

3 - Impact of Online Retail on Movement of Long Tail Products: An Empirical Study
Samayita Guha, sguha@mays.tamu.edu, Rakesh Reddy Mallipeddi, Subodha Kumar

Retailers have now started to pay attention to long tail products that individually have low demand but in aggregate can combine to create higher demand than few best-selling products. In this study, we propose an econometric model to examine the movement products in and out of long tail using data from a large retailer.

4 - How Much to Invest and How Much Information to Share for Information Security
Yueran Zhuo, University of Massachusetts, 121 Presidents Drive, Amherst, MA, 01003, United States, yzhuo@som.umass.edu, Senay Solak

In this study, we model the interplay between information sharing and technology investments for information security. As part of our findings, we identify policies defining optimal technology investments and information sharing levels for firms in different industries. We also present results on the value of sharing security information in different information security environments.

5 - How Information Sharing Helps Firms Fight Return Abuse: A Network Perspective
Serkan M. Akturk, Texas A&M.University, 4217 TAMU, Wehner 320 M, College Station, TX, 77843-4217, United States, makturk@mays.tamu.edu

In this paper, we study a setting where a service provider offers return information exchange (RIE) services that exhibit network externalities for participating retailers and manufacturers. Under different conditions of the network service, we derive equilibrium subscription fees and the sizes of the customer profiling, product tracking, and joint networks.

■ TB52

361E

Energy

Contributed Session

Chair: Site Wang, Clemson University, Clemson, SC, United States, sitew@clemson.edu

1 - Modeling Frequency Regulation in Isolated Power Systems

Miguel Carrion, Universidad de Castilla-La Mancha, Avda Carlos II I.s/n, Toledo, Spain, miguel.carrion@uclm.es, Rafael Zarate-Miñano, Miguel Cañas, Ruth Domínguez

Isolated power systems are particularly vulnerable to power plant failures. In order to guarantee the supply security in these systems, electrical energy is provided by a large number of small-sized generating units. Because of the low inertia of these units, frequency fluctuations in isolated systems are much higher than in interconnected systems. Considering this framework, we propose a stochastic unit commitment with frequency regulation constraints to model the operation of a renewable-dominated isolated power system. Uncertain renewable units and demand side management actions are explicitly considered. The proposed formulation is tested in a realistic case study.

2 - Arbitrage Pricing in Revenue Cap Regulation of Electricity Distribution

Timo Kuosmanen, Aalto University, Runeberginkatu 22-24, Helsinki, Finland, timo.kuosmanen@aalto.fi, Tuan Nguyen

Revenue cap is a widely used instrument in the regulation of local monopolies such as electricity and gas distribution firms. Due to its simplicity, most regulators apply Capital Asset Pricing Model (CAPM) to set the rate of return for the capital invested. However, the expected return and associated risks dependent on several latent factors besides the single market factor used in CAPM. Arbitrage Pricing Theory (APT) provides a more general and flexible approach to assess the risk and return. This paper explores the practical aspects of applying APT in regulation. We examine the real world example of revenue cap regulation of electricity distribution firms in Finland.

3 - An Energy Infrastructure Adaptation Framework for Changing Climatic Conditions

Site Wang, Clemson University, 100 Freeman Hall, Clemson University, Clemson, SC, 29634, United States, sitew@clemson.edu Site Wang, Los Alamos National Labotoary, TA-03, Building 1690, Room 101C, Los Alamos, NM, 87545, United States, sitew@clemson.edu, Russell Bent, Carleton Coffrin, Donatella Pasqualini, Nathan Urban, Sandra D.Eksioglu, Scott J. Mason

In recent years, global climate change has highlighted potential issues for coastal area energy infrastructure reliability. Changing climate increases uncertainty in predicting extreme weather such as tidal incursion and stronger, more frequent hurricanes. As it is critical to adapt energy infrastructures to these potential risks, we present a stochastic optimization framework for infrastructure adaptation to uncertain weather events using state-of-the-art climate simulation models for stochastic quantification. Our framework can provide decision makers with forward-thinking plans that consider adaptation costs and risks under exogenous stochastic hurricane events.

■ TB53

361F

Design of Transportation Infrastructure and Services

Sponsored: TSL, Intelligent Transportation Systems (ITS)

Sponsored Session

Chair: Yu Zhang, University of South Florida, 4202 E. Fowler Ave., ENB118, Tampa, FL, 33620, United States, yuzhang@usf.edu

1 - A New Resilience Measure for Infrastructure Restoration Plan Optimization Considering Unmet Demand in Transportation System after Disruptive Event

Tingting Zhao, Research Scholar, University of South Florida, 4202 E Fowler Avenue, Tampa, FL, 33620, United States, tingtingzhao@mail.usf.edu, Yu Zhang

A bi-level optimization problem is formulated for restoration plan optimization of transportation infrastructure system after a disruption, e.g. flood, hurricane or other natural disasters. The upper-level problem is to maximize the system resilience index, combining mobility and accessibility, with limited resources. The lower-level one is a network flow assignment problem considering unmet demand in the system after the disruption. We propose an efficient heuristic algorithm for solving this problem and examine its performance with a typical road network (Sioux-Falls network). With multiple random disruptions in the experiment system, enormous combinations of damaged links are generated. The restoration plan optimization method proposed in this work could effectively identify the links to be restored with resource constrains. Furthermore, we vary the number of damaged links to examine its impact on system resilience performance. All these numerical analysis results show that the proposed method could be of great help for decision makers not only for restoration stage but also for identifying critical road section sets that need more attention for maintenance.

2 - Scheduling Models in Multimodal Transportation Networks with Commuter Preferences

Julia Y. Yan, Massachusetts Institute of Technology, Cambridge, MA, 02143, United States, jyyan@mit.edu, Dimitris Bertsimas, Yeesian Ng

Modern transportation systems in urban settings are increasingly complex. Public transportation services are often operated at large scale and under tight budget constraints. Furthermore, passengers are able to make choices between a variety of commuting options. We develop novel formulations for minimizing system backlog in multi-modal networks, while accounting for operator budget concerns and commuter preferences. Our formulations can solve within minutes, and we show improvement over heuristics through simulations on real data from the Boston MBTA network.

3 - A Stochastic Programming Approach for Electric Vehicle Charging Network Design

Sina Faridimehr, Wayne State University, 4815 Fourth Street, Manufacturing Engineering Building, Detroit, MI, 48202, United States, sina.faridimehr@wayne.edu, Saravanan Venkatachalam, Ratna Babu Chinnam

Advantages of electric vehicles (EV) include reduction of greenhouse gas and other emissions, energy security, and fuel economy. The societal benefits of large-scale adoption of EVs cannot be realized without adequate deployment of publicly accessible charging stations. We propose a two-stage stochastic programming model to determine the optimal network of charging stations for a community. We conducted computational experiments using various publicly available data sources, and benefits of the solutions are evaluated both quantitatively and qualitatively for a given community.

4 - Revenue Management in Urban Parking Systems with Learning and Competition

Yuguang Wu, University of Wisconsin, Madison, WI, United States, wu376@wisc.edu, Qiao-Chu He, Xin Wang

We consider decentralized garages who maximizes their revenue when the parking demand is uncertain but spatially correlated. A "smart parking" company provides demand forecast to increase system efficiency. At an individual garage level, we analyze the optimal operational strategy to leverage its limited capacity. At a system level, we investigate the optimal parking data sharing policy for the society. We aim to provide guidelines for the "smart parking" company concerning the design of information system towards more efficient utilization of urban parking resources.

5 - Optimal Snow Removal Facility Locations for Stochastic Snowfall

Yufeng Zhang, University of Minnesota, 500 Pillsbury Drive S.E., Room 175, Minneapolis, MN, 55455, United States, zhan4879@umn.edu, Avinash Unnikrishnan, Alireza Khani

A MIP formulation is proposed for the optimal locations of snow truck stations to minimize the capital and operating cost of snow removal operations. Uncertainties of snowfalls are modeled by a chance constraint, which takes the correlation of snowfalls into consideration. The stochastic problem is reformulated to a MICQP to make it practically applicable for realistic problems. Several variations of the problem are solved based on the real case of the state of Minnesota.

■ TB54

362A

R&D Issues in Agribusiness

Invited: Agricultural Analytics

Invited Session

Chair: Saurabh Bansal, Penn State University, Penn State University, State College, PA, 16801, United States, sub32@psu.edu

1 - Optimizing the Classification of Soybean Varities as Elite Varities in a Three Stage Experimentation

Durai Sundaramoorthi, Washington University in Saint Louis, 10352 Conway Road, Saint Louis, MO, 63131, United States, dsundaramoorthi@gmail.com, Yujin Lee

As world population grows, the, need for more food is increasing. On the other hand, land available for farming is reducing. Agribusinesses use a multi-year testing strategy to narrow down the choice of new varieties introduced by breeders. Syngenta -an agribusiness - uses a three stage experimentation to choose a handful of elite soybean varieties at the end of stage three by starting with thousands of varieties in stage one. We use machine learning and optimization to identify elite varieties at the end of stage three.

3 - Design of Internet of Things (IoT) Framework for Agricultural Sector (IoT-Agro)

Pachayappan Murugaiyan, Pondicherry University, Tamilthai Nagar, Puducherry, 605001, India, pachayappanvn@gmail.com

In this paper an Internet of Things (IoT) framework for agricultural sector (IoT-Agro) in particular for sugar cane industry is proposed. IoT-Agro can best control and monitor the growth environment of sugar cane, achieve high and stable yield of sugar cane, monitor the pesticide level in crop, water level and soil moisture and also control the cultivation wastages. Based on proposed IoT-Agro framework a new collaboration model between the farmer (producer), mills (production) and government is designed. The proposed collaboration model will create a live communication platform and instant decision making flexibility between the decision maker's viz. farmers, mills and governments agencies

4 - Supplier Opportunistic Behavior in Post-disaster Agriculture Supply Chain

Hsin-Tsz Kuo, Doctoral Student, National Taiwan University, Taipei, 10617, Taiwan, d01741003@ntu.edu.tw, Jiuh-Biing Sheu

This paper address the causal relationships among supplier opportunistic intention, supplier power asymmetry, magnitude of disaster, and its antecedents in a post-disaster agriculture supply chain. We proposed a research model that supplier power asymmetry can moderate the relationships between supplier opportunistic intention and supplier attitude of competitor influence.

■ TB55

362B

Finance Methods

Sponsored: Financial Services

Sponsored Session

Chair: Christoph Frei, University of Alberta, Edmonton, AB, T6G 2G1, Canada, cfrei@ualberta.ca

Co-Chair: Abel Cadenillas, University of Alberta, Edmonton, AB, T6G 2G1, Canada, abel@ualberta.ca

1 - Bail-ins and Bailouts: Incentives, Connectivity and Systemic Stability

Benjamin Bernard, UCLA, Los Angeles, CA, United States, benbernard@ucla.edu, Agostino Capponi, Joseph E. Stiglitz

We analyze the stability of an interbank network, in which subsidized bail-ins or public bailouts can be coordinated to stop financial contagion. Banks are willing to contribute to a subsidized bail-in only if the social planner's threat to not bail out insolvent banks is credible. We characterize the optimal bail-in plan and show that the socially preferable network structure shifts from densely connected networks for small shocks to sparsely connected networks for large shocks. The presence of this resolution plan affects interbank trading decisions and we show that banks aim to arrive at a network structure that is "too interconnected to fail," thereby forcing the government to a public bailout.

2 - Optimal Contracting and Consumption/Portfolio Selection with Limited Commitment

Hyeng Keun Koo, PhD, Ajou University, Suwon, Korea, Republic of, koo_h@msn.com

Recently there has been a steady growth of literature on optimal contracting/equilibrium with limited commitment. In particular, there is now a newly emerging literature on contracting theory with limited commitment in continuous-time. There has also been a literature on consumption/portfolio selection with liquidity(or borrowing constraints). I will explain the connection between the two strands of literature and discuss new results relevant to the two strands of literature.

3 - The Optimal Band of Government Stabilization Fund

Abel Cadenillas, University of Alberta, Department of Mathematical Sciences, Edmonton, AB, T6G 2G1, Canada, abel@ualberta.ca, Ricardo Huaman-Aguilar

To mitigate the negative consequences of a crisis, an instrument of fiscal policy is the stabilization fund, which is a mechanism to save money in the good economic times to be used in the bad economic times. We present a model to study the optimal management of a stabilization fund.

4 - Managing Counter Party Risk in Over-the-counter Markets

Christoph Frei, University of Alberta, Mathematical and Statistical Sciences, CAB 621, Edmonton, AB, T6G 2G1, Canada, cfrei@ualberta.ca, Agostino Capponi, Celso Brunetti

We study how counterparty risk affects trading decisions in over-the-counter markets. Banks first manage their default risk, and then decide on credit default swap (CDS) trading volumes to hedge against an aggregate risk factor. Our model predicts that perfect risk sharing is only done between safe banks, while riskier banks maintain diverse post-trade exposures. The costly actions exerted by banks to reduce their default risk are not socially optimal. Banks may choose to reduce their default probabilities below the socially optimal level, depending on trade size limits and costs of risk management. The model produces new empirical predictions which are borne out by data from the CDS market.

■ TB56

362C

Recent Advances on Facility Location and Network Design Problems II

Sponsored: Location Analysis

Sponsored Session

Chair: Takamori Ukai, Keio University, Yokohama, 2238522, Japan, ukai@ae.keio.ac.jp

1 - Optimal Management Model for Road Maintenance by City Government

Mondo Sugiyama, The University of Tokyo, Ce408. 4-6-1, Komaba, Meguroku, Tokyo, 1538505, Japan, mondo@iis.u-tokyo.ac.jp, Yudai Honma

For the local government, the road maintenance and management is one of the important duties. The works of road maintenance lasts for many divergences including the identification of the repair points and the real repair, and the road total distance is also enormous. Therefore, effective scheduling planning of road maintenance is essential. In this study, the possibility to apply the scheduling model in the field of operations research to the road maintenance and management is examined. Based on the real road repair data in Japan, more effective repair scheduling plan will be proposed.

2 - Reliability Network Design for an Aircraft Door Management System

Lukas Schaefer, University of Edinburgh, JCMB, Room 6324, The King's Buildings, Edinburgh, EH9 2DG, United Kingdom, lukas.schaefer@ed.ac.uk

The door management system (DMS) is a safety system in an aircraft to check if all doors are properly closed and the cabin is correctly pressurized. As for every critical system in an aircraft, it has to meet safety regulations (redundancy, reliability) and should be designed optimally in terms of weight, costs, power consumption or reliability. This talk will introduce a new MILP formulation of the optimal redundancy and reliable design for a DMS. Furthermore, it will present an exact solving method for the redundancy problem and a heuristic for the reliability/redundancy problem.

3 - Big Data Location Analytics – Predicting Purchase Location with Mobile Location Data

Karthik Babu Nattamai Kannan, PhD Candidate, IT Management, Scheller College of Business, Georgia Tech, 800 West Peachtree NW, Atlanta, GA, 30308, United States, karthikbabu.nk@scheller.gatech.edu, Sridhar Narasimhan

We work with a leading national mobile carrier in the USA to explore how its customers choose the location of brick-and-mortar store to purchase or upgrade wireless service. We explore how understanding people's travel patterns is helpful in choosing the optimal number of stores in a given market based on maximum coverage model. We explore literature on firm expansion and franchising to develop a machine learning based heuristic solution procedure (work in progress).

4 - Ratio of Visible Green Associated with Pedestrian Location and Visual Line

Takamori Ukai, Keio University, 3-14-1, Hiyoshi, Kouhoku-ku, Yokohama, 2238522, Japan, ukai@ae.keio.ac.jp, Osamu Kurita, Yuki Hirasawa

Green gives people relaxing, comfortable and some positive effects. Ratio of visible green is an index that represents the ratio of greenery part to the entire vision field. Although some municipalities in Japan have employed this index to their policies, there are some differences between measuring methods that municipalities have employed. Furthermore, it is time consuming to measure it by taking photographs, because one have to go to the site.Therefore, it is meaningful to propose new convenient method for estimation. In this talk, we define ratio of visible green as the ratio of solid angle of trees to unit semi-sphere and propose estimation method regarding trees as spheres.

■ TB57

362D

Statistical and Optimal Learning

Sponsored: Simulation

Sponsored Session

Chair: Ilya O. Ryzhov, University of Maryland, 4322 Van Munching Hall, University of Maryland, College Park, MD, 20742, United States, iryzhov@rhsmith.umd.edu

1 - Optimization of Tree Ensembles

Velibor Misic, University of California Los Angeles, Los Angeles, CA, United States, velibor.misic@anderson.ucla.edu

Decision trees and tree ensemble models such as random forests are often used to predict the effect of different decisions. While such models are widely used for predictive purposes, little is known about how to use them for effective decisions. In this talk, we consider the problem of finding a decision that is optimal with respect to a tree ensemble model. We formulate this problem as a mixed-integer optimization model and present theoretical results on the structure of this model. We demonstrate the value of our methodology on real datasets and present two detailed applications to drug design and multiproduct pricing.

2 - Markov Decision Processes with Exogenous Variables

Robert Louis Bray, 830 Hinman Ave., 2s, Evanston, IL, 60202, United States, robertlbray@gmail.com

I present two new dynamic program solution methods: endogenous value iteration and endogenous policy iteration. I define the exogenous space of a Markov decision process as the vector space comprising the set of value function deviations that never influence the policy function. My algorithms iteratively apply Bellman contractions, projecting the portion of the value function that lies in the exogenous space to zero at each step. When the exogenous space is one-dimensional, my algorithms are equivalent to relative value iteration and relative policy iteration; but when the exogenous space is multi-dimensional, my algorithms can be faster.

3 - Derivative-based and Derivative-free Adaptive Sampling Trust Region Optimization

Raghu Pasupathy, Purdue University, West Lafayette, IN, United States, pasupath@purdue.edu, Susan R.Hunter, Sara Shashaani, Fatemeh S. Hashemi

We will present an adaptive sampling trust region method for solving unconstrained stochastic optimization problems where the objective function can only be estimated using an inexact oracle, e.g., Monte Carlo or quasi-Monte Carlo simulation. We will discuss both derivative-based and derivative-free versions of the algorithm, along with convergence calculations. We will also briefly demonstrate a global complexity result in a specific deterministic inexact oracle setting.

4 - Rate-optimality of the Complete Expected Improvement Criterion

Ye Chen, University of Maryland, 1305 Mathematics Building, University of Maryland, College Park, MD, United States, yechen@math.umd.edu, Ilya O.Ryzhov

Expected improvement (EI) is a leading algorithmic approach to simulation-based optimization. However,it was recently proved that, in the context of ranking and selection, some of the most well-known EI-type methods cause the probability of incorrect selection to converge at suboptimal rates. We investigate a more recent variant of EI (known as "complete EI") that was proposed by Salemi, Nelson, and Staum (2014), and summarize results showing that, with some minor modifications, complete EI can be made to achieve the optimal convergence rate in ranking and selection with independent Gaussian noise. This is the strongest theoretical guarantee available for any EI-type method.

■ TB58

362E

Applications of Facility Logistics - I

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Amir Gharehgozli, Texas A & M University, Galveston, TX, 77553, United States, gharehga@tamug.edu

1 - Emission Control Strategies in the Maritime Transport: LUG vs. Scrubber Debate

Okan Duru, Nanyang Technological University, 50 Nanyang, N1-01C-95, Singapore, 638798, Singapore, duruokan@yahoo.com

This paper investigates the trade-off between three major strategies for controlling Sulphur emissions from ships due to the new international regulations. According to the recent international regulation, shipping firms will need to change their fuel type or implement an emission control device to comply with the sulphur emission limits. Each of these choices will eventually have advantages and disadvantages in terms of cost and efficiency. This paper evaluates the selection of relevant control strategy for various kinds of ships.

2 - Berth Allocation – Do we have it all Wrong?

Stefan Voss, University of Hamburg, Von-Melle-Park 5, Hamburg, 20146, Germany, stefan.voss@uni-hamburg.de

The Berth Allocation Problem (BAP) aims at assigning and scheduling incoming vessels to berthing positions along the quay of a container terminal. During the last decades many terminal operators and academics have developed algorithms and decision support systems for optimizing berth planning including the BAP. Despite a wealth of existing systems as well as academic surveys there are still quite a few issues that seem to be neglected including the consideration of berth error as well as disturbances in the daily operation. Here, we set up a research agenda pointing out that we need to consider and model disturbances and stochastic influences to make the problem more realistic.

3 - Geometric Partitioning Algorithms for Facility Location Problems

Mehdi Behroozi, Assistant Professor, Northeastern University, Boston, MA, 02115, United States, m.behroozi@neu.edu, Reyhaneh Mohammadi

We present fast approximation algorithms for the continuous facility location problems such as k-centers problem and k-medians problem over a convex polygon. The objective here is to find the location of k facilities so as to minimize a distance-based cost function. Our strategy is to use a geometric partitioning scheme to partition the convex polygon into k sub-regions and allocate one facility to each sub-region.

4 - Synchronized Scheduling of Yard Cranes and Vehicles in Container Yards

Chenhao Zhou, National University of Singapore, 1 Engineering Drive 2, E1A-05-21, Singapore, 117576, Singapore, a0096340@u.nus.edu, Haobin Li, Byung Kwon Lee, Loo Hay Lee, Ek Peng Chew

In the container block, the handshake between a yard crane and a vehicle when handling over a container can lead to unproductive waiting time, and consequently low block throughput. This study aims to discuss the synchronized scheduling to reduce the waiting time and to improve the handling efficiency between yard cranes and vehicles. The decision elements are the handshake positions for handshaking, and the operations sequence of activities, under the Chebyshev metric of yard crane movement. The scheduling algorithm is proposed and examined its effectiveness on a simulation testbed.

5 - Modeling MIAPP NALT in Order Picking Applications with a Class Based Storage Policy

Jingming Liu, Research Assistant, University of Arkansas, 920 N Leverett, Apt 811, Fayetteville, AR, 72701, United States, liujingming1215@gmail.com, Haitao Liao, John A. White

A multiple-in-the-aisle pick positions (MIAPP) case picking operation is modeled as an M|Ek|1 queueing problem. In the queueing formulation, the narrow aisle lift truck (NALT) serves two types of customers: single-command storage, single-command retrieval. The travel time probability distributions are derived under a rectilinear travel and class-based storage policy, and an Erlang distribution is used to approximate the distribution of service times.

■ TB59

362F

Joint session RAS/Practice: Intermodal Transportation

Sponsored: Railway Applications

Sponsored Session

Chair: Nathaniel Richmond, University of Iowa, The Colony, TX, 75056, United States, nathaniel-richmond@uiowa.edu

Co-Chair: Mike D. Prince, BNSF Railway, BNSF Railway, Fort Worth, TX, 76244, United States, mike.prince@bnsf.com

1 - Breaking Deadlocks in Widespan Crane Planning

Steven Tyber, Operations Researcher, GE Transportation, 500 W. Monroe St, Chicago, IL, 60613, United States, tyber@ge.com

We explore the problem deadlocks in planning wide span crane operations. Like many scheduling problems, wide span crane tasks have precedence relations that need to be observed to produce a feasible plan. When a set of tasks are mutually dependent, they are said to be deadlocked and prevent any plan from being feasible. In this talk, we show how such deadlocks arise in wide span crane operations and how standard practices for arranging and loading units give rise to an easily executed solution to this challenging problem.

2 - Intermodal Hub Simulation
Mike D.Prince, BNSF Railway, 4853 Grinstein Drive, Fort Worth, TX, 76244, United States, mike.prince@bnsf.com

Intermodal hubs are the facilities at which BNSF Railway's intermodal trains interface with customers. This presentation will discuss an AnyLogic simulation model that was developed for the purpose of assisting in the capital expansion planning process for these facilities.

3 - Investigating General Intermodal Terminal Capacity Relationships with AnyLogic Simulations
Darkhan Mussanov, University of Illinois at Urbana-Champaign, RailTEC, 205 N.Mathews Avenue, Urbana, IL, 61801, United States, mussano2@illinois.edu, Tyler Dick

Currently, intermodal terminal capacity is largely evaluated on the basis of practitioner planning experience. The industry is in need of a more thorough understanding of the interaction between fundamental factors that influence intermodal terminal capacity. As a first step to create a tool for investigating the factors affecting intermodal terminal capacity, this research develops a simulation model of the intermodal terminal operation.

4 - Managing Intermodal Equipment under Supply and Demand Uncertainties – An Implementation of an Operations Research Tool in a North American Railway
Yudi Pranoto, Norfolk Southern Corporation, 1200 Peachtree Street Ne, Box 12-117, Atlanta, GA, 30309, United States, yudi.pranoto@nscorp.com, Clark Cheng

Intermodal units such as containers and trailers are transported by train using intermodal flatcars. The demand of intermodal flatcar is varies by location and by day of the week. In this presentation, we will discuss implementation of a forecasting tool to assist intermodal equipment manager to better plan for the availability of intermodal flatcars. Key concepts of prediction interval, network optimization, intermodal yard capacities, and equipment loading rules will also be discussed.

■ TB60

370A

Integrating Scholarship with the Teaching of OR/MS/Analytics

Sponsored: INFORMEd

Sponsored Session

Chair: Neil Desnoyers, Saint Joseph's University, Upper Darby, PA, 19082, United States, ndesnoye@sju.edu

1 - An Experiential Learning Activity for Integrating Optimization and Group Work in the ORMS Classroom
Mihai Banciu, PhD, Bucknell University, Lewisburg, PA, United States, mmb018@bucknell.edu

Traditionally, topics like linear and integer optimization in a spreadsheet-based modeling course are taught based on a "follow the instructor approach". We present a web-based interactive activity whereby students can work in small groups in the classroom, while the instructor aggregates the intermediate results into a master problem and provides instant feedback.

2 - Instructional Guidance for Client-Based ORMS Education
Susan E. Martonosi, Harvey Mudd College, Department of Mathematics, 301 Platt Boulevard, Claremont, CA, 91711, United States, martonosi@hmc.edu

How do we move beyond the theory of ORMS in our classrooms and give students the skills to be practitioners? Many ORMS programs have begun instituting field-based projects serving real clients as part of their curricula. This talk will offer the audience a set of design principles drawn from the myriad approaches described in ORMS educational literature.

3 - An Advance in Web-Based Spreadsheet Modeling Resulting from Classroom Use
Neil Desnoyers, Saint Joseph's University, 133 Green Valley Rd, Upper Darby, PA, 19082, United States, ndesnoye@sju.edu

Spreadsheets are moving online. Introduction of an OR/MS case in an MBA classroom helped uncover an issue modeling using Google Sheets and the OpenSolver tool. We apply lessons learned to the feedback loop between teaching and scholarship.

4 - Designing Educational Assessment via Network Optimization
Camilo Gómez, Universidad de los Andes, Cra 1 E.No 19 A.- 40, Bogata, Colombia, gomez.ch@uniandes.edu.co, Jorge Huertas, Jorge A. Leal

Network models are useful abstractions for a variety of systems. This work explores the application of network flows models in the organizational realm, approaching an education problem in an industrial engineering department, following ABET guidelines and standards. We propose different network optimization models at different scales of abstraction to promote the interactions between, and within, the courses towards the continuous improvement of the program. While there are challenges in the quantification of non-tangible aspects, the proposed approach proves useful to engage stakeholders in meaningful interactions and convey otherwise abstract features of complex systems.

■ TB61

370B

Sports Analytics II

Sponsored: SpORts

Sponsored Session

Chair: Stephen Hill, UNC, Wilmington, NC, United States, hills@uncw.edu

1 - Late Game Decision Making in the NFL
Stephen Hill, UNC Wilmington, NC, United States, hills@uncw.edu

Late-game decision-making in the National Football League (NFL) has drawn considerable scrutiny in recent years. In this presentation, an analysis of late-game decision-making is presented. In particular, the analysis focuses on field goal versus "going for it" decisions late in close games.

2 - Optimal Defensive Allocation in Baseball
Jim Ostrowski, University of Tennessee, 11421 Old Colony Pkwy, Knoxville, TN, 37934, United States, jostrows@utk.edu

We will discuss the problem of optimal allocation defensive baseball positions. By integrating open-source collected data into our integer formulation, we are able to of identify an optimal defensive allocation for MLB hitters that can have a significant impact on their batting average.

3 - A Playbook for Teaching Sports Analytics to Undergraduate Business and MBA Students
Scott Nestler, University of Notre Dame, 383 Mendoza College of Business, Notre Dame, IN, 46556, United States, snestler@nd.edu

The presenter teaches a half-semester length course in Sports Analytics to undergraduates and MBAs at the University of Notre Dame. Offensive plays — reaching out to faculty members at other schools who teach similar courses; allowing students freedom to use familiar tools or coding languages. Defensive plays — selecting Excel as a common language for class examples (may revisit in future with a more pro-style scheme that incorporates R); using a known but somewhat dated text (Winston's "Mathletics"). Please come listen and share your experiences in teaching quantitative techniques using a subject matter that students are truly excited about.

4 - An Approximate Dynamic Programming Approach to Determine the Optimal Substitution Strategy for Basketball
David Hughes, George Mason University, Fairfax, VA, United States, dhughe12@masonlive.gmu.edu

Coaches currently use a variety of substitution strategies (such as player rotations and playing the "next best" player). However, such strategies may not be optimal in terms of distributing rest over the course of a whole game. In part, this is because live monitoring of physiological factors is not authorized by the NCAA. Even with such data, it may not be obvious when to rest a skilled player in order to ensure that player is fresh throughout the game. This research develops an approximate dynamic programming (ADP) model of a coach's lineup decisions accounting for changing players' endurance levels and the uncertainty of the defensive intensity played against them.

5 - An Interactive Optimization Web App for the NHL Expansion Draft
Benjamin Potter, University of Toronto, Mechanical and Industrial Engineering, 5 Kings College Road, Toronto, ON, M5S.3G8, Canada, ben.potter@mail.utoronto.ca, Timothy Chan

The Vegas Golden Knights are the newest team to enter the NHL. The league laid out rules for an Expansion Draft where the existing teams protect some of their players from being drafted and Vegas fills its roster by selecting from the remaining players. We developed a web app based on integer programs that model the existing 30 teams' protection decisions and Vegas's draft decisions. The app allows fans to optimize the draft using one of a number of performance based metrics. Users can also plan for the future by balancing on-ice performance with financial flexibility objectives.

■ TB62

370C

Spatio-Temporal Models for Forecasting

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Yu Ding, Texas A&M University, College Station, TX, 77843-3131, United States, yuding@tamu.edu

Co-Chair: Ahmed Aziz Ezzat, Texas A&M University, College Station, TX, United States, aa.ezzat@tamu.edu

1 - Smart Energy: A Modern Data-Driven Perspective

Andrew Kusiak, The University of Iowa, Iowa City, IA, 52242, United States, andrew-kusiak@uiowa.edu

The world of energy is transforming towards renewable energy generation with wind energy experiencing the fastest growth. Renewable energy has introduced a shift from centralized to distributed generation. The cost to operate and maintain renewable energy plants is a major determinant of energy prices. Autonomy of renewable energy generators and plants offers a viable path to competitive prices of clean energy. Using wind industry as an example, problems awaiting research attention and solution approaches are outlined. A strategy to democratization of energy research aiming at accelerated response to meeting wind energy needs is presented.

2 - Distributed Ensemble Solar Power Forecasting through the Generalized Dynamic Factor Model

Duehee Lee, Assistant Professor, KonKuk University, Kwangjin Gu, Seoul, Korea, Republic of, hello.keanu@konkuk.ac.kr, Ross Baldick, Jaehyung Roh

Total daily solar irradiance for the next day is forecasted through an ensemble of multiple machine learning algorithms using forecasted weather scenarios from numerical weather prediction models. We also forecast the distributed solar power through the generalized dynamic factor model. Six interpolation functions are used to interpolate weather scenarios at non-integer grid points and performances are compared. The forecasting models are verified using data from the American Meteorological Society 2014 Solar Energy Prediction competition by observing the post-competition rankings. We achieved 16th place out of 160 in this competition, and our best post-competition ranking is 5th place.

3 - A Markov Switching Vector Autoregressive Stochastic Wind Generator for Multiple Spatial and Temporal Scales

Amanda Hering, Baylor University, Waco, TX, United States, Mandy_Hering@baylor.edu

Stochastic realizations of wind are important for wind energy grid integration and reliability studies. Here, we introduce a Markov-Switching Vector Autoregressive model (MSVAR) model and demonstrate its flexibility in simulating wind vectors for various temporal and spatial scales. In addition, we demonstrate how the model can be used to simulate wind vectors at multiple locations simultaneously. The parameter estimation and simulation algorithm is presented along with a validation of important statistical properties of each simulation scenario. The MSVAR is very flexible in characterizing a wide range of properties in the wind vector.

4 - Short-term Wind Forecasting using Spatio-temporal Asymmetric Models

Ahmed Aziz Ezzat, Texas A&M.University, aa.ezzat@tamu.edu

Despite the growing recognition for non-separable spatio-temporal models, a significant reliance on separable, fully symmetric models is still the norm in today's renewable industry. We explore the reasons behind the disregard of these models in wind farm analytics and devise a special pair of spatio-temporal lens that unearths the fine-scale spatio-temporal variations and interactions, at which the merits of the highly-statistically capable models are perceived. Given this lens, we investigate the potential benefits, in terms of inference and forecasting, achieved through extending non separable asymmetric spatio-temporal models for wind energy applications.

■ TB63

370D

Spatio-Temporal Conservation Models for Controlling Biological Invasions

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Esra Buyuktahtakin, New Jersey Institute of Technology, Newark, NJ, United States, esratoy@njit.edu

1 - Valuing Monitoring Networks for New Agricultural Pathogens

Tiesta Thakur, University of Minnesota, St. Paul, MN, 55108, United States, thaku035@umn.edu, Terry Hurley, Frances Homans, Robert Haight

US soybean production, a $30 billion industry, is threatened by soybean rust, a new agricultural pathogen that entered the U.S. in 2004. To monitor rust occurrence, a public-private partnership funds a sentinel plot network, which reached a peak of 900 plots in 2008. Soybean producers use sentinel plot information to assess annual risk of infection and make fungicide application decisions. To value the network, we first develop a dynamic, farm-level decision model and estimate producers' willingness to pay for sentinel plot information. Then, we use an assignment model to locate sentinel plots in the eastern U.S. to maximize net benefits. Results are compared with current plot locations.

2 - Optimal Survey Strategies in Early Detection Programs of Bio-invasions: Detect or Delimit?

Denys Yemshanov, Natural Resources Canada, 1219 Queen Street East, Sault Ste. Marie, ON, p6a2e5, Canada, Denys.Yemshanov@canada.ca, Robert G.Haight, Frank H.Koch, Robert Venette, Tom Swystun, Ronald Fournier, Yongguang Chen, Mireille Marcotte, Jean J.Turgeon

We present a scenario-based model that incorporates uncertainty about the arrival of an invasive species and damage from an outbreak and optimizes the deployment of surveys for early detection of the outbreak. The model minimizes time to first detection and overall damage from an outbreak in a landscape and accounts for decision-making aspirations towards worst-case outcomes. We apply the model to allocate early detection surveys of Asian longhorned beetle in the Greater Toronto Area, Canada. Our approach is focused to support early detection programs for novel invasive pests and pathogens

3 - A Multi-stage Stochastic Optimization Approach to Cost-effective Surveillance and Control of Biological Invasions

Eyyub Kibis, The College of Saint Rose, Albany, NY, United States, eyyubyunus@gmail.com, Esra Buyuktahtakin, Robert G. Haight, Kathleen S. Knight, Charlie Flower

In this study, we develop a new multistage stochastic programming model, which considers all possible scenarios for surveillance, treatment, and removal decisions over a planning horizon to control the emerald ash borer invasion in North America. Our objective is to maximize the net benefits of the ash trees on a given landscape by applying surveillance to the ash population, followed by treatment or removal of trees based on their infestation level. Due to the model's complexity, we develop new cutting planes to facilitate the solution process. Results provide insights into surveillance and control policies, and provide an optimal strategy to minimize EAB infestation with scarce resources.

■ TB64

370E

Retail Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Matthew A. Lanham, Purdue University, 403 W. State St., KRAN 466, West Lafayette, IN, 47907, United States, lanhamm@purdue.edu

1 - Assortment Optimization with Big Data: Weather, Social, Halo and Cannibalization

Victor Pereira, IBM, Columbus, OH, United States, vpereira@vt.edu

This talk showcases a complex and time-constrained data science project to optimize deodorant assortments at dozens of demographics-grounded store clusters. The project was sponsored by a CPG manufacturer on behalf of two major retailers and leveraged the effect of hyperlocal weather, changes in consumer sentiment towards product attributes, cluster-level halo and cannibalization, and minimum inventory for high-velocity SKUs. Over a billion rows of data occupying nearly 5TB were analyzed during this 8-week proof of concept. Model outputs matched the opinions of CPG experts at the product attribute level.

2 - Examining Multi-classification Methods for Consumer Choice
Matthew A. Lanham, Purdue University, West Lafayette, IN, United States, lanhamm@purdue.edu

This study examines multi-classification methodologies that a retailer might employ to gauge the propensity a product might sell when purchase substitution is inevitable. This study is important because retailers are routinely reevaluating the mix of products they offer consumers and often use predictive models that enable them to estimate the substitutability of their products. We model the substitution propensity for a set of products using a national retailer's data using common and less-common multi-classification methodologies and compare the results. We highlight where certain models perform better than others and discuss our future extensions of this study.

3 - A Two-stage Learning Approach to Improve New Item Forecasts in Retail
Inderjeet Singh, Infor Inc., Atlanta, GA, 30309, United States, Inderjeet.Singh@infor.com, Ronald P. Menich, Ashwin Mishra

Forecasting new items for planning, vendor ordering, pricing, allocation and replenishment functions is a challenging problem in retail. To forecast new items, legacy forecasting solutions require users to manually set up one or more clone item(s), leading to a tedious process. At Infor, we use an in-house implementation of Factorization Machines to generate more accurate forecasts. Our attribute-based demand forecasting solution offers clone free forecasts for new items. We recently implemented a simple two-stage learning approach to further improve our new item forecasts. We present real-life examples to elaborate the approach and talk about an implementation experience.

4 - Estimating Demand for Substitutable Products when Inventory Records are Unreliable
Daniel Waymouth Steeneck, Air Force Institute of Technology, WPAFB, OH, United States, steeneck@mit.edu, Fredrik Eng-Larsson, Francisco J. Jauffred

We present a procedure for estimating demand for subsitutable products when the inventory record is unreliable and only validated infrequently and irregularly. The procedure uses a structural model of demand and inventory progression, which is estimated using a modified version of the EM algorithm.

■ TB65

370F

Same-Day Delivery Logistics

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Ozlem Ergun, o.ergun@northeastern.edu

Co-Chair: Necati Duman, duman.n@husky.neu.edu

1 - A Robust Optimization Approach for Crowdsourcing Last-mile Deliveries
Soraya Fatehi, University of Washington, 5215 15th Avenue, Apt 15, Seattle, WA, 98105, United States, sfatehi@uw.edu, Michael R.Wagner

We study a robust optimization model of last-mile deliveries motivated by the Amazon Flex and Uber Eats programs. In these applications, the crowd is utilized for last-mile deliveries. We derive the optimal usage of the crowd to supplement traditional delivery options, to minimize the delivery cost per package, under delivery window constraints.

2 - Peer-to-Peer Transshipment in On-demand Same Day Delivery
Jane Lin, University of Illinois-Chicago, 842 W. Taylor Street (M/C 246), Chicago, IL, 60607, United States, janelin@uic.edu

In light of the emerging on-demand, same-day (ODSD) delivery service market, this study proposes, formulates, and evaluates a new ODSD delivery strategy using direct peer-to-peer transshipment (P2PT). P2PT involves direct en-route package relays among multiple couriers to extend beyond the normal service range of a single courier in order to reach the package's final destination. Our results show that P2PT improves initially with the economy of scale, and then flattens out in the static demand scenario or worsen in the real-time demand scenario. Compared with direct shipping, P2PT is shown a low cost strategy for the ODSD service with the economy of scale.

3 - Order Acceptance Mechanisms for Same-Day Delivery
Mathias A. Klapp, Pontificia Universidad Catolica de Chile, Santiago, 7820436, Chile, maklapp@ing.puc.cl, Alan Erera, Alejandro Toriello

We study same-day delivery by formulating the Dynamic Dispatch Waves Problem with Immediate Acceptance that models integrated request management and order distribution decision-making where delivery requests arise dynamically throughout the day. When a request arises, a decision is made immediately to accept (offer service) or reject (with a penalty). All accepted requests are included in dynamically-updated dispatch plans that serve each request by the end of the day. We provide computational experiments that estimate a cost increase of 4.4% when imposing immediate order acceptance.

4 - A Study to Improve Routing Precision in Same Day Delivery
Necati Oguz Duman, Northeastern University, Boston, MA, United States, duman.n@husky.neu.edu, Mehmet Talha Dulman, Ozlem Ergun

Most of the studies on vehicle routing problems assume that distances between nodes are given as parameters and they are accurate. However, in most real world applications, the nodes are given and distances between each pair must be acquired either from a map provider or with an approximation method. In this study, we analyze the relationship between driving distance and straight line distance and provide a regression model to predict the driving distance. To test the efficiency of our model, we use a simple routing algorithm with clustering and insertion methods in construction and several local search methods in improvement phases.

■ TB66

371A

TSL Special Session

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Lavanya Marla, U of Illinois at Urbana-Champaign, 104 S Mathews Avenue, Room 216E, Urbana, IL, 61801, United States, lavanyamarla@cmu.edu

1 - TSL Lifetime Achievement Award Winner
Lavanya Marla, U of Illinois at Urbana-Champaign, 104 S. Mathews Avenue, Room 216E, Urbana, IL, 61801, United States, lavanyam@illinois.edu

The TSL Lifetime Achievement Award winner, announced in the TSL Business Meeting on Monday, will present a plenary address to the TSL community.

■ TB67

371B

Tutorial: Analytics Applications for Additive Manufacturing

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Linkan Bian, Mississippi State University, 260 McCain Building, 260 McCain Building, Mississippi State, MI, 39762, United States, bian@ise.msstate.edu

Chair: Alaa Elwany, Texas A&M University, 3131 TAMU, College Station, TX, 77843-3131, United States, elwany@tamu.edu

1 - Tutorial: Analytics Applications for Additive Manufacturing
Linkan Bian, Mississippi State University, Industrial and Systems Engineering Department, P.O. Box 9542, Mississippi State University, MS, 39762, United States, bian@ise.msstate.edu, Alaa Elwany

Data analytics is playing a key role in advancing numerous research and application areas. Additive manufacturing is a particular area that can benefit greatly from data-driven analytics and predictive modeling, especially when properly integrated with relevant physics-based models and experimental methods. This tutorial will take a deep dive into how tools of data analytics can be applied in the modeling, analysis, and control of Additive Manufacturing processes. Topics in process planning and optimization, materials informatics, process monitoring, and quality control will be the focus of the tutorial.

■ TB68

371C

Joint Session QSR/ENRE Electricity: Prediction and Optimization in Electric Power Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Jinkoo Park, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea, Republic of, jinkyoo.park@kaist.ac.kr

Co-Chair: Eunshin Byon, University of Michigan, 1205 Beal Avenue, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States, ebyon@umich.edu

1 - Characterization of Lithium-ion Battery Model Uncertainty for Effective Battery SOC Estimation

Zhimin Xi, University of Tennessee-Knoxville, 851 Neyland Dr, 517 JDT, Knoxville, TN, 37996, United States, zxi1@utk.edu

Equivalent circuit models (ECMs) are major models employed in current battery management systems (BMS) for battery SOC estimation due to its high computational efficiency. However, fidelity of the ECMs varies for different battery operating conditions, thus often resulting in inaccurate battery SOC estimation. In this paper, approaches are developed to characterize the model uncertainty of an ECM under various battery operating conditions. Fidelity of the ECM is hence further improved without giving up the high efficiency of the model for onboard battery SOC estimation. Comparison study is conducted for the SOC estimation using the proposed approach and conventional method.

2 - Optimal Personnel Deployment Strategy for Self-perform Maintenance on Wind Farms

Jason Kriel Lawley, Texas A&M.University-College Station, 3780 Copperfield Drive, Apt 325, Bryan, TX, 77802, United States, jsnlawley@tamu.edu

Turbine maintenance is a major cost and key determinant of wind farm productivity. Many companies outsource critical maintenance while others perform these tasks in-house, referred to as self-perform maintenance. While expected to reduce time to profit on asset investment, self-perform requires an efficient personnel deployment strategy, proposed as the following: a balanced scorecard aligning data driven performance indicators to O&M deliverables, an optimization package delivering daily maintenance tasks paired with ideal teams of technicians, and a simulation model demonstrating implementation benefits. Development, features, and results of this strategy will be discussed.

3 - Adaptive Importance Sampling for Extreme Load Estimation in Wind Turbines

Qiyun Pan, University of Michigan, 1205 Beal Avenue, Department of IOE, Ann Arbor, MI, 48109-2117, United States, qiyun@umich.edu, Eunshin Byon, Henry Lam

To help wind turbine reliability analysis in a design stage, aeroelastic simulators have been developed to generate stochastic load responses imposed on a wind turbine. However, crude Monte Carlo sampling to simulate the extreme load associated with a small load exceeding probability is computationally prohibitive, and the estimation results are highly uncertain. We develop an adaptive importance sampling algorithm to iteratively refines the importance sampling density to efficiently estimate the extreme load.

4 - Game Theory Based Distributed Control Algorithm for Energy Storage Systems

Jinkyoo Park, Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of, jinkyoo.park@kaist.ac.kr, Heechang Ryu

We construct a game theoretic framework that can model the strategic interactions between the grid operator and energy users. The grid operator seeks to maximize their profit and reduce the peak load by applying demand response strategies, such as changing energy price. On the other side, the users aim to minimize their energy consumption costs by optimally operating ESSs that can charge the energy when the price is low and discharge the energy when the demand and price are high. With the constructed game model, we derive the equilibrium strategy for both grid operator and users that can lead the minimize energy consumption cost for the users and the reduced peak load for the grid operator.

■ TB69

371D

Vehicle Routing

Contributed Session

Chair: M'Hallah Rym, Kuwait University, P.O. Box 5969, Kuwait, 13060, Kuwait, rymmha@yahoo.com

1 - Research and Optimization of Facility Layout in Passenger Transfer Hall of Shapingba Transport Hub Based on Legion Simulation

Anjun Li, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, siyu.tao@okstate.edu, Qiyuan Peng, Qiyuan Peng, Siyu Tao, Siyu Tao, Siyu Tao

Transfer hall plays a significant role in transport hub, determining the hub's operating and evacuation efficient. Legion software is used to create the model and simulate pedestrians' movement in transfer hall of Shapingba transport hub. According to the simulation result, the existing layout scheme of various facilities in the hall is evaluated, and some possible congestion points are identified. Ultimately, some optimization suggestions, from the view of convenient transfer, are proposed.

2 - Generating Delivery Plans in Real Time by Dynamically Evaluating Multiple Scenarios

Yihuan Yang, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, Kowloon, Hong Kong, yyangax@connect.ust.hk, Xiangtong Qi

Many Internet sellers now commit a very short lead-time for delivery upon the confirmation of orders. This requires to generate a delivery routing plan in real time. This paper presents a solution framework that dynamically traces the buyers' ordering process. The core is a genetic algorithm designed to consider multiple possible delivery scenarios at the same time. It generates a pool containing situations which are more likely to happen and adjusts the pool according to current customers' purchasing progress. With consideration of possible scenarios in advance, a delivery route with low cost can be obtained immediately after the cutoff time.

3 - Branch-cut-price Algorithm for the Traveling Salesperson Problem with Hotel Selection

Luiz Henrique Barbosa, UFF, Niteroi, Brazil, luizhsb@gmail.com, Eduardo Uchoa

The Traveling Salesperson Problem with Hotel Selection (TSPHS), a natural extension of the classic Traveling Salesperson Problem, has only recently been introduced to the literature. Current approaches focus mainly in metaheuristic techniques. The lack of a robust a exact algorithm limits the extent to which this problem can be studied. This work proposes a sophisticated branch-cut-and-price algorithms, including recent techniques like ng-route pricing and limited memory subset row cuts. Computational results show that medium-sized instances can be solved.

4 - A Matheuristic Approach to the Orienteering Problem with Service Time Dependent Profits

Qinxiao Yu, Tianjin University, 92# Weijin Road Nankai District, Tianjin, China, yuqinxiao@tju.edu.cn

This paper addresses the orienteering problem with service time dependent profits (OPSTP), in which the profit collected at each vertex is characterized by a nonlinear function of service time, and the objective is to maximize the total profit by determining a subset of the vertices to be visited and assigning appropriate service time to each of them respecting to time budget. To solve this problem, we formulate a mixed integer nonlinear programming model and propose a two-phase matheuristic algorithm. Extensive numerical experiments are conducted for small and large scale instances. The results show that our proposed algorithm can be quite effective in finding good-quality solutions.

5 - A Hybrid Constraint Programming Very Large Neighborhood Search for Vehicle Routing Problems with Multiple Time Windows

M'Hallah Rym, Professor, Kuwait University, P.O. Box 5969, Safat, Kuwait, 13060, Kuwait, rymmha@yahoo.com

This paper models the vehicle routing problem with multiple time windows as a constraint program, and solves easy instances exactly. It approximately solves difficult instances using a hybrid iterated very large neighborhood search and a constraint programming heuristic. It obtains near-optimal feasible solutions that respect the time windows of the clients and depot as well as the capacity and load constraints of the vehicles. The computational investigation highlights the benefits of the hybridization as well as the cost saving it induces.

■ TB70

371E

Data Mining

Contributed Session

Chair: Gianluca Gazzola, Rutgers University, Piscataway, NJ, United States, ggazzola@rutgers.edu

1 - Deep Causal Inference

Yuanyuan Shen, Stanford Graduate School of Business, 10 Comstock Circle, Apt 325, Stanford, CA, 94305, United States, yyshen@stanford.edu

Kiva is an online non-profit microfinance platform that raises funds for the poor. To raise funds as fast as possible, borrowers have the option to form groups and post loan requests in the name of groups. While group loans pose less risk for investors than individual loans do, we study whether this is the case in a philanthropic online marketplace. We measure the effect of group loans on funding time and control for the loan sizes and other factors. Because loan descriptions play an important role in lenders' decision process on Kiva, we make use of this information through deep learning in natural language processing. We find that on average, forming group loans speeds up the funding time by at least two days.

2 - Uber Demand Modeling

Amir Mousavi, George Washington University, 475 K.St NW, Apt 419, Washington, DC, 20001, United States, ahmn00@gmail.com

Undoubtedly, UBER has become one of the most significant startups of the 21st century. Despite the simple and user-friendly interface, UBER runs complex processes behind the scenes. it is crucial to understand the demand; more specifically, the demand distribution in order to calculate the optimal price. This project uses historical data to determine the demand distribution at given times and locations.

3 - Analysis of Feature Extraction and Feature Selection Impact on Angiographic Disease Diagnosis Accuracy

Amirhossein Koneshloo, Texas Tech University, Lubbock, TX, United States, amir.koneshloo@ttu.edu

This study investigates the importance of appropriate Feature Extraction (FE) and Feature Selection (FS) to improve Angiographic disease diagnosis accuracy with multivariate statistical analysis such as kernel PCA. The data for this analysis comes from the Cleveland Clinic Foundation. Widely-used techniques, i.e. Support Vector Machine and Cross Validation, are applied for data classification and performance evaluation, respectively.

4 - Frequent Temporal Pattern Mining with Extended Lists

Anton Kocheturov, Research Assistant, Department of Industrial and Systems Engineering, UF, 2600 SW. Williston Road, Apt 707, Gainesville, FL, 32608-3949, United States, antrubler@gmail.com

In this paper we consider Temporal Pattern Mining (TPM) for extracting predictive class-specific patterns from multivariate time series. We suggest a new approach that extends usage of the apriori property which requires a more complex pattern to appear only at places where all its subpatterns appear as well. It is based on tracking positions of a pattern inside records in a greedy manner. We demonstrate that it outperforms the previous version of the TMP on several real-live data sets independent of the way how the temporal pattern is defined.

5 - Incremental Feature Importance Ranking for Mixed Classification Tasks

Alaleh Razmjoo, PhD Student, University of Central Florida, 4000 Central Florida Blvd, Orlando, FL, 32816, United States, Orlando, FL, 32816, United States, alaleh.razmjoo@knights.ucf.edu

Online data mining methods are normally adaptations of classical data mining techniques for learning in an incremental fashion. In this paper, we present a method for online feature importance ranking in online classification tasks. In this method, the merit of features is based on their impact on the classification outcome. Unlike available algorithms, our method could be applied for both continues and categorical features, without a need to discretization of the input. To evaluate the merits of the proposed method, we performed experiments on benchmark datasets. Primary experiments show promising results compared with available methods.

6 - Clustering-conditional-importance Variable Selection with Random Forests

Gianluca Gazzola, Rutgers University, 100 Rockafeller Road, 5th floor, Piscataway, NJ, 08854, United States, ggazzola@rutgers.edu

We present a variable selection algorithm that employs a novel variant of random-forest conditional-permutation-importance measure. This measure permutes observations within groups obtained by clustering, via a criterion defined by the structure of dependencies existing among variables, in order to eliminate unimportant and/or redundant predictors. The algorithm outperforms several other permutation-importance variable selection algorithms on both artificial and real-world data sets.

■ TB71

371F

Black-box or Simulation Optimization

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Zelda B Zabinsky, University of Washington, Seattle, WA, 98195-2650, United States, zelda@u.washington.edu

1 - A Two-time-scale Random Search Algorithm for Global Optimization

Qi Zhang, Stony Brook University, SUNY, Stony Brook, NY, 11794, United States, qi.zhang.1@stonybrook.edu, Jiaqiao Hu

We propose a random search algorithm for solving black-box optimization problems. The algorithm iteratively finds improved solutions by modifying and sampling from a probability distribution over the solution space. In contrast to existing algorithms in the class, which are mostly population-based, our approach employs a two-time-scale stochastic approximation idea and uses only a single candidate solution per iteration. We establish global convergence of the algorithm and present numerical results to illustrate its performance.

2 - An Epsilon-constraint Method for Integer-ordered Bi-objective Simulation Optimization

Kalyani S. Nagaraj, Oklahoma State University, 322 Engineering North, Industrial Engineering & Mgmt, Stillwater, OK, 74078, United States, kalyani.nagaraj@okstate.edu, Kyle Cooper, Susan R.Hunter

Consider the context of integer-ordered bi-objective simulation optimization, in which the feasible region is a finite subset of the integer lattice. We propose a retrospective approximation (RA) framework to identify a local Pareto set that involves solving a sequence of sample-path bi-objective optimization problems at increasing sample sizes. We apply the epsilon-constraint method to each sample-path bi-objective optimization problem, thus solving a sequence of constrained single-objective problems in each RA iteration. Our algorithm displays promising numerical performance.

3 - Parallel Simultaneous Perturbation Optimization

Atiye Alaeddini, Institute for Disease Modeling, 3150 139th Ave SE, Bellevue, WA, 98005, United States, aalaeddini@idmod.org, Atiye Alaeddini

Optimization is a common problem in stochastic simulations. The objective function, however, is time-intensive to evaluate, and cannot be directly measured. Individual realizations of the model are corrupted by noise. We consider the problem of optimizing the expected value of an expensive black-box function, from which observations are corrupted by Gaussian noise. We present Parallel Simultaneous Perturbation Optimization (PSPO), which takes advantage of parallel computing resources, like high-performance cloud computing. PSPO algorithm takes fewer time-consuming iterations to converge, automatically chooses the step size, and can vary the error tolerance by step.

4 - Sampling within Adaptive Level Set Approximations for Black-box Global Optimization

David Desmond Linz, University of Washington, 5246 NE 15th Avenue, Apt 101, Seattle, WA, 98105, United States, ddlinz@gmail.com, Zelda B.Zabinsky

Several random search approaches (e.g., pure adaptive search) have been shown to be effective for global optimization with expected performance that increases linearly with dimension. We explore a practical implementation that uses models in order to sample from a series of nested level set approximations. The paper describes a method for adjusting quantile levels and parameters to achieve a probability of successfully sampling within each level set. We explore the application of this framework to various model-based sampling methods. We discuss theoretical bounds for convergence and pair the results with numerical examples.

■ TB72

372A

Transportation Network Analysis

Sponsored: Optimization, Network Optimization

Sponsored Session

Chair: Bahar Cavdar, Middle East Technical University, Atlanta, GA, 30308, United States, bcavdar@metu.edu.tr

1 - A Traveling Repairman Problem with Job Dependencies

Feng Qiu, fqiu@anl.gov, Bahar Cavdar

Electricity service in power distribution network is often disrupted by various events (such as accidents and extreme weather). Many of the service disruptions are a result of physical damages of electrical components and require repair. We consider a power distribution network restoration problem with repair crew routing. We first present the description of the problem and its variations, and give a formulation in a general form. Then, we discuss the computational complexity of the problem. We present solution approaches and computational results.

2 - A Network-level Lane-based Mesoscopic Traffic State Estimation and Prediction Framework

Kerem Demirtas, Arizona State University, 699 S. Mill Ave. Tempe, Brickyard Engineering 553, Tempe, AZ, 85281, United States, kdemirta@asu.edu

Microscopic traffic models consider the interaction of individual vehicles with nearby vehicles as well as the transportation infrastructure in a very detailed resolution for a short-term horizon. On the other hand, in mesoscopic models, vehicles are considered either individually or in platoons, and how they move through the links of the network are governed by macroscopic traffic conditions. In this research, we propose a mesoscopic simulation framework that can enable traffic state estimation in a lane-level resolution for a network of connected links with multiple lanes. Preliminary results based on synthetic ground truth data generated by VISSIM are presented.

3 - Multiple Scenario Planning Approach for Two-stage Stochastic Team Orienteering Problems

Yongjia Song, Virginia Commonwealth University, 1015 Floyd Avenue, P.O. Box 843083, Richmond, VA, 23284, United States, ysong3@vcu.edu, Marlin Wolf Ulmer, Barrett Thomas, Stein W. Wallace

In this talk, we discuss study the multiple scenario planning approach in dynamic vehicle routing problems, from a stochastic programming perspective. In particular, we illustrate our preliminary findings using two-stage stochastic orienteering problems as test instances.

4 - A Tabu Search Heuristic for the Vehicle Routing Problem with Soft Time Windows under Fairness and Customer Service Perception Considerations

Bahar Cavdar, Middle East Technical Univeristy, Ankara, Turkey, bcavdar@metu.edu.tr, Joel Sokol

For vehicle routing problems with time windows, soft time window assumptions provide more opportunity to study the tradeoff between the efficiency-based objectives such as number of vehicles, travel distance and the objectives reflecting the customers' satisfaction such as total time window violation, number of violations. In this study, we develop a new tabu search heuristic for the vehicle routing problem with soft time windows. In addition to the traditional objectives, we also consider fairness and resulting service quality perception assuming that customers share information through word of mouth communication.

■ TB73

372B

A Short Introduction to Quantum Computing for the OR Community

Invited: Operations Research and the Future of Computing

Invited Session

Chair: Lior Horesh, IBM TJ Watson, Ossining, NY, 10562, United States, lhoresh@us.ibm.com

Co-Chair: Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY, 10598, United States, giacomo.n@gmail.com

1 - A Short Introduction to Quantum Computing for the OR Community

Giacomo Nannicini, IBM.T.J. Watson, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States, giacomo.n@gmail.com

Quantum computers have usually been considered unattainable devices, but quantum computing has come a long way since its inception in the 1980s. Indeed, universal quantum computers of small size are now available for general use - in the case of IBM's Quantum Experience, even for free. So what is a quantum computer, and what can it do differently from classical computers? In this tutorial we will describe the paradigm underpinning the behavior of quantum computers, treating quantum computers as purely mathematical objects. We will use a simple gate model and show the basic ideas underlying quantum algorithms more closely related to operations research. This introduction does not require any prior knowledge of physics, and will, in fact, not discuss any quantum physics at all. However, it requires some familiarity with linear algebra on complex vector spaces

■ TB74

372C

New ICS

Sponsored: Computing

Sponsored Session

1 - Embedded Code in GAMS - using Python as an Example

Michael R. Bussieck, GAMS, Washington, DC, United States, MBussieck@gams.com, Lutz Westermann

This talk is about a recent extension of the General Algebraic Modeling System (GAMS): The "Embedded Code" facility. With the data model used by GAMS, code for parallel assignment and equation definition is compact, elegant, and efficient. However, traditional data structures (arrays, lists, ...) are not natively available. Though it is possible to represent such data structures, the GAMS code can become unwieldy or inefficient. To overcome this and other issues, the Embedded Code facility was introduced recently. It allows the use of external code (e.g. Python) to access GAMS symbols in memory, so that the user can concentrate on the task at hand and not the mechanics of moving data in and out of GAMS.

2 - Integrating Optimization Modeling with General-purpose Programming for Efficient and Reliable Application Deployment

Robert Fourer, AMPL.Optimization Inc., 2521 Asbury Ave, Evanston, IL, 60201, United States, 4er@ampl.com, Filipe Brandao, Christian Valente

We describe a new framework that combines the advantages of modeling in a specialized optimization environment and of coding in a general-purpose programming language. Models are formulated concisely and naturally in AMPL, promoting ease of development, reliability of maintenance, and experimentation with solvers and data sources. APIs for a variety of full-featured programming languages permit AMPL models and scripts to be embedded into complex applications, gaining access to extensive libraries for data management and interface development. We illustrate the possibilities with two roll-cutting examples using Python, and a collaborative optimization environment built in Java.

3 - Optimizing in the Cloud – Deploying Optimization Models on the Cloud with Web Services REST API's

Bjarni Kristjansson, Maximal Software Inc., 2111 Wilson Boulevard, Suite 700, Arlington, VA, 22201, United States, bjarni@maximalsoftware.com

Over the past decade the IT has been moving steadfastly towards utilizing software on clouds using Web Services REST API's. The old traditional way of deploying software on standalone computers is slowly but surely going away. In this presentation we will demonstrate the MPL REST Server, which allows optimization models to be easily deployed on the cloud. By delivering optimization through a standard REST API, which accepts data in JSON format, the optimization becomes purely data-driven. Client applications can now be implemented relatively easily on different client platforms such as mobile/tablets or web sites, using just standard HTML/CSS with JavaScript, or any other preferred programming language.

4 - Min Cost Optimization for an Epic Major League Baseball Road Trip

Christopher Santos, United States Navy, OPNAV. N81 Assessment Division, 2000 Navy Pentagon, Rm 4D453, Washington DC, DC, 20350-2000, United States, christopher.p.santos@navy.mil

Baseball is America's Pastime and is the inspiration for many a childhood dream. What better way to be a fan of the game than to get a group of good friends together for an epic road trip to watch a game at all 30 Major League Baseball ballparks? While there exist online tools to minimize the number of days to accomplish such a trip, we wanted to optimize cost, but with our own custom constraints and requirements (read: make the trip fun and not grueling).The initial implementation of our optimization routine was performed using Python and GAMS with the CPLEX solver. We are currently porting over our model to Python and Pyomo with an open-source CBC solver.

■ TB75

372D

Nonlinear Optimization Algorithms

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Frank Edward Curtis, Bethlehem, PA, 18015, United States, frank.e.curtis@gmail.com

Co-Chair: Andreas Waechter, Northwestern University, Evanston, IL, 60208, United States, waechter@iems.northwestern.edu

1 - Failure of the Gradient Method on Nonsmooth Convex Functions

Azam Asl, NYU, 251 Mercer St., New York, NY, 10012, United States, aa2821@nyu.edu, Michael L.Overton

Motivated by the success of the BFGS method on nonsmooth functions, along with the difficulty of analyzing this phenomenon, we consider the behavior of the simpler gradient method on nonsmooth problems. We give an analysis of the gradient method with an Armijo-Wolfe inexact line search on the function $f(u,v)=alul+v$ where $a > 0$. We show that if a certain constant C, depending only on a and the Armijo parameter, is positive then the method converges to a point $(0, \bar v)$, although f is unbounded below. In contrast if $C \le -0.5$ then the points generated are unbounded below. Experimental results demonstrate that our analysis is reasonably tight.

2 - Logical Benders Decomposition for Quadratic Programs with Complementarity Constraints

Francisco Jara-Moroni, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States, franciscojaramoroni2013@u.northwestern.edu, Andreas Waechter, John E. Mitchell, Jong-Shi Pang

We study a logical Benders decomposition approach to solving binary-constrained quadratic programs with linear complementarity constraints. It is based on a satisfiability master problem to which feasibility cuts are added that are computed from primal and dual subproblems for chosen complementarity pieces and binary variables. Interpreting the logical Benders decomposition approach from a branch-and-bound point of view, we propose several new methods for strengthening the feasibility cuts and guiding the master problem solution. Their efficiency is assessed by numerical experiments.

3 - An Algorithm for Optimization Problems with Joint Chance Constraints using a Nonlinear Value-at-risk Formulation

Alejandra Pena-Ordieres, Northwestern University, Evanston, IL, United States, alejandra.pena@u.northwestern.edu, Andreas Waechter

In this work, we are presenting a nonparametric reformulation of an optimization problem with chance constraints. The probabilistic constraints will be redefined as the Value-at-Risk (VaR) and a smoothing technique will be applied on the historical empirical quantile via a Kernel. This method results in an approximation of the quantile function that reduces the nonconvexity of the feasible region derived from the empirical quantile approximation. Some computational results are included.

4 - A Trust Funnel Algorithm for Equality Constrained Nonconvex Optimization

Mohammadreza Samadi, PhD Candidate, Lehigh University, Bethlehem, PA, 18015, United States, mos213@lehigh.edu, Frank E. Curtis, Daniel Robinson

A method is proposed for solving equality constrained nonlinear optimization problems. The method employs a trust funnel approach consisting of two phases: a first phase to locate an ϵ-feasible point and a second phase to seek optimality while maintaining ϵ-feasibility. A two-phase approach of this kind based on a cubic regularization methodology was recently proposed, which completely ignores the objective function in the first phase. Our method achieves the same worst-case iteration complexity, but with a first phase that also accounts for improvements in the objective function. As such, the method requires fewer iterations, as the numerical experiments demonstrate.

■ TB76

372E

10:30 - 11:15 Responsive Learning Technologies/11:15- 12:00 FICO

Invited: Vendor Tutorial

Invited Session

1 - Online Games to Teach Operations and Supply Chain Management

Samuel C.Wood, Responsive Learning Techologies, 4546 El Camino Real, #243, Los Altos, CA, 94022, United States, wood@responsive.net

Littlefield Technologies, the Supply Chain Game, and the Sourcing Game are online competitive assignments used to teach topics including process analysis, inventory control, supply chain management, and sourcing and purchasing. We will describe the games' learning objectives, typical assignments, and actual game results.

2 - How to Deploy Your Analytic Models to Empower Non-Technical Business Users

James Williams, FICO, Roseville, MN, United States, JWilliams@fico.com

You have a team with great analytics background. They have developed advanced analytical tools using Python, R, or with your current traditional optimization solver. They have derived crucial insights from your data, and figured out how your decisions shape your customers' behaviors. Now it's time to put these critical analytical insights in the hands of your non-technical business users. In this tutorial, we will cover how FICO's Optimization Suite (including Xpress-Mosel, Xpress-Workbench, and Xpress-Insight) make it possible to embed your analytic models in user-friendly business-user facing applications. Learn how you can supercharge your analytic models with simulation, optimization, reporting, what-if analysis and agile extensibility.

■ TB77

372F

New Results for Coordinate Descent and Related Methods for Convex Optimization

Sponsored: Optimization, Linear and Conic Optimization

Sponsored Session

Chair: Robert Michael Freund, MIT, Cambridge, MA, 02139, United States, rfreund@mit.edu

Co-Chair: Haihao Lu, MIT, Cambridge, MA, 02142, United States, haihao@mit.edu

1 - Pathwise Coordinate Optimization for Nonconvex Sparse Learning

Tuo Zhao, Georgia Tech, Atlanta, GA, United States, tourzhao@gatech.edu

Nonconvex optimization arises in many machine learning problems. Although classical optimization theory has shown that nonconvex optimization is computationally intractable, practitioners have proposed numerous heuristic algorithms, which achieve outstanding performance in real-world applications. To bridge this gap between practice and theory, we propose a new generation of model-based optimization algorithms and theory, which incorporate the statistical thinking into modern optimization. We exploit hidden geometric structures behind nonconvex optimization problems, and obtain global optima with desired statistics properties in polynomial time with high probability.

2 - Relatively-continuous Convex Optimization via Mirror Descent Algorithm

Haihao Lu, MIT, 60 Wadsworth St, Apt.14E, Cambridge, MA, 02142, United States, haihao@mit.edu

The usual approach to developing and analyzing first-order methods for non-smooth convex optimization assumes that the objective function is uniformly Lipschitz continuous. However, in many settings the non-differentiable convex function is not uniformly Lipschitz continuous. Herein we develop a notion of "relative continuity" that is determined relative to a user-specified "reference function" (that should be computationally tractable for algorithms), and we show that many non-differentiable convex functions are relatively continuous with respect to a correspondingly fairly-simple reference function. We use mirror descent algorithm for solving problems in this setting.

■ TB78

381A

Leveraging OR to Assess and Enhance Power Systems Resilience

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Roshi Nateghi, rnateghi@purdue.edu

1 - Assessing Changes in Residential Electric Power Consumption Due to Emerging Changes in Climate and Technology

Hua Cai, Purdue University, West Lafayette, IN, 47907, United States, huacai@purdue.edu, Roshanak Nateghi, Ruoxi Wen, Benjamin Rachunok

The electricity sector - particularly the residential sector - is undergoing significant transformations due to the emerging changes in technology (e.g., distributed generation, electric vehicles), policy, and climate. However, the existing energy systems models (e.g., NEMS, MARKAL) are highly deterministic and do not adequately account for the uncertainties associated with future climate or technology adoption scenarios. Using agent-based models, we aim to estimate the residential electricity use over the next 30 years, considering not only the energy demand for space conditioning with different housing characteristics, but also the adoption and use of EV and PV at the household level.

2 - Assessing Residential Power Inadequacy Risks in the U.S.

Roshanak Nateghi, Purdue University, West Lafayette, IN, 47907, United States, rnateghi@purdue.edu

The US power system is increasingly vulnerable to adverse impacts of extreme weather and climate events. Supply inadequacies can result from unanticipated climate-induced shifts in demand. This talk is primarily focused on the risks associated with deviated residential demand patterns due to climate variability and change. A data-driven approach is leveraged to identify and assess the risk factors that render the residential electricity sector vulnerable in face of future climate variability and change. The proposed method, can be used by the energy professionals and regulators to design effective mechanisms to minimize supply inadequacy in face of climate variability and change.

3 - Enhancing Resilience of the Electric Power Sector after Hurricane Sandy

Cameron MacKenzie, Iowa State University, 3029 Black Engineering, Industrial and Manufacturing Systems Eng, Ames, IA, 50011, United States, camacken@iastate.edu, Christopher Zobel

This talk presents a framework to help a decision maker allocate resources to increase his or her organization's resilience to a system disruption, where resilience is measured as a function of the average loss per unit time and the time needed to recover full functionality. Enhancing resilience prior to a disruption involves allocating resources from a fixed budget to reduce the value of one or both of these characteristics. The optimization model is applied to an example of increasing the resilience of an electric power network following Superstorm Sandy.

4 - Parallel Computing of Stochastic Programs with Application to Energy System Capacity Expansion

Run Chen, Purdue University, 1399 Neil Armstrong Drive, Apt 7, West Lafayette, IN, 47906, United States, chen885@purdue.edu, Andrew Lu Liu

Power grids' planning and operations exhibit extreme multiscale, ranging from hourly operation to decades of planning. The linkage such decisions can be treated in a primal-dual fashion to produce multiple independent subproblems. We propose to use a primal-dual-based proximal method to design a parallel algorithm to solve such multiscale problems. Convergence can be shown for both convex and non-convex problems. We use the algorithm to demonstrate the importance to consider ramping constraints in finer time-scale in long-term capacity planning with large-scale renewable resources.

5 - Possible Improvements for Generation Reserves to Back-up Wind in the Dutch Electricity Market

Robin Broder Hytowitz, Johns Hopkins University, 3400 North Charles Street, Ames 313, Baltimore, MD, 21218, United States, hytowitz@jhu.edu, Ozge Ozdemir, Paul Koutstaal, Benjamin Field Hobbs

Reserve capacity is needed in an electric system in case of a contingency. With the increased penetration of renewable energy in the Netherlands, a new type of renewable contingency can require additional reserve on the system. The Netherlands currently procures reserve months in advance through long time contracts with little coordination with its neighbors. This project suggests improvements that can be made to the process of procuring, allocating, and activating reserve. A nodal model of Europe is used to analyze the improvements, employing a future scenario with high wind penetration. Comparison of different improvements will elucidate which have the most benefits to the system as a whole.

■ TB78B

380B

Automotive

Contributed Session

Chair: Mark Colosimo, Urban Science Applications, Inc., Detroit, MI, United States, macolosimo@urbanscience.com

1 - Location Optimization Solution in Car Auction Industry

Wennian Li, Data Scientist, Cox Automotive, 18th Floor, 1001 Summit Blvd, Atlanta, GA, 30319, United States, li_wennian@hotmail.com

Cox Automotive is a leading provider of products and services for automotive dealers and car buyers. The company unites 30+ brands, including AutoTrader.com, Kelley Blue Book, Manheim, NextGear Capital, and vAuto, to help transform the way people buy and sell cars. The Location Optimization project helps the sellers to determine where to sell their inventory and gain more profit/ROI without lower the sale through rate and velocity at both wholesale and retail market. We provide a package solution for the seller not only just the suggested solution to locate their inventory, but also interactive interface for the current inventory, market status and suggested solutions.

2 - Using Leading Economic Indicators to Predict Changes in Monthly Car and Light Truck Sales in the United States Market

Karl Majeske, Associate Professor, Oakland Unverisity, School of Business Administration, Rochester, MI, 48309, United States, majeske2@oakland.edu

This research uses economic indicators (e.g., unemployment rates, gas price, consumer confidence, ect.) as independent variables to predict changes in car and light truck sales. Each economic indicator is evaluated in a variety of ways (actual values, monthly change and annual change) to determine the best measure to relate with sales. In addition, the economic indicators are lagged over a collection of time periods to identify the time lag that best correlates it's change to a related change in car and light truck sales. Establishing representations and time lags for a collection of economic indicators will allow determining how to identify an economic signal that future sales will change.

3 - Automobile Logistics Optimization Between Mexico and the United States

Ahad Ali, Associate Professor, Lawrence Technological University, 21000 West Ten Mile Road, 21000 West Ten Mile Road, Southfield, MI, 48075, United States, aali@ltu.edu

The goal of this project is to optimize the logistics of an automobile company between Mexico and the U.S. The logistics involved are the ones between the manufacturing plants of one of these companies in Mexico, how they interact between each other, and how they transport the products from one country to another. The methods that are going to be used are optimization methods and simulation. The possible outcome of this research is to optimize the logistics method one of these companies use in order to reduce costs and time. Optimization techniques and simulation will be done in order to reduce the costs and time of transferring the car parts between plants and countries.

4 - The Future of Autonomous Carsharing - A Delphi Study

Katrin Merfeld, EBS.Universitaet fuer Wirtschaft und Recht, Gustav-Stresemann-Ring 3, Wiesbaden, 65189, Germany, katrin.merfeld@ebs.edu, Mark-Philipp Wilhelms, Karin Kreutzer, Sven Henkel

Autonomous driving is set to disrupt the mobility landscape in the coming years. Academia predominantly examines individual aspects of this novel technology, such as enhanced traffic safety or ethical issues. As individual adoption may be hindered by financial hurdles, autonomous cars will be especially relevant for carsharing practices. We conducted a four-stage Delphi study with 40 international experts from various sectors to elicit drivers, barriers and future developments of carsharing with autonomous vehicles. We discuss our findings and draw implications for managers and further academic research.

5 - Time to Recall Decision Making

Chelsey Helena Hill, Drexel University, Gerri C. LeBow Hall Room #730, 3220 Market Street, Philadelphia, PA, 19104, United States, chh35@drexel.edu, Chaojiang Wu

This paper investigates the impact of the time-to-recall decision on marketing and operations performances in the automobile industry. While we find that the consumer market seems to have little response to the delay of recalls, recall effectiveness deteriorates. This motivates the creation of an analytical model to quantify the impact of this delaying effect on recall costs. Using the estimated relationship between time and effectiveness from our empirical model, we present an analytical model minimizing total recalls costs. The findings reveal that an early recall decision is primarily driven by higher liability costs, and later recall decisions are driven by the cost of sales disruption.

6 - Evaluating the Qualitative Aspects of Automotive Dealerships Alongside Traditional Quantitative Metrics

Mark Colosimo, Urban Science Applications, Inc., 400 Renaissance Center, Suite #2900, Detroit, MI, 48315, United States, macolosimo@urbanscience.com

Quantitative metrics to evaluate automotive dealerships is a practice that has existed and grown over many decades. Now, even more data is available and the number of metrics of Key Performance Indicators is overwhelming to those trying to operate a dealership business. Additionally, these indicators do not tell the whole story. There are many other activities within a dealership that are not measured or require additional research in order to determine their impact on desired outcomes. This study begins to simply what a dealership operator must regularly review to obtain a complete perspective on their operation, while incorporating new analysis via survey results of actual dealership operators.

■ TB79

381B

Railway Operations

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: S Viswanathan, Nanyang Business School, Nanyang Avenue, Singapore, 639798, Singapore, asviswa@ntu.edu.sg

1 - Inspecting Railways for Defects: A Game Theoretic Approach

Pedro Cesar Lopes Gerum, Rutgers University, New Brunswick, NJ, pedro.gerum@gmail.com, Melike Baykal-Gursoy

Train track inspections are important to repair defects that could cause delays or accidents. Even though most train companies have inspection guidelines, there is little research done on optimal track inspection scheduling policies. Our research addresses this issue by using game theoretic concepts to determine the optimal strategy for inspection crews. We define a number of zero-sum hider and searcher games, each with increased complexity. The higher the complexity, the more accurate the strategy represents the true optimal strategy for the problem; however, the more complex the game is, the more data is needed. Additionally, we provide data analysis on train track defects, exemplifying how the parameters for the games can be defined.

2 - Evolution and Development of Railway Passenger Hub

Liwen Wang, Southwest jiaotong University, chengdu, China, siyu.tao@okstate.edu
Liwen Wang, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, siyu.tao@okstate.edu, Qiyuan Peng, Qiyuan Peng, Siyu Tao, Siyu Tao, Siyu Tao

This article studies optimization method of railway passenger hub in the big city of contemporary in China. It reviews evolution stages and its inner dynamic on railway passenger hub in China and abroad, comparatively analyzes the different cases in order to sum up the valuable experience. It shows that railway station in urban centers of China should be both transport nodes and urban places, Urban-Station Complex is its development trend only in necessary given conditions.

3 - Exact and Heuristic Algorithms for the Real-time Train Scheduling and Routing Problem

Marcella Sama, Post-Doc, Roma Tre University, 79 via della Vasca Navale, Roma, 00146, Italy, sama@ing.uniroma3.it, Andrea D'Ariano, Marco Pranzo, Dario Pacciarelli

This talk deals with the real-time train scheduling and routing problem. The problem is NP-hard and finding a good quality solution in a short computation time for practical size instances is a challenging task. We propose a solution approach based on the relaxation of train routing constraints in the formulation. Working in the relaxed problem allows to quickly compute good quality lower bounds, and represents the first step toward the development of a branch-and-bound algorithm for the overall problem. Computational experiments are performed on several networks and disturbed traffic situations.

4 - Railroad Crew Balancing Model

Jaydeep Kumar Chanduka, Masters' Student, University of Illinois, Urbana-Champaign, 1618 Melrose Park Court, Urbana, IL, 61801, United States, jkc2@illinois.edu

In this paper, we are trying to minimize the operational cost of crew balancing in a railroad network by optimizing crew deadhead, crew assignment, and train delay decisions. We assume that there is not always sufficient crew at each terminal for all the trains. Some of the crew must be deadheaded to different terminals while others have to be detained at other terminals to match all the trains. All the major constraints of the railway industry are considered in this paper. Some of them being: mandatory minimum rest, crew ordering, and detention rules. Crew pairing and assignment is a very intensively studied problem in the airline industry but railroad industry has evaded this problem so far. In this paper, the problem is formulated by applying the concept of "virtual crew" and a multi-day time period is studied. The effect of single day model and multi-day model is analysed with one home terminal and a number of away terminals. The results show that multi-day model gives a better performance in terms of objective values and computational time.

5 - Scheduling Trains to Minimize Peak Power and Maximize Regenerative Braking Power Utilization

S. Viswanathan, Professor of Operations Management, Nanyang Technological University, Nanyang Business School, Nanyang Avenue, Singapore, 639798, Singapore, asviswa@ntu.edu.sg, Mahendra Birhade, Rohit Bhatnagar

We address energy-efficient train scheduling for urban Mass Rapid Rail Systems. We formulate and solve an IP model that aims to minimize both peak power and total energy consumption. Test results on real problem instances obtained from the Mumbai Suburban System show that on average our model reduces the peak power demand by 28% and increase the regenerative braking energy utilization by 7.5 % while limiting the average trip time increases to only 2%.

■ TB80

381C

Planning and Operation of Energy and Chemical Hubs with Renewables and Storage

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Kaveh Rajab Khalilpour, Monash University, Melbourne, Australia, kr.khalilpour@monash.edu

1 - Expansion Planning under Long-term Uncertainty for Hydrothermal Systems with Volatile Resources

Álvaro Lorca, Pontificia Universidad Católica de Chile, Departamento de Ingeniería Eléctrica, Av Vicuna Mackenna 4860, Santiago, 7820436, Chile, alvarolorca@uc.cl, Benjamín Maluenda, Matias Negrete-Pincetic, Daniel Olivares

The significant integration of volatile energy sources in power systems stimulates the use of greater operational details in power system expansion planning models. Motivated by this, we will present a stochastic expansion planning model for hydrothermal power systems, including uncertainty in water inflows and using representative days to capture inter-hourly phenomena such as renewable power production profiles and energy storage. Computational experiments showing the advantages of the proposed model for an actual power system will also be presented.

2 - Enhanced Representative Days and System States Modeling for Energy Storage Investment

Diego Alejandro Tejada Arango, Universidad Pontificia Comillas, 23 Alberto Aguilera, Madrid, 28015, Spain, dtejada@comillas.edu, Sonja Wogrin, Efraim Centeno

In this work, we analyze the impact of different options to represent the operation decisions in the study of energy storage (ES) investment for long-term planning models. We compare the representative days and the system-states approaches for the representation of these operation decisions. We proposed enhanced versions of these approaches to improve the ES investment approximation. An Spanish case study isevaluated and the results are used to identify the potential profits that energy storage investment can obtain.

3 - A Risk-averse Approach for the Planning of a Hybrid Renewable Energy System

Ozlem Yilmaz, Bilkent University, Universiteler Mah, Bilkent/Cankay, Ankara, 06800, Turkey, ozlem.yilmaz@bilkent.edu.tr, Ozlem Cavus, Ayse Selin Kocaman

We consider a risk-averse approach to a two stage stochastic programming problem that aims to design a hybrid renewable energy system consisting of solar panels and hydropower stations in a most cost effective way in order to satisfy the demand for energy. We use Conditional Value at Risk (CVaR) as the measure of risk and propose a scenario-wise decomposition algorithm to solve this model. The main source of the randomness is water inflow to the reservoirs. We therefore generate scenarios for inflow using a modified K-NN method developed by Prairie et.al (2006).

■ TB81

382A

Distributionally Robust Optimization: Theory and Applications

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Ruiwei Jiang, University of Michigan, University of Michigan, Ann Arbor, MI, 48109, United States, ruiwei@umich.edu

1 - Distributionally Robust Optimization with Principal Component Analysis

Jianqiang Cheng, University of Arizona, jqcheng@email.arizona.edu, Richard Li-Yang Chen, Habib Najm, Ali Pinar, Cosmin Safta, Jean-Paul Watson

In this talk, we propose a new approximation method to solve distributionally robust optimization problems with moment-based ambiguity sets. Our approximation method relies on principal component analysis (PCA) for optimal lower dimensional representation of variability in random samples. We show that the PCA approximation yields a relaxation of the original problem and derive theoretical bounds on the gap between the original problem and its PCA approximation. Furthermore, an extensive numerical study shows the strength of the proposed approximation method in terms of solution quality and runtime.

2 - Optimized Bonferroni Approximations of Distributionally Robust Joint Chance Constraints

Weijun Xie, Georgia Institute of Technology, 4301 Lakeshore Xing NE, Atlanta, GA, 30324, United States, wxie33@gatech.edu, Shabbir Ahmed, Ruiwei Jiang

In this paper, we study a conservative approximation - referred to as a Bonferroni approximation - of a joint chance constraint, i.e. a chance constraint involving a system of multiple uncertain constraints. We show that such a Bonferroni approximation is exact when the uncertainties are separable across the individual constraints, i.e., each uncertain constraint involves a different set of uncertain parameters and corresponding distribution families. We show that, while in general the optimization over the Bonferroni approximation is NP-hard, there are various sufficient conditions under which it is convex and tractable.

3 - Distributionally Robust Contingency-Constrained Unit Commitment

Chaoyue Zhao, Oklahoma State University, 4599 North Washington Street APT.32J, Stillwater, OK, 74075, United States, cherryzhao09@gmail.com

In this work, we propose a distributionally robust optimization approach for the contingency-constrained UC problem. We consider a case where the true probability distribution of contingencies is difficult to accurately estimate. Instead of assigning a probability estimate for each contingency scenario, we consider a set of contingency probability distributions based on the N - k security criterion and moment information. Our approach considers all possible distributions in the ambiguity set, and is hence distributionally robust. Meanwhile, as this approach utilizes moment information, it can benefit from available data and become less conservative than robust optimization approaches.

4 - Ambiguous Risk Constraints with Moment and Unimodality Information

Ruiwei Jiang, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48109, United States, ruiwei@umich.edu, Bowen Li, Johanna Mathieu

We study risk constraints based on probabilistic guarantee and conditional value-at-risk under distributional ambiguity. We find that these risk constraints can be recast as a set of second-order conic constraints if we characterize the ambiguity based on moment and unimodality information. We demonstrate the theoretical results via a computational case study on power system operations.

■ TB82

382B

Parallelization and Evaluation of Stochastic Programming Algorithms

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Jean-Paul Watson, Sandia National Laboratories, Albuquerque, NM, 87113-2065, United States, jwatson@sandia.gov

1 - Parallel Decomposition and Analysis of Contingency-Constrained AC Optimal Power Flow Problems

Jean-Paul Watson, Distinguished Member of Technical Staff, Sandia National Laboratories, 7305 Blue Cypress Avenue NE, Albuquerque, NM, 87113-2065, United States, jwatson@sandia.gov, Carl Laird, Anya Castillo

We present a nonlinear stochastic programming formulation for the contingency-constrained optimal power flow problem. Using a non-linear AC power flow model, we construct a nonlinear, multi-scenario optimization formulation where each scenario considers nominal operation followed by a failure an individual transmission element. Given the number of potential failures in the network, these problems are large, yet must be solved rapidly. We demonstrate that this multi-scenario problem can be solved quickly using a parallel decomposition approach based on progressive hedging and nonlinear interior-point methods. Parallel and serial timing results are shown using Matpower test cases.

2 - Evaluation of Decision Systems in the Presence of Uncertainty

David L. Woodruff, University of California-Davis, Graduate School of Management, One Shields Avenue, Davis, CA, 95616, United States, dlwoodruff@ucdavis.edu

When inputs are uncertain, the performance of a decision system requires consideration both of the way stochastic processes are modelled as well as the optimization models and methods. In this talk we will describe ongoing work to provide software to support this sort of validation.

3 - Internal Decomposition Approaches for Nonlinear Programming Problems in Power Systems

Carl Laird, R&D Software and Engineering, Sandia National Laboratories, Albuquerque, NM, United States, cdlaird@sandia.gov

Stocahstic programming is an important tool for advanced design and operation of power transmission systems. To ensure optimal solutions are feasible for the real system, there is a need to include rigorous nonlinear models of AC transmission within the multi-scenario problem. In this presentation, we discuss key applications of nonlinear stochastic programming in power systems and compare different decomposition strategies for these large-scale nonlinear optimization problems.

4 - A Framework for Modeling and Optimizing Dynamic Systems under Uncertainty

Bethany Nicholson, Sandia National Laboratories, 11600 Academy Rd NE, Apt 3924, Albuquerque, NM, 87111, United States, blnicho@sandia.gov, John Siirola

There are many classes of optimization problems that are not easily represented in most Algebraic modeling languages (AMLs). These problems are typically reformulated before implementation, requiring significant effort from the modeler and obscuring the original problem structure or context. In this talk we show how the Pyomo AML can be used to represent complex models using high-level constructs. We describe the model transformations available in Pyomo for transforming high-level constructs to solvable forms, we demonstrate the combination of Pyomo extensions for stochastic programming and dynamic optimization, and we show the scalability of this framework on large-scale models.

■ TB83

382C

Optimization, Robust

Contributed Session

Chair: Jagdish Ramakrishnan, Walmart Labs, 1000 National Ave, Unit 214, San Bruno, CA, 94066, United States, jagdish.ram@gmail.com

1 - Stochastic Variance Reduction Method with Low Memory and Operation Cost for Smooth Finite Sum Optimization

Jourdain Lamperski, Massachusetts Institute of Technology, 540 Memorial Drive, Cambridge, MA, 02139, United States, jourdain@mit.edu

We propose a stochastic variance reduction method for the minimization of a smooth finite sum of convex functions. Current stochastic variance reduction methods enjoy a faster convergence rate than "vanilla" methods like stochastic gradient descent, but incur either a higher operation or memory cost. We show in the context of logistic regression that our method preserves the operation and memory complexity of stochastic gradient descent while enjoying the faster sublinear rate of convergence. Various aspects of the convergence analysis generalize to the setting of smooth finite sum optimization. We present several numerical results that support our theoretical analysis.

2 - Topology Optimization using Conditional Value at Risk

Geoffrey Oxberry, Member of the Technical Staff, Lawrence Livermore National Laboratory, 2934 Worthing Common, Livermore, CA, 94550, United States, oxberry1@llnl.gov

Traditional approaches to formulating stochastic topology optimization problems for additive manufacturing tend to use linear combinations of the mean and standard deviation of a design figure of merit (e.g., compliance). However, this choice of objective/constraint underweights tail events for non-normal random variables. We propose replacing these mean-plus-standard-deviation expressions with the conditional value-at-risk (CVaR), and argue that it better compensates for worst-case tail events.

3 - An Inexact Bundle Method for Risk-averse Two-stage Stochastic Optimization

Ricardo A. Collado, Assistant Professor, Stevens Institute of Technology, 1 Castle Point Terrace, Hoboken, NJ, 07030, United States, ricardo.collado@stevens.edu, Somayeh Moazeni

We consider multistage stochastic optimization problems with elements of risk aversion obtained via dynamic coherent risk measures. For these problems we develop inexact and sampled bundle methods that require only a fraction of cut and subgradient generating problems to be solved. We demonstrate our methods with an application to network interdiction.

4 - Optimization of a Portfolio of American Options with Continuous Strikes

Dmitry Chernikov, University of Arizona, Tucson, AZ, 85705, United States, dchernikov@email.arizona.edu, Pavlo A. Krokhmal

In this work we consider an options portfolio optimization problem where strikes of options are included as continuous control variables. Such a setting can be interesting from the perspective of the asset liability management, the sell side, or from the point of view of a person who has an opportunity to buy and sell an option with any strike they choose. We present different ways to formulate and solve such a problem including MIP and biconvex maximization. In case of biconvex formulation, by employing problem's special structure we derive an algorithm that is guaranteed to converge to a KKT point. Numerical results are demonstrated.

5 - Dual Approximate Dynamic Programming for Multi-stage Stochastic Unit Commitment

Jagdish Ramakrishnan, Data Scientist, Walmart Labs, 1000 National Ave, Unit 214, San Bruno, CA, 94066, United States, jagdish.ram@gmail.com, James Luedtke

We study the multi-stage stochastic unit commitment problem in which commitment and generation decisions can be made and adjusted in each time period. We formulate this problem as a Markov decision process, which is "loosely coupled" in the sense that if the demand constraint is relaxed, the problem decomposes into a separate, low-dimensional, Markov decision process for each generator. We demonstrate how the dual approximate dynamic programming method of Barty, Carpentier, and Girardeau (2010) can be applied to obtain bounds and a policy for this problem, and present numerical results.

Tuesday, 12:05 - 1:35PM

■ TC01

310A

Meet the Editors

Sponsored: Decision Analysis

Sponsored Session

Chair: L Robin Keller, University of California, Irvine, University of California, Irvine, Irvine, CA, 92697-3125, United States, LRKeller@uci.edu

1 - Meet the Editors

L.Robin Keller, University of California, Irvine, Paul Merage School of Business, Irvine, CA, 92697-3125, United States, LRKeller@uci.edu

Editors at major outlets for Decision Analysis research will discuss their experiences in evaluating decision analysis research, followed by a Q&A session.

2 - Panelist, Editor, Decision Analysis

Rakesh Kumar Sarin, University of California-Los Angeles, Anderson School, Suite B519, 110 Westwood Plaza Box 95148, Los Angeles, CA, 90095-1481, United States, rakesh.sarin@anderson.ucla.edu

3 - Panelist, Department Editor for Decision Analysis, Management Science

Manel Baucells, University of Virginia, Darden School of Business, 100 Darden Boulevard, Charlottesville, VA, 22903, United States, mbaucells@gmail.com

4 - Panelist, Area Editor for Decision Analysis, Operations Research

Kevin F.McCardle, UCLA, Anderson School at UCLA, 110 Westwood Plaza Box 951481, Los Angeles, CA, 90095-1481, United States, kevin.mccardle@anderson.ucla.edu

5 - Panelist, Department Editor for Decision Analysis, IISE Trans. (Oper. Engr. & Anal. focus)

Ali E.Abbas, University of Southern California, Center for Interdisciplinary Decisions and Et, Industrial and Systems Engineering and Public, Los Angeles, CA, 90015, United States, aliabbas@usc.edu

■ TC02

310B

Decisional Conflicts and Incentives in Healthcare

Sponsored: Decision Analysis

Sponsored Session

Chair: Mehmet U.S. Ayvaci, University of Texas at Dallas, Richardson, TX, 75080-3021, United States, mehmet.ayvaci@utdallas.edu

Co-Chair: YeongIn Kim, University of Texas-Dallas, Richardson, TX, 75080, United States, yxk130930@utdallas.edu

1 - Strategic Flexibility in Health Practice Guidelines under Litigation Concerns

YeongIn Kim, University of Texas-Dallas, 800 W. Renner Road, Apt 711, Richardson, TX, 75080, United States, yxk130930@utdallas.edu, Mehmet U. Ayvaci, Srinivasan Raghunathan, Turgay Ayer

We examine the optimal formulation of guidelines in a generic health screening with consideration for the physician's increased liability risk under ubiquitous health information and information technologies. We find that under the litigation concern, the social planner strategically provides guidelines with flexible recommendations regarding which patients should undergo the test while providing rigid guidelines regarding the physician's decisions based on test results. Strategic flexibility in guidelines may lead to lower utilization of health care services, depending on the benefit and cost of the test considered.

2 - Clinical Ambiguity and Conflicts of Interest in Interventional Cardiology Decision-making

Tinglong Dai, Johns Hopkins University, 100 International Dr, Baltimore, MD, 21202, United States, dai@jhu.edu, Xiaofang Wang, Chao-Wei Hwang

Conventional wisdom suggests that more-precise diagnostic testing will help to reduce overtreatment. However, the literature rarely recognizes that the decision about whether to administer these tests is itself endogenous. In this paper, we examine inappropriate usage of percutaneous coronary intervention (PCI) procedures for stable coronary artery disease patients. Advanced intracoronary tests such as fractional flow reserve provide more precise and objective measures of the physiologic severity of coronary stenosis. We model both clinical ambiguity and conflicts of interest in an interventional cardiologist's decision to administer advanced tests.

3 - Design of Two-tiered Payment Model for Maternity Care

Cheng Zhu, McGill University, 701-801 Sherbrooke Est, Montreal, QC, H2L.0B7, Canada, cheng.zhu@mail.mcgill.ca, Beste Kucukyazici

The amount of unnecessary C-Sections, which expose proven higher postpartum complications of mothers and newborns as well as heavy economic burden, has been increasing constantly and this growth raises great concerns for the policy makers. This research proposes a two-tiered payment mechanisms to reimburse obstetricians, in order to reduce unnecessary C-sections while retain it for those who need it, resulting in enhanced birth quality with alleviated economic burden for overall health care system. The optimal reimbursement schemes are further verified empirically with large data sets.

■ TC03

310C

Environmental Policy and Decision Analysis

Invited: Tutorial

Invited Session

1 - Environmental Policy and Decision Analysis

Max Henrion, Lumina Decision Systems, Inc, Los Gatos, CA, United States, henrion@lumina.com

Climate change and other environmental crises create a growing need for analysts who can design and evaluate policies that reconcile environmental and economic sustainability. I'll explain the practical value of decision analysis, influence diagrams, treating uncertainty, multi-attribute tools, creative option design, and model-driven stakeholder conversations. I'll illustrate the use of these methods in the successful "rigs to reefs" analysis of how to decommission California's offshore oil platforms, which achieved policy consensus.

■ TC03A

Grand Ballroom A

Financial Engineering in Applied Probability II

Sponsored: Applied Probability

Sponsored Session

Chair: Ning Cai, Hong Kong University of Science & Technology, Kowloon, Hong Kong, Hong Kong, ningcai@ust.hk

Co-Chair: Xuewei Yang, Nanjing University, Nanjing, 210093, China, xwyang@nju.edu.cn

1 - Stochastic Game of Finite Fuel Problem

Renyuan Xu, University of California-Berkeley, 4141 Etcheverry Hall, OR.Department, Berkeley, CA, 94720, United States, dorisxu1026@gmail.com, Xin Guo

In general, finding a Nash equilibrium or proving Pareto optimality for continuous-time stochastic game with multiple players is hard, even when there are only two players in the game. Mean Field Game (MFG) provides a powerful tool and analytically feasible framework to approximate the Nash equilibrium of the N-player stochastic games. In this talk, we will first present the stochastic game for the classical finite fuel follower problem in the seminal paper by Benes, Shepp, and Witsenhausen (1980). We will then solve and compare with explicit solutions for the Nash equilibrium and the Pareto optimality for the two-player game, and the corresponding MFG when the number of players goes to infinity.

2 - An Optimal Stopping Problem under General Levy Model

Wei Zhang, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, wzhangas@ust.hk

We consider a pricing problem of one financial instrument, which is essentially an optimal stopping problem, under the general L\'{e} model. We give both the probabilistic and the algebraic characterization of the continuation region. Finally, we give some examples under some specific L\'{e}vy models.

3 - Credit Ratings as Regimes: Evidence from the Sovereign Credit Default Swaps Market

Xuewe I. Yang, Nanjing University, Hankou Road 22, Gulou District, Nanjing, 210093, China, xwyang@nju.edu.cn

We study sovereign credit risk through a rating-based regime switching model. Each country's default intensity consists of a rating-modulated systematic factor and an idiosyncratic factor. The rating-dependence enables the model to conduct cross-sectional predictions, generate model-implied ratings, and jointly capture CDS spreads of multiple countries. Consequently, a 17-parameter version of the model fits CDS spreads of 68 countries equally well with the classical country-by-country model with hundreds of parameters. The systematic factor along with the observed (model-implied) ratings can explain more than 60% (80%) of the variations of sovereign CDS spreads of all countries.

4 - Mean-variance-Skewness Portfolio Selection

Jingnan Chen, Singapore University of Technology and Design, 20 Dover Drive, Singapore, 138682, Singapore, jingnan_chen@sutd.edu.sg, Fang Zhen

We introduce a mean-variance-skewness portfolio selection model to account for the asymmetry in portfolio returns. Assuming a multivariate skew-normal distribution for asset returns, we obtain a mean-variance-skewness efficient frontier and derive a closed-form optimal portfolio strategy. In addition, we propose a three-moment capital asset pricing model incorporating skewness for asset valuation. The superiority of our mean-variance-skewness portfolio strategy over the classical mean-variance strategy is demonstrated through empirical tests.

■ TC03B

Grand Ballroom B

Advances in E-commerce

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Van-Anh Truong, Columbia University, Mudd Hall, New York, NY, 10027, United States, vt2196@columbia.edu

1 - Online Resource Allocation under Arbitrary Arrivals: Optimal Algorithms and Tight Competitive Ratios

Will Ma, MIT, willma353@gmail.com, David Simchi-Levi

We consider the problem of allocating fixed resources to heterogeous customers arriving sequentially, under the framework of competitive analysis, which does not assume any predictability in the sequence of customer arrivals. We derive the first optimally-competitive algorithms when there are both multiple resources, and different rewards for allocating resources to different customers. Our algorithms are simple, intuitive, and robust, and broadly expand the applicability of competitive analysis, in areas such as online advertising, matching markets, and personalized e-commerce. We test our methodology extensively on the publicly-accessible hotel data set of Bodea et al.

2 - Approximation Algorithms for Dynamic Assortment Optimization Models

Ali Aouad, Massachusetts Institute of Technology, Cambridge, MA, United States, aaouad@mit.edu, Retsef Levi, Danny Segev

Motivated by retailing in highly-differentiated markets, we study joint assortment optimization and inventory management. Here, customers show a dynamic substitution behavior elicited by stock-out events. We devise the first provably-good algorithms by revealing hidden submodular-like structure. Our approximation factor is best-possible under a general rank-based model, while we obtain constant-factor guarantees under popular specialized structures, such as Multinomial Logit. Our approach is an order of magnitude faster than existing heuristics and increases revenue by 6% to 12% in the experiments.

3 - Peak-end Demand Models and their Impact on Promotion Planning

Tamar Cohen, Massachusetts Institute of Technology, Cambridge, MA, United States, tcohen@mit.edu, Georgia Perakis

We consider the problem of promotion planning for a single product. We propose a new demand model that predicts actual sales more accurately than current methods. By utilizing the structure of this proposed demand model, we suggest a tractable Dynamic Programming approach and provide conditions under which it solves the promotion planning problem exactly. In the cases where these conditions do not hold, we provide an analytical guarantee. Finally, we test our approach on sales data and demonstrate improvement in the precision of the demand prediction as well as an increase in revenue.

4 - Dynamic Optimization of Mobile Push Advertising Campaigns

Xinshang Wang, Columbia University, New York, NY, United States, xw2230@columbia.edu, Van-Anh Truong, Shenghuo Zhu, Qiong Zhang

We study a novel resource-allocation problem where mobile push messages must be sent to hundreds of millions of users. Each message yields a reward when it generates a clickthrough, subject to a budget constraint. The problem aims to maximize total reward without overwhelming each user with too many messages. We propose an algorithm that sends push messages in two cycles and makes use of information observed in the first cycle to adapt decisions in the second cycle. The algorithm has a provable regret that is asymptotically smaller than the regret of simple LP-base algorithms. Numerical experiments on real data sets show that the former improves the regret of the latter by at least 10%-50%.

■ TC03C

Grand Ballroom C

Economic Models in OM

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Manu Goyal, University of Utah, Salt Lake City, UT, 84112, United States, manu.goyal@eccles.utah.edu

1 - Price and Customization of a Conspicuous Good in Monopolies and Duopolies

Cheryl Druehl, Associate Professor, George Mason University, Fairfax, VA, 22030, United States, cdruehl@gmu.edu, Jesse Bockstedt

Consumers increasingly desire uniqueness, but within recognizable status-oriented brands. The model investigates the customization and pricing decisions of conspicuous goods in monopoly and duopoly settings. The firm trades-off the cost vs the demand-enhancing impact of customization, which allows better matching of customers' tastes. We find that the monopolist always benefits from offering horizontal product customization. In a duopoly market, however, a prisoner's dilemma scenario results. The dominant strategy is for both firms to offer a customizable good, but this outcome is not Pareto optimal.

2 - RFQ, Sequencing, and the Most Favorable Bargaining Outcome

Leon Zhu, University of Southern California, University Park Campus, Bridge Hall 401T, Los Angeles, CA, 90089, United States, leonyzhu@usc.edu, Ying Rong, Huan Zheng

We study quantity-dependent pricing contracts with exclusion clauses in a dual-sourcing setting when the suppliers are imperfect substitutes. We analyze the negotiations between a buyer and two suppliers both with and without a request for quotation (RFQ) stage that precedes the negotiation. We show that the buyer can leverage the RFQ stage even under a full information setting when the negotiation sequence is endogenously determined by the final quotations of the RFQ process. Specifically, the buyer's equilibrium payoff with RFQ dominates the most favorable equilibrium under bargaining without RFQ.

3 - Buyback Pricing of Durable Goods in Dual Distribution Channels
Gokce Esenduran, Ohio State University, 2100 Neil Avenue, 656 Fisher Hall, Columbus, OH, 43210, United States, esenduran@gmail.com, Lauren Xiaoyuan Lu, Jayashankar M. Swaminathan

In the U.S. automobile industry, manufacturers distribute cars through dealers and rental agencies. Rental agencies can compete against dealers by selling slightly used rental cars in the sales market. To mediate this conflict between the two intermediaries, manufacturers launched buyback programs to repurchase used rental cars from rental agencies and redistribute them through dealers. Manufacturers can precommit a buyback price to rental agencies at the time of initial sales or postpone the pricing to the time of repurchase. Using a two-period model with and without competition, we aim to understand how to manage buyback pricing to maximize manufacturer profits in dual distribution channels.

4 - Ethics, Bounded Rationality and the Hold Up Problem
Manu Goyal, University of Utah, 1655 E Campus Center Drive, 7235 Sfebb, Salt Lake City, UT, 84112, United States, manu.goyal@eccles.utah.edu, Krishnan S. Anand

In our study of the hold up problem, in addition to the classical profit-maximizing firm unconstrained by ethics, we model an ethically-constrained firm that honors its contractual obligations irrespective of legal restraints. We prove that under bounded rationality, the ethically-constrained firm can obtain strictly greater profits than the unconstrained profit-maximizing firm, even when (i) the unconstrained firm has access to a superset of the ethical firm's strategies, and (ii) the ethical firm is unable to reveal its ethical commitment to its contracting partner. Thus, we show that a commitment to ethics, while of course being morally desirable, can be a superior business strategy.

■ TC04

320A

Teaching Innovations in Operations/Sustainability

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Erica Plambeck, Stanford University, Stanford, CA, 94305-5015, United States, elp@stanford.edu

1 - Sustainability in a Core OM Class
Erica Plambeck, Stanford University, Stanford, CA, 94305-5015, United States, elp@stanford.edu

I will speak about a new case and teaching materials for introducing climate science, life cycle analysis, and product-process innovation for net zero emission buildings, used in the base course in operations management for Stanford MBA students. I may also speak briefly about teaching for Stanford's joint MBA - MS Environment and Resources degree program.

2 - Business Sustainability as Extreme Operations
Andre Du Pin Calmon, INSEAD, Boulevard de Constance, Fontainebleau, 77300, France, andre.calmon@insead.edu

We present an overview of the new case studies and material developed for the course "Business Sustainability," an MBA elective at INSEAD. This course reframes sustainable operations as "extreme operations" and connects operations management and business model innovation to topics such as circular economy, industry self-regulation, and climate change. The course has attracted a wide range of students and has become one of the most popular MBA electives at INSEAD.

3 - Combining Curricular and Co-Curricular Approaches to Teaching Business Sustainability
Beril Toktay, Georgia Institute of Technology, Atlanta, GA, United States, beril.toktay@scheller.gatech.edu

In the presentation, I will share my experience teaching sustainability in our operations management program as well as promoting sustainability infusion at Scheller College and Georgia Institute of Technology.

4 - Share YOUR Teaching Innovations and Ideas
Erica Plambeck, Stanford University, Graduate School of Business, Knight Management Center, Stanford, CA, 94305-7298, United States, elp@stanford.edu

The final 15 minutes of session are reserved for discussion. Please share your innovations, needs and opportunities in teaching for environmental sustainability.

■ TC05

320B

Computational Modeling for Public Health Decision Making

Sponsored: Health Applications

Sponsored Session

Chair: Ozgur M Araz, PhD, University of Nebraska-Lincoln, Lincoln, NE, 68588-0491, United States, oaraz2@unl.edu

1 - Modeling the National, State, and Individual-level Impact and Cost-effectiveness of HPV Vaccination
David Durham, PhD, Yale University, New Haven, CT, United States, david.durham@yale.edu, Martial Ndeffo-Mbah, Laura Skrip, Forrest Jones, Chris Bauch, Alison Galvani

Vaccines provide strong protection against cancer-causing HPV. However, coverage remains below targets and varies greatly across the US. We modeled HPV transmission, vaccination, and cervical cancer at the national, state, and individual levels. At the national level, the nonavalent vaccine, which covers more serotypes but at a greater cost, was cost-effective compared with older HPV vaccines. At the state level, the benefit gained per vaccine was greatest in states with the lowest coverage, due to decreasing marginal returns. At the individual level, the lifetime cancer risk was greatly reduced among vaccinated women, while herd immunity slightly reduced risk among unvaccinated women.

2 - Our Walk to the End of Cancer? Understanding Long-term Trends in Medical Screening
Ozge Karanfil, Harvard T.H. Chan School of Public Health, 651 Huntington Avenue, FXB Building, 643E, Boston, MA, 02115, United States, karanfil@hsph.harvard.edu, John D. Sterman

We develop a broad boundary feedback theory and formal model to explain dynamics of screening. The theory includes a decision-theoretic core, and feedbacks conditioning formal guidelines and actual practice. The model is generic but to provide context we use PSA screening as a motivating example to present a behaviorally realistic model that creates oscillations in policy recommendation thresholds. This core model, entailing only the evidence generation and translation processes, demonstrates how oscillations are natural to this category of problems due to inherent delays in evidence-based screening. These fluctuations lead to long periods during which guidelines are suboptimal.

3 - The Potential Impact of the Affordable Care Act and Medicaid Expansion in North Carolina on Reducing Colorectal Cancer Screening Disparities Among African American Males
Leah Frerichs, PhD, University of North Carolina Chapel Hill, NC, United States, leahf@email.unc.edu, Wizdom Powell, Rachel M. Townsley, Maria Esther Mayorga, Giselle Corbie-Smith, Stephanie B. Wheeler, Kristen Hassmiller

We used an individual based simulation model to estimate the impact of ACA and Medicaid expansion in NC on colorectal cancer (CRC) screening, incidence and death among African American (AA) and White males. Using a synthetic population of NC males, we simulated the natural progression of CRC, CRC screening compliance (by demographic characteristics and insurance status), and CRC incidence, survival, and death. ACA and Medicaid Expansion policy scenarios reduced disparities in CRC screening between AA and white males. Due to savings in treatment costs, Medicaid Expansion has potential to result in $9.6 million in cumulative cost savings for White males and $5.1 million for African American males.

4 - Assessing Jail Based Sexually Transmitted Disease Screening Programs for Optimized Public Health Benefit
Ozgur M.Araz, P.O. Box 880491, CBA 260, Lincoln, NE, 68588-0491, United States, oaraz2@unl.edu, Maytee Cruz-Aponte

We present a mathematical model of Chlamydia trachomatis (CT) transmission dynamics with two interacting populations and analyze the impact of both screen-treat operations and behavioral interventions. Analytical assessment of the public health interventions are presented in support of extracting the value of the screening and treatment operations using the jail systems and theoretical and practical insights are provided for various scenarios of controlling the epidemic for general cases. Numerical simulation results are then analyzed and presented for a predefined specific population in a case study in order to evaluate the effectiveness of the public health programs.

■ TC06

320C

Improving Access and Outcomes in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Maria Esther Mayorga, North Carolina State University, Raleigh, NC, 27695, United States, memayorg@ncsu.edu

1 - Resource Allocation Strategies under Dynamically Changing Patient Health Conditions

Siddhartha Nambiar, North Carolina State University, 1120 Clarion Heights Lane, Apt 303, Raleigh, NC, 27606, United States, snambia@ncsu.edu, Maria Esther Mayorga

Consider a group of patients being treated for a disease (such as Sepsis), whose condition may change over time. Resources allocated to a patient (e.g. bedside lactate) influence their disease progression and outcomes. In this study, our goal is to allocate limited number of resources to patients, depending on their health states, in order to maximize outcomes. We formulate two models; an MDP model with resources allocated dynamically, and a jackson queueing network, where the number of resources is assigned in advance. The performance of these policies is then tested against existing practices and heuristics.

2 - Evaluating Hospital Readmission Decisions

Gabriel Zayas-Caban, University of Wisconsin, Madison, WI, United States, zayascaban@wisc.edu, Amy Cochran, Keith Kocher

The Hospital Readmissions Reduction Program penalizes hospitals with excess re-admissions. Re-evaluating admissions decisions, providers have considered delays or increases in decisions. To understand the impact of these changes on patient outcomes, we analyzed over 150,000 encounters in the Emergency Department from the University of Michigan from 2012 through 2015. A Hidden Markov model is fit to the data to capture the interplay between confounding latent variables (e.g. patient severity) and admission decision process. This allowed us to gain insight into how decisions are made and how changes in decisions impact patient outcomes.

3 - Strategies for Improving Specialty Care Appointment Scheduling

Ashley N. Anhalt, University of Pittsburgh, 525 S. Aiken Avenue, APT.3, Pittsburgh, PA, 15232, United States, ana88@pitt.edu, Arnab Bhattacharya, Jeffrey P. Kharoufeh

In resource-constrained environments, patients are often unable to schedule specialty care appointments within a reasonable time. We first present a stochastic optimization model that aims to maximize the proportion of patients who are scheduled within a prescribed time threshold, subject to provider availability. However, due to intractability of the model, we subsequently devise and analyze a set of computationally-efficient strategies that significantly reduce appointment scheduling delays. Our strategies are illustrated for a major healthcare provider's cardiology unit.

4 - Microsimulation Model using Christiana Care Early Warning System (CEWS) to Evaluate Physiological Deterioration

Shengfan Zhang, University of Arkansas, Fayetteville, AR, United States, na, Bin Li, Muge Capan

Patients often exhibit signs of physiologic deterioration in the hours before harm events occur. Christiana and Wilmington Hospitals are adapting the Christiana Care Early Warning System (CEWS) to detect all-cause acute clinical deterioration impacting inpatients and support clinical decision making. We used a microsimulation model to simulate the inpatients cohort's CEWS value and to explore the possible intervention policies on mortality, length of stay, average percent time over critical CEWS thresholds with the change of policies.

■ TC07

322A

Operations Research for Critical Care

Sponsored: Health Applications

Sponsored Session

Chair: Vedat Verter, McGill University, Montreal, QC, H3A 1G5, Canada, vedat.verter@mcgill.ca

1 - Dynamic Patient Location in the ICU

Hamidreza Eslami, McGill University, Montreal, QC, Canada, hamidreza.eslami@mail.mcgill.ca

Healthcare location studies at patient level usually target the groups of patients and not the individual ones. Due to the critical status of the ICU patients, their location on the ICU may have significant impacts on the unit operations and costs. We develop a model to optimally locate the incoming ICU patients on the floor so that the overall nurse costs and patient relocation costs are minimized by considering the evolvement of patients' health status. Therefore, the patients who are prone to get better at the same time and thus share a nurse, will be located in adjacent rooms.

2 - Evaluating the Performance of Emergency Department Physicians

Raha Imanirad, Harvard University, Boston, MA, United States, rimanirad@hbs.edu

Given the vital role of emergency department (ED) physicians in the timely and effective delivery of care, it appears pertinent to have a measure of physician performance in place. Despite recent advances, however, a standard metric for evaluating ED physicians has yet to emerge. In this study, we use data envelopment analysis (DEA) to evaluate the performance of ED physicians based on two measures of quality and speed. In addition to identifying which physicians demonstrate best practices, we conduct various statistical analyses to examine which variables are associated with higher levels of physician performance.

3 - Measuring Emergency Care Networks with Location Allocation Models and GIS

Peter Vanberkel, Dahousie University, P.O. Box 1000, Halifax, NS, B3 H.4R2, Canada, peter.vanberkel@dal.ca

The objective of this study is to measure how the Nova Scotian Emergency Medical System (EMS), consisting of Emergency Departments (EDs) and ambulance services, covers the population. This study uses location-allocation models including the P-median problem (PMP) and P-centre problem (PCP). We analyze the existing network by computing the weighted travel distance of the population to each facility, the maximum distance any person must travel, and the number of people within a specified distance from a facility. We also consider several proposed changes to the network and compute the degree of improvement expected using these metrics.

■ TC08

322B

Disaster and Emergency Management

Contributed Session

Chair: Zeina Bousaid, Lamar University, Beaumont, TX, United States, zbousaid@lamar.edu

2 - An Emergency Logistics Distribution Approach for Real-time Response to Relief Demand in Uncertain Environment

Yajie Liu, Associate Professor, National University of Defense Technology, NUDT, Changsha, 410073, China, liuyajie@nudt.edu.cn, Zhiyong Wu, Yue Wang, Jianmai Shi

When making emergency distribution plans in response to disasters, we should not only consider uncertain and dynamic input data but also the real-time adjustment requirements of the existing plans. A multi-commodity, multi-period distribution model is presented to minimize the total weighted unmet demands. Moreover, a rolling horizon-based framework that is based on the robust optimization and model predictive control approaches is proposed to obtain robust relief distribution plans and adjust them in accordance with updated real-time information. A numerical example based on the Great Sichuan Earthquake is utilized to investigate the application of our proposed model and approaches.

3 - Integrated Logistics Decisions and Representative Objectives of Preparedness and Response Phases of Disaster Operations

Syed Tariq, Lahore University of Management Sciences (LUMS), Shah House, A-10, Block 2, Chapal Sun City, Lahore, 75280, Pakistan, 14080009@lums.edu.pk, Muhammad Naiman Jalil

Disaster response operations are linked to preparedness. The response stage consists of three sub-stages: 1) Emergency response, 2) Continuum response, and 3) Initial recovery response (Sheu and Pan, 2016). In this paper, we present a model which utilizes objective functions which better represent the objectives of Humanitarian actors at each stage. The stages are modeled in conjunction with each other to see the impact of decisions made at each stage on overall performance.

4 - Determining Inventories of Relief Supplies During Disaster Response Operations by Predicting Non Linear Human Behavior with a System Dynamics Model

Zeina Bousaid, Lamar University, 4400 SMLK Jr. Pkwy, P.O. Box 10643, Beaumont, TX, 77710, United States, zbousaid@lamar.edu, Alberto Marquez

Forecasting relief supplies is a challenge due to uncertainties, limited resources, delays, disruptions, and complex human factors. We propose system dynamics to model people's behavior during evacuation, and to forecast the relief inventory needed during disaster response operations. Our model consists of four compartments communicating through feedback loops and generating complex nonlinearities. FEMA Hurricane Evacuation reports are used for numerical validation, along with regression analysis, and Monte Carlo simulation. Risk is quantified, and policies are suggested for better response.

■ TC09

330A

Big Data and Innovation

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Serguei Netessine, University of Pennsylvania, Wharton School, Philadelphia, PA, 138676, United States, serguei.netessine@insead.edu

1 - When to Innovate and When to Grow? Empirical Analysis of Startup Operation

Christophe Pennetier, INSEAD, 6 Marina Boulevard, # 27-15, Singapore, 018985, Singapore, christophe.pennetier@insead.edu, Serguei Netessine, Karan Girotra

We conduct a thorough examination of the effects of business model innovation on startups' performance (probability to raise funding, exit) and we empirically evaluate them. We by that offer a new perspective to the pivoting approach that has captured practitioners' attention in the past few years since the Lean Startup framework became widely adopted.

2 - Impact of Telematics: An Empirical Study of Drivers' Behavior

Vivek Choudhary, INSEAD Business School, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, Vivek.Choudhary@insead.edu, Serguei Netessine

Telematics is one of the hottest developments in the automobile insurance industry. Adoption of this innovation suggests that this is going to be the future of motor insurance. We study a novel private dataset from a start-up company operating in this space. Using this dataset, which consists of trip level details; we study the effect of providing feedback of drivers' behaviour on driving performance.

3 - Impact of Mobile Channel on Demand Concentration

Fangyun Tan, Southern Methodist University, 6212 Bishop Blvd, Dallas, TX, 75275, United States, ttan@cox.smu.edu, Nitish Jain

We analyze a large transactional data from an Indian online apparel to understand the impact of mobile channel on demand concentration. Utilizing the natural experiment where the company shut down its PC channel and kept only their mobile channel, we find that the mobile channel reduces the demand concentration because its search costs are higher than those in the PC channel. We show evidence of the mechanisms and discuss the implications for operational decisions.

4 - Reading Between the Stars: Understanding the Effect of Online Customer Reviews on Product Demand

Hallie Cho, INSEAD, Singapore, 138676, Singapore, hallie.cho@insead.edu, Sameer Hasija, Manuel Sosa

Many studies have examined star ratings in customer reviews and established that they are a relevant source of quality information. We examine the sentiments of text reviews and study the interplay between sentiments and star ratings and how this relates to product demand. To fully exploit the abundance of online reviews, we implemented a novel algorithm that reads the text portion of customer reviews and assesses its sentiment. We find that sentiments and star ratings both have a decreasingly positive effect on product demand and that their interaction effect on demand suggest they act as complements, not substitutes.

■ TC10

330B

Value of Information in Games and Mechanism Design

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Leon Zhu, University of Southern California, Los Angeles, CA, 90089, United States, leonyzhu@usc.edu

1 - Price Competition in Customer Inertia Markets with Capacity Uncertainty

Junhyun Bae, Cornell University, Ithaca, NY, United States, jb2258@cornell.edu, Li Chen, Yao Cui

In this paper, we investigate price competition under capacity uncertainty in which consumers have costs of switching between two firms. While previous literature has examined the effect of switching costs on prices, our paper addresses the effect of capacity uncertainty on prices. Using a two-period duopoly setting, we show that capacity uncertainty increases price in both periods and it diminishes price discount in the first period.

2 - Resolving Supplier Information Asymmetry: Reliability or Improvement Cost?

Yutian Li, PhD Candidate, University of Miami, Coral Gables, FL, 33146, United States, ytli@umiami.edu, Sammi Tang

We consider a manufacturer who sources from an unreliable supplier. The supplier can take costly effort to improve its reliability, but has private information about both its initial reliability level and improvement cost. We examine which type of supplier information is more valuable to the manufacturer. For that, we study two models with different asymmetric information, and compare how each type of information affects manufacturer's profit, information rent and channel loss differently.

3 - Analytical Solution to a Partially Observable Machine-maintenance Problem

Weihua Zhang, University of British Columbia, Sauder School of Business, University of British Columbia, Vancouver, BC, V6T.1Z2, Canada, weihua.zhang@sauder.ubc.ca, Hao Zhang

We examine a classic machine-maintenance problem in which the state of the system evolves as a hidden Markov process under production. The state can be observed upon inspection and reset by replacement. The goal is to find a production-inspection-replacement policy to minimize the expected discounted cost over an infinite horizon. We adopt a new framework to derive an exact, analytical solution to this problem and uncover an elegant cyclic structure in the optimal solution, which are unavailable through the Bayesian framework. We find that the well-known and puzzling non-monotone optimal policy results from the transient behavior under optimal control.

4 - Position Ranking and Auctions for Online Marketplaces

Heng Zhang, University of Southern California, Los Angeles, CA, 91776, United States, hengz@usc.edu, Leon Yang Chu, Hamid Nazerzadeh

E-commerce platforms connect thousands of sellers and consumers every day. We study how such platforms should rank products displayed, and utilize the top slots with auction design. We present a model that considers consumers' search costs and seller externalities. This model allows us to study a multi-objective optimization, whose objective includes consumer and seller surplus, and sales revenue, and derive the optimal ranking. Motivated in part by the sponsored search program, we propose a so-called surplus-ordered ranking mechanism for selling top slots, which is near-optimal. When the platform sells all slots, we show that our mechanism can be implemented as a NE in a modified GSP auction.

■ TC11

332A

Healthcare Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Sukriye Nilay Argon, University of North Carolina, Chapel Hill, NC, 27599, United States, nilay@unc.edu

Co-Chair: Serhan Ziya, University of North Carolina, Chapel Hill, NC, 27599, United States, ziya@unc.edu

1 - Do Mandatory Overtime Laws Improve Quality? Staffing Decisions and Operational Flexibility of Nursing Homes

Lauren Xiaoyuan Lu, University of North Carolina at Chapel Hill, Kenan-Flagler Business School, CB #3490, Mccoll Building, Chapel Hill, NC, 27599, United States, lauren_lu@unc.edu, Susan F.Lu

During the 2000s, over a dozen U.S. states passed laws that prohibit health care employers from mandating overtime for nurses. Using a nationwide panel dataset from 2004 to 2012, we find that these mandatory overtime laws reduced the service quality of nursing homes, as measured by an increase in deficiency citations. This outcome can be explained by two undesirable changes in the staffing hours of registered nurses: decreased hours of permanent nurses and increased hours of contract nurses per resident day. These observations are consistent with the predictions of a stochastic staffing model that incorporates demand uncertainty and operational flexibility.

2 - Transitional Care Appointment Scheduling

Benjamin Grant, Kellogg School of Management, 1881 Oak Avenue, # 1307W, Evanston, IL, 60201, United States, b-grant@kellogg.northwestern.edu, Itai Gurvich, R. Kannan Mutharasan, Jan A. Van Mieghem

In this paper we develop a framework modeling transitional-care appointment scheduling from the perspective of the hospital or social planner who takes into account the total cost of transitional-care under a value-based compensation model. We employ a stochastic dynamic programming model rich enough to capture many of the complexities that exist in practice, while enabling interesting insights and evaluation of a variety of simple scheduling policies compared to theoretical optimal policies.

3 - Optimal Workload Management During a Physician's Shift in Emergency Departments

Zhankun Sun, City University of Hong Kong, 7-242, 7/F, Academic 3, Tat Chee Avenue, Kowloon Tong, Hong Kong, zhanksun@cityu.edu.hk, Nan Liu

ED physicians can dynamically adjust their workload to reduce patient handovers which raise safety concerns due to the discontinuation of care. We present a dynamic programming model to inform patient flow management during a single ED physician's work shift. Our results can help understand physician's strategic choice of idling at the end of the shift and provide decision support.

4 - Managing EMS Systems with User Abandonment in Emerging Economies

Lavanya Marla, The University of Illinois, lavanyam@illinois.edu, Kaushik Krishnan Sarang Deo (sarang_Deo@isb.edu)

Abstract: We introduce, and consider an issue specifically seen in Emergency medical Services in emerging economies, called in-service abandonment. Due to resource constraints in the system, patients have a limited willingness to wait for ambulances. Because actual wait times are censored in the data, we build a maximum likelihood estimation to estimate the waiting times based on the Proportional Hazards Model. We employ a simulation-based greedy optimization approach to find good allocations to match the demand waiting time estimates, and demonstrate that policy changes that simply re-arrange ambulances at the current bases, increase fleet size or dispatch policy are unlikely to cause significant gains. Instead, we posit, and demonstrate using the data, that re-designing the base set using a huge optimization model that considers each street corner as a base, allows us to identify better base locations for ambulances. We demonstrate that the new system design matches the demand profiles better, decreasing inefficiencies in the system due to abandonment.

■ TC12

332B

Inventory Control with Additive Manufacturing

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Rob Basten, Eindhoven University of Technology, Eindhoven, 5600 MB, Netherlands, R.J.I.Basten@tue.nl

Chair: Jing-Sheng Jeannette Song, Duke University, Durham, NC, 27708-0120, United States, jssong@duke.edu

1 - Improving Effectiveness of Spare Parts Supply by Additive Manufacturing as Dual Sourcing Option

Nils Knofius, University of Twente, Enschede, Netherlands, n.knofius@utwente.nl, Matthieu van der Heijden, Andrei Sleptchenko, Henk Zijm

We discuss the value of sourcing spare parts with a combination of additive manufacturing (AM) and conventional manufacturing (CM) methods. In the dual sourcing literature, costs are higher and lead times are lower for the fast supply option. In our case, we also need to consider that AM parts show a different failure behavior than CM parts. As a consequence, the sourcing decision may impact future demand. Numerical experiments and a case study show that dual sourcing reinforces the value of AM methods in the low-volume, downtime-critical spare part business.

2 - Assessing the Impact of Additive Manufacturing on Spare Parts: An Inventory Management Perspective

Jakob Heinen, Kuehne Logistics University, Grosser Grasbrook 17, Hamburg, 20457, Germany, johannes.jakob.heinen@the-klu.org, Kai Hoberg

Spare parts are often identified as a relevant application area for additive manufacturing. Characterized by relatively low demand over long periods, additive manufacturing has the potential to reduce inventory costs and offset higher unit production costs. We develop an approach for selecting the manufacturing technology for spare parts based on supply chain related costs and derive optimal inventory policy parameters. Using a data set for 53,457 spare parts over 9 years, we assess additive manufacturing's potential for a leading intralogistics manufacturer. Based on an analysis by part category, a significant share of spare parts can be economically produced using additive manufacturing.

3 - Temporary Replacements of Spare Parts through Additive Manufacturing

Rob Basten, Eindhoven University of Technology, Eindhoven, 5600MB, Netherlands, r.j.i.basten@tue.nl, Bram Westerweel, Geert-Jan Van Houtum

When spare parts have long supply lead times, equipment may experience high downtime costs during stockouts. We propose to use additive manufacturing, i.e., 3D printing, to supply temporary replacements. Analyzing the resulting model and using empirical data leads to interesting insights.

4 - Impact of Additive Manufacturing on After-sales Service Supply Chains

Brian Tomlin, Tuck School of Business, Dartmouth College, 100 Tuck Hall, Hanover, NH, 03755-9000, United States, brian.tomlin@tuck.dartmouth.edu, Sang Kim

In this preliminary research we study how additive manufacturing (3D printing) technology changes the incentive dynamics between a manufacturer and a supplier in after-sales service supply chains. Because spare parts needed for repairs and maintenance can be 3D printed on the fly, the importance of parts inventory management and related service offerings can be diminished. At the same time, an issue arises as to how component design licensing should be arranged between the buyer and the supplier. We investigate new challenges introduced by additive manufacturing technology through the lens of contracting and game-theoretic analysis.

■ TC13

332C

Game Theory

Contributed Session

Chair: Nabeel Hamoud, University of Milwaukee, Milwaukee, WI, United States, nmhamoud@uwm.edu

1 - Disease Dynamics on a Network Game: A Little Empathy Goes a Long Way

Ceyhun Eksin, Georgia Tech, 310 Ferst Drive, Cherry Emerson Building, Atlanta, GA, 30332, United States, ceyhuneksin@gatech.edu, Jeff S. Shamma, Joshua S. Weitz

Individuals change their behavior during an epidemic in response to whether they and those they interact with are healthy or sick. Healthy individuals may utilize protective measures while sick individuals may adopt preemptive measures to stop disease spread to their contacts. Yet, in practice both protective and preemptive behavior come with costs. We propose a stochastic network disease game that captures the self-interests of individuals during disease spread on a network. We show that there is a critical level of concern, i.e., empathy, by the sick individuals that eradicates the disease fast while the protective measures cannot eradicate the disease without the preemptive measures.

2 - A New Incomplete Information Approach to Modeling Payment and Concession Period Bargaining in Public Private Partnership Agreements

Ahmadreza Talebian, Postdoctoral Fellow, University of Memphis, 302 Eng Admin Bldg, 3795 Central Ave, Memphis, TN, 38152, United States, ataleb2@uic.edu, Sabyasachee Mishra

In this study, we first propose a complete information bargaining game to understand the interactions between agents negotiating to form a P3 agreement for a smart transportation infrastructure system. Then we extent the model to an incomplete information setting, in which the public agency does not have full information about the cost information of the private agency. This is a plausible setting in the real-world as private companies often consider their financial information sensitive to profitability and thus maintain it confidential. In addition to analytically solving the problem, we perform numerical analysis and offers policy-relevant insights into the state-of-the-practice.

3 - The Role of Third Part Retailer at Designing Online Return Policies: Analytical Approach

Maryam Mahdikhani, Rutgers University, 1 Washington Park, Room 442, Newark, NJ, 07102, United States, m.mahdikhani@rutgers.edu, Yao Zhao

Nowadays, online retailers are competing to increase their market share, and marginal profit rate by offering more services, specifically with focusing on the return policy. Although a generous return policy will be welcome by the customers, and therefore will enhance demand in the long term, this will increase cost due to increased likelihood of return. This paper develops a cost-minimization model by considering the risk mitigation from online retailers to the third part retailers in order to obtain optimal policies. We extend the model by considering the win-win-win strategy for the online retailers, customers, and third part retailers.

4 - Network Interactions and the Social Value of Information

Gowtham Tangirala, Columbia Business School, 3022 Broadway, 4th Floor West, New York, NY, 10027, United States, gtangirala18@gsb.columbia.edu, Alireza Tahbaz-Salehi

In this paper, we study the social value of information in a standard finite-agent beauty contest setting, but allowing the agents to have asymmetric coordination motives. We show that the extent of agents' overreaction/under-reaction to public information relative to the team-efficient benchmark depends on the details of their coordination motives. We also show that even though economies that are efficient under complete information have the same equilibrium welfare when the fundamental is common knowledge, that statement may no longer hold in the presence of incomplete information.

5 - An Election Game Based on Discretization of the Hotelling - Downs Model

Timothy Murray, Graduate Student, University of Illinois, Urbana-Champaign, Urbana, IL, 61801, United States, tsmurra2@illinois.edu

We present a discretized version of the Hotelling-Downs election game based on centroidal clustering of opinion polls. We show that it can be modeled as a congestion game, addressing the common issues of non-independent voter opinions and non-existence of a pure Nash equilibrium (PNE) when there are more than two candidates. Furthermore, we show that a PNE still exists when a non-shared penalty is added to each edge in the congestion game which can be used to model the cost of running a campaign. Finally, we provide a quadratic time algorithm for computing a PNE.

6 - Game Theoretic Modeling of Water Energy Nexus in the Presence of Competition Between Interdependent Firms

Nabeel Hamoud, PhD Student, University of Wisconsin-Milwaukee, P.O. Box 413, Milwaukee, WI, 53201, United States, nmhamoud@uwm.edu, Jaejin Jang

A game theoretic model of the Water-Energy Nexus is introduced to find the equilibrium of the water and electricity markets, when some of the output of a firm in one market (e.g. water market) is an input of another firm in a different market (e.g. electricity market) and vice versa. The firms make their decisions of the quantity to produce simultaneously. The result shows that market power is practiced and output is withheld when less players exists. It also shows that technology efficiency allows a player to capture more market share. It also increases the output of the firm, the total output of the industry and the output of the cross industry; hence reducing the market prices of the two goods.

■ TC14

332D

Robust and Stochastic Optimization in Healthcare

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Chaithanya Bandi, Northwestern University, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

1 - Design of Patient Flows via Robust Analysis of Fork-join Queues

Chaithanya Bandi, 2001 Sheridan Road, Suite 566, Evanston, IL, 60208, United States, chaitu1287@gmail.com

We consider the patient flow design in hospitals and model them using fork-join queues. Using robust queueing theory approaches, we provide tractable solutions.

2 - Ambulance Emergency Response Optimization in Developing Urban Centres

Justin James Boutilier, University of Toronto, 532 Palmerston Boulevard, Apartment 6, Toronto, ON, M6G 2P5, Canada, j.boutilier@mail.utoronto.ca, Timothy Chan

Time sensitive medical emergencies are a major health concern comprising one third of all deaths in low and middle income countries (LMICs). Despite evidence that ambulance services can save lives, poor access and availability of emergency medical care in LMICs continues to be a widespread problem. In this paper, we develop a novel ambulance location-routing model, tailored to address the challenges faced by urban areas in LMICs. We use extensive field data from Dhaka, the capital of Bangladesh and one of the most densely populated cities on earth, to apply our modelling framework.

3 - Robust Multi-period Regional Capacity, Location, and Access of Rural Cardiovascular Service under Uncertainty

Dominic Johannes Breuer, Healthcare Systems Engineering Institute, Boston, MA, 02119, United States, dbreuer@coe.neu.edu, Nadia Lahrichi, Mohit Shukla, James C. Benneyan

Timely access to cardiovascular services in rural areas is difficult to ensure due to long wait times, travel distance, and practice capacity restrictions. A robust multi-period model is developed to determine long-term locations, staffing, and assignment of patients with heterogeneous care needs under uncertainty. The objective is to improve access by minimizing patients' travel distance, out-of-network referrals, and costs. The models are tested with a large health system in Maine. The model has important implications on existing and rapidly expanding health systems to aid their decisions related to care allocation.

■ TC15

332E

Procurement Mechanisms

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Mili Mehrotra, University of Minnesota, Minneapolis, MN, 55455, United States, milim@umn.edu

Co-Chair: Tharanga Kumudini Rajapakshe, University of Florida, Gainesville, FL, 32608, United States, tharanga@ufl.edu

1 - On the Real-time Procurement of Impressions by Mobile-promotion Platforms

Manmohan Aseri, University of Texas-Dallas, 2200 Waterview Parkway, Apt 1738, Richardson, TX, 75080, United States, mxa113030@utdallas.edu, Milind Dawande, Ganesh Janakiraman, Vijay S.Mookerjee

A mobile-promotion platform enables advertisers to launch their personalized mobile advertising campaigns. The platform bids on behalf of dynamically-arriving campaigns to procure impressions at an ad exchange. We offer an effective rolling-horizon procedure, with an attractive guarantee, in which the platform periodically re-computes its policy for the procurement of impressions.

2 - Sustaining a Good Impression: Mechanisms for Selling Impressions at Ad Exchanges

Sameer Mehta, sameer.mehta@utdallas.edu, Milind Dawande, Ganesh Janakiraman, Vijay S.Mookerjee

At mobile ad exchanges, impressions are sold to advertisers through an auction mechanism. The status quo mechanism selects a single ad for display over the lifetime of an impression. We argue that such a mechanism leads to allocative inefficiency. To address this efficiency loss, we consider mechanisms in which multiple ads can be displayed sequentially over the lifetime of an impression. We obtain an optimal mechanism for this setting. Our analysis reveals that on an aggregate level, the optimal mechanism is a win-win for the ad exchange and the advertisers. We also obtain a "socially-responsible" optimal mechanism that guarantees a higher surplus to the ad exchange and the advertisers in the long run.

3 - The Effect of Supply Flexibility on Price-only Contracts for Fixed-price Newsvendors

Mehdi Hosseinabadi Farahani, PhD Student, The University of Texas at Dallas, 800 W. Campbell Road, Richardson, TX, 75080-3021, United States, mxh143930@utdallas.edu, Milind Dawande, Haresh B. Gurnani, Ganesh Janakiraman

We analyze a contract in which a supplier, who is exposed to disruption risks, presents a wholesale price and a supply-flexibility parameter to a buyer facing the newsvendor problem. The supplier is allowed to deviate from the order quantity by at most the flexibility parameter. We find the optimal contract when the demand distribution has an increasing generalized failure rate and show that the order quantity under the supply-flexibility contract is higher than that under the price-only contract. Furthermore, the supply-flexibility contract improves the supply chain efficiency. More interestingly, profits of the supplier and the buyer both increase by introducing flexibility into the contract.

4 - Sourcing under Multiple Attributes: Cost-sharing Mechanisms

Shivam Gupta, Texas State University, 601 University Drive, San Marcos, TX, 78666, United States, s_g515@txstate.edu, Milind Dawande, Ganesh Janakiraman, Shouqiang Wang

We propose a simple cost-sharing mechanism for a principal procuring a product (or service for a project) under multidimensional information asymmetry on the agent's cost and non-cost attributes. We establish its optimality/near-optimality under several special cases, and provide valuable insights into the nature of cost-sharing for its use in practice.

■ TC16

332F

Operations Management

Contributed Session

Chair: Yen-Ju Chiang, National Cheng Kung University, Tainan, Taiwan, r48031016@mail.ncku.edu.tw

1 - Recurrent Neural Networks with Long Term Dependencies in Machine Tool Wear Diagnosis and Prognosis

Jianlei Zhang, Research Assistant, North Carolina State University, Raleigh, NC, United States, jzhang45@ncsu.edu, Binil Starly

Automated real-time tool condition monitoring is critical to improving productivity and part quality in manufacturing processes. This paper proposes a Recurrent Neural Network (RNN) approach for online diagnosis and prognosis of the tool wear. It avoids an analytic model for specific tool wear model, and aims to capture the long term dependencies. Without increasing the complexity of the Neural Networks, our approach can realize multi-step ahead tool wear prediction and Remaining Useful Life forecast. This is realized by applying real time indirect measurements obtained from vibration signals and power signals during the machining process.

2 - Comparing Multiple Linear Profiles for Determining Alternative Processes

Chen-ju Lin, Associate Professor, Yuan Ze University, No. 135 Yuan Tung Rd., Taoyuan, 320, Taiwan, chenju.lin@saturn.yzu.edu.tw, Yuan-Chung Chuang

A product can be manufactured by using alternative processes to reach a predefined product specification. Having several alternative processes can have flexible production scheduling, increase capacity utilization, or reduce lead time. To maintain consistent product performance, this research aims at identifying the alternative processes having similar quality performance to the current production process. Linear profile data for quality characteristic is investigated. A step-up procedure is developed to distinguish profiles from a controlled profile. The simulation results show that the proposed method is more powerful in differentiating profiles than using Bonferroni adjustment.

3 - A Comprehensive Learning Model for Determining Optimal Investments in a Dyadic Chain

Didun Peng, Purdue University, Krannert Graduate School of Management, west lafayette, IN, 47906, United States, peng67@purdue.edu, Robert Plante, Jen Tang

We explore the optimal investment in quality improvement efforts within a centralized dyadic supply chain, in which a manufacture outsources product components to several suppliers. The end product's quality depends on several performance measures, each of which is affected by the interaction of the various supplier sourced components. Manufacturer and suppliers both incur quality-related cost, encouraging both parties to invest in quality-improvement efforts for each component. We attribute quality improvement and concurrent degradation to suppliers' comprehensive learning curve, which considers autonomous and induced learning, and their respective knowledge depreciation.

4 - Product Branding in the International Context a Case of Norwegian Fashion Apparel Manufacturing Industry

Rhythm Wadhwa, NTNU, Teknologiveien 22, Gjoevik, 2821, Norway, rhythmwadhwa@hotmail.com

The paper investigates the product branding and supply chain issues of Norwegian fashion brands and their positioning in the international apparel retail industry. The research questions explored include current state challenges, knowledge and perception of brands, regional differences regarding fashion and consumer behavior. Qualitative semi structured interviews and survey research methodology was used for investigation.

5 - The Myths and Clarification for the Theory of Constraints

Kan Wu, Nanyang Technological University, School of MAE, 50 Nanyang Ave, Singapore, 639798, Singapore, kan626@gmail.com

The theory of constraints was proposed in the mid-1980s and has had a significant impact on the productivity improvements in many manufacturing systems. While it is intuitive and easy to understand, its conclusions are mainly derived from deterministic settings or based on the first moment results. Since production systems are stochastic in general, some of its conclusions are not rigorous and have to be modified. In this study, we show that the process of ongoing improvement may lead to unfavorable outcomes and a throughput bottleneck should be planned for certain types of machines. Specifically, if a system has no bottleneck, every station will be a bottleneck.

6 - Market Anomalies of Open Innovation

Yen-Ju Chiang, Student, National Cheng Kung University, No.1, University Road, Tainan, 701, Taiwan, r48031016@mail.ncku.edu.tw, Shuang-Shi Chuang

Past research focus on close innovation, bus we emphasize open innovation which means cooperate with other organizaions by their knowledge. And we adopt the

■ TC17

340A

Scheduling & Queueing

Sponsored: Applied Probability

Sponsored Session

Chair: Mor Harchol-Balter, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, harchol@cs.cmu.edu

1 - Scheduling on Queues under Imperfect Information: Stability and Robustness

Zheng-Yuan Zhou, Stanford University, Stanford, CA, 94305, United States, zyzhou@stanford.edu, Mehdian Saied, Nicholas Bambos

Scaling up schedulers in computing systems (e.g., data centers) and communication networks may require sampling queue depths at random times and/or communicating the information with substantial random delays over relatively large distances to the schedulers. Imperfect state information (noisy, delayed, partial) can severely affect system performance in terms of backlog congestion and even queue stability. We discuss canonical scheduling examples and examine their stability and performance under increasingly "looser" state information in the interest of evaluating their robustness.

2 - Optimally Scheduling Jobs with Multiple Tasks of Unknown Duration

Ziv Scully, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, zscully@cs.cmu.edu, Guy Blelloch, Mor Harchol-Balter, Alan Scheller-Wolf

We consider optimal job scheduling where each job consists of multiple tasks, each of unknown duration, with precedence constraints between tasks. A job is not considered complete until all of its tasks are complete. Traditional heuristics, such as favoring the job of shortest expected remaining processing time, are suboptimal in this setting. Furthermore, even if we know which job to run, it is not obvious which task within that job to serve. In this talk, we characterize the optimal policy for a class of such scheduling problems. We show the policy is simple to compute in many practical cases.

3 - Near Optimal Performance via Fixed-width Parallelization

Benjamin Berg, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, bsberg@cs.cmu.edu

Running jobs in parallel is an excellent way to reduce their mean response time. In applications such as jobs running on multiple cores, the user chooses the level of parallelization for her jobs. We propose instead that the system should choose the level of parallelization so as to minimize mean response time across jobs. Interestingly, we find that a fixed level of parallelization suffices. While one might imagine that a system should dynamically change a job's level of parallelization based on the current system state, our work shows that the right static level of parallelization yields near-optimal performance. Joint work with: Jan-Pieter Dorsman and Mor Harchol-Balter

■ TC18

340B

Special Session: Machine Learning

Sponsored: Applied Probability

Sponsored Session

1 - Machine Learning and Operations Research

Gah-Yi Ban, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, gban@london.edu

Machine Learning for Applied Probability Society.

■ TC19

342A

Ops-Finance: Risk, Strategy, and Service

Sponsored: Manufacturing & Service Oper Mgmt, iFORM

Sponsored Session

Chair: Mike Pinedo, mpinedo@stern.nyu.edu

Co-Chair: Yuqian Xu, New York University, New York, NY, 10012, United States, yxu@stern.nyu.edu

1 - The Effectiveness of Supplier Buy Back Finance: Evidence from the Chinese Automobile Industry

Weiming Zhu, IESE Business School, Avenida Pearson 21, Barcelona, 08034, Spain, zhuwm923@gmail.com, Tunay Tunca

Facing a budget-constrained buyer, a novel approach for large suppliers is adopting buy-back financing schemes to relieve their downstream partners and reduce channel costs. Through counterfactual analysis, we analyze the efficiency of these financing schemes. We find that such contract agreements can improve channel efficiency over traditional financing methods.

2 - Default Risk Premia and a Non Linear Asset Pricing Model

Yi Zhang, Illinois Institute of Technology and Accenture Management Consulting, Chicago, IL, United States, marco.y.zhang@chicagobooth.edu, John R. Birge

The value of an equity investment can be framed as an embedded call option on a firm's assets. The embedded call option creates a non-linear relationship between stock returns and underlying risk factors. In addition, losses given default create discontinuities in the value of these options that are differentially determined for firms with distinct characteristics, such as size and value. We introduce a non-linear equity pricing model that includes these aspects of potential default consequences and seems to explain and predict individual stock returns.

3 - Merchant Energy Trading in a Network

Selvaprabu Nadarajah, College of Business, University of Illinois at Chicago, 601 South Morgan Street, UH 2406, Chicago, IL, 60607, United States, selvan@uic.edu, Nicola Secomandi

Motivated by practice, we formulate a merchant trading energy in a network of storage and transport assets as a Markov decision process with uncertain energy prices. We develop tractable approximate dynamic programming methods to obtain operating policies and bounds, also highlighting the importance of joint storage and transport optimization.

4 - Operational Risk Management: Preventative v.s. Corrective Controls

Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, United States, yxu@stern.nyu.edu, Lingjiong Zhu, Mike Pinedo

In this paper, we consider a stochastic control framework with a jump process to analyze the impact of large shocks caused by operational risk events on a financial firm's value process. We study capital investments in the infrastructure of a financial firm that aims at mitigating the impact of operational risk events. We characterize the analytical solutions of optimal investment strategies as a function of the rm's growth rate, the jump process parameters, and a loss reduction function. Our modeling framework, combining a typical operational risk process with stochastic control, suggests a future research direction in operations management and operational risk management.

5 - Sourcing from Suppliers with Financial Constraints and Performance Risk

Jing Wu, City University of Hong Kong, Department of Management Sciences, Rm 7-233, Lau Ming Wai Academic Building, Hong Kong, Hong Kong, jingwu49@cityu.edu.hk, Christopher S.Tang, S. Alex Yang

Two innovative financing schemes have emerged in recent years that were intended to enable suppliers to obtain financing for production, Purchase Order Financing (POF) and Buyer Direct Financing (BDF). In this talk, we use a game-theoretical model to examine the relative efficiency of these two schemes. We find that both POF and BDF yield the same payoff under symmetric information, and However, information asymmetry only lowers the efficiency of POF when the supplier's asset level is sufficiently low.

■ TC20

342B

Telecommunications

Contributed Session

Chair: Kagan Gokbayrak, Bilkent University, Ankara, Turkey, kgokbayr@bilkent.edu.tr

1 - Local Search Methods for Link Scheduling Problem of Wireless Mesh Networks

Kagan Gokbayrak, Professor, Bilkent University, Ankara, 06800, Turkey, kgokbayr@bilkent.edu.tr, Yucel Naz Yetimoglu

We aim to increase the average connection speed of a wireless mesh communication network, whose transmissions are scheduled to occur at different time slots, by decreasing the average queueing delay. Under steady state conditions, the average queueing delay is linearly proportional to the average queue size, so we search for the link schedule that minimizes the time-average of the sum of queue lengths over all nodes. We formulate a Mixed Integer Linear Programming problem and solve this NP-hard problem by the Simulated Annealing and the k-change local search methods. We also conduct computational experiments on several example networks to demonstrate the performances of these methods.

2 - A Branch and Cut Algorithm to Design LDPC Codes with out Small Cycles in Communication Systems

Banu Kabakulak, PhD, Bogazici University, Industrial Engineering, Department, Istanbul, 34342, Turkey, banu.kabakulak@boun.edu.tr, Z. Caner Ta kın, Ali Emre Pusane

In a digital communication system, information is sent from one place to another over a noisy communication channel using binary symbols (bits). Original information is encoded by adding redundant bits, which are then used by low-density parity-check (LDPC) codes to detect and correct the errors. Error correction capability of an LDPC code is severely degraded due to small cycles in its bipartite graph representation (Tanner graph). We introduce an integer programming formulation for generating Tanner graphs which do not include cycles smaller than a given size. We propose a branch-and-cut algorithm for its solution.

3 - Device Caching in Mobile Networks: Modeling and Optimization

D I.YUAN, Professor, Uppsala University, Department of Information Tech, Uppsala, 751 05, Sweden, di.yuan@it.uu.se, Tao Deng, Ghafour Ahani, Pingzhi Fan

Caching files at user devices in mobile networks is gaining research interest in the field of telecommunications. We consider a cost-optimal caching problem for device-to-device communications. In this presentation, we provide recent results on modeling and optimization of the cost-optimal caching problem. Specifically, we discuss a bounding approach using integer programming, to approximate the cost function that models mobility using stochastic distribution, and derive a low-complexity algorithm. Performance evaluation of the proposed schemes are presented and discussed.

■ TC21

342C

Optimization for Disaster Response

Invited: InvitedNatural Hazard Planning

Invited Session

Chair: Elise Miller-Hooks, George Mason University, miller@gmu.edu

Co-Chair: Vadim Sokolov, George Mason University, SEOR Dept., MS4A6, 4400 University Drive, Fairfax, VA, 22030, United States, vsokolov@gmu.edu

1 - The Information Collecting Vehicle Routing Problem: Stochastic Optimization for Emergency Storm Response

Lina Al-Kanj, Princeton University, Olden Street, Sherrerd Hall, Office 115, Princeton, NJ, 08542, United States, lina.kanj@gmail.com

In this talk, a new policy is presented that routes a utility truck to restore outages in the power grid using trouble calls and the truck's route as mechanisms for collecting information to create beliefs about outages. This means that routing decisions change our belief about the network, creating the first stochastic vehicle routing problem that explicitly models information collection. First, the problem is formulated as a sequential stochastic optimization. Then, a stochastic lookahead policy is presented that uses Monte Carlo tree search to produce a practical policy that is asymptotically optimal. Simulation results show that the developed policy has a close-to-optimal performance.

2 - Restoration of Services in Disrupted Infrastructure Systems: A Network Science Approach
Aybike Ulusan, Northeastern University, 409 Huntington Avenue, Apt #17, Boston, MA, 02115, United States, ulusan.a@husky.neu.edu, Ozlem Ergun

The goal in this study is to establish the functionality of the disrupted service networks operating on infrastructure systems in a timely manner by prioritizing the restoration operations. As an illustrative case study, we consider a road network blocked by debris in the aftermath of a natural disaster, where the services correspond to the emergency relief efforts flowing from relief providers to disaster sites. We propose a heuristic that prioritizes the restoration activities based on a novel centrality measure that captures the service related operational characteristics of the infrastructures.

3 - Integrating Location and Network Restoration Decisions in Relief Networks under Repair Time Uncertainty
Ece Sanci, University of Michigan, 3552 Greenbrier Blvd, Apt 463C, Ann Arbor, MI, 48105, United States, ecesanci@umich.edu, Mark Stephen Daskin

We propose a two-stage stochastic programming model to locate emergency response facilities prior to a disaster. These facilities are used to distribute emergency relief items to disaster victims using the road network after the disaster. We integrate location and network restoration decisions so that the unmet demand at inaccessible demand points can be met as paths between these demand points and facilities become available. We capture uncertainty in the network availability by incorporating the repair times required to restore the damaged roads. Our computational results show significant improvement in unmet demand and cost measures compared to the model omitting repair decisions.

■ TC23

342E

Innovations in Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Goker Aydin, Johns Hopkins University, Baltimore, MD, 21202, United States, goker.aydin@jhu.edu

Co-Chair: Shengqi Ye, Shengqi.Ye@utdallas.edu

1 - Real-time Spatial Dynamic Pricing for Balancing Supply and Demand in a Network
George Chen, University of Texas at Dallas, Richardson, TX, United States, georgeqc@umich.edu, Yanzhe Lei, Stefanus Jasin

Motivated by recent expansion of mobile ride-hailing apps in the taxi industry in big cities, we study a real-time spatial dynamic pricing problem where a firm who uses many units of reusable resources (e.g., taxis) in a network to serve price-sensitive customers who arrive over a finite selling season (e.g., one day) in a stochastic and nonstationary fashion. For any origin-destination pair, the quoted price equals a nominal price times an origin-specific price multiplier. The firm can dynamically change quoted prices by adaptively adjusting the price multipliers over time. We develop a Network Balancing Control that has asymptotically optimal performance and discuss some extensions.

2 - Price, Wage and Fixed Commission in On-Demand Matching
Yun Zhou, Rotman School of Management, Toronto, ON, Canada, Yun.Zhou13@Rotman.Utoronto.Ca, Ming Hu

Motivated by the emerging sharing economy, we study an on-demand matching platform which crowdsources a service from independent suppliers and sells it to customers. The platform offers a wage to the supply side and charges a price to the demand side. Under market uncertainty, we study the performance of the widely practiced, flat, across-the-board commission contracts, under which the platform takes a fixed cut and the wage is equal to a preset fraction of the price, regardless of what price is charged.

3 - Optimal Spending for a Search Funnel
Shengqi Ye, The University of Texas at Dallas, 800 West Campbell Road, Richardson, TX, 75080, United States, shengqi.ye@utdallas.edu, Goker Aydin, Shanshan Hu

Sponsored search marketing has been a major advertising channel for online retailers. Recent observation indicates that not all customers finalize their purchase decision after their first search query. Instead, customers might take a path of keywords and clicks - a search funnel - to complete a conversion. Noting this behavior, we investigate a retailer's optimal advertising budget allocation across keywords in the search funnel.

■ TC24

342F

Topics in Revenue Management and Pricing I

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Stefanus Jasin, University of Michigan, Ann Arbor, MI, 48105, United States, sjasin@umich.edu

1 - Dynamic Inventory Control with Stockout Substitution and Demand Learning
Boxiao (Beryl) Chen, University of Illinois at Chicago, Chicago, IL, United States, bbchen@uic.edu, Xiuli Chao

Stock-out substitution is the phenomenon that if the first-choice product of a customer is out of stock, besides leaving the market immediately, the customer may also substitute for other products. In this paper, we study a data-driven inventory management problem and infer the customer substitution behavior from historical sales data.

2 - Assortment Optimization with Small Consideration Sets
Jacob Feldman, jbfeldman@wustl.edu, Alice J. Paul, Huseyin Topaloglu

We study a customer choice model that captures purchasing behavior when customers substitute a limited number of times. Under this model, we assume each customer is characterized by a ranked preference list of products and that upon arrival, they will purchase the highest ranking product in her list that is offered. We assume that these rankings contain at most k products. This paper focuses on the assortment optimization problem under this choice model. First, we show that this problem is NP-hard even for k=2. Motivated by this result, we then develop a novel linear programming based rounding algorithm for the assortment optimization problem for general k.

3 - Design of Futures Contracts for Risk Averse Internet Advertisers
Antoine Desir, Columbia IEOR.Department, 601 W. 113th Street, Apt 3J, New York, NY, 10025, United States, ad2918@columbia.edu, Maxime Cohen, Nitish Korula, Balasubramanian Sivan

We consider the problem of selling ad impressions to risk-averse advertisers via Internet display advertising platforms. Advertisers' buying choices typically include two options: Either they commit to a reservation contract in advance, or they buy programatically in real time via an exchange. In this paper, we formally study how risk aversion affects the desire for guarantees, and their pricing. We propose an additional programmatic purchase option (called Market Maker) which acts like an automated reservation. We show that adding the Market-Maker contract results in a Pareto improvement in the seller revenue and in the sum of advertiser utilities.

4 - Joint Dynamic Pricing and Order Fulfillment for E-commerce Retailers
Yanzhe (Murray) Lei, University of Michigan, Ann Arbor, MI, United States, leiyz@umich.edu, Stefanus Jasin, Amitabh Sinha

We consider a joint dynamic pricing and order fulfillment optimization problem in the context of e-commerce retail, where a retailer sells multiple products to customers from different locations and fulfills orders through multiple fulfillment centers. The objective is to maximize the total expected profits, defined as the revenue minus the shipping cost. We propose two heuristics that are easily implementable and show both theoretically and numerically their good performances compared to reasonable benchmarks.

■ TC25

350A

Strong and Extended Formulations for Unit Commitment Problems

Invited: Energy Systems Management

Invited Session

Chair: Yongpei Guan, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611, United States, guan@ise.ufl.edu

1 - Polynomial Time Algorithms and Extended Formulations for Unit Commitment Problems
Kezhuo Zhou, University of Florida, 411 Weil Hall, Gainesville, FL, 32611, United States, zhoukezhuo@ufl.edu, Kai Pan, Yongpei Guan

In this talk, we develop polynomial time dynamic programming algorithms for unit commitment(UC) problems with general convex or piecewise linear cost functions. The algorithms are also extended to stochastic UC with piecewise linear cost. Extended formulations and physical insights are explored based on these dynamic programming algorithms.

2 - A Computational Study for the Unit Commitment Model
Jianqiu Huang, University of Florida, 411 Weil Hall, Dept of Industrial and System Engineering, Gainesville, FL, 32608, United States, jianqiuhuang@ufl.edu, Kai Pan, Yongpei Guan

In this talk, we present the recent progress on the polyhedral study of the power system operation problems. The computational studies verify the effectiveness of our proposed approach.

3 - Unified Formulations for Combined-Cycle Units
Yongpei Guan, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611, United States, guan@ise.ufl.edu, Lei Fan, Yanan Yu

In this talk, we describe and develop edge-based and node-based formulations for combined-cycle units (CCUs) with different levels of accuracy in respecting physical restrictions of each turbine, from no restriction requirement of each turbine, to include min-up/-down time restrictions of each turbine, to finally include most restrictions such as min-up/-down time, capacity, and ramping restrictions of each turbine. We develop corresponding models for Independent System Operators (ISOs) and Vertically Integrated Utilities (VIUs), respectively. These models demonstrate the complexity in terms of the size of decision variables and show the tradeoff between accuracy and computational complexity. In general, to the best of our knowledge, this letter provides one of the first models that can capture both configuration-based model needs and all physical restrictions for each turbine within CCUs.

4 - Improving International Oil and Gas Supply Projections
Tuncay Alparslan, Operations Research Analyst, U.S. Department of Energy, Washington, DC, United States, Tuncay.Alparslan@eia.gov

While there are many models of energy production, no existing model adequately estimates worldwide oil and gas production, conversion, and logistics in a single integrated decision framework that also reflects coproduction of oil and gas resources. To better capture the interplay between shared resources and markets, U.S. Energy Information Administration is developing the Global Hydrocarbon Supply Module (GHySMo). GHySMo provides flexible geographic resolution, endogenous modeling of other fuels, and resource trade-offs that will advance current models. We will present model structure, core innovations, and early results with a focus on logistics and integration.

■ TC26

350B

Network Analytics and Telecommunications

Sponsored: Telecommunications

Sponsored Session

Chair: Michael Bartolacci, Penn State Berks, Penn State Berks, bethlehem, PA, 18017, United States, mbartolacc@aol.com

1 - A Dynamic Flocking Algorithm for Topology Control in Mobile Ad HOC Networks
Abdullah Konak, Penn State Berks, Tulpehocken Road, PO.7009, Reading, PA, 19610, United States, konak@psu.edu

Mobile Ad Hoc Networks (MANETs) has many application areas, including sensor networks, vehicular networks, robot swarms, and disaster emergency networks. On the other hand, MANETs have dynamic topologies which could be disconnected because of mobility of nodes. This paper presents an improved flocking algorithm to maintain the connectivity of a MANET using autonomous and intelligent agents. In the proposed flocking algorithm, agents modify their behavior parameters dynamically based on the size of their neighborhoods. A simulation study is conducted to investigate the performance of the new algorithm. Simulation results show that the algorithm outperforms earlier approaches.

2 - Cooperative Human-centric Sensing (HCS) Communications
Albena Mihovska, Aalborg University, Center for TeleInfrastruktur, Fredrik Bajers Vej 7C1, Aalborg, 9000, Denmark, amihovska@btech.au.dk

Human-Centric Sensing (HCS) is a newly emerged concept in the context of the Internet of Things (IoT) and the active and assisted living (AAL) scenario. HCS connectivity, also referred to as "smart connectivity" enables applications that are highly personalized and often time-critical. In a typical HCS scenario, there may be many hundreds of sensor streams connections; centered around the human, who would be the determining factor for the number, the purpose, the direction and the frequency of the sensor streams. This conribution investigates the delivery of a personalized assistive applications for a scenario of several users within the same HCS environment.

3 - A Distributed Server Provisioning Algorithm for Data Centers with Nonstationary User Requests
Yongkyu Cho, POSTECH, 77 Cheongam-ro, Pohang-si, Korea, Republic of, yongkyu.cho@lstlab.org, Young Myoung Ko

In the era of growing information communication technology, large-scale data centers are inevitable solutions for processing and storing huge amount of incoming data. Large-scale data centers, however, consume tremendous amount of energy. Achieving energy-efficiency is one of the key problems in data center operations. In the previous research study, we proposed a distributed speed scaling and load balancing algorithm for reducing energy consumption while attaining a desired quality of service when the user requests are stationary stochastic processes. In this research study, we seek how to extend the previous algorithm when the user requests are arriving in nonstationary fashion.

■ TC27

350C

Social Media Analysis: Marketing and Management Applications

Invited: Social Media Analytics

Invited Session

Chair: Soo Jeong Hong, Michigan State University, East Lansing, MI, 48824, United States, hongsoo3@msu.edu

1 - The Effect of Social Media Information on Financial Analysts
Kwangjin Lee, Michigan State University, East Lansing, MI, 48824, United States, leekwan6@msu.edu

The news media is an important information intermediary in financial markets. Social media encourage participation, collaboration, and information sharing and has transformed the disclosure landscape. While social media allow investors to become more informed and thereby contribute to a reduction in information asymmetry, there is limited evidence on how social media messages affect financial analysts. Using a sample of S&P 500 firms over the period 2012 - 2014, I examine whether and how social media information influences financial analysts.

2 - Effect of Social Media Messages on Stock Price Behavior During Firm Crises
Soo Jeong Hong, Michigan State University, 404 Wilson Rd, Room 309, East Lansing, MI, 48824, United States, hongsoo3@msu.edu

This study examines whether and how social media messages influence on stock price behavior under firm crises situations. Regression analyses on a sample of S&P 500 firms from 2004 to 2015 show the effect of volume and valence of social media messages on abnormal returns. Results suggest theoretical and practical implications.

■ TC28

350D

Auctions and Economics

Invited: Auctions

Invited Session

Chair: Benjamin Brooks, University of Chicago, Chicago, IL, United States, babrooks@uchicago.edu

1 - An Ascending Auction with Multidimensional Signals
Tibor Heumann, tahe@princeton.edu

A single-unit ascending auction in which agents observe multidimensional Gaussian signals about their valuation of the good is studied. A class of equilibria is constructed in two steps: (i) the private signals of each agent are projected into a one-dimensional equilibrium statistic, and (ii) the equilibrium strategies are constructed "as if" each agent observed only his equilibrium statistic. Novel predictions of ascending auctions that arise only when agents observe multidimensional signals are provided.

2 - Selling to Intermediaries: Optimal Auction Design in a Common Value Model
Benjamin Brooks, University of Chicago, Chicago, IL, United States, Dirk P.Bergemann, Stephen Morris

We characterize revenue maximizing auctions when the bidders are intermediaries who wish to resell the good. The bidders have differential information about their common resale opportunities: each bidder privately observes an independent draw of a resale opportunity, and the highest signal is a sufficient statistic for the value of winning the good. If the good must be sold, then the optimal mechanism is simply a posted price at which all bidders are willing to purchase the good, and all bidders are equally likely to be allocated the good, irrespective of their signals. If the seller can keep the good, then under the optimal mechanism, all bidders make the same expected payment and have the same expected probability of receiving the good, independent of the signal. Conditional on the good being sold, the allocation discriminates in favor of bidders with lower signals. In some cases, the optimal mechanism again reduces to a posted price. The model provides a foundation for posted prices in multi-agent screening problems.

3 - Collusion in Markets with Syndication

John Hatfield, McCombs School of Business, 2110 Speedway, Stop B6600, Austin, TX, 78172, United States, john.hatfield@gmail.com, Scott Kominers, Richard Lowery

Markets for IPOs and debt issuances are syndicated, in the sense that a bidder who wins a contract may invite losing bidders to join a syndicate to fulfill the contract. We show that in such markets, standard intuitions from industrial organization can be reversed: Collusion may become easier as market concentration falls, and market entry may facilitate collusion. In particular, price collusion can be sustained by a strategy in which firms refuse to join the syndicate of any firm that deviates from the collusive price. Our results thus can rationalize the apparently contradictory facts that the market for IPOs exhibits seemingly collusive pricing despite its low level of market concentration.

4 - Signal Design and Costly Entry

Vitor Farinha-Luz, ancouver School of Economics, 6000 Iona Drive, Vancouver, QC, Canada, vitor.farinhaluz@ubc.ca

A buyer observes a noisy signal about his own value for a good before making a costly entry decision. The signal structure can be designed by the seller, who cannot commit to a posted price post-entry. Following entry, the buyer perfectly observes his valuation and the seller makes him an offer. I show that, if entry occurs with interior probability, the optimal information structure provides partial information and solves a trade-off between efficient entry and guaranteeing positive rents to the buyer.

■ TC29

350E

Analytics for Social and Business Networks

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Kang Zhao, University of Iowa, Iowa City, IA, 52242, United States, kangzhao7@gmail.com

1 - Binary Matrix Completion Methods for Reciprocal Recommendation with Applications in Online Dating

Qihang Lin, University of Iowa, 21 East Market Street, S380, Pappajohn Business Building, Iowa City, IA, 52245, United States, qihang-lin@uiowa.edu, Kang Zhao, Xi Wang

The success of an online dating site depends on its effectiveness in recommending potential partners to each other. Compared to the traditional recommendation systems, the recommendation systems used by online dating sites must predict the mutual interests of a male and a female users in each other, which is a reciprocal recommendation system. In this paper, we study various binary matrix completion methods that can integrate the different behavior information of male and female users to improve the overall prediction accuracy for reciprocal recommendation. The proposed method is based on solving non-convex matrix optimization problems by alternating proximal gradient methods.

2 - Understanding the Impact of Individual User's Rating Patterns on Predictive Accuracy of Recommender Systems

Jingjing Zhang, Indiana University, 1309 E.10th St, HH4143, Bloomington, IN, 47405, United States, jjzhang@indiana.edu, Xiaoye Cheng, Lu Yan

This paper investigates how the rating patterns of individual users affect the performance of recommendation algorithms. We measure each individual user's rating patterns from three different perspectives: rating value, rating structure and neighborhood network embeddedness. We study how these three groups of rating measures influence the recommender systems' predictive accuracy performance for each user. Our experiments use five real-word datasets with varying characteristics. Our experimental results show consistent and significant effects of several rating measures on recommendation accuracy.

3 - Analyzing Firms' Performance -A Supply Chain Network Perspective

John Rios, University of Iowa, Iowa City, IA, 52242, United States, john-riosrodriguez@uiowa.edu, Kang Zhao, Jennifer Blackhurst

This research explores the relationship between the performance of a firm and the structure of its supply chain and competition networks. The analysis starts with building the supply chain network and the competition network among 4.7k firms. Incorporating baseline features of firms' individual characteristics, we show that firms' structural features based on its supply chain network and competition network (e.g., diversity or coordination) contribute to the analysis of firms' performance.

4 - Multi-label Annotation Aggregation in Crowdsourcing

Xuan Wei, University of Arizona, Tucson, AZ, United States, weix@email.arizona.edu, Dajun Daniel Zeng, Junming Yin

As a means of human-based computation, crowdsourcing has been widely used to annotate large-scale unlabeled datasets. One of the obvious challenges is how to aggregate these possibly noisy labels provided by a set of heterogeneous annotators. When each instance is associated with many possible labels simultaneously, the problem becomes even harder because of its combinatorial nature. In this paper, we present new flexible Bayesian models and efficient inference algorithms by taking both annotator reliability and label dependency into account. Extensive experiments on real-world datasets reveal that the proposed methods outperform other competitive alternatives.

■ TC30

350F

Health Analytics with User-generated Data

Invited: Social Media Analytics

Invited Session

Chair: Shuai Huang, University of Washington, University of Washington, Seattle, WA, 98195, United States, shuai.huang.ie@gmail.com

Co-Chair: Xia Hu, PhD, Texas A&M University, College Station, TX, 77843, United States, hu@cse.tamu.edu

1 - Mental Health Monitoring using Dynamic Vocal Biomarkers

Ying Lin, University of Houston, Houston, TX, 77030, United States, ylin58@uh.edu, Shuai Huang

Modes disorder is inherently related to emotion. With recent progresses in linking the acoustic and linguistic features to emotion, automatic analysis of audio data could provide a powerful tool to assist in detection and monitoring of mode disorder. The audio data contains a rich array of features, such as the pitch, energy and linguistic content, that can inform or indicate signify emotion changes in the communication. This study employed a variety of signal processing techniques to convert the audio signals into dynamic vocal biomarkers that capture the acoustic and linguistic features in speech. We further monitored the underlying emotion based on the identified dynamic vocal biomarkers.

2 - Graph Theoretic Compressive Sensing Approach for Classification of Global Neurophysiological States from Electroencephalography Signals

Prahalada Rao, University of Nebraska-Lincoln, Lincoln, NE, United States, rao@unl.edu
Prahalada Rao, University of Nebraska-Lincoln, Lincoln, NE, 68588, United States, rao@unl.edu, Samie Tootooni, Chun-An Chou, Vladimir Miskovic

We present a data-fusion framework integrating graph theoretic and compressive sensing (CS) techniques to detect global neurophysiological functions states using high-resolution electroencephalography (EEG) recordings. Acute stress experiments were induction (and control procedures) were used to elicit distinct states of neurophysiological arousal. Our experimental results revealed that the proposed graph theoretic compressive sensing approach yielded better classification performance (~90% F-score) compared to SVM use with statistical features (~50% F-Score).

■ TC31

351A

Risk Analysis

Contributed Session

Chair: Sadegh Kazemi Zarkouei, Washington State University, Pullman, WA, United States, m.kazemi@wsu.edu

1 - Pricing Decisions when Consumers Have Access to Quality Reviews and a Secondary Market

Sadegh Kazemi Zarkouei, Washington State University, Todd Hall Addition 470, Pullman, WA, 99164, United States, m.kazemi@wsu.edu, Michelle Wu

We are studying the effect of strategic consumers' behavior on a firm's profit when consumers socially interact among each other in the primary and secondary market in two periods. When the firm introduces a new product to the primary market, it may face a group of strategic consumers in the first period who postpone their purchases with the hope of a discounted price in the second period. These forward-looking behaviors are exacerbated when consumers have the opportunity to socially interact with each other through quality reviews. The presence of social learning and the secondary market significantly influence the consumers' purchasing decision and the firms optimal profit.

2 - A Multi-level Demand System for Differentiated Fare Products in Airline Industry

Hunkar Toyoglu, Senior Director, Sabre Airline Solutions, Southlake, TX, 76092, United States, hunkar.toyoglu@sabre.com, Yuhui Shi, Evrim Dener, Mu Liu, Joakim Kalvenes

We discuss econometric and theoretical considerations in specifying a demand system and suggest a flexible model to understand the competition between differentiated fare products in airline industry. We develop a multi-level hierarchical demand system and provide formulas and derivations in estimating own and cross price elasticity of demand in an unrestricted manner. Using transaction data, we estimate expenditure elasticity, own-price and asymmetric cross-price elasticity of demand for airlines and their competitors. We then identify which fare products are equivalent in the eyes of consumers, conduct competitive analysis and draw inference on the competitive structure in a market.

3 - Improving Overbooking Decisions using Customers Past Behaviour

Vinaysingh Chawan, Indian Institute of Management Indore, IIM.Indore Campus, Fac. Block B, Indore, 453556, India, vinaysingh@iimidr.ac.in

Overbooking models depend upon predictions of last moment cancellations and no-shows. A model is proposed to use CRM data to build predictive models that classify customers and assign a probability of cancellation/no-show to each customer/class. This predictive model is augmented with a revenue management model that considers the trade-offs associated with the overbooking decisions. The potential for revenue enhancement with this method is estimated using simulated data.

4 - A Choice Based Optimization Approach in Flexible Mobility on Demand

Shadi Sharif Azadeh, Assistant Professor, Erasmus University Rotterdam, Burgemeester Oudlaan 50, Rotterdam, 3062 PA, Netherlands, sharifazadeh@ese.eur.nl, Michel Bierlaire, Bilge Atasoy, Moshe E.Ben-Akiva, Yousef Maknoon

One of the main challenges of operation managers is to decide about how to o er a mix of products to the customers at a given time with the objective of maximizing the expected revenue as well as maximizing the customers' satisfaction. The expected revenue from an o er set is defined by the price and the demand of each of the o ered products. Smart phones have revolutionized urban transportation and mobility. We introduce an integrated choice-based optimization model that takes into account the cost of routing for taxis and shared taxis while accounting for customer choice behavior.

5 - Drivers of Degree of Hotel Revenue Management System Sophistication

Lizao Zhang, Washington State University, 1630 NE Valley Rd Apt V303, Pullman, WA, 99163, United States, lizao.zhang@wsu.edu, Timothy K.Baker, Xun Xu

We aim to develop a measure of hotel revenue management system sophistication. We revise a general taxonomy for the hotel settings and use it as a dependent variable to test the drivers of the need for revenue management system sophistication. We generate the drivers by delving into the literature of management, organizational behavior, and marketing; and test the drivers using hotels from North America.

6 - Cognitive Pricing for Personalized Bundle of Products and Services

Shuyu Chu, Virginia Institute of Technology, 1880 Pratt Drive, XV, Suite 1100-1, Blacksburg, VA, 24060, United States, cshuyu@vt.edu, Zhengliang Xue, Huijing Jiang, Xinwei Deng

We integrate classification, regression and optimization models to provide pricing solutions for bundles of product and service businesses, in which the services are highly customized projects, possibly associated with hardware and software orders. The services have distinguished features such as the band of labor force involved, service contents (travel expense, setup, maintenance, etc.), the duration of service, risk of project, and service category. The model considers the risk and cost involved during the project, and increase the expected profit by comparing optimal prices with actual prices in a business case study.

■ TC32

351B

Supply Chain, Shipping and Transportation

Contributed Session

Chair: Tao Lu, Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands, lu@rsm.nl

1 - Contracting for Product Support under Information Asymmetry

Nishant Mishra, Faculty of Business and Economics, KU. Leuven, Naamsestraat 69, Leuven, 3000, Belgium, nishant.mishra@kuleuven.be, Dong Li, Serguei Netessine

Despite advantages of Performance-based contracts (PBC) that have been highlighted in many previous studies, the more traditional Transaction-based Contracts (TBC) are still widely adopted in the product support industry. In this paper, we build a stylized adverse selection model to explore the hidden superiorities of TBC in screening products with different failure rates when the information about product reliability is privately owned by the customer. We find that TBC can achieve separation of product reliability without losing efficiency in setting service capacity, whereas, PBC requires interactions of pricing and capacity decision, resulting in over-investment in repair capacity.

2 - A Scenario Generation Approach for Integrated Supply Chain Network Design with Risk Considerations

Minghe Sun, Professor, The University of Texas at San Antonio, One UTSA Circle, San Antonio, TX, 78249, United States, minghe.sun@utsa.edu, Zhimin Guan, Jin Tao, Hao Wu

An optimization approach is developed for integrated design and operations for resilient supply chain networks with disruption risks. A mixed binary integer programming model is formulated. Scenarios are used to describe disruption events. Uncertainties in supplies, demands and prices are also considered. A region-wide dual-sourcing strategy, strategic emergency inventories and alternative sourcing facilities are used to increase network resilience. The Sample Average Approximation method is used to solve the proposed model with disruption risks. An illustrative example demonstrates the validity of the model and sensitivity analysis results provide important references.

3 - Deployment of Online Pickup Facility Networks for Omnichannel Supply Chain Management with GIS

Byeong-Yun Chang, Ajou University, San5 Woncheon-dong, Yeongtong-gu, Suwon, 443-749, Korea, Republic of, bychang@ajou.ac.kr, Choonki Min

Omni-channel supply chain management is one of the most challenging research fields in operations management arena. In this study we propose a method combining GIS and multi-criteria decision models to allow retailers providing online pickup service for omnichannel operation to determine locations for pickup sites and the type of the facilities.

4 - The Impact of Service Oriented Manufacturing on Core Enterprise in Supply Chain

Ruihan Zhang, Harbin Engineering University, No. 145, Nantong Avenue, Nangang District, Ha, Harbin, 150000, China, zhangruihan0826@163.com, Bing Sun

Based on the mediating role of core enterprise cost, the effect of Service-Oriented Manufacturing on core enterprise performance is explored. The result indicates that (1) Service-Oriented Manufacturing has a positive effect on the core enterprise performance; (2) Core enterprise cost in supply chain has a negative effect on the core enterprise performance; (3) Core enterprise cost plays a partial mediated role in the relationship between Service-Oriented Manufacturing and the core enterprise performance. This paper is funded by the International Exchange Program of Harbin Engineering University for Innovation-oriented Talents Cultivation.

5 - Path Based Versus Lane Based Formulation of Network Design Problems

Gokhan Memisoglu, LLamasoft Inc, 2813 Barclay Way, Ann Arbor, MI, 48105, United States, Gokhan.memisoglu@llamasoft.com, Ali Taghavi, Nejat Karabakal, Zheng Ouyang

Path-based formulation and lane-based formulation are usually the alternative approaches used in designing a supply chain network. In this study we review the main use cases for either of these formulations along with their pros and cons. Later, we present how we integrate these formulations for solving network design problems and show a number of related business problems solved by Llamasoft's network optimization tool (Supply Chain Guru).

6 - Shipping to Heterogeneous Customers with Competing Carriers

Tao Lu, Assistant Professor, Rotterdam School of Management, Erasmus University, Mandeville Building T09-03, P.O. Box 1738, Rotterdam, 3062 PA, Netherlands, lu@rsm.nl, Ying-Ju Chen, Jan C. Fransoo, Chung-Yee Lee

We consider a shipper selling a perishable product to heterogeneous customers in a destination market. The product can be shipped via two competing carriers with distinct speeds. Our analysis reveals a trade-off between the benefits from differentiation and competition. Dual-mode shipping can therefore be inferior to restricting to a single mode.

■ TC33

351C

Data-driven Analysis for Air Transport

Sponsored: Aviation Applications

Sponsored Session

Chair: Catherine Cleophas, RWTH Aachen University, Aachen, 52072, Germany, catherine.cleophas@rwth-aachen.de

Co-Chair: Virginie Lurkin, Ecole Polytechnique Fédérale de Lausanne, Route Cantonale, Lausanne, 1015, Switzerland, virginie.lurkin@epfl.ch

1 - The Impact of Airline Market Competition Structure on Fares

Susan Hotle, Assistant Professor, Virginia Tech, 200 Patton Hall, 750 Drillfield Drive, Blacksburg, VA, 24061, United States, shotle3@vt.edu, Stephanie Atallah

In recent years, changing economic conditions have led airlines to realign service to the most profitable routes and reduce operating costs. This presentation evaluates how non-stop airline markets have evolved with an emphasis on the continuity of service and the relationships between competition structure, market airport sizes, and fares. This analysis is performed using DB1B, OAG airline schedules, and the FAA's Airport Classification on size for years 2005-2015.

2 - A Nonparametric Approach to Estimating Air Travel Demand Structures from Panel Data

Johannes Jörg, RWTH Aachen University, Aachen, 52072, Germany, johannes.ferdinand.joerg@ada.rwth-aachen.de, Catherine Cleophas

Analyzing historical sales data to draw conclusions on the underlying demand structure is a central theme of revenue management. This contribution focuses on the estimation of demand segments present in a market using nonparametric methods on panel data. We employ finite mixtures to model purchase events over time frames and obtain estimators for purchase probabilities and market share. The approach shows promising performance when applied to simulated panel data sets with a MNL customer choice model.

3 - Using Online Surveys to Develop Choice Set Generation Models

Laurie A.Garrow, Georgia Institute of Technology, School of Civil & Environmental Engr, 790 Atlantic Drive, Atlanta, GA, 30332-0355, United States, laurie.garrow@ce.gatech.edu, Ziran Chen, Mohammad Ilbeigi

We designed an online experiment to capture how individuals filter and screen alternatives for discrete choice modeling applications. We ran this experiment on Amazon Mechanical Turk (AMT) and Qualtrics. We present preliminary results comparing responses obtained from AMT (a crowdsourcing Internet marketplace), Qualtrics (a traditional marketing survey panel), and an online survey conducted by the Resource Systems Group that recruited participants from airlines' frequent flyer databases. Based on these results, we offer a conceptual framework for how online surveys can be used to develop a choice set generation model for airline itinerary choice applications.

■ TC34

351D

Operations Research and Intelligence

Sponsored: Military Applications

Sponsored Session

Chair: Andrew Oscar Hall, United States Military Academy, West Point, NY, 10996, United States, andrew.hall@usma.edu

1 - Hazardous Materials (hazmat) Transport Risk Assessment Considering Terrorist Assaults

Zafer Yilmaz, McGill University, Montreal, QC, Canada, zyilmaz1996@gmail.com, Vedat Verter

Terrorist attacks against military convoys including hazmat trucks have increased during the past decade. We developed a methodology that incorporates the risk of such attacks as well as the accident risks. A case study focusing on the eastern part of Turkey suffering from terrorist attacks will be presented. Based on data from the past five years, the proposed risk assessment method is incorporated in a GIS framework so as to identify the best paths among the common origin-destination pairs.

2 - Second-order Extensions to Nearly Orthogonal-and-balanced Mixed-factor Experimental Designs

Zachary C.Little, Air Force Institute of Technology, Wright-Patterson AFB, OH, United States, zach.c.little@gmail.com Zachary C.Little, The Perduco Group, Beavercreek, OH, United States, zach.c.little@gmail.com, Jeffery D. Weir, Raymond R. Hill, Brian B.Stone, Jason K.Freels

Many simulation studies can involve a large number of both quantitative (how many?) and qualitative (which type?) decisions with different numbers of choices for each. Second-order extensions are developed for the nearly orthogonal-and-balanced (NOAB) design that accounts for such varied decisions, allowing analysts to better examine possible two-way interactions and quadratic effects. A case study is presented for evaluation and comparison of NOAB design construction approaches for a design space involving notional Intelligence, Surveillance, and Reconnaissance (ISR) decisions.

3 - Data Science Application for Medical Intelligence"

Russell Walter, U.S. Army, Washington, DC, 22207, United States, walt@mail.mil

We examined machine learning and natural language processing to detect articles containing relevant warnings of disease outbreak. For years, medical intelligence analysts have categorized articles based on relevant information they contained, yielding an extensively labelled dataset to train a machine learning classifier. Differences between classes are subtle. Applying several machine learning algorithms, the biggest sensitivity resulted from the preparation of the training corpus and not the models' parameters. Lessons learned regarding data having large class imbalances are also shared.

■ TC35

351E

Supply Chain Management, Green

Contributed Session

Chair: Elif Elcin Gunay, Iowa State University, Ames, IA, United States, eekabeloglu@gmail.com

1 - Optimality of Rule-based Allocation Planning in Customer Hierarchies with Stochastic Demand wnd Heterogeneous Service-level Targets

Konstantin Kloos, Research Assistant, University of Wuerzburg, Stephanstraße 1, Wuerzburg, 97070, Germany, konstantin.kloos@uni-wuerzburg.de, Benedikt Schulte, Richard Pibernik

To account for the multi-level hierarchical structure of sales organizations companies often times refrain from centralized optimization-based approaches but use simple allocation rules (i.e. per commit, rank based,...) better suited for decentralized, top-down planning regimes. Using the global optimum as a benchmark, we show analytically that these simple rules are optimal only under very restrictive conditions. Based on our analytical insights we develop two new rules resulting in optimal allocations under less restrictive conditions. In a numerical experiment we show that these new approaches consistently out perform conventional simple rules and lead to close-to-optimal results.

2 - Optimal Product Architecture and Supply Chain Configuration Designs under Labor Cost Fluctuation

Elif Elcin Gunay, Iowa State University, Ames, IA, United States, eekabeloglu@gmail.com, Kijung Park, Gul Kremer

Many companies utilize globally distributed supply chains in order to take advantage of lower labor costs in different countries. Changes in both the value and the volatility of labor costs can affect the production costs unexpectedly. At the same time, the product architecture i.e. the way product is assembled, and the quality and cost of components can be major factors affecting the production cost. This study proposes a stochastic optimization model for deciding the optimal product architecture and the supply chain configuration simultaneously, considering randomness in labor costs. Simultaneous consideration of these decisions enables improvements in product design as well as supply chain.

3 - The Impact of the Supply Chain on the Success of Product Pre-announcements

Laharish Guntuka, Doctoral Student, University of Maryland College Park, 3346 Van Munching Hall, College Park, MD, 20742, United States, lguntuka@rhsmith.umd.edu, Curt Grimm, David E. Cantor

We explore factors that influence a consumer's willingness to purchase a competitor's pre-announced product. Using competitive dynamics and relational view theories, we investigate how issues in the supply chain moderate these relationships. Example of factors explored include competitive aggressiveness, geographic and reputational concerns. We designed a behavioral experiment to test our research questions.

4 - Healthcare Supply Chain vs. Traditional Supply Chains: A Comparative Analysis

Balaraman Rajan, Assistant Professor, California State University East Bay, 25800 Carlos Bee Blvd, Hayward, CA, 94542, United States, balaraman.rajan@csueastbay.edu, Vishwanath Hegde

We compare and contrast the healthcare supply chain structure with that of traditional supply chains using publicly available financial data and analyzing financial ratios. We find that companies that operate in different stages of the healthcare supply chain do exhibit different characteristics and develop a framework to analyze the healthcare supply chain stages. We then draw inferences about the structural difference from traditional supply chains based on the performance of companies in comparable stages.

5 - How do Supply Chains Benefit from Supply Chain Finance? A Large Scale Empirical Investigation

David Wuttke, EBS.Universität, Burgstr. 5, Oestrich-Winkel, 65375, Germany, david.wuttke@ebs.edu

Supply chain finance gains increasing popularity among buyers and suppliers. In this study, we test a series of hypotheses on decisions and strategies related to the use supply chain finance in practice. Based on secondary data from a leading supply chain finance provider this study reveals substantial impact of supply chain finance on payment terms.

6 - Do Social Ties along the Supply Chain Foster Corporate Innovation?

Audrey Mathews, Illinois Institute of Technology, 3300 South Federal Street, Chicago, IL, 60616, United States, amathew2@hawk.iit.edu, Jiong Sun, Yiwei Fang

This paper investigates whether, and to what extent, managers' social ties between suppliers and major customers foster alternative information channels which ultimately lead to innovation by the supplier. We find that with more social connections, supplier firms invest more in R&D, and in turn, generate more supplier patents and patent citations. We also find that these additional patents and citations are associated with greater firm value for the supplier, as well as for customer firms.

■ TC36

351F

12:05 - 12:50 Provalis Research/ 12:50 - 1:35 Frontline Systems, Inc.

Invited: Vendor Tutorial

Invited Session

1 - Provalis Research

Adam Alami, Provalis, Montreal, QC, Canada, adam@provalisresearch.com

Operations Research and Management Sciences involves researching incident reports, corporate reports, news articles, press releases, social media and much more. The volume of available text has exploded in the digital age. It is extremely time consuming, expensive and in many cases impossible to read each and every document related to one's research. Automated content analysis makes it possible to systematically import and analyze very large volumes of text documents without spending vast sums on hiring coders. This presentation will showcase the different content analysis approaches such as computer assisted qualitative coding; text mining; content analysis dictionaries or taxonomies and supervised machine learning. We will discuss when one technique may be more appropriate than another and how they can work together to analyze text data.

2 - AnalyticSolver.com: Data Mining, Simulation and Optimization in Your Web Browser

Daniel H.Fylstra, Frontline Systems, Inc., P.O. Box 4288, Incline Village, NV, 89450-4288, United States, daniel@solver.com

AnalyticSolver.com is the new, simple, point-and-click way to create and run analytic models using only your web browser - that also works interchangeably with your spreadsheet. Whether you need forecasting, data mining and text mining, Monte Carlo simulation and risk analysis, and conventional and stochastic optimization, you can "do it all" in the cloud. We'll show how you can upload and download Excel workbooks, pull data from SQL Server databases and Apache Spark Big Data clusters, solve large-scale models, and visualize results - without leaving your browser. If you're more comfortable working on your own laptop or server, we'll show how you can do that, too.

■ TC37

352B

Managing Customer Contact

Sponsored: Service Science

Sponsored Session

Chair: Moein Khanlari, University of New Hampshire, 10 Garrison Avenue, Room 313, Durham, NH, 03824, United States, moein.khanlari@unh.edu

1 - Feature Selection for Voice Self-Service Transfer Rate in Insurance Call Centers

Rodrigo Andrade, Stevens Institute of Technology, 1 Castle Point Terrace, Hoboken, NJ, 07030, United States, rcaporal@stevens.edu, Somayeh Moazeni

We study effective features for the transfer outcome of a call arriving at the self-service voice response system based on customers' information from massive data of an insurance company. Our findings indicate that the call duration, distinct channels of contact, average temperature, customer types, and specific intents are relevant features to determine whether the call is transferred. Although customers' location is essential to select the active set of features we found no correlation between the country's region and the selected features. Managerial insights into policyholders' behavior are discussed. The algorithm is scalable and applicable to other business analytics applications.

2 - Impact of Extended Warranty Information Availability Strategies on Consumers' Product and Warranty Purchase Decisions

Moein Khanlari, University of New Hampshire, 10 Garrison Avenue, Room 313, Durham, NH, 03824, United States, moein.khanlari@unh.edu, Paul Messinger

In this paper, we ask whether and how the availability of Extended Warranty(EW) information during product choice might affect buyers' product and EW purchase decisions. Our results from a series of choice experiments show a combination of effects in this scenario that are attributable to two distinctive groups of customers. We observe lower sensitivity to EW prices combined with buying EWs for higher quality products (i.e. a reparative EW-focused mindset) attributable to risk-averse consumers, as well as a lower EW purchase likelihood associated with lower sensitivity to product prices (i.e. a preventative product-focused mindset) attributable to consumers with low risk aversion.

3 - Issues in Public Sector Service

Paul R.Messinger, University of Alberta, Faculty of Business, 3-20e Faculty of Business Bldg, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca

We study problems for public consultation arising out of the long lifecycles of major municipal projects. We propose a framework that breaks the practice of public-involvement processes into Planning, Engagement, Impact, and Assessment/organizational learning. Conduct (or practice) is preceded by Commitment and followed by Outcomes. Using interview, survey, and field data, we consider the applicability of the framework and discuss the differences in public involvement processes of several U.S. and Canadian cities.

■ TC38

352C

Multiple Criteria Optimization and Issues in Choice Behavior

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Hannele Elina Wallenius, Aalto University, Espoo, Finland, hannele.wallenius@aalto.fi

1 - Considerations of Choices with Decreasing Marginal Values

Jyrki Wallenius, Aalto University School of Business, Runeberginkatu 22-24, Helsinki, Finland, jyrki.wallenius@aalto.fi, Tolga Genc, Pekka J.Korhonen, Xu Peng

Our problem is to "fill" a basket with multiple goods using win-win and tradeoff strategies, assuming decreasing marginal value functions. Our ultimate goal is to increase knowledge of a Decision Maker's (DM) behavior in such stepwise choice situations. A key question is how to find the Most Preferred Final Basket and how to recognize it. The basket can be filled either with identical or different (various) goods. Some empirical experiments are used to illustrate the considerations.

2 - Predicting Choice Quality with Decision Style, Cognitive Reflection and Decision Environment

Tommi Juhani Pajala, Aalto University, Melkonkatu 19 A.29, Helsinki, 00210, Finland, tommi.pajala@aalto.fi

Psychological measures of decision style are rarely used in economic decision research. However, they could have value in explaining individual differences in a Multiple Criteria Decision Making task. I investigate whether decision style and cognitive measures together with the decision environment can explain choice quality. 159 participants answered the psychological measures and made 26 choices in a setting with six alternatives and six criteria. Low Cognitive Reflection and high Alternative Search were related to higher choice quality. Other decision style variables showed no effects. Conclusions are robust to a variety of model specifications, software packages, and priors.

3 - Approximated Set-valued Mapping Approach for Handling Multi-objective Bilevel Problems

Pekka Malo, Aalto University School of Business, Runeberginkatu 22-24, Helsinki, 00100, Finland, pekka.malo@aalto.fi, Ankur Sinha, Kalyanmoy Deb

A significant amount of research has been done on bilevel optimization problems both in the realm of classical and evolutionary optimization. However, the multiobjective extensions of bilevel programming have received relatively little attention from researchers in both the domains. In this paper, we develop insights into multiobjective bilevel optimization through theoretical progress made in the direction of parametric multiobjective programming. We introduce an approximated set-valued mapping procedure that would be helpful in the development of efficient evolutionary approaches for solving these problems.

4 - Multi-criterion Optimization using Evolutionary Algorithms

Kalyanmoy Deb, Michigan State University, Electrical & Computer Engineering, 428 S. Shaw Lane, East Lansing, MI, 48824, United States, kdeb@egr.msu.edu

In this talk, we shall present a 25 years of research and application of multi-criterion optimization and decision-making using evolutionary algorithms. The so-called EMO field, started in early nineties, have become a mainstream research area within evolutionary computation, with 500+ PhD theses, commercial softwares, and high impacting (one having 24000 citations) journal papers.

■ TC40

352E

2017 INFORMS Prize Winner

Sponsored: INFORMS Prize

Sponsored Session

Chair: Tarun Mohan Lal, Mayo Clinic, Rochester, MN, 55905, United States, mohanlal.tarun@mayo.edu

1 - Informs Prize Winner Showcase – the Walt Disney Company

Dayana Cope, The Walt Disney Company, P.O. Box 10000, Lake Buena Vista, FL, 32830, United States, dayana.cope@disney.com, Peter Buczkowski, Haining Yu

This presentation will include a summary of the Prize winning application submitted by The Walt Disney Company.

2 - Analysis in the United State Air Force: 2017 Informs Prize Presentation

Mark Gallagher, Doctorate, United States Air Force, Arlington, VA, United States, mark.a.gallagher16.civ@mail.mil

The Secretary of the Air Force signed our winning nomination for the INFORMS Prize. We highlighted 3 exemplar topics of aircraft repair, nuclear deterrence, and testing. We had 17 additional topics in operation effectiveness, logistics, manpower, acquisitions, and cost analysis. Leaders from Congress, US and allied defense forces, industry, professional societies, and academia endorsed the Air Force. We summarized recent Air Force research, publications, and awards. We discussed the history of operations research in the Air Force along with contributions to the foundations of operations research. We conclude with how the Air Force develops, trains, and organizes analysts.

■ TC41

352F

Health Care, Public Health

Contributed Session

Chair: Xin Ding, University of Houston, Houston, TX, United States, xding@uh.edu

1 - Holistic Data Analytics and Lean in Architectural Healthcare Pre-design

Sung Nam Hwang, Data Analytics and Senior Modeling Specialist, CallisonRTKL, 1717 Pacific Ave, Dallas, TX, 75201, United States, shwang@rtkl.com, Cortney Asberry

As healthcare systems implement EMR to store key information, exploring this data becomes crucial to strongly support process improvement initiatives seamlessly aligned with the schematic design process prior to any construction. Building new ORs adjacent to existing ORs adds more complexities during design phases since considering multiple transitional phases without deteriorating quality of service. Therefore, applying holistic data analytics, along with process analysis techniques, enables all members to understand pros and cons with respect to KPIs. Consequently, the schematic design process is better coordinated with all known and potential needs from clients.

2 - On Reducing Waiting Time for Specialists in Emergency Department

Cheng Zhu, McGill University, 701-801 Sherbrooke Est, Montreal, QC, H2L.0B7, Canada, cheng.zhu@mail.mcgill.ca, Beste Kucukyazici

From Emergency Department (ED) decision makers' perspective, we first decide the optimal specialist response policies for time-dependent patient arrivals, and then propose the optimal patient prioritization policies accordingly, in order to reduce the total LOS. Parameters are derived from 40,000 annual ED visits in a local hospital, and verified with ARENA simulation.

3 - Process Innovation in the Pharmaceutical Industry

Ivan Lugovoi, HEC Paris, 1 Square Theodore Judlin, Paris, 75015, France, ivan.lugovoi@hec.edu

Using a unique dataset of process - patent expert evaluations, we explore the benefits from process innovation. Combining our data with the sales of eighty generic pharmaceutical products over a ten-year period we find that process-patent activation is associated with a significant increase in a company's market share. To explain what drives this effect we evaluate process innovation across three dimensions: novelty, strength and depth. We find that two of these dimensions are mainly responsible for explaining the effect: i) the strength of a firm's process-patent portfolio for a given product and ii) the depth of a firm's process-patent portfolio for a given product.

4 - Does Hospital Operational Data Contain Signals of Resiliency and Safety Risk?

Dana Womack, PhD Candidate, Oregon Health & Science University, 48230 NW. Narup Road, Portland, OR, 97106, United States, womacda@ohsu.edu, Michelle Rose Hribar, Nancy Vuckovic, Paul Gorman

Acute care nurses enhance resiliency and enable patient care units to function under varying conditions by adjusting their work to meet ever changing patient needs. Adaptive strategies such as early task initiation, task deferral and delegation vary by workload state. We identify strategies frequently employed by nurses in normal, high and extreme workload states. We then explore whether "echoes" of these adaptive behaviors can be identified in ambient data generated by medication dispensing, nurse call and other systems used in care delivery. Analysis of ambient data may inform patient safety and improve the work experience of nurses by providing early signals of workload state transitions.

5 - The Impact of Focus Strategy and Market Competition on Cost Efficiency

Xin Ding, University of Houston, T2-230C, Technology I I.Building, Houston, TX, 77204, United States, xding@uh.edu, Xiaosong David Peng, Gregory R. Heim

In this study, we examine the longitudinal impact of focus strategy on cost efficiency in U.S. hospitals. We hypothesize that as the level of focus increases, hospital cost efficiency increases at a decreasing rate. In addition, we also hypothesize that focus helps improve cost efficiency in a competitive market when specialty hospitals are not present. Lastly, we propose that focus strategy has the strongest effect on cost efficiency for proprietary hospitals in highly competitive markets.

■ TC42

360A

Material Networks

Invited: Invited OR and Advanced Manufacturing

Invited Session

Chair: Sergiy Butenko, Texas A&M University, College Station, TX, 77843-3131, United States, butenko@tamu.edu

1 - Introduction to Network Analysis in the Context of Materials Networks

Vladimir Boginski, University of Central Florida, 12800 Pegasus Dr., Orlando, FL, 32541, United States, Vladimir.Boginski@ucf.edu

We discuss several concepts from network analysis and their potential interpretations in networks of materials. In particular, dense clusters in networks, such as cliques and clique relaxations will be addressed from the perspective of materials networks.

2 - Materials Networks: Construction and Structural Properties

Vladimir Boginski, University of Central Florida, Orlando, FL, United States, Vladimir.Boginski@ucf.edu, Alexander Veremyev

In this talk we well discuss how we construct materials networks based on similarity among their density of states functions and overview their basic structural properties.

■ TC43

360B

Models and Algorithms for Radiation Treatment Planning

Sponsored: Public Sector OR

Sponsored Session

Chair: Gino J Lim, University of Houston, Houston, TX, 77204, United States, ginolim@uh.edu

Co-Chair: Azin Khabazian, University of Houston, 5465 Braesvalley Dr. Apt 566, Houston, TX, 77096, United States, akhabazian@uh.edu

1 - A New Model and Algorithm for Planning Tomotherapy Delivery

Wilmer Henao, University of Michigan, 555 E. William Street, Apt 16C, Ann Arbor, MI, 48104, United States, wilmer@umich.edu

Current tomotherapy treatments for cancer tumors are developed assuming instantaneous opening and closing of gantry leaf apertures. Hence, conventional treatment planning spurs an excessive number of leaf events, leading to inaccuracies in dose delivery, and machine attrition. We propose a treatment model that explicitly controls the number of leaf events. The result is a treatment plan that represents dose effects more realistically, but which is modeled by a large-scale combinatorial problem. We therefore implement a fast iterative heuristic algorithm that achieves high-quality results.

2 - Incorporating Linear Energy Transfer in the Optimization of Intensity Modulated Proton Therapy

Azin Khabazian, University of Houston, Houston, TX, 77096, United States, akhabazian@uh.edu, Wenhua Cao, Gino Lim, Pablo Yepes, David Grosshans, Radhe Mohan

We developed a new optimization approach for incorporating linear energy transfer (LET) in intensity modulated proton therapy (IMPT) treatment planning. We hypothesize that the modified objective function will produce IMPT plans that not only satisfy clinical dose criteria but also achieve reduced LET distributions (thus lower biologically effective dose distributions) in critical structures and increased LET in target volumes compared to plans created based on conventional objectives. The resulting plan is compared with the conventional dose optimization regarding dose, LET and the product of dose and LET distributions

3 - Impact of Robust Optimization on Variable Relative Biological Effectiveness in IMPT Dose Distributions

Xuemin Bai, University of Houston, Houston, TX, 77054, United States, baid8432@gmail.com, Wenhua Cao, Hans-Peter Wieser, Gino J. Lim, Radhe Mohan

Robust optimization has been adopted to ensure robustness of intensity modulated proton therapy (IMPT) treatment plans in face of physical uncertainties such as range and setup errors. However, it has been established using a simplified constant value of relative biological effectiveness (RBE) for protons instead of using more complex and accurate variable RBE models. In this work, we investigate the impact of robust optimization on biologically effective IMPT dose distributions using a recently published RBE model for one phantom case and two head and neck cancer patient cases.

■ TC44

360C

Operations Management/Marketing Interface

Contributed Session

Chair: Refik Gullu, Bogazici University, Istanbul, Turkey, refik.gullu@boun.edu.tr

1 - Optimizing Revenue of Share-private Parking System

Shuo-Yan Chou, The National Taiwan University of Science and Technology, Office: MA217, No. 43, Section 4, Keelung Rd, Taipei City, 106, Taiwan, sychou@mail.ntust.edu.tw

This study proposes a share-private parking system to increase the availability of parking spaces by optimizing the utilization rate of the existing parking spaces. Through this system, parking spaces owners share their parking spaces when they do not use it and generate revenue. On the other hand, drivers can easily find the available parking space and make a reservation. The main objective of this system is optimizing the revenue from sharing without disturbing the parking owner needs. Before releasing the private parking space to public, the proposed system analyzes the usage pattern of parking owner to find optimal acceptance rate for incoming reservation.

2 - Multiproduct Price Optimization under the Multilevel Nested Logit Model

Hai Jiang, Associate Professor, Tsinghua University, Dept of Industrial Engineering, Tsinghua University, Beijing, 100084, China, haijiang@tsinghua.edu.cn, Rui Chen

We study the multiproduct price optimization problem under the multilevel nested logit model. When the price sensitivities are identical within each primary nest, that is, within each nest at level 1, we prove that the profit function is concave with respect to the market share variables. We proceed to show that the markup is constant across products within each primary nest, and that the adjusted markup is constant across primary nests at optimality. This allows us to reduce this problem to an equivalent single-variable maximization problem involving a unimodal function. We also investigate the oligopolistic game and characterize the Nash equilibrium.

3 - On the Dependence of Customer Valuation and Service Requirement

Chenguang Allen Wu, Northwestern University, 2145 Sheridan Road, Room C229, Evanston, IL, 60208, United States, allenwu@u.northwestern.edu, Achal Bassamboo, Ohad Perry

In many services, the value of service may depend on each customer's individual service requirement. We therefore consider a queueing model in the presence of a stochastic dependence between customers' valuation and service requirement. We employ a bivariate dependence order to rank the strength of dependence and show that the provider's revenue is strictly decreasing in the strength of dependence. We demonstrate via numerical examples that the revenue loss caused by a positive dependence can be substantial. Moreover, we show that a positive dependence can also lead to a violation to a known result in the literature that the provider always prefers a large market size when there is no dependence.

4 - Capacitated Assortment and Price Optimization under the Nested Logit Model

Rui Chen, Tsinghua University, Shunde Building of Tsinghua University, Beijing, China, chenr15@mails.tsinghua.edu.cn, Hai Jiang

We study the capacitated assortment and price optimization problem, where a retailer sells categories of substitutable products subject to a capacity constraint. The goal of the retailer is to determine the subset of products as well as their selling prices so as to maximize the expected revenue. We model the customer purchase behavior using the nested logit model and formulate this problem as a non-linear binary integer program. We then propose an efficient algorithm to obtain its ϵ-approximate solution based on solving a series of multiple-choice parametric knapsack problems.

5 - Modeling Correlation in Competitive Revenue Management

Refik Gullu, Professor, Bogazici University, Bogazici University, Industrial Engineering Department, Istanbul, 34342, Turkey, refik.gullu@boun.edu.tr, Engin Yildiz, Taner Bilgic

We model a competitive revenue management game where two firms choose their prices to maximize their revenues. Respective valuation of the firms by consumers (consumers' willingness-to-pay) are correlated random variables. A consumer who is willing to pay a higher than average price to a product or service may be willing to pay a lower or higher than average price for its competitor. We discuss structural properties of the response function, show the existence of unique price equilibrium, and present interesting comparative statics of the game for the case where the willingness-to-pay random variables take a particular bivariate exponential distribution.

■ TC45

360D

Revenue Management

Contributed Session

Chair: Peter McGlaughlin, University of Illinois at Urbana-Champaign, Urbana, IL, United States, mcglghl2@illinois.edu

1 - The Interaction between Product Rollover Strategy and Pricing Scheme

JingChen Liu, Peking University, Yiheyuan Road 5th, Haidian District, Beijing, 100871, China, liujingchen@pku.edu.cn, Xin Zhai, Lihua Chen

This study proposes a two-period model incorporating forward-looking consumers and market heterogeneity to explore the interaction between rollover strategy and pricing scheme of an innovating firm offering trade-in program. The firm uses either single or dual rollover to launch new generation, and chooses from price skimming and penetration pricing for consumer segment. We find that the optimal pricing scheme and rollover strategy depends on the innovation increment of new product, the salvage value of old product and how strategic consumers are. Moreover, the firm can be worse off deploying trade-in especially when innovation increment is not sufficient or consumers are relatively myopic.

2 - Product Recall through Group-buying with out Deadline

JingChen Liu, Peking University, Yiheyuan Road 5th, Haidian District, Beijing, 100871, China, liujingchen@pku.edu.cn, Ming Hu, Xin Zhai

This study considers a monopolistic firm selling one contemporary product to consumers with heterogeneous valuation who arrive according to a Poisson process. In order to better price discriminate between high- and low-end consumers, the firm can set up a product recall program, under which the firm will offer the recalled product to consumers who join if the sign-up number reaches the pre-announced threshold. We find that product recall program can perform as a win-win solution, namely the firm can improve its own profit without harming the consumers.

3 - An Analysis of Buy X Get 1 Free Reward Programs

Yan Liu, Tianjin University, Room C1211, The 25th Building, Tianjin University, No. 92 Weijin Road, Tianjin, 300072, China, hnnyly@gmail.com, Dan Zhang

"Buy x, get 1 free" reward programs are widely observed in practice. We model such programs as an infinite horizon stochastic game between a monopolistic seller and a population of customers with different product valuation and shopping frequencies. We characterize conditions under which the programs are profitable and discuss their welfare implications. Moreover, we show that "buy 1, get 1 free" program provides a tight bound on seller revenue and is optimal under certain conditions.

4 - Reinforcement Learning for Network Revenue Management

Peter McGlaughlin, Graduate Student, University of Illinois at Urbana-Champaign, 409 W. Elm St, Apt 12, Urbana, IL, 61801, United States, mcglghl2@illinois.edu

Network Revenue Management concerns the optimal allocation of a fixed set of resources across various segments of market demand. Applications require heuristic solutions as the underlying optimization problem is intractable. We propose reinforcement learning as an alternative. Recently, these algorithms enjoyed widely popularized success in solving large, challenging sequential decision making problems. Thus, reinforcement learning seems a natural candidate for a new approach to network revenue management. Numerical experiments show significant revenue increases, about 10%, over existing heuristics.

■ TC46

360E

Scheduling with Applications

Invited: Project Management and Scheduling

Invited Session

Chair: Rodrigo A. Carrasco, Ph.D., Universidad Adolfo Ibáñez, Santiago, 7941169, Chile, rax@uai.cl

1 - Incorporating Suppliers into Capital Project Scheduling

Arman Jabbari, University of California-Berkeley, 2012 Del Norte, Berkeley, CA, 94707, United States, a.jabbari@berkeley.edu, Philip Kaminsky

The majority of capital projects are completed after their intended completion date and over budget, often due to inefficiencies in the way their supply chains are managed. After conducting extensive with practitioners in the oil and gas industry, we have identified the relationship between the project schedule and the procurement plan as one cause of these problems. As part of a larger project to develop approaches to simultaneously develop schedules and plan procurement, we need to bound certain online scheduling problems. Here, we prove that the DSPT algorithm is 2-competitive for the online version of minimizing modified total tardiness.

2 - Preemptive Parallel-machine Scheduling Problem of Maximizing the Number of On-time Jobs

Marc E. Posner, Ohio State University, 296 Baker Systems Engineering, 1971 Neil Avenue, Columbus, OH, 43210-1271, United States, posner.1@OSU.edu, Hui-Chih Hung, Bertrand M.T. Lin, Jun-Min Wei

We study the classical preemptive parallel-machine scheduling problem of maximizing number of on-time jobs. While known to be NP-hard, no theoretical analysis of approximation algorithms exists. We propose heuristics based on different design strategies, which have asymptotically tight relative errors of 1/2. Experimental tests evaluate computational performance. As part of the analysis, a new non-standard mixed integer formulation is developed.

3 - Cutting-plane Methods for Resource-constrained Project Scheduling Problems in Strategic Mine-planning

Alessandro Hill, Universidad Adolfo Ibanez, Santiago, Chile, alessandro.hill@uai.cl, Marcos Goycoolea

We consider resource-constrained project scheduling problems which are powerful models for mine planning. These notoriously hard problems aim at scheduling given tasks under bounded availability of multiple resources per time period, while respecting given precedence relations, in order to minimize the total project duration or maximizing a profit function. We present novel polyhedral techniques based on various problem-specific cuts. In our mathematical programming framework, we borrow fast enumeration subroutines from constraint programming. We show the detailed potential of our approaches within branch and cut algorithms for literature instances as well as real-world problems.

4 - Activity Scheduling in Mine Construction

Valentina Rojas, Universidad de Chile, Santiago, Chile, vjrojasc@gmail.com, Rodrigo A. Carrasco, Alessandro Hill, Nelson Morales

Construction of a mine is critical because it defines the available area for production, but proper model of a plan schedule can be hard, because there may be different ways to reach certain part of the mine, different potential technologies to use or because some activities may collaborate in order to achieve a common goal. In this talk we present a MIP model that abstracts these considerations and compare solution approaches on several mining methods.

■ TC47

360F

Leveraging Online Platforms to Manage Services

Sponsored: EBusiness

Sponsored Session

Chair: Sreekumar R. Bhaskaran, Southern Methodist University, Dallas, TX, 75275, United States, sbhaskar@mail.cox.smu.edu

1 - Leveraging Online Platforms to Manage Services

Sanjiv Erat, University of California-San Diego, Rady Sch. Mgmt. Otterson Hall, 9500 Gilman Drive MC 0553, La Jolla, CA, 92093-0553, United States, serat@ucsd.edu

Many large firms are increasingly relying on open innovation, often requesting their own customers to brainstorm and come up with new products and services. While firms are becoming more adept at using IT to collect ideas from outside the firm boundaries, the evaluation and filtering of ideas is still a costly and labor intensive process. This talk shall discuss how some recent innovations in natural language processing can be effectively leveraged to automate the evaluation and filtering of large idea pools, thus making open innovation accessible and affordable even for smaller firms.

2 - Strategies of Coupon Issuance in Service Industries

Simin Li, Kellogg School of Management, Northwestern University, 2211 Campus Drive, Evanston, IL, 60208, United States, simin.li@kellogg.northwestern.edu, Kejia Hu, Martin Lariviere

We empirically study how service providers strategically design coupons, based on marginal service cost (MSC), to facilitate demand-supply coordination during rush hours. We find service providers with higher MSC launch coupons earlier with less discount. We confirm strategic coupon issuance effectively shift demand of experienced coupon users. Via counterfactual analysis, we propose a strategy tailoring to MSC and customer responsiveness.

3 - Platform Preannouncement Strategies: the Strategic Role of Information in Two-sided Markets Competition
Rajiv Mukherjee, Southern Methodist University, 11113 New Orleans Dr, Frisco, TX, 75035, United States, rajiv.mukherjee@gmail.com, Ramnath K. Chellappa

We use a game theoretic model to study the role of information contained in the firm's preannouncement strategy before releasing a new version of its platform to a two sided market in a competitive setting. We also explore the impact of installed base, switching and multi-homing on such strategies.

4 - On the Reliability of Online Reviews of Physicians
Atanu Lahiri, University of Texas at Dallas, University of Texas - JSOM, 800 W. Campbell Rd, #SM33, Richardson, TX, 75080, United States, atanu.lahiri@utdallas.edu, Danish Saifee, Vijay S. Mookerjee

We look at the reliability of online reviews of physicians by comparing such reviews with other data sources as well as by examining their ability to predict clinical outcomes.

■ TC48

361A

Behavioral Operations: Theory Development and Hypothesis Testing

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Xiaoyang Long, HKUST University, xlongaa@connect.ust.hk

Co-Chair: Javad Nasiry, Hong Kong University of Science and Technology-HKUST, Lee Shau Kee Business Building, Room 4079, Hong Kong, 00000, Hong Kong, nasiry@ust.hk

1 - Transparency in Procurement Mechanisms
Ignacio Rios, Stanford University, 63 Abrams Ct., Apt. 519, Stanford, CA, 94305, United States, iriosu@stanford.edu, Ruth Beer, Daniela Saban

Motivated by the recent initiatives to increase the transparency in procurement in both in the public and private sector, we experimentally investigate the impact of different levels of transparency on a procurement game in which the director of an organization delegates purchasing decisions to the employees. We posit that, when purchasing decisions are delegated to agents, increased transparency can affect agents' actions through peer effects.

2 - Reciprocity in Demand Allocation Games
Yinghao Zhang, University of Cincinnati, 614A Carl H. Lindner Hall, 2925 Campus Green Dr., Cincinnati, OH, 45221, United States, zhang5y7@ucmail.uc.edu, Lin Tian, Tianjun Feng

We consider a situation with two competing retailers who make inventory decisions. The total market demand is divided proportional to their stocking levels. Experimental results suggest that human subjects' decisions systematically deviate from the Nash Equilibrium. We use theory of reciprocity to explain this off-equilibrium behavior.

3 - A Data-driven Approach for Promotions and Rewards Programs
Rim Hariss, Massachusetts Institute of Technology, Operations Research Center, 1 Amherst Street, Cambridge, MA, 02142, United States, rhariss@mit.edu, Georgia Perakis, Yanchong Zheng

Consumer-facing companies often adopt promotions and loyalty/rewards programs to attract customer demand and keep retention. In this work, we investigate the impact of promotions and rewards programs on customer choices and behaviors, develop a data-driven framework to accurately and dynamically predict market demands, then develop a prescriptive model for promotions and loyalty programs, such as advising on frequency and design of such programs.

4 - Designing Seat Belts for Boundely Rational Contract Designers. A Choice Set Reduction Experiment.
Valery Pavlov, Senior Lecturer, University of Auckland Business School, University of Auckland, Private Bag 92019, Auckland, 1142, New Zealand, v.pavlov@auckland.ac.nz, Bingkun Zhu

Supply chain contracting experiments commonly find that retailers often reject suppliers' "take-it-or-leave-it" offers. Dealing with rejections, suppliers face a cognitively demanding task of designing contracts that optimally trade off their profit and the probability of rejection. As a result of the problem complexity, suppliers' offers exhibit a substantial degree of bounded rationality. In our laboratory experiment, we test predictions of random choice models that eliminating suboptimal contracts from the supplier choice set improves the performance of a two-part tariff contractual form.

■ TC49

361B

Practice/eBusiness III

Contributed Session

Chair: Xing Liu, Huazhong University of Science and Technology, Luoyu Road 1037, Wuhan, China, Wuhan, 1, China, 1393096617@qq.com

1 - Exploring the Relationship Between Offline Locations and Online Rating Behavior
Dominik Gutt, Paderborn University, Warburger Str 100, Paderborn, 33098, Germany, dominik.gutt@uni-paderborn.de, Juergen Neumann, Dennis Kundisch

This study examines the relationship between rating outside of a customer's home area and the magnitude of online ratings. We employ a data-driven identification of a customer's geographic home area and use variation in this variable to identify the consequences for the magnitude of online ratings. We find that customers who give a rating while traveling give, on average, higher ratings than locals. However, this relationship is moderated by the posting time of a review relative to consumption, with more negative ratings posted by travelers during or shortly after consumption. These results come with substantial implications for a business's average rating and for customer decision making.

2 - The Importance of Multisensory Feedback and Sensory Congruence in Virtual Product Experience
Cheng Luo, Tianjin University, Tianjin, China, cheng.luo@tju.edu.cn

As mouse-driven desktops give way to touchscreen and mid-air gesture-based devices, inquiries into the design and use of new interaction technologies deserve further investigation. This study explores how multisensory feedback and sensory congruence provided by interaction technologies shape virtual product experience. Drawing on literature on virtual product experience and sensory-based interaction, we propose that visual feedback and haptic feedback would enhance product tangibility and thus reduce consumers' shopping risk perceptions. Furthermore, the interaction effect between visual and haptic feedback on product tangibility would be moderated by sensory congruence.

3 - A New Application for Worst Case Resistance Testing
Stephen France, Mississippi State University, 324 McCool Hall, 40 Old Main, Mississippi State, MS, 39762, United States, sfrance@business.msstate.edu, Frank Adams, Myles Landers

Wave analysis assessments of non-response bias seem inadequate when internet samples can complete data collections in minutes. We adapt an extant procedure - worst-case resistance testing, often used to assess the file-draw problem in meta-analysis - to address the problem. The procedure assesses a study's non-response bias vulnerability based on the sample size, mean and standard deviation of specific survey item replies.

4 - How Internet Celebrity Attract Our Customers? the Effects of Internet Celebrity E-commerce Attractiveness on Customers' Repurchase Intention
Xing Liu, Huazhong University of Science and Technology, Luoyu Road 1037, Wuhan, China, Wuhan, China, 1393096617@qq.com

The success of emerging Internet celebrity e-commerce (ICEC) depends on the repurchase of their customers. Drawing on attractive and identification theories, we examine the role of ICEC attractiveness (in terms of product attractiveness, live streaming attractiveness, and internet celebrity attractiveness) in influencing internet celebrity identification and the influence of such identification on customers' repurchase intention. The findings of this study contribute to a better understanding how Internet celebrity e-commerce attract and retain repeat customers through their attractiveness.

■ TC50

361C

Connected and Automated Transportation

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Husain Abdul Aziz, PhD, Oak Ridge National Laboratory, Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, TN, 37831, United States, azizh@ornl.gov

1 - Simulating the Operations of Shared Autonomous Vehicle Fleets
Krishna Gurumurthy, University of Texas-Austin, Stop C1700, Austin, TX, 78712, United States, na, Kara Kockelman

Simulation of fleets of shared autonomous vehicles (SAVs) exist for various travel settings, using Austin, Texas data. Reliance on all-electric vehicles lowers replacement rates (from 1 SAV for 9 household vehicles to 1-to-5, in some cases) and raises empty-mileage (to 20% of fleet VMT). Dynamic ride-sharing (among strangers) raises replacement rates (to 10:1, for example) and lowers empty-VMT (becoming negative in some cases). Increasing a served region's size, to enable all trip distances, does not appear to raise empty-VMT, but response times are higher in exurban settings, and untenable with all-electric fleets.

2 - Automated Vehicle Performance at Intersection. Integration of Empirical Evidence with Simulation
Ramin Arvin, Graduate, University of Tennessee-Knoxville, 325 John D. Tickle Building, Knoxville, TN, United States, rarvin@vols.utk.edu

Automated Vehicles (AV) can potentially improve the current state of transportation by reducing human errors, and improving safety and reliability. In this paper, we develop crash scenarios using early empirical evidence from real-life AV-involved crashes in a simulation framework. The Wiedemann car-following model in SUMO simulates both traffic flow and crashes. Therefore it was used to quantify crash rates under different AV market penetration scenarios.

3 - Roads in Transition: Integrated Modeling of a Manufacturer-traveler-road Infrastructure System in a Mixed Autonomous/Human Driving Environment
Bo Zou, Assistant Professor, University of Illinois at Chicago, 2073 Engineering Research Facility, 842 W. Taylor Street, Chicago, IL, 60607, United States, bzou@uic.edu, Mohamadhossein Noruzoliaee, Yang Liu

This study develops an integrated modeling framework for autonomous vehicle (AV) manufacturer-traveler-road infrastructure system in a futuristic, mixed traffic environment. The modeling system involves manufacturer decision, multiclass traveler decision on vehicle and routing choice, and variable road capacity, and is formulated as an MPCC. To solve the MPCC to global optimality, multiple MILP-based approximation techniques are developed. The effectiveness of the solution approach is demonstrated with extensive numerical experiments in a Singapore case study.

4 - Machine Learning Based Traffic Signal Control Algorithms for Connected and Automated Transportation
Husain Aziz, Dr., Oak Ridge National Laboratory, 1 Bethel Valley Road, Oak Ridge, TN, 37831-6017, United States, azizh@ornl.gov

The anticipated deployment of the connected and automated vehicles (CAVs) offer the opportunity to leverage connectivity and automation for efficient operations of signalized intersection in transportation networks. CAVs can act as mobile sensors with a unique opportunity for data collection that can be used for real-time optimization of traffic signal settings. Machine learning based signal control techniques are expected to adapt to the changing traffic condition both temporally and spatially. We developed a machine-learning based signal control scheme that leverages the available data in a CAV environment and accounts for energy and mobility.

■ TC51

361D

Recommender Systems

Sponsored: Information Systems

Sponsored Session

Chair: Konstantin Bauman, New York University, New York, NY, 10012, United States, kbauman@stern.nyu.edu

1 - Boosting Recommendation Diversity through Stochastic Item Selection
Kartik Hosanagar, University of Pennsylvania, 3730 Walnut Street, 500 Jon M.Huntsman Hall, Philadelphia, PA, 19104-6340, United States, kartikh@wharton.upenn.edu, Alex Miller

The standard k-nearest neighbor collaborative Filtering algorithm is well known to exhibit systematic popularity bias, by which products with higher market shares are disproportionately more likely to be recommended. We propose a novel method that recommends items with probabilities proportional to each item's sales or views among similar users. Using a dynamic simulation analysis, we show that our approach dramatically increases both aggregate and individual-level recommendation diversity while simultaneously increasing recommendation accuracy.

2 - Comparing the Effects of Disparate Sources of Information on Consumers' Product Selection: A Process-oriented View
Jingjing Zhang, Indiana University, 1309 E 10th St, HH4143, Bloomington, IN, 47405, United States, jjzhang@indiana.edu, Binny Samuel, Vijay Khatri

The objective of this project is to develop an understanding of consumers' information integration process in the online shopping setting. We are interested in identifying the sequence in which consumers use to integrate different sources of information (i.e., product description, online word-of-mouth, and personalized recommendations) in their product selection process.

3 - Recommender System and Cross-selling: Monopoly and Duopoly
Abhijeet Ghoshal, University of Louisville, Room 377, College of Business, Louisville, KY, 40292, United States, abhijeet.ghoshal@louisville.edu, Sumit Sarkar, Vijay Mookerjee

Recommendations provided by firms change how customers search products by helping customers find their preferred products. In the process, firms learn the preferences of customers and make cross-selling offers. Considering these factors, we study how firms price products in monopolistic and duopolistic markets and highlight the role of cross-selling. In duopoly, cross-selling may compel the firm with inferior recommender system to reduce its price when the superior firm improves its system, a counter-intuitive result since improvement of the system of the latter firm decreases competition.

■ TC52

361E

Energy

Contributed Session

Chair: Deepak Rajan, Lawrence Livermore National Laboratory, Livermore, CA, United States, rajan3@llnl.gov

1 - Impact of Various Cascading Assumptions on Defensive Investments
Sinan Tas, Assistant Professor, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI, 53818, United States, sinantas@gmail.com

Cascading failure is often overlooked when analyzing how vulnerable power grids, or similar capacity-constrained networks, are. In this study, we first model cascading failure probabilistically, and then analyze how various cascading assumptions about the network and the attacker can change our investments to make the system more secure or resilient.

2 - Optimal Allocation of HVDC Interconnections for the Exchange of Energy and Reserve Capacity Services
Stefanos Delikaraoglou, Technical University of Denmark, Akademivej, Building 358, Kgs. Lyngby, 2800, Denmark, sdelikaraoglou@gmail.com

The European market structure separates energy and reserve trading leading to inefficient utilization of HVDC interconnections, since their capacity must be ex-ante allocated between these services. To improve market efficiency, we propose a decision-support tool that enables an implicit temporal coupling of the different trading floors, using as control parameters the inter-area transmission allocation between energy and reserves and the reserve requirements. The proposed mechanism, formulated as a stochastic bilevel program, is aligned with the existing market and reduces expected system cost for high shares of intermittent renewables.

3 - Efficient Design for Short Term Markets in the European Electricity System - First Results from a Stochastic Multi Stage Energy System Model
Frieder Borggrefe, German Aerospace Center, Pfaffenwaldring 38-40, Stuttgart, 70563, Germany, frieder.borggrefe@dlr.de

This paper introduces an integrated model for short-term markets within the European electricity system. Aim of the model is to analyze and compare future market designs. The paper shows first results from a simplified commitment and dispatch model including day-ahead, intraday & balancing markets and imbalance settlement rules.The second part compares market designs and influence of uncertainty on market decisions. Due to complexity of the model it is difficult to scale it to the full European market. The paper outlines next steps to expand this model and discusses challenges when applying it HPC. The model results are part of the BEAM-ME project.

4 - Prediction Based Electricity Forward Pricing Model in Japan Electric Power Exchange

Yuji Yamada, Professor, University of Tsukuba, 3-29-1 Otsuka Bunkyo-ku, Tokyo, 112-0012, Japan, yuji@gssm.otsuka.tsukuba.ac.jp

In this paper, we demonstrate the prediction based electricity forward pricing model in JEPX, where we decompose the log-price process into the trend function and its residual based on the generalized additive model (GAM). We then apply the autoregressive moving average model (ARMA) for the residuals to estimate the conditional expectation of JEPX spot price, and derive the forward price with arbitrarily delivery period based on the Esscher transformation.

5 - Accelerating Scenario Decomposition Schemes using Optimal Scenario Grouping

Deepak Rajan, Lawrence Livermore National Laboratory, Box 808, L-495, Livermore, CA, 94551, United States, rajan3@llnl.gov, Kevin C. Ryan, Shabbir Ahmed, Santanu Subhas Dey

We present a scenario grouping scheme for accelerating scenario decomposition algorithms to solve stochastic integer programs. The scenario grouping scheme is quite general and applicable to any scenario decomposition scheme, which can be implemented in a distributed framework. We illustrate the effectiveness of the proposed scheme on hard-to-solve stochastic unit commitment instances.

■ TC54

362A

Environmental Aspects of Transportation Systems

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Gisele Mendy Bilek, University of Pau and the Adour countries, 8 Allees des Platanes, Bayonne, 64100, France, gisele.mendy-bilek@univ-pau.fr

1 - A Soft System Based Framework for Sustainable Freight Transportation

Ravi Shankar, Professor, Indian Institute of Technology Delhi, New Delhi, India, ravi1@dms.iitd.ernet.in, Vijayta Fulzele

The major challenge for any freight transporter is to effectively develop proper fit between organisation goals and sustainability initiatives. Soft System Methodology has been adopted to design this framework. This fundamental and comprehensive framework helps in better adoption of sustainability in freight operations.

2 - Energy-efficient Peer-to-peer Ridesharing Optimization

Yanshuo Sun, Research Scientist, Univ of Maryland, 1173 Glenn Martin Hall, College Park, MD, 20742, United States, gexingba@gmail.com, Zhi-Long Chen, Lei Zhang

The Peer-to-peer (P2P) dynamic ridesharing has been promoted as a promising mobility option to reduce the system-wide cost by consolidating similar trips into one. As the problem shares some features with pickup and delivery problems, even static problem instances are computationally very expensive and exact solutions can be found only for small or medium-sized problems. A highly efficient set packing type formulation is thus proposed to solve relatively large problems (e.g., 500 vehicles and 1000 riders) optimally in almost real-time. Real-world tests in the Washington DC-Baltimore region are performed to explore the potential of dynamic P2P ridesharing for system-wide energy use reduction.

3 - Modeling Enablers of Dedicated Freight Corridor for Sustainable Freight Transportation

Ravi Shankar, Professor, Indian Institute of Technology-Delhi, New Delhi, 110016, India, r.s.research@gmail.com, Devendra Kumar Pathak, Devendra Choudhary

India is witnessing an unprecedented decline in modal share of rail freight transportation. Dedicated freight corridors (DFCs) are being implemented to reduce carbon emissions and decongest freight traffic. This study attempts to identify enablers of DFC to achieve sustainability in freight transportation. Exploratory factor analysis is employed to identify hidden constructs and total interpretive structural modeling has been used to explicate the inter-relationship among these enablers.

4 - The Impact of a Mandatory Program for Measuring and Reporting Co2 Emissions on Environmental Practices: the Case Study of Road Transportation in France

Gisele Mendy Bilek, Associate Professor, IAE Business School, University of Pau and the Adour countries, 8 Allees des Platanes, Bayonne, 64100, France, gisele.mendy-bilek@univ-pau.fr, Nathalie Fabbe-Costes, Arnaud Bilek, Elodie Kacoui Maurin

Since 2013, a mandatory program to inform CO2 emissions of transport services on French territory has been implemented. This research analyzes the motivations and constraints associated with the application of the device and the impact on environmental practices. On the basis of a national survey, the researchers propose a typology of companies applying the decree, identifies factors of influence and possible avenues for improvement. A model based on systems dynamics theory makes it possible to simulate several scenarios with regard to the evolution of the device.

■ TC56

362C

Health Care, Other

Contributed Session

Chair: Bhavin Shah, Indian Institute of Management, Indore, Indore - Madhya Pradesh, India, bhavinj@iimidr.ac.in

1 - Assessing In-stent-restenosis Risks of Patients After Coronary Stent Placement

Halenur Sahin, Middle East Techical University, Ankara, Turkey, halenur.sahin@metu.edu.tr, Serhan Duran, Ertan Yakici

Aging and some lifestyle habits cause plaque accumulation in cardiac veins and narrows the arteries. Stents are used in balloon angioplasty to keep the vessel open but the stented vessel has a risk of re-narrowing due to recovery response of the stented segment. It is called in-stent-restenosis. Our objective is to develop a model to classify patients due to their risks of restenosis by using OR and statistical tools. With this model, it is intended to bring patient specific follow-up proposals to protect them from an emergency case, more medication requirement, and risk of losing effectiveness of treatment. In this context, mathematical models and effective solution methodologies will be presented.

2 - A Discussion of the Capital and Human Resources of the Aging Care System in Taiwan

Ching Ying Huang, Assistant Professor, National Cheng Kung University, Tainan, Taiwan, isastat@mail.ncku.edu.tw

Aging in place let the elderly stay in the familiar environment not feel be abandoned. How the local community provides the care assistance to the aging population and increases their independence is an issue. In Taiwan, the care organizations are classified into three levels, A, B, and C that helps the daily life of the local elderly. Under limited resources, how to run the care system in an efficient way is difficult. We mimic the system of an A-class care organization with ARENA. Four types of the aging services, energy station, day care center, dementia day care, and housing are discussed. The research attempts to answer how much the capitals and the resources should input in an A-class care organization.

3 - Competition Between For-profit and Not-for-Profit Hospitals

Steven Mark Shugan, University of Florida, 2030 NW. 24th Avenue, Gainesville, FL, 32605, United States, steven.shugan@warrington.ufl.edu, Jihwan Moon

For-profit and not-for-profit hospitals differ on many factors including their objectives. Using a two-stage game theoretic optimization, we model competition between these hospitals. With an extensive database of US hospitals, we show, consistent with model predictions, nonprofits are more profitable than for-profits, nonprofits have higher equilibrium prices than for-profits, competition increases the differences between these hospitals, and nonprofit make greater investments in premium medical services. We provide additional empirical findings and implications for hospital and public policy.

4 - Measuring Complexity in Healthcare Systems

Farzad Zaerpour, University of Calgary, 407 10 Brentwood CMNW, Calgary, AB, T2L2L6, Canada, farzad.zaerpour@haskayne.ucalgary.ca, Diane P.Bischak, Mozart Batista de Castro Menezes

In this work we study a complexity measure and its relationship with performance measures within the healthcare system. We borrow the measure from manufacturing systems to assess how well a healthcare system can manage the complexity induced by the patient group mix. We illustrate the use of the measure in an emergency department (ED) setting. An emergency department is a complex system with random arrivals of patients who may have different classifications based on personal history and health condition. We present findings on the impact of complexity levels on ED quality performance.

5 - Homophily Effect of Doctor Behavior Over Time in Online Healthcare Communities: Evidence from China

Panpan Wang, Shanghai Jiao Tong University, Shanghai, China, wpp_cq@qq.com, Jifeng Luo

This research empirically investigate the patterns of physicians' adoption and usage behaviors in online healthcare community over time across locations. Based on existing literature, we propose that doctors' adoption behavior is more influenced by their peers similar both in geography and demography. We collected data on historical online activities of 26499 physicians in 31cities of China from a large Chinese healthcare website. We use logit model to study doctors' adoption behavior. Homophily effect(i.e. demographic similarity and geographical proximity) of doctor's behavior over time will be reported.

6 - Vendor Selection in Hospitals for Consumables and Non-consumables

Bhavin J. Shah, Associate Professor, Indian Institute of Management, Indore, Faculty Office # C-206, First Floor,, Prabandh Shikhar,, Indore - Madhya Pradesh, 453556, India, bhavinj@iimidr.ac.in, Hasmukh Gajjar, Peeyush Pandey

We study various parameters governing vendor selection in hospitals for consumables and non-consumables category. We come up with unique membership functions for each category to select the vendor.

■ TC57

362D

Stochastic Optimization

Sponsored: Simulation

Sponsored Session

Chair: Raghu Pasupathy, Purdue University, pasupath@purdue.edu

1 - Exact and Inexact Subsampled Newton Methods for Optimization

Raghu Bollapragada, Northwestern University, Evanston, IL, United States, raghu.bollapragada@u.northwestern.edu, Richard Byrd, Jorge Nocedal, Albert Solomon Berahas

In this talk, We study the solution of stochastic optimization problems in which approximations to the gradient and Hessian are obtained through subsampling. We first consider Newton-like methods that employ these approximations and discuss how to coordinate the accuracy in the gradient and Hessian to yield a superlinear rate of convergence in expectation. We also consider inexact Newton methods and investigate what is the most efficient linear solver in terms of computational complexity.

2 - Optimizing the Design of a Latin Hypercube Sampling Estimator

Alexander Zolan, University of Texas-Austin, 204 E Dean Keeton Street, Stop C2200, Austin, TX, 78712, United States, alex.zolan@utexas.edu, John Hasenbein, David Morton

We present a method of reducing the variance of a Latin hypercube sampling (LHS) estimator by using an approximation of the estimator's variance and formulating a nonlinear program. We solve this problem exactly via a dynamic program for each random component, using a discrete set of candidate stratum boundary points. We present conditions for this technique to guarantee variance reduction, compared to LHS with equal-probability strata. We assess the impact of our sampling method on bias in optimal values obtained via solving stochastic programs, versus common techniques in the literature.

3 - The Adaptive Sampling Line Search Method for Unconstrained Stochastic Optimization

Raghu Pasupathy, Purdue University, West Lafayette, IN, 47906, United States, pasupath@purdue.edu, Fatemeh S. Hashemi, Michael R. Taaffe

We present the adaptive sampling line search method for solving unconstrained stochastic optimization problems where the objective function can only be estimated using an inexact oracle, e.g., Monte Carlo, QMC, or numerical quadrature. We will discuss two flavors (fixed-step and backtracking search) of the proposed method along with convergence calculations and global complexity results. The complexity results are especially illuminating when compared with classical results on the complexity of line search methods in presence of an exact oracle.

■ TC58

362E

Smart Facilities

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Margarit Khachatryan, PhD, Monsanto, Monsanto, MO, United States, margarit.khachatryan@monsanto.com

1 - Multiple In-the-aisle Pick Positions AS/RS with Class-based Storage

Faraz Ramtin, Carian Consulting Group, South Plainfield, NJ, United States, faraz.ramtin@knights.ucf.edu, Jennifer A. Pazour

An automated storage and retrieval system with multiple in-the-aisle pick positions (MIAPP-AS/RS) is a semi-automated case-level order fulfillment technology. The put-away to the storage locations and replenishment to pick positions are performed by the crane and the in-the-aisle case-picking is done by order pickers. We develop closed-form expected travel time models for the class-based storage assignment policy. Also, we develop optimization models to find the optimal boundary of the classes as well as allocation of the SKUs to classes. The objective of the models is to minimize the expected travel time subject to different operating policies, demand profiles, and shape factors.

2 - Model Based Approach to Smart Warehousing

Leon McGinnis, Georgia Institute of Technology, Isye Dept, 755 Ferst Drive, Atlanta, GA, 30332-0205, United States, leon.mcginnis@isye.gatech.edu, Camilo Bernal-Nisperuza, Francisco Perez Hellec, Mohamed El Tonbari

A formal warehouse system model integrates multiple viewpoints, and supports design, planning and control to achieve "smart warehousing." It also provides a basis for automating the generation of a range of analysis models to support design decision making. The use case is a highly automated facility for dispensing drugs.

3 - Integrated Cross-docking and Assignment

Arpan Rijal, Erasmus University, Rotterdam, Netherlands, rijal@rsm.nl, René B.M. De Koster, Marco Bijvank

Companies use cross-docking to simultaneously minimize transport and inventory holding cost. We study scheduling and dock assignment of inbound and outbound trucks at an LTL cross-dock. We develop an ALNS-based heuristic that beats state-of-the-art sequential truck scheduling and assignment methods both in solution quality and speed and that works for real-life instances. Tests on instances based on operations of a Dutch retailer reveal that the integrated model can vastly reduce internal transport and late departures.

4 - An Analysis of Storage Policies on a Multi-dock Unit-load Warehouse with Contour-line Shaped Storage Regions

Mahmut Tutam, PhD Candidate, University of Arkansas, 1359 N Leverett Avenue, Fayetteville, AR, 72703, United States, mtutam@uark.edu, John A.White

In this paper, the performance of a unit-load warehouse is studied when storage regions can be any shape under class-based storage policies. Specifically, unit-loads are assigned to storage regions on a priority basis. Storage regions are either rectangle shaped or contour-line shaped. Expected distance traveled with rectangle-shaped storage regions are compared with their counterpart contour-line based storage regions. Minimizing expected round-trip distance, the best rectangle-shaped storage regions are determined for different locations of docks

5 - Robotic Warehouses; State-of-the-art and Research Opportunities

René B.M. De Koster, professor of Logistics and Operations Management, Erasmus University-Rotterdam, Rotterdam, Netherlands, rkoster@rsm.nl

The new generation of warehouses will be fully robotized. Managers can select from different competitive robotic techniques to fulfill the customer orders. We develop analytical performance models and use them to optimally size the systems for costs, throughput and response time, and for comparison between the most popular robotic techniques. However, so far many new systems and techniques have not received any research attention.

■ TC59

362F

Joint Session RAS/Practice: Yard Perfomance Modeling

Sponsored: Railway Applications

Sponsored Session

Chair: Michael F. Gorman, University of Dayton, Dayton, OH, 45469, United States, michael.gorman@udayton.edu

1 - A Multipurpose Yard Simulation Model

Michael F. Gorman, University of Dayton, 300 College Park, Dayton, OH, 45469, United States, michael.gorman@udayton.edu

In practice, it is a challenge to estimate yard capacity. Yard simulations attempt to describe yard operations to allow evaluation of changes in policy at a yard. Unfortunately, yard simulations are highly specific to the layout of a specific yard, and are not reusable. I develop a general purpose, reusable yard simulation model that gives good high-level estimates of yard performance and can be applied to many different yards. Model input requirements are minimal. The model provides insight int receiving and departure track use, bowl inventory levels, and car, block and train throughput. To my knowledge, no other multipurpose yard simulation is found in the literature or in use at railroads.

2 - Investigating the Relationship Between Volume, Blocking Complexity and Railway Classification Yard Performance with Simulation

Tyler Dick, University of Illinois at Urbana-Champaign, 1241 Newmark Lab MC-250, 205 N Mathews Avenue, Urbana, IL, 61801, United States, ctdick@illinois.edu, Nao Nishio

In designing a train plan for a railway network, one decision is to determine the number of blocks to be handled by each train and the number of blocks to be assembled at each classification yard while maintaining a certain level of service. This research uses simulation and factorial experiment design to investigate the relationship between yard throughput volume, the total number of blocks processed and the level of service. Following this initial analysis, the research will be expanded to examine the influence of train arrival rate, overall yard configuration and other yard operational factors on the developed capacity relationship.

3 - Yard Planner: A Digital Force Multiplier for Railroad Classification Yards

Jeremiah Dirnberger, Product Manager, GE Transportation, Jacksonville, FL, United States, jeremiah.dirnberger@ge.com

GE's Yard Planner, part of a broader "Yard of the Future" vision, is a decision support system designed to aid the planning of activities in classification yards. It provides real time planning and optimization for all car processing activities, such as train-to-track assignments, block-to-track assignment, build sequence, etc. The pilot is being developed for hump yards with Norfolk Southern, but efforts are already under way at GE to expand the product to support flat-switching operations of varying size and complexity. This presentation will discuss the solution approach, lessons learned through the development process, and planned/actual results from the pilot roll-out at Macon Yard.

■ TC60

370A

Addressing Challenges in Teaching Analytics

Sponsored: INFORMEd

Sponsored Session

Chair: Janet M. Wagner, Stockton College of New Jersey, 101 Vera King Farris Drive, Galloway, NJ, 08205, United States, janet.wagner@stockton.edu

1 - A Process Mining Approach Towards Identification of Recurring Behavioral Patterns in Course Sequences

Jie Tao, Assistant Professor in Information Systems, Fairfield University, 1073 N.Benson Rd, Fairfield, CT, 06824, United States, jtao@fairfield.edu

Course planning at universities have received increasing interests from both researchers and practitioners. In this article, I propose an analytical framework in order to identify recurring course behavioral patterns from course sequencing datasets. The framework processes and analyzes the raw course sequencing datasets for the purpose of presenting insightful, actionable rules. A case study is then conducted in order to demonstrate and evaluate the proposed framework, with the course sequencing data of MBA students at XYZ University. After empirical evaluations , the findings from the case study are correct and actionable, in both contexts of course sequencing/planning and process mining.

2 - Teaching Students to Frame the Analytics Problem

Satish V. Nargundkar, Clinical Professor, Georgia State University, 2802 Fairlane Dr., Atlanta, GA, 30340, United States, snargundkar@gsu.edu, Subhashish Samaddar

Students often have difficulty interpreting a business case and framing it as an analytics problem when needed. Specifically, learning to identify a dependent variable, and determining if a continuous or binary dependent is more appropriate is the first step. Identifying an outcome period and a time frame from which to collect sample data is the next task. Finally, what questions should one ask of the client before the project begins? Examples are presented to help students understand these critical tasks at the start of an analytics project.

3 - Insights to the Usefulness of More Gamification in Classrooms

Sinan Tas, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI, 53818, United States, tass@uwplatt.edu, Pamela Tas

Gamification is using game elements in a classroom setting in order to make classes more engaging for an effective learning experience. Many educators may find it challenging to figure out how much to gamify their classes. Is there too little or too much gamification? In this empirical study, we compare different levels of gamification to determine if there are significant differences in student learning and motivation.

4 - Specification Grading in an Introductory Business Analytics Course

Janet M.Wagner, Dean, Stockton University, 101 Vera King Farris Drive, Galloway, NJ, 08205, United States, janet.wagner@stockton.edu

Specification grading is an alternative to common "points based" grading systems, and its proponents claim it supports course rigor, increases student motivation, while simultaneously reducing the instructor's grading time. In this talk I will discuss how I set up a core undergraduate course in Business Analytics (in the Information Systems Curriculum) around specification grading, and discuss how well this system did or didn't support the three goals above. Spoiler alert: it worked pretty well.

■ TC61

370B

Sports Analytics III

Sponsored: SpORts

Sponsored Session

Chair: Benjamin Grannan, Virginia Military Institute, Lexington, VA, 24450, United States, grannanbc@vmi.edu

1 - Optimized Team Scheduling for Collegiate Baseball Summer Leagues

Benjamin Grannan, Assistant Professor, Furman University, Greenville, SC, 29601, United States, grannanb@gmail.com

An optimization based approach to team scheduling for collegiate summer baseball leagues is presented.

2 - Airline Revenue Management for Mega Sporting Events

Yuqi Peng, University of South Carolina, Columbia, SC, United States, Yuqi.Peng@grad.moore.sc.edu, Mark Ferguson, Ovunc Yilmaz

Using game information from the 2012 NCAA Men's Basketball Championship and an extensive database of air travel ticketing data, we explore the connection between the knockout game results (Sweet Sixteen and Elite Eight) and air travel demand for the neutral site where the next stage (Final Four) will be played. We use a difference-in-differences approach to identify specific demand patterns and present market-level heterogeneity. Based on our findings, we offer a new pricing strategy to help the airline industry improve their revenue management solutions around sporting events.

3 - Round-robin Tournaments Generated with the Circle Method Have Maximum Carry-over

Dries Goossens, Ghent University, Tweekerkenstraat 2, Gent, 9000, Belgium, Dries.Goossens@ugent.be, Frits C.Spieksma, Annette Ficker, Erik Lambrechts

The Circle Method (aka the polygon method, or the canonical procedure) is widely used in the field of sport scheduling to generate schedules for round-robin tournaments. The so-called carry-over effect value is a number that can be associated to each roundrobin schedule; it represents a degree of balance and fairness of a schedule. We prove that, for an even number of teams, the Circle Method generates a schedule with maximum carry-over effect value, answering an open question.

4 - Predicting MLB Game Outcomes through Simulation

Justin Long, Slippery Rock University, 5902 Westridge Circle NW, North Canton, OH, 44720, United States, jbl1005@sru.edu

In this study, Major League Baseball is explained using a Markov Chain Method, as each game state is independent of all previous states excluding the one immediately prior. To model this, data from every game in the 2010 through 2015 seasons are used to calculate probabilities of all possible state transitions. Offensive playing ability and home-field advantage are taken into consideration by partitioning probabilities into different transition matrices. For a given team, simulations are utilized to mimic the series of an entire season; this result provides an overall expected win-percentage. Predictions can be used by managers, players, and fans for varying purposes.

■ TC62

370C

Bayesian and Maximum Entropy Reilability and Operations Models

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ehsan S. Soofi, University of Wisconsin-Milwaukee, Milwaukee, WI, 53201, United States, esoofi@uwm.edu

Co-Chair: Refik Soyer, George Washington University, Washington, DC, 20052, United States, soyer@gwu.edu

1 - Information Theoretic Multistage Sampling Framework for Medical Audits

Tahir Ekin, Texas State University, 601 University Dr. Mccoy 451, San Marcos, TX, 78666, United States, t_e18@txstate.edu, Rasim M. Musal

The sampling resource allocation decisions for medical audits are crucial and challenging because of the large payment amounts and heterogeneity of the claims. This talk introduces an iterative stratified sampling method that uses Lindley's entropy measure to evaluate the expected amount of information. We use U.S. Medicare Part B claims outpatient payment data and investigate the versatility of the framework for different overpayment scenarios and resource allocation designs. The proposed method results in reasonable coverage and lower estimation errors while outperforming Neyman Allocation. The framework also can be used to make probability statements on variables of interest.

2 - New Maximum Entropy Newsvendor Models

Mahsa Mardikoraem, University of Wisconsin-Milwaukee, 1560 N Prospect Ave, Milwaukee, WI, 53202, United States, mardiko2@uwm.edu, Amirsaman Hamzeh Bajgiran, Ehsan S. Soofi

We use the maximum entropy procedures that provide new models for the distribution of demand in the newsvendor problem. Our proposed models include the generalized error family with members such as the normal and Laplace distributions. We also include partial information about the demand provided by under and over stock costs in the maximum entropy calculation via local information constraints. This formulation gives change point demand distributions. Examples include two-piece demand distributions with uniform, exponential, or truncated normal for demand below the order quantity and exponential or truncated normal for demand above the order quantity.

3 - Entropy of Stock-out Distribution and Bayes Risk of the Mean Stock-out

Ehsan S.Soofi, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, esoofi@uwm.edu, Majid Asadi, Nader Ebrahimi, Khosro Pichka

We study uncertainty and prediction of the stock-out as functions of the inventory level. The distribution of the stock-out, given the inventory, is the residual of the demand. The residual entropy of the stock-out measures the uncertainty and the mean stock-out is the optimal prediction under the quadratic loss. We present applications of the available results for the residual entropy and the mean residual to the stock-out and give new results. Considering variation of the inventory level, we use the expected entropy to measure anticipated uncertainty about the stock-out and compute Bayes risk of the mean stock-out.

4 - Augmented Probability Simulation for Accelerated Life Test Designs

Refik Soyer, PhD, George Washington University, Washington, DC, United States, soyer@gwu.edu, Nicholas Polson

Designing accelerated life tests presents a number of conceptual and computational challenges. We propose a Bayesian decision-theoretic approach for selecting an optimal design, and develop an augmented probability simulation approach to obtain the optimal design. The notion of a "dual utility probability density" enables us to invoke the concept of a conjugate utility function. For accelerated life tests, this allows us to construct an augmented probability simulation which simultaneously optimizes and calculates the expected utility. To illustrate our methodology, we consider a single-stage accelerated life test design; our approach naturally extends to multiple stage designs.

■ TC63

370D

Transportation, Operations

Contributed Session

Chair: Monia Rekik, Laval University, 2325 rue de la Terrasse, Quebec, QC, G1V 0A6, Canada, monia.rekik@cirrelt.ca

1 - Non Price Reactions to Price Competing Entry

Amirhossein Alamdar Yazdi, PhD Candidate, University of Massachusetts, Isenberg School of Management, 121 Presidents Drive, Amherst, MA, 01003, United States, aalamdaryazd@som.umass.edu

I study non-price responses to price competition in the airline industry. I look at how incumbent carriers adjust service quality and supply in response to low-cost carrier entry. Our initial results show that incumbent firms service quality improves in the threat-of-entry period but worsens after the entrance of a low-cost carrier.

2 - Sequencing Triple-spreader Crane Operations: Mathematical Formulation and Genetic Algorithm

Shabnam Lashkari, PhD. Student in Industrial Engineering, University of Wisconsin-Milwaukee, 1559 N Prospect Avenue, Apt 202, Milwaukee, WI, 53202, United States, lashkari@uwm.edu, Matthew Petering, Yong Wu

This paper investigates the problem of scheduling a triple-spreader (i.e. tandem-lift) crane when lifts are subject to a weight limit. We formulate the problem as an integer linear program and develop a fast method for computing a lower bound on the optimal objective value. In addition, we devise a genetic algorithm that produces high quality solutions for small, medium, large, and very large problem instances.

3 - Local Container Drayage Problem under a New Operation Mode

Zhaojie Xue, Shenzhen University, Room A423, Civil Engineering Building,, Shenzhen University, Nanshan District, Shenzhen, China, zjxue@szu.edu.cn

This study examines the Local Container Drayage Problem (LCDP) under an operation mode in which a tractor can be detached from its companion trailer and assigned to a new task. We have incorporated a set of temporal constraints into the classical VRP to realize this operation by utilizing the idle time available to tractors and coordinating the empty containers moving between customers. A combinatorial benders' cuts algorithm and a tabu search algorithm are proposed. Some numerical experiments are conducted to assess the performance of the proposed algorithm, quantify the benefit of the new operation mode, and identify the conditions under which the mode is effective.

4 - A Robust Approach to Airport Gate Assignment with a Solution-dependent Uncertainty Budget

Chao Zhang, Sun Yat-Sen University, No. 135, Xingang Xi Road,, Zhenghuantang B509, Guangzhou, China, chaozhang1209@gmail.com, Liang Xu, Fan Wang, Feng Xiao

Airport gate assignment (AGA) aims to assign flights to gates according to their arrival and departure times. To tackle flight delays in airports, we propose a robust airport gate assignment (RAGA) to maximize the probability that the total real-time gaps between consecutive flights at the same gate is no less than a pre-specified target. Then we develop an asymptotically tight upper bound for the violation probability. Based on the upper bound, a solution-dependent uncertainty budget is introduced to develop a robust counterpart for the RAGA. Empirical study on ShuangLiu International Airport (CTU) indicates that our proposed robust approach for AGA outperforms existing methods.

5 - Combinatorial Bid Generation for TI Services Procurement

Monia Rekik, Associate Professor, Universite Laval, 2325 rue de la Terrasse, Quebec, QC, G1V. 0A6, Canada, monia.rekik@cirrelt.ca, Farouk Hammami, Leandro C. Coelho

We address the Bid Generation Problem in combinatorial auctions for the procurement of TL transportation services. The objective is to identify profitable transportation contracts to bid on based on the carrier existing network and other operational constraints. An Adapted Large Neighborhood Search heuristic is proposed. Computational results show that the ALNS heuristic performs well in terms of CPU time and solution quality.

■ TC64

370E

Complex Data Analysis and its Applications

Sponsored: Data Mining

Sponsored Session

Chair: Neng Fan, University of Arizona, Tucson, AZ, 85721, United States, nfan@email.arizona.edu

1 - Fitting Phase-type Distribution to Healthcare Transition Data

Wanlu Gu, 827 E Drachman St, Tucson, AZ, 85719, United States, wanlugu@email.arizona.edu, Neng Fan

The length of stay (LOS) is a term to describe the duration of a single stay in hospital, it as well as the time interval between a discharge and the next admission are important measures of healthcare utilization. In this talk, we fit a phase type distribution to LOS data from The University of Arizona Cancer Center. In order to eliminate confounding factors, we study data of patients with one typical type of disease at a time. By selecting proper number of phases (LOS groups), we can grasp the heterogeneity of these phases and connect it with the patients' trace after discharge. Then some actions can be taken to improve the efficiency of healthcare utilization.

2 - Distributionally-robust CVAR Formulation of SVMs using Wasserstein Metric

Ammon Washburn, University of Arizona, 2525 N Los Altos Avenue, Apt 155, Tucson, AZ, 85705, United States, wammonj@email.arizona.edu, Neng Fan, Helen Zhang

There has been many variants of Support Vector Machines that use different norms or penalty functions in order to accomplish feature selection, good generalization and robustness to outliers. We propose to unify all of them under a framework that comes CVaR in financial applications. Then we will show properties of the resulting quadratic program as a function of parameters and provide an algorithm that will compute the whole solution path for two out of three of the parameters in about the time it takes to solve one using interior points methods.

3 - Use of Phase Type Distribution in ALT Data Analysis

Samira Karimi, University of Arkansas, 1219 Storer Ave, Apt 39, Fayetteville, AR, 72703, United States, sakarimi@email.uark.edu, Haitao Liao

Accelerated life testing (ALT) is a powerful tool for estimating a product's reliability. In ALT, a spectrum of accelerated conditions (such as pressure, temperature, voltage, stress, etc.) is utilized to generate failures in a shorter period of time in comparison to normal conditions. To model and analyze the resulting lifetime and censoring data, one is required to relate the data to the applied stress factors over time. In this research, ALT data is modeled by a phase-type distribution, and an Expectation-Maximization algorithm is developed to estimate the model parameters. A numerical study is presented to illustrate the performance and precision of the proposed method.

4 - Graph Clustering with Uncertainty

Yujia Zhang, 4901 E Sunrise Drive, Apt 1013, Tucson, AZ, 85718, United States, yujiazhang@email.arizona.edu

During this talk we will review certain models and algorithms for clustering of data with uncertainty. First the methods for modeling uncertainty data will be reviewed. Then we concentrate on the graph models for clustering. In the end we will review and compare algorithms for solving these models.

■ TC65

370F

Transportation and Logistics Research in Taiwan, a Special Session for IJOR and JIPE

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: I-Lin Wang, National Cheng Kung University, Industrial Information Management, 1 University Road, Tainan, 70101, Taiwan, ilinwang@mail.ncku.edu.tw

1 - Optimal Fleet Deployment for Electric Vehicle Sharing Systems

Chung-Cheng Lu, National Chiao Tung University, Hsinchu City, Taiwan, jasoncclu@nctu.edu.tw

This study deals with the fleet deployment problem for electric vehicle (EV) sharing systems that service tourists in scenic areas. The problem aims to determine the number of plug-in EVs deployed at each rental station such that the profit of the system operator is maximized. The operational aspects of plug-in EVs are taken into account, including electricity energy consumption, battery capacity and charging requirements. A mathematical programming model of the problem is developed.

2 - Ship Routing and Freight Assignment Problem for Liner Shipping Considering Northern Sea Route

Dung-Ying Lin, National Cheng Kung University, 1 University Road, Transportation Management, Tainan City, Taiwan, dylin@mail.ncku.edu.tw

In recent years, the Northern Sea Route (NSR) has attracted significant attention with respect to liner shipping. In this research, we investigate the NSR planning problem and construct a time-space network-based mathematical formulation to analyze the ship routing and freight assignment problem in liner shipping. To solve the resulting program, we propose a Lagrangian relaxation-based decomposition algorithm that facilitates the network features. The proposed framework is empirically applied to a case from Company C. The results show that navigation skill, bunker price, delay penalty and service commitment are the primary factors that affect the NSR's commercial practicability.

3 - On Multi-parametric Costs Perturbation of the Integer Program with a Motivational Problem of the Dynamic Ambulance Allocation

Yu-Ching Lee, National Tsing Hua University, No 101, Section 2, Kuang-Fu Road, Engineering Building I, Hsinchu, Taiwan, ylee77@uiuc.edu, Chor-Yiu Sin, Albert Y. Chen

A two-stage stochastic integer programming model is developed to minimize the expected response time in every designated period by dynamically deciding the numbers of the ambulances to be allocated and re-allocated at each base. Practically, the expected response time is approximated by a finite number of draws of the scenarios whose probabilities are forecasted based on the historical counts of the ambulance requests. We evaluate the robustness of this allocation model with regard to the accuracy of the forecasted probabilities by the technique of the multi- dimensional cost sensitivity for the IP.

4 - Optimal Security Deployment over Moving Trains in Rail Transit Networks

I-Lin Wang, National Cheng Kung University, Industrial Information Management, 1 University Road, Tainan, 70101, Taiwan, ilinwang@mail.ncku.edu.tw, Tai-Chia Huang, Shiue-Mei Sun, Yun-Hsuan Lu

Rail transit systems usually operate with fixed routes and schedules to provide more reliable and less polluted commuting services to move more people within urban areas. Due to their predictable schedules, attacks over trains may lead to severe casualties. Yet current practices usually deploy security on static stations rather than moving trains. We investigate effective security deployment over moving trains by mathematical programming models. Maximum coverage to passengers on trains can be calculated. We also consider a variant of network interdiction problem to deploy security so that the maximum number of passengers affected by a single attack over a train segment can be minimized.

5 - Price Strategy and Capacity Allocation for Crystal Cycle of TFT-LCD Industry

Kang-Ting Ma, Post-doctor Researcher, National Tsing Hua University, Hsinchu, Taiwan, ktma@ie.nthu.edu.tw, Che-Wei Chou, Chen-Fu Chien

Variances of supplies and demands in TFT-LCD industry fluctuate prices namely crystal cycle. By the contrast, as supplies are shortage, manipulating prices affect the demands. A two-stage mathematical model is proposed to maximize profit of the manufacturer that determines the price strategy of product portfolio. Manufacture resources are allocated in the first stage. Rising prices for brand's demand fulfillment are provided, and a new capacity will be reallocated in second stage. A hybrid particle swarm optimization algorithm is developed to solve the nonlinear two-stage mathematical model, and the algorithm is quite efficient by designing of initial solutions and local search procedure.

■ TC66

371A

Best Paper and Best Dissertation session

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Lavanya Marla, University of Illinois at Urbana-Champaign, 104 S Mathews Avenue, Room 216E, Urbana, IL, 61801, United States, lavanyamarla@cmu.edu

1 - Best Paper Award Session Finalists

Andres Medaglia, Universidad de los Andes, Bogota, Colombia, Medaglia

Finalists and winner(s) of the best paper award, announced in the TSL Business Meeting on Monday, will present their papers.

■ TC67

371B

Data-driven Approaches to Predictive Analytics

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Abdallah A. Chehade, University of Michigan-Dearborn, 815 Eagle Heights Apt D, Madison, WI, 53705, United States, abdallahch89@gmail.com

Co-Chair: Raed Al Kontar, University of Wisconsin-Madison, Madison, WI, 53706, United States, alkontar@wisc.edu

1 - A Multi-task Learning Approach for Improved Forecast of Passenger Inflow Time Series

Zhenli Song, HKUST, Hong Kong, Hong Kong, zsongae@connect.ust.hk, Ke Zhang, Fugee Tsung

Public transportation services such as, Urban Railway Transit (URT) systems, play an increasingly important role in people's commute. However, there has been little research on the influence of passenger crowding on the URT systems. To fill this research gap, we propose a state space model to predict the passenger inflow time series under the multi-task learning framework. By incorporating engineering knowledge into the prior, the methodology would produce more accurate and robust estimate of the parameters. We adopt the EM algorithm and Laplace's method for MAP estimate of the parameters. A real case study on Hong Kong's MTR passenger flows is presented to illustrate the effectiveness of our model.

2 - System-wide Prediction and Visualization of Passenger Distribution in Urban Rail Transit Network with Automatic Fare Collection Data

Andi Wang, Georgia Institute of Technology, Atlanta, GA, United States, andi.wang@connect.ust.hk, Min Jiang, Fugee Tsung

We propose a scheme to achieve real-time passenger distribution prediction in the urban metro system, based on the entry and exit time stamps generated by the automatic fare collection system. First, we infer each individual's travel pattern and location distribution with historical data, and store the information in the data center. Then the information is integrated with real-time entry and exit data streams to achieve passenger distribution prediction with acceptable computational cost. The effectiveness of the scheme is validated with real data set from the MTR system in Hong Kong.

3 - Functional Data Based Computer Model Calibration for Design Optimization

Wenbo Sun, University of Michigan, 2013 Medford Road, Ann Arbor, MI, 48104, United States, sunwbgt@umich.edu, Judy Jin, Matthew Plumlee

Computer simulations are widely used to improve system design. This often requires to firstly calibrate the computer simulation model by using a UQ (uncertainty quantification) method and then search for an optimal design solution. The existing methods require explicitly defined simulation parameters (e.g. to minimize the simulation model's bias) and a well fitted metamodel that can accurately surrogate the simulation behaviors, which are hard for complex systems. We presented a new approach to search for the optimal design from a set of parameters that subject to constraints on simulation model's bias. A case study is illustrated for the vehicle design optimization to minimize injuries in crash.

4 - Structural Degradation Modeling Framework for Sparse Data Sets with an Application on Alzheimer's Disease

Abdallah A. Chehade, University of Michigan-Dearborn, Dearborn, MI, United States, abdallahch89@gmail.com, Kaibo Liu

The accessibility and development of information technologies have facilitated the collection and storage of information from a massive number of operating units, which provides a great opportunity to better understand the degradation process. While in practice the number of recorded units can be large, there are often limited available observations in most of the units. To address the unique challenges in the "sparse data environments", this paper proposes a structural degradation modeling (SDM) framework. On one hand, our idea is inspired by the recommender system. On the other hand, the proposed SDM is also tailored to the needs of degradation modeling.

■ TC68

371C

Quality and Statistical Decision Making in Health Care Applications

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Shuai Huang, University of Washington, Seattle, WA, 98195, United States, shuai.huang.ie@gmail.com

1 - A Regression Tree Method to Analyze Data in Functional Brain Activation Experiments

Doowon Choi, doowon.choi@tamu.edu

Functional brain activation experiments are widely conducted in neuroimaging research. In the experiment, behavior and functional brain activation of people under certain task are measured in an attempt to understand the underlying neural correlates in human brain. This work proposes a regression tree based methodology to analyze data in such experiments. In the case study, this method is applied to data from a functional near-infrared spectroscopy (fNIRS) study using a risk decision-making task and insightful inference is obtained.

2 - A Dictionary Learning Based Contemporaneous Health Index for Degenerative Disease Monitoring

Aven Samareh, University of Washington, Seattle, WA, 98105, United States, asamareh@uw.edu, Shuai Huang

We present a general formulation for personalized data fusion of multivariate longitudinal clinical measurements to create a contemporary health index (CHI) to monitor patient condition over time. Named as DL-CHI, our model combines longitudinal data fusion, classification, and dictionary learning and is applied on two real-world problems, Alzheimer's disease and surgical site infection.

3 - Optimal Coverage Control in Body Sensor Networks for Spatiotemporal Cardiac Monitoring

Rui Zhu, Pennsylvania State University, University Park, PA, United States, rzz45@psu.edu, Bing Yao, Hui Yang

Body Sensor Networks (BSNs) has emerged as a key technology for improving the quality of life through wearable sensing, smart health monitoring. However, a fundamental problem in BSN design is the optimal sensor placement. For example, sensors are approximately uniformly distributed on the body surface in current ECG systems. Little has been done to optimize the location and number of sensors. This paper proposes a new strategy for the optimal sensor placement to capture a complete picture of cardiac dynamics. Furthermore, this novel methodology is applicable to network design with nonstationary distribution in many other disciplines, e.g., environment surveillance network, facility layout.

4 - Osteonecrosis in Chilean Patients with Systemic Lupus Erythematosus

Jennifer Mendoza-Alonzo, University of South Florida, Tampa, FL, United States, jennifermend@mail.usf.edu, José Zayas-Castro, Karina Soto-Sandoval

Systemic Lupus Erythematosus (SLE) is chronic, incurable, and autoimmune disease. A secondary disease associated with SLE is Osteonecrosis (ON). The objective of this study is to develop a model to determine if a Chilean patient who has already SLE can be diagnosed with ON at an early stage. The sample size is 41 Chilean patients with SLE. The input variables are pharmacological, demographic, and risk factors suggested by the literature. The outcome variable is the development of the disease ON. With this study is expected to contribute with more information about the multiple-factors that influence the development of ON to allow early detection of this diseases in patients with SLE.

■ TC69

371D

Spatial Optimization and Conservation Reserve Design

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Bistra Dilkina, Georgia Institute of Technology, Atlanta, GA, 30332, United States, bdilkina@gmail.com

1 - A Robust Optimization Approach for Solving Problems in Conservation Planning

Zulqarnain Haider, University of South Florida, ENG 302, University of South Florida, Industrial and Management Systems Engineering, Tampa, FL, 33620, United States, zulqarnain@mail.usf.edu, Hadi Charkhgard, Changhyun Kwon, Julien Martin

In conservation planning, the data related to specie populations is sparse, and unreliable. Thus, applying deterministic or stochastic approaches to the problems in conservation planning either ignores the uncertainty completely or does not accurately account for the nature of uncertainty. We propose a robust optimization (RO) approach to problems in conservation planning. We explore the reserve selection and invasion control problems to show the value of the RO approach. Several novel techniques are developed to compare the results by the RO approach and the deterministic approach. It is demonstrated that the proposed approach finds more applicable conservation planning strategies.

2 - Wildlife Corridor Sub-network Selection Optimizing for Probability of Connectivity

Bistra Dilkina, Georgia Institute of Technology, 1304 Klaus Bldg, 266 Ferst Dr, Atlanta, GA, 30332, United States, bdilkina@gmail.com

Corridor analysis results in a network representing the best pathways connecting pairs of habitat areas. One widely-used metric in ecology for the overall network connectivity is Probability of Connectivity (PC), where link probabilities are an exponential function of link resistance length. Due to limited budgets, the full corridor network usually cannot be conserved. Hence, we propose the PC-based Corridor Sub-network selection problem to select a subset of the corridor links of limited size or cost, while maximizing the PC of the protected part of the network. We present both a MIP model for finding optimal solutions of small networks, as well as a highly-scalable and effective greedy algorithm.

3 - Dynamic Optimization of Landscape Connectivity Embedding Spatial-capture-recapture Information

Yexiang Xue, Cornell University, Institute for Computational Sustainability, 344 Gates Hall, Ithaca, NY, 14853-7501, United States, yx247@cornell.edu

Maintaining landscape connectivity is increasingly important in wildlife conservation, especially for species experiencing the effects of habitat fragmentation. We propose a novel approach to dynamically optimize landscape connectivity. Our approach is based on a mixed integer program, embedding a spatial capture-recapture model that estimates the density, space usage, and landscape connectivity for a given species. Our method takes into account the fact that local animal density and connectivity change dynamically and non-linearly with different protection plans. We show that our method scales to real-world size problems and outperforms the solution quality of competing approaches.

■ TC70

371E

Data Mining

Contributed Session

Chair: Misuk Lee, Seattle University, 901 12th Ave, Seattle, WA, 98122, United States, leem@seattleu.edu

1 - Development of a Dynamic Tool for Continuous Survival Analysis Transplant Survivor

Hamidreza Ahady Dolatsara, Auburn University, 311 West Glenn Ave., Apt. 28, Alabama, Auburn, AL, 36830, United States, hamid@auburn.edu, Fadel Mounir Megahed, Ali Dag, Ying-Ju Chen

The objective of this study is presenting a tool that can be utilized for data cleaning, feature extraction, and prediction on transplants' survival analysis. Investigated transplants are kidney, heart, Lung, and intestine. Based on the dependent variable a dynamic process perform data cleaning process on the dataset. The cleaned data goes through feature selection and prediction phases. Well known machine learning algorithms are utilized in order to extract important features and develop predicting models. Finally, the output of models and other relevant information will be shown or emailed to the investigator(s).

2 - A Method to Measure Mobile Applications User Engagement (MAUE)

Lior Turgeman, IBM.Research Laboratories, Haifa, Israel, tur.lior@gmail.com, Idan Ben Harush, Otis Smart, Max Jacubowsky, Nicole Jayne, Nili Ifergan

We propose a new method to measure User engagement (UE) with mobile applications by analyzing temporal changes in a defined set of usage metrics, yielding a general metric - mobile applications user's engagement (MAUE). Our proposed approach has been applied to the usage data of 40004 users of The Weather Company (TWC) application. Based on our results, we propose two new engagement measures, "engagement stability", and "engagement breakpoint", allowing monitoring UE of users' segments, as well as gaining deeper understanding of the influence of different app updates, or certain features, on their usage behavior.

3 - A Customized Spectral Clustering Approach for Pre Selection on Dynamic Taxi Sharing Trips

Yeming Hao, University of Maryland-College Park, College Park, MD, 20740, United States, yhao@umd.edu, Ali Haghani

A customized spectral clustering approach is developed to narrow down the searching space for dynamic taxi sharing. Both taxi route geographical locations and heading directions are considered in the approach. Real world taxi data (New York City taxi data) is used in the implementation and results show the approach can reduce the taxi sharing matching calculation time while maintain beneficial (for both taxi providers and users) matching results.

4 - Modelling Passengers' Airport Choice in Multi-airport Regions: A Data Mining Approach

Misuk Lee, Assistant Professor, Seattle University, 901 12th Ave, Seattle, WA, 98122, United States, leem@seattleu.edu

Air travelers' airport choice is a critical component of transportation planning in many multi-airport regions. This study proposes the use of data mining models in passengers' airport choice. We compare different data mining and statistical models using data collected in the Seoul/Incheon metropolitan area.

■ TC71

371F

Applications of Global Optimization

Sponsored: Optimization, Global Optimization

Sponsored Session

Chair: Ismet Sahin, Texas Southern University, 3100 Cleburne St, Houston, TX, 77004, United States, isahin@gmail.com

1 - Time-varying Linear and Semidefinite Programs

Bachir El Khadir, Princeton University, Princeton, NJ, United States, bkhadir@princeton.edu, Amir Ali Ahmadi

We study linear semidefinite programs whose data (e.g., the matrices A, b and c in the LP case) are not constant but vary polynomially with time. We show that, under some conditions, we can approximate the optimal value of these problems arbitrarily well by searching for solutions that are polynomial functions of time themselves. Furthermore, we show that the problem of finding the optimal polynomial solution of a given degree can be cast exactly as a semidefinite program.

2 - Hypergraph Theoretic Polyhedral Relaxation of a Class of 0-1 Polynomial Program

Dongwoo Kang, Korea University, 145 Anam-Ro, Seongbuk-Gu, Seoul, 02841, Korea, Republic of, towarmer@korea.ac.kr, Hong Seo Ryoo

Logical Analysis of Data (LAD) is a combinatorial optimization-based machine learning methodology. A key stage of LAD is pattern generation that can be cast as a 0-1 multilinear program in maximization form. We study its Boolean multilinear polytope via hypergraph theoretic analysis of the 0-1 representation of a set of data under analysis and discover a new class of strong(-er) valid inequalities, including facet defining inequalities. We demonstrate the usefulness of new results on benchmark data mining datasets.

3 - Accurate Beamforming by using Population Based Optimization Method

Ismet Shin, Texas Southern University, Houston, TX, United States, isahin@gmail.com, Nuri Yilmazer

In this paper, we have presented an accurate beamforming technique, which is a spatial filtering used in smart antenna technology, relies on population based optimization. The proposed algorithm uses a single snapshot of data taken from a Uniform Linear Array (ULA). Population based optimization algorithms are used to determine the optimal values of the complex valued antenna array weights. The complex antenna weight vectors adjust the phase shift at the output of each antenna element in a ULA which is analogous to the phase shifter in the analog system. The simulation results show that proposed algorithm accurately maximizes the signals in the direction of Signal of Interest and null Jammers.

4 - Electrical Power Grid Optimization using Semi-markov Decision Process (SMDP)

Ismet Sahin, Texas Southern University, 3100 Cleburne Street, Houston, TX, United States, isahin@gmail.com, Abayomi Ajofoyinbo

This paper presents a semi-Markov decision process (SMDP)- based model for electric power grid optimization in terms of available power and distribution configurations. For this purpose, a novel SMDP- based model is constructed for maximizing delivery configurations subject to power flowing through transmission line. Through optimal analysis, the conclusion is reached that the technique presented in this paper provides optimal performing configuration.

■ TC72

372A

Optimization, Nonlinear Programming

Contributed Session

Chair: Zhi Zhou, Argonne National Laboratory, Argonne, IL, United States, zzhou@anl.gov

1 - Rate of Convergence of the Bundle Method and Selective Linearization Algorithm for Large Scale Convex Optimization

Yu Du, Assistant Professor, University of Colorado Denver, 1475 Lawrence St, Denver, CO, 80202, United States, duyu197@gmail.com, Andrzej Ruszczynski

The number of iterations needed by the bundle method for nonsmooth optimization to achieve a specified solution accuracy can be bounded by the product of the inverse of the accuracy and its logarithm, if the function is strongly convex. The result is true for the versions of the method with multiple cuts and with cut aggregation. We also illustrate the related efficient selective linearization algorithm on the large scale statistical learning problems.

2 - Maximizing Resilience of Transmission Power Grids through a Bi-level Restoration Model

Saeedeh Abbasi, University of Houston, 2821 Greenridge Dr, Apt 100, Houston, TX, 77057, United States, sabbasi5@uh.edu, Masoud Barati, Gino J.Lim

Power grid's outdoor facilities are vulnerable to extreme events, and their failure could trigger the failure of the whole network. The imposed complete blackout lasts for a long period while terribly costs. Therefore, it is so crucial to make the grid resilient, and an appropriate fast restoration is demanded to mitigate these impacts. In this study, the power grid resiliency is quantified and maximized in a bi-level optimization framework and solved through an iterative optimization algorithm (IOA) and a mathematical program with equilibrium constraint (MPEC). The model's performance is analyzed with 6- and 118-bus IEEE test systems.

3 - Survivable All-optical Networks: Extensions to the Routing and Wavelength Assignment Problem

Mehdi Hemmati, Sharif University of Technology, Tehran, Iran, Islamic Republic of, soheilmn@gmail.com, Cole Smith

All-Optical Networks (AONs) form the foundation of the Internet backbone. They transmit the data over light rays, which require dedicated wavelengths. Hence, the routing problems in AONs are coupled with wavelength assignment tasks, which result in the Routing and Wavelength Assignment (RWA) problem. Due to the massive amount of data transmission over AONs, their vulnerability to disruptions are of high importance. We discuss variations of the RWA problem to study the resilience of AONs in the presence of intentional or unintentional disruptions. We propose multi-level integer programs and investigate the solution techniques by studying the solution space of the related optimization problems.

4 - Probabilistic Interdiction for Power Systems

Kaarthik Sundar, Post-doctoral Researcher, Los Alamos National Laboratory, 3000 Trinity Drive, Apt 40, Los Alamos, NM, 87544, United States, kaarthik01sundar@gmail.com, Carleton Coffrin, Harsha Nagarajan, Russell Bent

A probabilistic version of the N-k interdiction problem in power transmission networks is considered. The probability of failure of each component in the network is known a priori and the goal of the problem is to find a set of k components that maximizes disruption to the system loads weighted by the probability of simultaneous failure of the k components. The resulting problem is formulated as a bilevel mixed-integer nonlinear program. Convex relaxations, linear approximations, and heuristics are developed to obtain feasible solutions that are close to the optimum via a cutting-plane algorithm. Extensive numerical results corroborate the effectiveness of the proposed algorithms.

5 - An Auction-driven Mechanism for Electric Transmission Network Design

Juan Andrade, PhD Student, University of Texas-Austin, 1616 Guadalupe Street, Austin, TX, 78701, United States, jandraderam@utexas.edu, Ross Baldick

This paper proposes a combinatorial auction formulation for electric transmission network design, where market participants can bid for the geographic location of their points of interconnection and its capabilities, according to their willingness to pay. The formulation proposed identifies the projects that maximize the social welfare, and obtains the network topology necessary to support those projects. The proposed approach allows to consider quantitatively the perspective of different market participants at the early beginning of transmission planning. This may reduce the negative consequences of transmission shortfall, without over building transmission infrastructure.

6 - Distribution Network Reconfiguration Considering Decentralized Autonomous Electric Vehicles

Zhi Zhou, Argonne National Laboratory, 9700 South Cass Avenue, Bldg 221, Argonne, IL, 60439, United States, zzhou@anl.gov, Zhaomiao Guo

Autonomous electric vehicles (AEVs) provide unique opportunities to cope with the uncertainties in electricity distribution network (DN), but the effects are limited by the inherent radial topology. We investigate the potential benefits (e.g. reducing line losses, battery degradation, etc.) of dynamic DN reconfiguration (DDNR) based on AEVs spatial-temporal availability. A mixed integer programming model is proposed to optimally coordinate the charging/discharging of AEVs with day-ahead DDNR plan, while satisfying AEVs' daily travel demand in a two-settlement setting. Numerical findings will be presented through the IEEE 33-node test feeder and Sioux Falls transportation network.

■ TC73

372B

Meta-Algorithmics

Invited: Operations Research and the Future of Computing

Invited Session

Chair: Holger Hoos, University of British Columbia, Vancouver, NB, N6T I24, Canada, hoos@cs.ubc.ca

1 - Algorithm Selector and Prescheduler in the ICON Challenge

François Gonard, INRIA, Paris, France, francois.gonard@inria.fr

Algorithm portfolios are known to offer robust performances, efficiently overcoming the weakness of every single algorithm on some particular problem instances. In order to get the best out of an algorithm portfolio, one can either use an algorithm selection (AS) approach, or define a scheduler, sequentially launching a few algorithms on a limited computational budget each. The ASAP system presented here relies on the joint optimization of a pre-scheduler and a per instance AS, selecting an algorithm well-suited to the problem instance at hand. ASAP has been thoroughly evaluated against the state-of-the-art during the ICON challenge for algorithm selection, receiving an honourable mention.

2 - A Machine Learning Approach to Re-designing Branch-and-Bound Search

Bistra Dilkina, Georgia Institute of Technology, 1304 Klaus Bldg, 266 Ferst Dr, Atlanta, GA, 30332, United States, bdilkina@gmail.com, Elias Khalil

Branch-and-Bound approaches have been improved over many years by a series of ideas from operations research and computing. However, many of the components of this complex complete search strategy used in state of the art solvers are highly engineered and to a large extent static. We investigate the use of machine learning ideas to re-vamp diverse aspects of the branch-and-bound search in order to discover new strategies and heuristics in a data-driven and adaptive way that can be useful both broadly as well as fine-tuned to domain-specific families of instances.

3 - Generation Techniques for Linear and Mixed Integer Programming Instances with Controllable Properties

Simon Bowly, Monash University, Clayton, 3800, Australia, simon.bowly@monash.edu, Kate Smith-Miles, Davaatseren Baatar, Hans Mittelmann

The results of empirical analysis of optimisation algorithm performance are highly dependent on the quality of test instances available. Real world data sets may lack diversity in feature and performance data spaces, while random generation can produce instances which are not applicable to the problem being studied. We propose a new framework which shifts test instance generation to an encoded space. Through its application to the generation of linear and mixed integer programming test cases we demonstrate the potential to improve the quality of metadata used in algorithm analysis.

4 - How Simple is Too Simple: Evaluating Increasingly Sophisticated Techniques for Algorithm Portfolios

Chris Cameron, University of British Columbia, Vancouver, BC, Canada, chris.cameron.queens@gmail.com, Holger Hoos, Frank Hutter, Kevin Leyton-Brown

State-of-the-art methods for building algorithm portfolios have achieved notable success on computationally-hard problems such as SAT. While these methods are often quite complex, we are not aware of any previous, systematic study of the extent to which this complexity is warranted. We created a wide design space of algorithm portfolio techniques and evaluated the resulting designs on a comprehensive set of benchmarks (ASlib 2.0), which includes industrial problems in SAT and CSP. In particular, we investigated three design axes: (1) model sophistication (from model-free to model-based cost-sensitive classification), (2) feature sophistication

■ TC74

372C

Optimization in Computational Geometry

Sponsored: Computing

Sponsored Session

Chair: Paul Brooks, Virginia Commonwealth University, Richmond, VA, 23284, United States, jpbrooks@vcu.edu

1 - Snug Simplices

Ghasemali Salmani Jajaei, Virginia Commonwealth University, Richmond, VA, United States, salmanijajaeg@vcu.edu

We propose procedures for enclosing convex hulls of finite m-dimensional point sets with simplcies. A simplex is called snug if it intersects the convex hull in some way. The procedures will assess how the snug simplices generated contain the convex hulls by comparing their volumes. In general, calculating the volume of general polyhedra is difficult, however, we are able to find closed form formulas for certain simplices. Our goal is to find a tight simplex, one in which its facets coincide perfectly with the facets of the convex hull.

2 - Approximate Convex Hulls

Robert Graham, McGill University, Montreal, QC, Canada, robert.graham2@mail.mcgill.ca

This talk will cover joint work with Adam Oberman on the pixel purity algorithm for computing approximate convex hulls. I will explain how the algorithm computes the curvature of points and prove consistency and convergence. I will also extend the algorithm to compute approximate convex hulls described in terms of hyperplanes

3 - Linear Optimization Over the Field of Puiseux Fractions

Benjamin Schroter, TU. Berlin, Berlin, Germany, schroeter@math.tu-berlin.de

The field of real Puiseux Series is a real closed field which extends the real numbers by an infinitesimal element t. This field is again totally ordered, i.e, t is smaller than any positive real number but larger than zero. In particular Puiseux Series allow to study aspects of algebraic geometry via polyhedral geometry. They are an important link between linear optimization and tropical optimization.

We present our implementation of a well suited subfield for exact computations, which we call the field of Puiseux Fractions. Our implementation in the software polymake allows to compute linear programs and convex hulls of polyhedra over rationals extended with the indeterminate t.

4 - The Recommender Problem with Convex Hulls

Marie-Laure Bougnol, Professor of DSIM, Jacksonville University, mbougno@ju.edu, Jose H. Dula

Consider a collection of users and items they may score using an ordinal scale. Consider a specific user and an item yet unscored by this user. The challenge in this version of the recommender problem is to estimate this user's score for the item. An idea central to this problem is the identification of "like-minded peers" and use their scores to make the estimate We propose procedures based on computationally geometry to identify peers and use them to estimate scores.

■ TC75

372D

Nonsmooth Optimization

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Damek Davis, dsd95@cornell.edu

1 - Generic Acceleration Schema Beyond Convexity

Courney Paquette, PhD, University of Washington-Seattle, Seattle, WA, United States, cykempton@gmail.com

We introduce a generic "acceleration" scheme that can leverage arbitrary linearly convergent convex optimization algorithms to solve possibly nonconvex optimization problems. The proposed

approach simultaneously enjoys best known complexity bounds up to log terms for both convex and nonconvex settings. A class of problems for which the technique is not applicable consists of minimizing compositions of nonsmooth convex functions and smooth maps. I will describe how a simple Gauss-Newton algorithm combined with smoothing and fast-gradient subproblem solves yields a scheme with overall efficiency $O(1/e^3log(1/e))$. This appears to be the best know complexity bound for this problem class.

2 - Taming Nonconvexity with Data

Zhaoran Wang, PhD, Princeton, NJ, United States, zhaoranwang@gmail.com

In this talk, I will illustrate how statistical thinking enables us to harness the power of nonconvex optimization. In specific, I will present an algorithmic framework for exploiting the latent geometry induced by the randomness of data. By integrating three new global exploration meta-algorithms — namely, homotopy continuation, tightening after relaxation, and noise regularization — with local search heuristics — such as the variants of gradient descent — this unified framework leads to new nonconvex optimization algorithms for a broad variety of challenging learning problems.

3 - Proximally Guided Stochastic Subgradient Method for Nonsmooth, Nonconvex Problems

Damek Davis, Cornell University, 218 Rhodes Hall, Hoy Road, Ithaca, NY, 14850, United States, dsd95@cornell.edu

We introduce a stochastic projected subgradient method for a wide class of nonsmooth, nonconvex functions, which includes the additive and convex composite classes. At a high-level the method is an inexact proximal point iteration in which the strongly convex proximal subproblems are quickly solved with a specialized stochastic projected subgradient method. The primary contribution of this work is a simple proof that the proposed algorithm converges at the same rate as the stochastic gradient method for smooth nonconvex problems. This result validates the use of stochastic subgradient methods in nonsmooth, nonconvex optimization as is common when optimizing neural networks.

4 - The Radial Subgradient Method

Benjamin Grimmer, Cornell University, Ithaca, NY, United States, bdg79@cornell.edu

We present a subgradient method for minimizing non-smooth, non-Lipschitz convex optimization problems. We extend the work of Renegar by taking a different perspective, leading to an algorithm which is conceptually more natural, has notably improved convergence rates, and for which the analysis is surprisingly simple. At each iteration, the algorithm takes a subgradient step and then performs a line search to move radially towards (or away from) a known feasible point. Our convergence results have striking similarities to those of traditional methods that require Lipschitz continuity. Costly orthogonal projections typical of subgradient methods are entirely avoided.

■ TC76

372E

Leveraging Structure in Discrete Optimization

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Christian Tjandraatmadja, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, ctjandra@andrew.cmu.edu

1 - On Relaxations of Products of Functions

Taotao He, 1303 Palmer Drive, Apt 212, West Lafayette, IN, 47906, United States, he135@purdue.edu, Mohit Tawarmalani

We develop a new relaxation that exploits function structure while convexifying a product of d functions. The function structure is encapsulated using at most n over and underestimators. We convexify the function product in the space of estimators. The separation procedure generates facet-defining inequalities in time polynomial in d. If the functions are non-negative, the concave envelope can be separated in O(d nlog(n)). We extend our construction to infinite families of under and overestimators. Finally, we interpret the relaxation procedure for non-negative functions as expressing the product as a telescoping sum followed by a simple relaxation operator.

2 - Incorporating Decision Diagrams into MIP Solving

Christian Tjandraatmadja, Carnegie Mellon University, Tepper School of Business, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, ctjandra@andrew.cmu.edu, Willem-Jan Van Hoeve

We present techniques that use decision diagrams to enhance mixed-integer programming solvers. Decision diagrams are embedded into the branch-and-bound tree and yield cutting planes and bounds that aid the solving process. We provide computational experiments that show these methods are effective in situations that admit strong decision diagram relaxations.

3 - Multi-objective Maximization of Monotone Submodular Functions
Rajan Harish Udwani, Massachusetts Institute of Technology, 70 Pacific Street, 809, Cambridge, MA, 02139, United States, rudwani@mit.edu

The best known algorithm for multi-objective maximization of monotone submodular functions, from Chekuri et.al. (2010), is a randomized (1-1/e)-\epsilon approximation algorithm for maximization subject to a Matroid constraint. However, the runtime scales exponentially in the number of functions, limiting this number to be a small constant. We focus on the special case of multi-objective maximization subject to a cardinality constraint (say k elements), and show constant factor approximations for up to o(k) many functions (problem is known to be inapproximable for \Omega(k) functions). We extend the (1-1/e) algorithm from above but also give a simpler and much faster (1-1/e)^2 approximation.

4 - A Logic-based Benders Approach to Home Healthcare Scheduling
Ryo Kimura, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, rkimura@andrew.cmu.edu, John Hooker, Aliza R.Heching

We propose an exact optimization method for home healthcare scheduling based on logic-based Benders decomposition (LBBD). The objective is to match patients with healthcare aides and schedule multiple home visits over a given time horizon, so as to maximize the number of patients served. Using LBBD, we decompose the problem into a master problem, solved by mixed integer programming, and several small scheduling subproblems, solved by constraint programming. We find that LBBD is far superior to mixed integer programming and optimally solves problems of realistic size, if the aim is to conduct staff planning on a rolling basis, and if there are a limited number of temporal dependencies between visits.

■ TC77

372F

Optimization, Integer Programming

Contributed Session

Chair: Thibaut Vidal, PUC-Rio, Departamento de Informatica, Rio de Janeiro, Brazil, vidalt@inf.puc-rio.br

1 - Scenario Based Economic Dispatch with Adaptable Risk Levels in Uncertain Power Systems
M. Sadegh Modarresi, Research Assistant, Texas A&M.University, 1907 Dartmouth St, Apt 602, College Station, TX, 77840, United States, sadegh.modarresi@tamu.edu, Hao Ming, Le Xie

This paper presents a data-driven scenario approach to 1- dispatching power systems with high levels of uncertain resources in the real-time stage, and 2-at the day-ahead electricity market clearing process with the presence of demand response providers. By taking historical samples and generating appropriate sample-based uncertainty sets, this approach quantifies the relationship between the risk of violating the constraints and the cost conservativeness of the dispatch. Numerical simulations suggest that this approach could be a promising alternative in future electricity markets with uncertain load and generation resources.

2 - Parametric Analysis of Semidefinite and Second Order Conic Optimization
Ali Mohammad-Nezhad, PhD Student, Lehigh University, 200 W Packer Ave., Bethlehem, PA, 18015, United States, alm413@lehigh.edu, Tamas Terlaky

We consider the parametric analysis of semidefinite and second-order conic optimization problems when the right-hand side or the objective coefficients vector is perturbed along a certain direction. We introduce the concept of the optimal partition to characterize the optimal value function and the optimal set mapping and highlight the contrast with the case of LO. We show that under a nondegeneracy condition, the optimal set mapping is continuous, but in order to gain Lipschitz continuity, we need strict complementarity condition too. Further, we show that at a transition point, where the optimal partition changes, the higher order derivatives of the optimal value function do not exist.

3 - Finding Infimum Point with Respect to the Second Order Cone
Marta Cavaleiro, Rutgers University, Management Science and Informations Systems, 100 Rockefeller Road, Piscataway, NJ, 08854, United States, marta.cavaleiro@rutgers.edu, Farid Alizadeh

We define the notion of infimum and supremum of a set of points with respect to the second order cone. These problems can be formulated as second order cone optimization and thus solved by interior point methods in polynomial time. We present an extension of the simplex method to solve these problems and show some applications.

4 - Cluster Analysis is Convex
Madhushini Narayana Prasad, PhD Student, The University of Texas at Austin, 9226 Jollyville Road, Unit 150, Austin, TX, 78759, United States, madhushini@utexas.edu, Grani Adiwena Hanasusanto

In this work, we show that the popular k-means clustering problem is amenable to an exact conic programming reformulation. The emerging convex problem is NP-hard but admits a tractable polynomially solvable semidefinite programming (SDP) relaxation. We prove that this resulting SDP is equivalent to the state-of-the-art SDP approximation scheme and enjoys the same 2-approximation ratio. In contrast to this scheme, our proposed SDP reformulation yields solutions that can be used to directly identify the clusters. We assess the performance of our reformulation in numerical experiments and demonstrate its superiority over the state-of-the-art scheme and the classical Lloyd's algorithm.

5 - A Stochastic Frank-wolf Algorithm for Sparse and Non-stationary Environments
Davoud Ataee Tarzanagh, University of Florida, 1400 Stadium Rd, University of Florida, Gainesville,, FL, 32611, United States, Tarzanagh@ufl.edu, George Michailidis

The conditional gradient method, also known as -Ω for convex problems has lately regained popularity thanks to its projection-free property and its ability to exploit the structured constraints appearing in machine learning and big data applications. However, our understanding of this algorithm in the online and non- stationary setting is fairly limited, especially for problems with very noisy and/or sparse gradients. In this talk, we propose a stochastic variant of the Frank-Wolfe algorithm, based on adaptive estimates of lower-order moments. Our method is aimed towards problems involving large data sets and/or sparse gradients.

6 - Separable Convex Optimization with Nested Lower and Upper Constraints
Thibaut Vidal, PUC-Rio, Departamento de Informatica, Rua Marques de Sao Vicente, 225, Rio de Janeiro, 22453-900, Brazil, vidalt@inf.puc-rio.br, Daniel Gribel, Patrick Jaillet

We study a generalized convex resource allocation problem arising in production planning, vessel speed optimization, and support vector machine applications. We propose a decomposition algorithm, which uses monotonicity properties to generate bounds from recursive calls and eliminate linking constraints. These principles are very different from the usual greedy-scaling or even flow-propagation methods currently known. It improves upon the best known complexities, producing an integer or continuous solution in linearithmic time, and solving problems with one million variables in one minute.

■ TC78

381A

Low-Carbon Power Sector: Policy and Technology Analysis

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Afzal Siddiqui, University College London, University College London, London, United Kingdom, afzal.siddiqui@ucl.ac.uk

1 - Regional Carbon Policies in an Interconnected Power System. How Expanded Coverage Could Enhance Prospects for Emissions Leakage
Makoto Tanaka, National Graduate Institute for Policy Studies (GRIPS), 7-22-1 Roppongi, Minato-ku, Tokyo, 106-8677, Japan, mtanaka@grips.ac.jp, Verena Viskovic, Yihsu Chen, Afzal Siddiqui

Reaching objectives under unilateral CO2 reduction policies can be delayed by carbon leakage. In the context of power markets, this is of concern in regional interconnected power systems with inconsistent policies. Using a stylised bi-level model of such a market where regions are connected with a congested line, we explore the effects of mitigating leakage by accounting for emission from the non-regulated region when setting the policy in the regulated region. We find that the overall emissions in the system decrease; however, the marginal value of transmission capacity increases, thus, providing more incentive for expanding the capacity of the line, which could potentially lead to more leakage.

2 - Evaluating an Interconnection Project: Do Strategic Interactions Matter?

Sebastien Debia, GERAD / HEC Montreal, 6100 Avenue Wilderton, Montreal, Canada, sebastien.debia@hec.ca, David Benatia, Pierre-Olivier Pineau

High-Voltage Direct Current (HVDC) merchant transmission lines allows trade across separate power markets and often in different countries. The flows on existing cross-border lines are often assessed as suboptimal, which may be due to the light regulation that often prevails in this case. We use a two-stage game formulated as an Equilibrium Problem with Equilibrium Constraints (EPEC) to model the strategic trade between the New York (US) and Quebec (Canada) systems. The impact of trade on local price levels may be of concern and calls for the functional unbundling of traders and generators.

3 - The Impact of Forward Contracts on Market Equilibrium in Renewable Energy Policy

Ryo Ito, 7416606@ed.tus.ac.jp, Ryuta Takashima

Recently various policies for reducing greenhouse gas emissions have been implemented by concerns about global warming. Those policies include schemes for promoting renewable energy such as feed-in tariff, feed-in premium, and renewable portfolio standards. Those policies directly impact the power prices by favoring power produced by renewables. On the other hand, it is shown that forward contracts mitigate market power in Allaz and Vila (1993). In this work we investigate a relationship between forward contracts and renewable energy policy for the competitive equilibrium. We show an effect of forward contracts and renewable energy scheme on market power on the spot market.

4 - Enhanced Representative Days and System States Modeling for Energy Storage Investment

Diego Tejada, Universidad Pontificia Comillas, Comillas, Spain, diego.tejada@iit.comillas.edu

In this work, we analyze the impact of different options to represent the operation decisions in the study of energy storage (ES) investment for long-term planning models. We compare the representative days and the system-states approaches for the representation of these operation decisions. We proposed enhanced versions of these approaches to improve the ES investment approximation. An Spanish case study is evaluated and the results are used to identify the potential profits that energy storage investment can obtain.

■ TC78B

380B

Technology Management

Contributed Session

Chair: Kemal Gursoy, Rutgers University, Piscataway, NJ, United States, kgursoy@business.rutgers.edu

1 - Research on Synergy Degree Between Tech-innovation and Sci-tech Capital

Yanqiu Song, Central University of Finance and Economics, Haidian, 39th South College Road, Beijing, China, sunny_syq@163.com, Chang Yuan, Li Huijia

The coordinated development of technology innovation and capital is vital to achieve high industry value in China. Interactively considering the technology outcome and investment performance, this study aims to measure the synergy degree of 30 provinces(autonomous regions and municipalities) in China between 2000 and 2013. A synergy degree measure model based entropy is adopted to calculate the order degree of each sub-system and evaluate the coordinated situation of the integral system. The results show that the synergy between tech-innovation and sci-tech capital system shows a downward trend. There isn't mutually promoting coordinated development mechanism in China.

2 - Game Theoretic Approach in Capacity and Production Decisions for Indium

Sang-Phil Kim, Winona State University, Somsen 406, Winona, MN, 55987, United States, Ksphil@me.com, Chul Hun Choi, Jinjian Cao, Seokcheon Lee, Fu Zhao

Clean energy technologies, a solution to global warming challenge, require some rare materials and concerns about their rapid increasing demand have been raised recently. Indium, critical for thin-film solar photovoltaic and LED lighting, is one of the materials. Moreover, it is a by-product of zinc production thus the supply heavily relies on the production quantity of zinc. Therefore, simultaneous decisions in capacity and production quantity for both materials are necessary for sustainable supply of indium. Game theoretic approach (under duopoly market condition) is applied to seek the equilibrium values for capacity and production quantity of both materials in different market scenarios.

3 - China's Synergy Degree of Water-energy-food Nexus Basing on Entropy-based Collaboration Model

Guijun Li, Professor, Central University of Finance and Economics, 39th South College Road, Haidian District, Beijing, 100081, China, ligj@cufe.edu.cn, Yulong Li, Daohan Huang

The collaboration development of water, energy and food resources is vital to achieve sustainability in China. Basing on interactions in the processes of production, consumption and management, this paper first builds the index system at the country level. And then using the index system, a collaboration model basing on information entropy is adopted to calculate the synergy degree of water-energy-food nexus (WEF-Nexus) in China between 2002 and 2015, together with the order degree of subsystems and the development level of WEF-Nexus. Results show that the synergy of WEF-Nexus in China is uptrend from severe disorder to coordination during 2002-2015, and is also sensitive to external drivers.

4 - Biosystems Characterization, Modeling and Optimization

Yazeli E. Cruz-Rivera, The Applied Optimization Group, UPRM, PO Box 9000, Mayaguez, PR, 00681, United States, applied.optimization@gmail.com, Clara Isaza, Steven Mirsky, Mauricio Cabrera-Ríos

In everyday life, we are surrounded by systems of living organisms that can influence the behavior of other living organisms, i.e. by biosystems. Biosystems encompass topics from agriculture to health diseases. There is a need for interdisciplinary work to better understand, represent, and make competitive decisions in regards of these systems. In this work biosystems understanding is sought through statistical characterization, representation through statistical modeling, and decision-making through optimization, all within a biological framework. Two biosystems are studied: hairy vetch as a cover crop for corn, and the identification of important genes in Alzheimer's Disease.

5 - Extended Kalman Filter for Predicting Sustainability

Kemal Gursoy, Assistant Professor of Professional Practice, Rutgers University, 100 Rockafeller Road, Building A, Room 5146, Piscataway, NJ, 08854, United States, kgursoy@business.rutgers.edu

In order to survive, we must learn how to measure the magnitude of the impact we make to our environment and predict the change in our environment. This brings an immense challenge of collecting facts, and extracting sufficient, reliable, information from this incoming stream of immense amount of observations. In this work, we present an extended Kalman filter for predicting sustainability.

■ TC79

381B

Application of OR and Analytics in the Energy Sector

Invited: OR and Oil and Gas

Invited Session

Chair: Peter Schipperijn, Chevron, Houston, TX, 77002, United States, apsc@chevron.com

1 - Asset and Project Valuation from Portfolio Optimization

Anthony Kenck, Chevron, Houston, TX, United States, anrk@chevron.com, Mal Wright, P. Val Kranak

The efficient frontier concepts developed by Markowitz, which compare return to standard deviation are of marginal use for most corporations in their decision-making. Executives are faced with more mundane tradeoffs, such as evaluating the difference between investing for growth vs striving for return on capital. We show an approach to balance competing objectives in order to ascertain the portfolio value of an asset or investment opportunity. The portfolio value of an opportunity is a function of the opportunity itself, portfolio requirements, constraints, and the inventory of opportunities. This framework can also be used when the information around a given opportunity is sparse.

2 - Application of Data Science in Chevron Upstream Sector

Yuanbo Lin, YLCV@chevron.com

Chevron has been leveraging data science to drive functional excellence and deliver business value in the upstream sector over the past several. This talk will showcase advanced modeling and analytics in addressing challenges in upstream activities like drilling, completions, asset development, and operations. The associated business value and impact will be highlighted for the four use cases discussed. We attribute much of the success to management support, close collaboration between business and analytics team, and a clear value-driven approach.

3 - When to Walk Away – Assessing Net Pay Thresholds in an Exploration Well

Patrick Burdett, Chevron, Houston, TX, United States, PBurdett@chevron.com

With drilling costs exceeding a million dollars per day in deep water wells, it is essential to understand when, in real time, to walk away from an exploration well that is sub-economic. A critical indicator of the economic viability of a field is the net pay thickness seen in the exploration well. This presentation address how a minimum economic pay thickness can be calculated beforehand that will give a real-time signpost on economic viability, and how that threshold can be adjusted on the fly for other information obtained from the well.

4 - A New Approach to Analyzing Data Acquisition Programs Before and After Data Come in

Jincong He, Chevron, Heyj@chevron.com

Data acquisition programs, such as surveillance and pilot, play an important role in reservoir management and are crucial for minimizing subsurface risks and improving decision quality. However, these projects often involve significant cost in terms of both capital investment and production downtime. In this talk I will present some recently developed methodologies to maximize "the bang for the buck", i.e., to optimize the program design before data come in, and rapidly integrate and interpret the data after they come in.

5 - Decisions using Monte Carlo: More Samples May not be Better

Mark A.Powell, Attwater Consulting, Webster, TX, United States, mark.powell@attwaterconsulting.com

Monte Carlo is one of the most ubiquitous analytics tools used in risk and decision making. The literature on Monte Carlo errors is rich, and the general consensus is that more samples reduce the errors. Quantification of the absolute error in any particular Monte Carlo however remains elusive. A new method to quantitatively bound Monte Carlo errors for any simulation using any number of samples will be presented, along with a decision strategy to take advantage of these error bounds. We will find that many decisions do not require tons of expensive Monte Carlo samples using this strategy.

■ TC80

381C

Resilience in the Energy Sector

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Spada Matteo, Paul Scherrer Institute, Villigen PSI, 5232, Switzerland, matteo.spada@psi.ch

Co-Chair: Feng Qiu, Argonne National Laboratory, Lemont, IL, 60439, United States, fqiu@anl.gov

1 - Resilience of the European Natural Gas Network

Peter Lustenberger, Future Resilient Systems (FRS), Singapore-ETH Centre (SEC), Singapore, Singapore, lustenberger@frs.ethz.ch, Patrick Gasser, Wansub Kim, Matteo Spada, Peter Burgherr, Stefan Hirschberg, Bozidar Stojadinovic

Energy systems are regularly subjected to major unforeseen disruptions that are triggered by natural and human-made causes, which affect the economy and society. This calls for resilience assessment, including consideration of disruption and recovery processes of the system under investigation. This study presents, on the one hand, an assessment of probabilistic disruption processes caused by both natural hazards and technical failures and, on the other hand, potential recovery processes, applicable to the European natural gas network and its components.

2 - Smart and Resilient Energy

Matthew Wood, United States Army Engineer R&D Center, 686 Virginia Road, Concord, MA, 01742, United States, Matthew.D.Wood@usace.army.mil, Igor Linkov

There is a growing effort in the electricity generation and distribution industry to use smart technologies to promote efficiency and minimize the frequency and duration of outages. Smart energy technologies collect, analyze and utilize data in real time, and include SCADA systems, unmanned aerial vehicle surveillance, remote vibration monitoring, etc. Many smart technologies contribute to energy sector resilience. However, the reliance on highly-connected smart technologies leaves the energy sector vulnerable to unanticipated or targeted disruptions. This presentation serves to discuss the contribution, both positive and negative, of smart energy technologies on system resilience.

3 - Optimal Post-disruption Resilience-oriented Restoration for Interdependent Infrastructure Network

Yasser Adel Almoghathawi, University of Oklahoma, 1506 E Lindsey St., Apt. P, Norman, OK, 73071, United States, moghathawi@ou.edu, Kash Barker

We propose a multi-objective optimization model using mixed-integer programming for restoring the interdependent infrastructure networks after a disruptive event. The model considers the availability of limited time and resources with two disruption scenarios, complete and partial, for the disrupted network components, nodes or links. It aims to (i) minimize the total cost of restoration, and (ii) maximize the combined resilience of interdependent infrastructure networks considering the physical interdependencies between them. The proposed model is illustrated through a set of interdependent infrastructure networks after hypothetical earthquakes in Shelby County, TN, United States.

4 - Quantifying and Visualizing the Economic Impact of Commercial Districts Due to an Electric Power Outage

Jose Emmanuel Ramirez-Marquez, Stevens Institute of Technology, Castle Point on Hudson, School of Systems & Enterprises, Hoboken, NJ, 07030, United States, jmarquez@stevens.edu, Andrea Garcia tapia, Kash Barker

The level of dependence of communities on electric power, from social behavior to economic productivity, is significantly high, revealing how vulnerable communities are to a power outage. Assessing the economic impact of electricity outages after a disruption in the service is a challenging task, especially when costumer's interruption costs vary from type of user. A geospatial visualization is presented to observe and compare the areas that are more vulnerable in terms of economic impact based on the areas covered by each distribution substation.

■ TC81

382A

Dynamic Robust Optimization and Learning

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Yehua Wei, Boston College, Chestnut Hill, MA, 02467-3809, United States, yehua.wei@bc.edu

Co-Chair: Dan Andrei Iancu, Stanford University, Stanford, CA, 94107, United States, daniancu@stanford.edu

1 - Monitoring with Limited Information

Do Young Yoon, 37 Angell Ct, Apt 319, Stanford, CA, 94305, United States, doyoung@stanford.edu, Dan Andrei Iancu, Nikolaos Trichakis

We study a dynamic decision problem under limited information, in which a decision maker chooses when to monitor a system - which allows gaining more information about current and future states of the system - as well as whether to stop the monitoring process and take a particular action. With robust optimization framework, we solve for a monitoring policy that maximizes the worst-case stopping reward. Our main results show that, under mild conditions, a static monitoring policy is equivalent to a fully dynamic policy along the worst-case path. We then provide several methods for obtaining an optimal static monitoring policy and present a robust optimal algorithm for the dynamic decision problem.

2 - Discrete Convexity and Dynamic Robust Optimization

Dan Andrei Iancu, Stanford University, 655 Knight Way, Stanford, CA, 94107, United States, daniancu@stanford.edu, Yehua Wei

We discuss necessary and sufficient conditions for the optimality of specific classes of policies in dynamic robust optimization. We then focus on the specific case of affine policies, and show how our conditions can be used to recover and generalize several existing results in the literature. Our treatment draws interesting connections with the theory of discrete convexity (L-natural / M-natural convexity and multimodularity) and global concave envelopes, which may be of independent interest.

3 - A Constraint Generation Algorithm for Two-stage Robust Network Flow Problem

Yehua Wei, Boston College, 140 Commonwealth Avenue, Chestnut Hill, MA, 02467-3809, United States, yehua.wei@bc.edu, David Simchi-Levi, He Wang

We propose a new method for solving two-stage robust network flow problems with polyhedral uncertainty set. By exploiting the network structure of the problem, we suggest a reformulation where its number of constraints is exponential with the number of nodes in the network, but independent with the number vertices in the uncertainty set. We then develop an effective constraint generation algorithm for solving the two-stage robust optimization problem, and apply our method to several application domains.

4 - Out-of-Sample Analysis of Robust Empirical Optimization

Andrew Lim, National University of Singapore, 15 Kent Ridge Drive, Mochtar Riady Building, Singapore, 119245, Singapore, andrewlim@nus.edu.sg

We study the out-of-sample performance of distributionally robust data driven optimization. The key result is that the reduction in the variance of the out-of-sample reward that results from "robustifying" empirical optimization is an order of magnitude greater than the impact on the mean. Implications for calibration of robust optimization models is also discussed.

■ TC82

382B

Recent Advances in Multistage Stochastic Programs

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Yongjia Song, Virginia Commonwealth University, Richmond, VA, 23284, United States, ysong3@vcu.edu

1 - Two-stage Linear Decision Rules for Multistage Stochastic Programming

Merve Bodur, University of Toronto, 5 King's College Road, Toronto, ON, M5S.3G8, Canada, bodur@mie.utoronto.ca, James Luedtke

Multistage stochastic linear programs (MSLP) can be approximated by applying linear decision rules (LDR) on the recourse decisions. This reduces MSLP (its dual) into a static problem which provides an upper (lower) bound on the optimal value. We introduce two-stage LDR whose application reduces MSLP (or its dual) into a two-stage stochastic LP. In addition to yielding better policies and bounds, this approach requires many fewer assumptions than are required to get an explicit reformulation when using the static LDR approach. On a capacity expansion model, we find that the two-stage LDR policy has expected cost 20-34% lower than the static LDR policy, and yields lower bounds that are 0.1-3.3% better.

2 - Regularized Decomposition Methods for Multistage Convex Optimization Problems

Miguel Lejeune, Professor, George Washington University, Washington, DC, 20052, United States, mljne@yahoo.com, Vincent Guigues, Walid Tekaya

We design regularized variants of the Dual Dynamic Programming (DDP) and Stochastic Dual Dynamic Programming (SDDP) algorithms to solve dynamic convex programming problems. We show the convergence of the proposed algorithms and study their computational performance. The algorithms are used on portfolio optimization problems with direct and indirect transaction costs. In particular, we propose a risk-neutral portfolio selection model included market impact costs and cast as a multistage stochastic second-order cone programming problem.

3 - Speeding-up a Modified SDDP Method for Risk-averse Energy Storage Optimization using Importance Sampling

Juliana Nascimento, Princeton University, Sherrerd Hall, Operations Research and Fincl. Engineering, Princeton, NJ, 08544, United States, jnascime@princeton.edu, Joe Durante, Daniel Jiang, Warren B.Powell

Stochastic dual decomposition procedure (SDDP) has been widely used for stochastic linear programs. We study SDDP in the context of optimizing grid-level storage, using a new hidden semi-Markov model (HSMM) for modeling the behavior of wind. Our HSMM has been shown to accurately reproduce the crossing-time behavior of the wind, which captures the amount of time that actual wind sample paths are above or below forecasts. The HSMM requires that we capture complex temporal interdependencies, but provides more robust solutions. We use an additive utility function and demonstrate a novel importance sampling technique to speed-up the backward pass of SDDP.

4 - Regularized Decomposition Methods for Multistage Stochastic Linear Programs

Yongjia Song, Virginia Commonwealth University, 1015 Floyd Avenue, P.O. Box 843083, Richmond, VA, 23284, United States, ysong3@vcu.edu, Wim van Ackooij, Welington de Oliveira

We consider well-known decomposition techniques for multistage stochastic programming and a new scheme based on normal solutions for stabilizing calculations as the iteration process progresses. The given algorithms combine ideas from finite perturbation of convex programs and level bundle methods to regularize the so-called forward step of these decomposition methods. We also improve the backward step (that generates cuts, approximating the cost-to-go functions) by employing an adaptive partition-based approach to reduce the computational burden. Numerical experiment results on a hydrothermal scheduling problem will be shown.

■ TC83

382C

Optimization, Robust

Contributed Session

Chair: Yang Zhan, City University of Hong Kong, Kowloon, Hong Kong, yangzhan3-c@my.cityu.edu.hk

1 - Optimizing Black Box Functions with Xpress

Majid Bazrafshan, Lead Consultant, FICO, 3957 Rue Berri, Montreal, QC, H2L.4H2, Canada, majidbazrafshan@fico.com, Zsolt Csizmadia

Optimization of black box functions are challenging due to the lack of information that defines them. The best method depends on the application; and while there may be no free lunch one property seems common: the expensive part is often the evaluations. A tempting solution is to use a solver that uses multiple evaluations per iteration organized into parallel calls. Doing so faces the same black box challenge; while the modeler knows the assumptions of the black-box, the solver is unlikely to offer just the right facilities to accommodate those. We show how FICO Xpress comes around these problems by providing automatic generation of parallel versions for user functions that remain fully customize-able.

2 - Solving L0-constrained Sparse Inverse Covariance Estimation

Dzung Phan, IBM.Research, 1101 Kitchawan Road, P.O. Box 218, Yorktown Heights, NY, 10598, United States, phandu@us.ibm.com, Matt Menickelly

Sparse inverse covariance matrices are utilized to model conditional dependences between variables in a network. Sparsity is often used for either interpretability of model or to avoid overfitting. We directly constrain sparsity by specifying a maximally allowable number of nonzeros. We present an efficient proximal projected Newton algorithm with warm starts for solving the l0-constrained GGM learning problem.

3 - A Second Order Method for Non-convex Optimization with Logarithmic Complexity

Santiago Paternain, University of Pennsylvania, Philadelphia, PA, United States, spater@seas.upenn.edu, Aryan Mokhtari, Alejandro Ribeiro

The problem of minimizing non-convex functions is central to many applications such as neural networks and matrix factorization. The main issue in solving these problems origins in the proliferation of saddle points. In this work, we present a modified Newton's method by replacing the negative eigenvalues of the Hessian by their absolute values to correct the curvature of the descent direction. This modification leads to a novel method that escapes the saddles exponentially fast. Moreover, we show that with probability 1-p the proposed algorithm outputs a solution within the epsilon radius of a local minimum of the objective function after running for O(log(1/p)+ log(eps)) iterations.

4 - Robust Operational Decisions for Multi Period Industrial Gas Pipeline Networks under Uncertainty

Pelin Cay, PhD Candidate, Lehigh University, Harold S. Mohler Laboratory, 200 W. Packer Ave, Bethlehem, PA, 18015, United States, caypelin@gmail.com, Camilo Mancilla, Robert H. Storer, Luis F. Zuluaga

Industrial gas companies plan daily gas production levels to minimize total production cost per day. While meeting the customer demand and physical constraints in a gas pipeline network leads to a challenging optimization problem, daily planning requires multi-period formulation with ramping limitation of the plants. In this study, we apply a heuristic approach to find a feasible solution for industry-sized problems. Moreover, we provide a lower bound solution to produce global optimality gap of the heuristic solution by the convex reformulation of the standard problem. Numerical experiments show advantages of using the developed heuristic compared to solving the standard formulation.

5 - A Smooth Path Following Algorithm for Market Equilibrium under a Class of Piecewise Smooth Concave Utilities

Yang Zhan, City University of Hong Kong, Kowloon, Hong Kong, yangzhan3-c@my.cityu.edu.hk, Chuangyin Dang

This paper presents a smooth path-following algorithm for computing market equilibrium in a pure exchange economy under a class of piecewise-smooth concave utilities, which can be expressed as $u(x)=\min_l\{f_l(x)\}$ with $f_l(x)$ being a smooth concave function for all l. As a result of a smooth technique for minimax problems, a smooth homotopy mapping is derived from the introduction of logarithmic barrier terms and an extra variable. With this mapping, it is proved that there always exists a smooth path leading to a market equilibrium as the extra variable approaches zero. Numerical results are given to further demonstrate the effectiveness and efficiency of the algorithm.

Tuesday, 12:30 - 2:30PM

■ Tuesday Poster

Exhibit Hall

Tuesday Poster Session

Poster Session

1 - The Effect of Air-high Speed Railway Joint Transport on Inland Air Harbor Hinterland

Si Chen, Southwest Jiaotong University, Chengdu, China, chensi@swjtu.cn, Mi Gan, Mi Gan, Mi Gan, Shuai Yang, Mingfei Wang

To estimate the impact of air-high speed railway freight transport in China, we applied the improved gravity model and data visualization to express the changes of strength about inland air harbor appeal to its hinterland. Through the comparison of changes in hinterland intensity and scope of service, the advantage of air-rail intermodality has been proved.

2 - Uncertainty Analysis of Species Distribution Models

Xi Chen, University of Texas at Austin, 3500 Greystone Drive, Apt 271, Austin, TX, 78731, United States, carol.chen@utexas.edu

Species distribution models (SDM) are commonly used to predict the geographic distributions of animals or plants species. However, most of SDM methodology produces point estimates. We present two strategies for quantifying the uncertainty of maximum entropy SDM methods: a bootstrap method, and an analytic method. We describe both methods, and compare and contrast their performance on two examples of different sizes. Both Dengue importation probability and Aedes aegypti mosquito suitability examples show that the methods generate comparatively the same results and the novel analytic method we introduce is dramatically faster than the bootstrap method.

3 - Investment Plan Against Malicious Attacks on Power Networks: Multilevel Game-theoretic Models with Shared Cognition

Hamzeh Davarikia, Research Assistant, University of Arkansas at Little Rock, 2801 S.University Avenue, Little Rock, AR, 72204, United States, hxdavarikia@ualr.edu

We developed a tool for utility transmission planners to protect power network from potential attacks. An extended tri-level mixed-integer linear-programming interdiction-model returns the best-protecting strategy. Deception is an integral part of the mathematical model, accomplished by releasing misinformation based on shared cognition theory. In addition, the multi origin-destination model allows the impact of disabled facilities to become transparent. The results from IEEE 24 and 118 Bus Test Systems show the viability of the model, including its capacity to impute the worth of deception.

4 - Value of Information for Systems Inspection

Joao Jose de Farias Neto, Doctor, Collective Decisions Ltda., Sao Jose dos Campos, Brazil, joaojfn@ig.com.br

The compromise between over-inspection (due to unwarranted fears) and under-inspection (due to excessive confidence) depends on two factors: the reliability level considered as satisfactory and the amount of effort (time and money) worth dedicating. Since inspecting a system means acquiring information about its subsystems, we propose the use of the concept of Value of Information (VoI), to achieve the balance in a rational manner. For that, the joint VoI of sets of subsystems must be evaluated; a special software - VIPDecisions (R) - is presented, that allows it. An example is given as a toy-problem.

5 - A New Linear Programming Algorithm for Big Size Problem Based Direction of Zoutendijk

Ivan Derpich, Dr., University of Santiago of Chile, Av Ecuador 3769, Santiago, Chile, ivan.derpich@usach.cl

A new algorithm to solve problems of linear programming for big size problems is presented. It is based on directions of Zoutendijk and it presents polynomial complexity.

6 - IPREP: Improving Perioperative Efficiency and Patient Throughput

Ged Doyle, Lead Practitioner, University Hospitals Birmingham, Mindelsohn Way, Edgbaston, Birmingham, B15 2TH, United Kingdom, ged.doyle@uhb.nhs.uk, Laura Boyle, Adele Marshall, Anthony Staines

The challenge is to reduce delays and 'silo' working. The technique involves modelling preliminary patient movement data using SIMUL8 to identify bottlenecks. Discrete Event Simulation has been used to observe the effects of introducing new approaches to improving the patient pathway. A clinical intervention trial will be selected from the DES output.The focus of the research is to establish a cohesive pathway for surgical patients where all the hospital departments work together to ensure improved throughput and efficiency.

7 - Scheduling Optimization of Local Farmers

sefakor Fianu, North Carolina A&T.State University, 1601 E.Market St, Greensboro, NC, 27411, United States, sfianu@aggies.ncat.edu, Lauren Berrings Davis

Local farmers face challenges such as; seasonality, transportation, food safety, and packaging requirements that prevent them from meeting the demand of institutions like universities. This research is part of the University Food Systems project aimed at connecting local farmers and universities in North Carolina. We solve the transportation problem by developing weekly schedules that minimizes the distance traveled by farmers to drop off their produce at crossdocking facilities. The schedules addresses capacity, collection frequency and food spoilage constraints.

8 - Efficiency Analysis of Basic Public Health Care Units that Operate under Brazilian Unified Health System

Carlos Ernani Fries, Associate Professor, Federal University of Santa Catarina, Caixa Postal 5185, Florianopolis, 88040-970, Brazil, carlos.fries@ufsc.br, Eduardo W. Benvenuti, Ricardo F. Giglio

The UBSs (basic health units) play a fundamental role in guaranteeing integral health care in Brazil. However, economic flutuations and federal government financial difficulties have imposed challenges in order to maintain public health care services. This work aims at contributing to better managerial practices focusing on improvements in the basic health care services. We have applied statistical techniques and DEA models in data from a medium-sized city. Results suggest characteristics that might have influence on the UBSs' efficiencies and the potential to guide other cities to perform systematic efficiency evaluations in their health services, thus facilitating better resource usage.

9 - A Robust Optimization Model for an Invasive Species Management Problem

Nahid Jafari, Assistant Professor, SUNY, Farmingdale, 2350 Broadhollow Road, Farmingdale, NY, 11550, United States, jnahid@hotmail.com

Invasive species pose a significant threat to global biodiversity. Managing invasive species often involves modeling the species' spread pattern, estimating control costs and damage costs due to the invasion, designing control efforts, and accounting for uncertainties in model parameters. Dealing with uncertainty is the most important part of the process, since biological, environmental, and economic factors can cause parameter values to vary greatly. We present a robust spatial optimization model (an integer programming model) to select treatment sites in a way that maximally reduces the size of an invasive population, given a constraint on financial resources.0

10 - System Monitoring with Sensor Time Series Data from Manufacturing Process

Youngseon Jeong, Chonnam National University, 77 Yongbong-ro, Buk-gu, Gwangju, 61186, Korea, Republic of, youngseonjeong@gmail.com

This research proposes a new statistical process control procedure for time series data having systematic variations of curves at local regions. To monitor possible systematic changes of curves at certain local regions, in this paper, we use the selected coefficients in the wavelet domain. Evaluation with real-life data sets shows that the proposed procedure performs better than several techniques extended from methods based on single-curve-based data reduction.

11 - VMT Impact of Shared Autonomous Vehicle in Orange County, California: Simulation Approach

Jae Young Jung, Operations Research Scientist, Ford Motor Company, 15403 Commerce Drive South, Dearborn, MI, 48120, United States, jjung22@ford.com, R. Jayakrishnan

Although Shared Autonomous Vehicles (SAVs) with self-driving capabilities will have benefits on driving efficiency and traveler convenience, there has been a growing concern about increasing Vehicle-miles traveled (VMT) due to empty hauls with SAVs, limiting the sustainability benefit. First, this simulation study demonstrates SAVs fleet operations in Orange County, California and identifies VMT increase compared to private vehicle usage. Second, the study suggests a ride-share strategy with SAVs and explores the potential benefit of ride-sharing to maximize the SAVs utilization.

12 - A Spatial Analysis for Airport Congestion

Fecri Karanki, Research Assistant, North Dakota State University, FARGO, ND, United States, fkaranki@gmail.com

In recent years, airport congestion has been a topic of much discussion. This study will show that one of the most important reason of airport congestion is the neighbor airport proximity. While airport capacity is taken as the main reasons for airport congestion, airspace capacity is ignored. However, airports, which are very close with each other, have to share the airspace. Thus, in this study, the capacity of airports is analyzed in 3 factors: gate(terminal), runway and air space. The effects of airspace capacity on congestion will be shown by the proximity between airports. The preliminary results of this study show that less distance between neighboring airports causes more delays at airports.

13 - Job Shop to Cellular Manufacturing: An Implementation in RF/microwave Manufacturing

Okan Karatay, Production Manager, Aselsan, Konya Yolu 8 km Ogulbey Mh. 3051 sk no:3, Ankara, 06830, Turkey, okaratay@aselsan.com.tr, Yuce Cinar Baysal

Nowadays, one of the effective ways of dealing with manufacturing drawbacks in a high mix low volume environment is the Cellular Manufacturing (CM). In this study, we first propose a manufacturing cell that is designed to replace the traditional job shop layout of Aselsan Inc. based on lean perspective. Secondly, we focus on the scheduling that creates the continuous flow and provides the line balance. In addition, employee originated challenges of adopting CM are also deeply investigated. Thirdly, we evaluate the performance of the CM with the conventional production layout by using the company's KPI. Finally, we derive some suggestions on how human aspects of CM can be improved for future studies.

14 - Learning in Discrete Optimization

Elias B.Khalil, PhD Student, Georgia Tech, North Avenue, Atlanta, GA, 30332, United States, lyes@gatech.edu

The branch-and-bound algorithm for solving Mixed Integer Programs (MIP) involves decisions that are currently addressed heuristically. Instead, we propose to use machine learning (ML) to make better-informed, input-specific decisions in MIP branch-and-bound. For branching and primal heuristic selection, our ML approaches significantly improve solver performance on heterogeneous MIPLIB instances and certain homogeneous families of instances. For some classical combinatorial problems, we propose a deep graph embedding framework for learning powerful greedy heuristics, and show that the learned heuristics are competitive with existing heuristics for VertexCover, MaxCut and TSP.

15 - Development of Accelerated Reliability Demonstration Test Plan under a Nonlinear Random-coefficients Model

Seongjoon Kim, Assistant Professor, Chosun University, 3F Dept. of IE, 2nd Engineering Building, 309 Pilmun-daero, Dong-gu, Gwangju, 61452, Korea, Republic of, seongjoon.kim@chosun.ac.kr, Suk Joo Bae

Due to tight time-to-market constraints, manufacturers have to assure product reliability in a short period of time and with limited resources. In this circumstance, reliability demonstration test(RDT) is widely used to demonstrate whether a product meets a pre-determined reliability level. In this research, we propose a method for Reliability Demonstration by Accelerated Degradation Test in the context of a nonlinear random-coefficients model. The proposed method is illustrated with display back-light unit(BLU) case and is applied to demonstrate the luminosity reliability.

16 - Millennials' Social Networking Behavior

Anita Lee-Post, University of Kentucky, Department of Marketing and Supply Chain, 435Q.Business & Economics Bldg, Lexington, KY, 40506, United States, dsianita@uky.edu

The purpose of this research is to further our understanding on Millennials' social networking behavior. Past literature has characterized Millennials as narcissists with a high level of technological competency but a low level of privacy concerns and commitment. A correlation study is sought to investigate the relationships among the characteristics of Millennials and their social networking behavior using a survey methodology. Theoretical and practical implications of findings from this study will be presented.

17 - A Semiparametric Trajectory Model to Predict Cognitive Decline in Lewy Body Dementia

Xiaoxia Li, North Dakota State University, Fargo, ND, 58102, United States, xiaoxia.li.lisa@gmail.com, Cannan Bilen-Green, Kambiz Farahmand, Linda Langley

Lewy bodies dementia (LBD) is a neurocognitive disorder that result in memory loss and other cognitive or functional decline. LBD progression is highly diverse, and the symptoms vary differently from case to case. However, it is essential to map the cognitive decline to the severity of the impact of the symptoms on daily life. Clinical Dementia Rating SUM score (CDR SUM score) is a comprehensive evaluation tool. In this study, we built a semiparametric model showed robustness in both explaining the data and predictions. The study results revealed the factors associated with cognitive decline rate in terms of CDR SUM score, and gave implications on accurate CDR SUM score prediction.

18 - Handling Passenger Flows and Transfers in Flight-to-gate Reassignment Procedures During Schedule Disruptions

Moschoula Pternea, PhD Candidate, University of Maryland, College Park, MD, 20742, United States, mpternea@umd.edu, Ali Haghani

The problem of reassigning flights to airport gates arises when unexpected disruptions render the planned assignment infeasible or impractical. In this context, one of the biggest challenges is to handle passenger flows, which are involved in the prevention of missed transfers, as well as the optimization of total walking distance for connecting passengers. We present an IP-based framework to handle the computational complexity of passenger flows by considering the layout of the airport and scheduled flights of the aircraft for the same day in order to prevent delay propagation across the whole network. Our experiments reveal the tradeoffs between different aspects of the solution quality.

19 - Assessing the Health and Wellness Outcomes of Infants Born to Teen Mothers

Toyya A.Pujol, PhD Student, Georgia Institute of Technology, Atlanta, GA, United States, pujol@gatech.edu, Nicoleta Serban, Julie L.Swann

The research will explore the impact of teen pregnancy on the health and wellness outcomes of infants. Causal effects of teen pregnancy were found by matching teen and adult mothers and performing a pairwise comparison for each outcome. The mothers were matched using demographics, health status, and Medicaid eligibility. Outcomes of the infants were restricted to the first year of birth and included addiction rates, health status, foster care, number of Emergency department and wellness visits. Analysis of outcomes includes using the Poisson means test and binomial proportion test.

20 - An Evolutionary Approach to Finding Improved Airplane Boarding Order

Ed Ramsden, Murata Power Solutions, 1080 County Street, Attleboro, MA, 02703, United States, ed@edscave.com

This project proposes a method for improving seat-to-zone assignments for boarding passenger aircraft. A simulation model is used to generate overall boarding times for different passenger seat-to-zone assignments, and an evolutionary algorithm uses the results of the simulation model to search for seat-to-zone assignments which result in minimal boarding times.

21 - Intensity Based Resilience Metric: An Exploration in Social and Physical Systems

Daniel Hernando Romero, University of South Florida, 4411 Shady Terrace Ln, Unit A, Apt 212, Tampa, FL, 33613, United States, danielromero@mail.usf.edu
Daniel Hernando Romero, Universidad del Norte, Barranquilla, Colombia, danielromero@mail.usf.edu, Alex Savachkin

A new resilience metric is proposed and evaluated in social and physical systems. The intensity based metric includes the disruption magnitude to enable a fair comparison when different events are studied. The analysis is carried out in a community under a pandemic influenza outbreak and in a supply chain. The results are contrasted with traditional average performance metrics.

22 - Spatio-temporal Characteristics of Freeway Traffic State Transitions

George Saman, California State University-Fullerton, Fullerton, CA, United States, georgesaman@csu.fullerton.edu, Paulina Reina

Empirical data at a freeway site was analyzed to investigate features of traffic state transitions from free-flow to congested state and vice versa. It was observed that transition durations range approximately from 15 to 35 minutes on average during congestion onset and clearance. Results also suggest that the rate of transition growth increases as the transition zone travels upstream of the bottleneck and that merges and diverges have no effect on the transition mechanism. These findings can have significant implications on the effectiveness of traffic management strategies during periods of transitions.

23 - An Approach Towards Automation of Model Selection

Mohammadali Shirazi, Texas A&M University, College Station, TX, United States, alishirazi@tamu.edu, Dominique Lord

We present an alternative to typical Model Selection strategies. Unlike typical methods, our approach looks at the characteristics of data to come with the best model. Our approach is easy to use and do not need any post-modeling inputs. It is particularly most suitable for instances when many alternatives with different complexities exist or the analyst deals with big data.

24 - Sustainable Supply Chain Management and the Issue of Social Sustainability

Bruno Silvestre, Associate Professor, University of Manitoba, Winnipeg, MB, Canada, b.silvestre@umanitoba.ca, Dafne Moraes

The social dimension of sustainability has been poorly investigated when compared to the environmental dimension in sustainable supply chain management studies. This lack of attention is problematic for the theory and practice of sustainable supply chains. We employ the concepts of supply chain engagement and motivation to shed light on the topic and improve our understanding of supply chain social sustainability. We selected eight cases of social initiatives undertaken by companies and used them as examples of the four different supply chain approaches to social sustainability. We finish the paper with implications for the practice and contributions to the supply chain management theory.

25 - A Modified Pharmacokinetic/pharmacodynamic Model for the Electrically Activated Silver-titanium Implant System

George Tan, Assistant Professor, Texas Tech University, Box 43061, 905 Canton Ave, Lubbock, TX, 79409, United States, george.z.tan@ttu.edu

Silver-based systems activated by low intensity direct current continue to be investigated as an alternative antimicrobial for infection prophylaxis and treatment. The objective of this study was to develop a semi-mechanistic pharmacokinetic/pharmacodynamic (PK/PD) model providing the quantitative relationship between the critical system parameters and the degree of antimicrobial efficacy. The model allowed the determination of the effective ranges of current intensity and anode surface area, within which the system has the optimal antimicrobial efficacy.

26 - Impacts of Height Restriction and Relaxation by Sky Factor Focusing on Digestion Floor Area Ratio and Building Height

Hiroko Watanabe, Graduate Student, The University of Tokyo, Ce-408, 4-6-1, Komaba, Meguro, Tokyo, 153-8505, Japan, hiroko@iis.u-tokyo.ac.jp, Yudai Honma, Kentaro Honma, Kotaro Imai

In this paper, we compare the impacts of height restriction and relaxation by sky factor in terms of digestion floor area ratio and building height. By considering the various site shape and building shape, we evaluate how these regulation affects the digestion floor area ratio and building height. The analyses enable us to grasp the situations which a relaxation by sky factor have large advantages. Main results of this paper are as follows: (i) a relaxation by sky factor is advantageous when the site has large frontage; (ii) by utilizing the setback regulation, it is possible to acquire enough floor are ratio when the site of depth becomes large.

27 - New Approach for Failure Mode and Effect Analysis using Linguistic Distribution Assessments and Todim Method

Hu-Chen Liu, Shanghai University, Shanghai, China, huchenliu@foxmail.com, Lu Zhen, Jianxin You, Jianxin You, Mengmeng Shan

This paper applies linguistic distribution assessments to represent FMEA team members' risk evaluation information and employs an improved TODIM (an acronym in Portuguese of interactive and multicriteria decision making) method to determine the risk priority of failure modes. Both subjective weights and objective weights of risk factors are taken into account while conducting the risk analysis process. Finally, an empirical case concerning the risk evaluation of a grinding wheel system is presented to demonstrate the practicality and effectiveness of the proposed new FMEA model.

28 - Does Sharing Bicycles Hurt Traditional Public Transportations

Ling Gai, Shanghai University, Office 432, School of Managent, Shanghai University, No. 599 Shangda Road, Shanghai, 201444, China, lgai@shu.edu.cn

Sharing bicycles with the characteristics of easier access and lower price come into people's daily life, they are becoming one of the primary traffic modes besides public bus and taxi. In this paper, we study the influences of sharing bicycles on the traditional public transportation system, including the market demand, their pricing policy and net profits. We also consider the case that the government joins in the market by imposing carbon taxes. The ring Hotelling model is applied to fulfill the analysis.

29 - A View From the Top: An Examination of Innovation Idea Selection Factors in Large Organizations, from the Executive Perspective

Troy A.Montgomery, University of South Florida, Tampa, FL, United States, tmontgomery@mail.usf.edu

Factors impacting the front end of innovation are vital to the overall success of the innovation process and have received considerable attention. However, factors that impact the specific activity of idea selection in large organizations have received less attention. This research utilized the proven methods of grounded theory to address the question: what are the critical factors large organizations consider when selecting innovation ideas? Data from 28 senior level executives provided a view from the top into these critical factors.

30 - Examining the Effect of the Price Display Format in Advertisement on Consumer Perception

Yoshiyuki Okuse, Professor, Senshu University, 2-1-1 Higashi Mita, Tama-ward, Kawasaki City Kanagawa Pref, 214-8580, Japan, okuse@senshu-u.jp

The purpose of this research is (1) to examine the relationship between price perception and the layout in the advertisement, and (2) to examine the influence of psychological distance on price perception.

31 - Interventional Radiology Resource Modeling and Simulation – A Case Study

Michael Prokle, Data Scientist, Philips Research North America, 371 Broadway, Apt 3, Cambridge, MA, 02139-1722, United States, michael.prokle@philips.com, Sebastian Flacke, Christoph Wald, Paul W. McGunigle, Robert San Soucie, Joanie Davis, Ranjith Tellis, Nandini Raghavan, Sandeep Dalal, Eran Simhon, Christopher S. Hall

We model and simulate an interventional radiology department (IR-Dept) seeking to decrease patient wait times. An IR-Dept's performance depends on the simultaneous availability of professional resources (e.g. physician, nurse), physical assets (procedure room, equipment), clinical workflow (e.g. prep-procedure-recovery) and its ability to handle inherently stochastic processes (e.g. patient arrivals, procedure times). We show how these aspects can be simulated and validate the model's output (i.e. patient wait times) against an actual day in a hospital's IR-Dept. Further, we use this model to show how this IR-Dept can optimize its staffing schedule to improve patient wait times.

32 - Optimizing Transportation Network for SF Express

Ziheng Liu, Machine Learning Engineer, SF Technology Co.,Ltd., Software Industry Base 1B, Shenzhen, 518000, China, liuziheng@sf-express.com

SF Express is a express services company based in Shenzhen, China. Established in 1993, SF has extended its services to all over Mainland China with more than 13,000 service points and approximately 15,000 operating vehicles. Rapid expansion of the business has posed challenges to SF and necessitated innovations. In order to promote the long-term development of SF Express, we have initiated two nationwide projects - business region partitioning and transit center selection to lower the operating cost of SF's transportation network. Multiple operations research and machine learning algorithms were utilized to solve the problems.

33 - Forecasting Delivery Amount for SF Express

Benyu Wang, SF Technology Co., Ltd., Software Industry Base 1B, Shenzhen, 518000, China, wangbenyu@sf-express.com

SF Express is a delivery service company based in Shenzhen,China. Established in 1993, SF has extended its services to all over Mainland China with more than 13,000 service points approximately 15,000 operating vehicles. Rapid expansion of the business has posed challenges to SF and necessitated innovations. In order to make staffing decisions and build work schedules for SF express, we have initiated a forecasting project for different types of delivery services and three different time units. Various time series, deep learning and machine learning models were utilized to solve the problems.

34 - Teaching Operations Research with MATLAB

Mary C. Fenelon, Product Marketing Manager, MathWorks, 3 Apple Hill Dr., Natick, MA, 01760-2098, United States, mary.fenelon@mathworks.com, Teresa Hubscher-Younger

This presentation shows how to use MATLAB tools for statistics, machine learning, optimization and discrete event simulation in an operations research course. Use Live Scripts and Apps for interactive lectures. Develop optimization models for decisions and design taking advantage of the newest MATLAB features. Develop simulation models to simulate different test scenarios and collect data that you could use for analysis and prediction. Access MATLAB Online through a browser or MATLAB Mobile from your phone. Create and grade assignments with Cody Coursework.

35 - Chance Constrained Programs with Mixture Distributions

Sun Wenjie, Mr, Tongji University, Shanghai, China, r13381638770@sina.com, Zhaolin Hu

Chance constrained programs (CCP) are important models in stochastic optimization and risk management. In the conventional literature on CCPs, underlying distribution modeling the randomness of the problem is usually assumed to be given in advance. However, in practice, such a distribution needs to be specified by the modelers based on the information available. This is called input modeling. In this paper we consider input modeling in CCPs. We propose to use mixture distributions to fit the data available and to model the randomness. We demonstrate the merits of using mixture distributions and show how to handle the CCPs with mixture distributions under several scenarios.

36 - A Randomized Strategy for Fare Inspection in Santiago Transit System.

Carlos Bonet Flores, Universidad de Chile, Republica 779, Santiago, Chile, carlos.bonet@ing.uchile.cl, Jose Correa, Andreas Wiese, Bastian Matias Bahamondes, Fan Wang

We implement a randomized strategy for fare inspection in Santiago transit system. We used a model based on bilevel programming, in wich first the leader determines probabilities for inspecting at diferent locations, and then the evaders respond by optimizing their routes given the inspection probabilities and travel times.

37 - School Choice Mechanism in Chile.

Natalie Epstein, Universidad de Chile, Fernandez Concha 477, Santiago, Chile, natalie.epsteinr@gmail.com, Jose Correa, Juan Escobar, Carlos Bonet, Bastian Matias Bahamondes, Martin Castillo, Maria Angelica Bosh

We describe the main challenges in the recent implementation of a stable matching algorithm for the Chilean primary and secondary school systems. The system successfully run in 2016 in the small region of Magallanes with almost 4000 applications. This year the system scales to about 80.000 applications and in steady state regime there will be about 500.000 applications per year.

38 - A Regularized Inverse Optimization Method to Decide Optimal Product Characteristic Combination and Consumer Taste Segmentation

CY (Chor-yiu) Sin, National Tsing Hua University, Kuang-Fu Road, Hsinchu, 30013, Taiwan, cysin@mx.nthu.edu.tw

Recent advances of the random coefficient demand model uses the constrained optimization modeling technique of mathematical program with equilibrium constraints (MPEC) and connects the specially-interested problem to the continually-developing power of nonlinear programming solvers. In this work, we construct a semi-nonparametric MPEC by relaxing the distributional assumption on the random coefficient. The empirical study investigating the UK vehicle market share of 212 vehicle models in UK with a large number of potential customers from Year 2001 to Year 2015 shows the effectiveness of this approach. We predict the responses in both the business market and the consumer market.

39 - Reverse Logistics and Shipping Waste Modeling

Mazen I. Hussein, Assistant Professor, University of Wisconsin-Platteville, 150 Stonebridge Road, Apartment 206, Platteville, WI, 53818, United States, mazenhussein2212@gmail.com

A model based on theory and several modeling techniques is used to estimate and predict the movement and flow of different kinds of waste. Variety of data resources was used. The results can be used as an input to other projects regarding the flow of commodities, logistics, and transportation.

40 - A Dynamic Programming Approach to Determining Residential Thermostat Set Points for Demand Response

Arnab Roy, Graduate Fellow, University of Louisville, 3177 South 3rd Street, Louisville, KY, 40214, United States, arnab.roy@louisville.edu, Lihui Bai

We propose a dynamic programming approach to determine the optimal set point for a smart thermostat during periods surrounding a Demand Response event. The objective is to minimize the total energy consumption during the peak period (high price) period while keeping the inside temperature within user-defined tolerable range. It is applied in three stages of the event: pre-, during and post-event. The algorithm is tested on three prototypical homes with low, medium, 41

41- A Machine Learning Framework for Industrial Energy Assessments at Small and Medium-sized Enterprises

Hadi Karimi, Clemson University, 1108 Tiger Blvd., Apt. 117, Clemson, SC, 29631, United States, hkarimi@clemson.edu, Sandra D. Eksioglu, Jay Devkota

In this study we are developing a machine learning framework to facilitate the industrial energy assessment process at small and medium size enterprises. The machine learning framework has two main stages: at first stage, we develop a predictive model to characterize baseline energy use by taking into account the climate conditions and production factors. At second stage, we measure the industrial energy savings by developing a multivariate regression equation and disaggregating the savings after taking the total derivative of the energy use equation.

42 - Confidence Regions for the Location of the Global Optimum of a Polynomial Model

Adam Meyers, Pennsylvania State University, 1006 Golfview Avenue, Apt 3, State College, PA, 16801, United States, acm4688@gmail.com

Our problem is to find a confidence region (CR) for the location of the global optimum of a polynomial model. Previous work culminated in an R package that finds CRs for quadratic polynomial regression and thin plate spline models. Our goal is to extend this package to accommodate polynomial models of higher degree and with a larger number of variables. In particular, we will discuss the solution method of the problem of finding the global minimum of a polynomial subject to polynomial inequalities. This involves solving semidefinite programming relaxations of increasing order whose solutions are guaranteed to converge monotonically to the global optimum. We will also discuss its implementation in R.

43 - Multi Attribute Trade Off in Supplier Selection Problem

Somaye Ramezanpour Nargesi, University of Texas at Arlington, 807 S.Center Street, Apt 108, Arlington, TX, 76010, United States, somaye.ramezanpournargesi@mavs.uta.edu

Supplier selection has been known as one of the most critical business decisions . In this research, we are going to use discrete choice setting to study how people do trade-off among price, availability and quality of the products offered by different suppliers, when they are actually choosing suppliers in an incentivized experimental setting. Aside from studying multi-attribute trade off, we will look at potential decision biases and the effect of number of choice on those biases.

44 - New Algorithms for Inference in Dynamic Stochastic Block Models

Mehrnaz Amjadi, PhD Student, College of Business, University of Illinois at Chicago, University hall, 601 S.Morgan St, 24th floor, UH2401, Chicago, IL, 60607, United States, mamjad2@uic.edu, Theja Tulabandhula

Although the computational and statistical trade-offs for modeling single graphs are relatively well understood, extending such results to sequences of graphs is difficult. In this work, we propose two models for such sequences that capture: (a) link persistence between nodes across time, and (b) community persistence of each node across time. In the first model, we assume that the latent community of each node does not change, and in the second model we relax this assumption. For both models, we propose computationally efficient inference algorithms, which leverage community detection methods that work on single graphs. We provide simulation results validating their performance.

45 - A Decomposition Framework for System Optimal Dynamic Traffic Assignment Problem

Mehrzad Mehrabipour, Graduate Research Assistant, Washington State University, 1630 NE Valley Road, Pullman, WA, 99164, United States, mehrzad.mehrabipour@wsu.edu, Ali Hajbabaie

Computational complexity of cell transmission model based Dynamic Traffic Assignment (DTA) limits its applications to large transportation networks. This study develops a scheme to decompose the network into several sub-problems. The proposed methodology is applicable to larger transportation networks and finds solutions that are within 5% gap with the optimal solution in various case study networks.

46 - Redesign of Patient Flow and Resource Allocation in a High Volume Emergency Department

Melih Celik, Middle East Technical University, ODTU. Endustri Muh. Bolumu, Universiteler Mh. Dumlupinar Bl. No: 1, Ankara, 06800, Turkey, cmelih@metu.edu.tr, Sakine Batun, Nur Keskin, Alpin Ilayda Ozmen, Deniz Tanrikut, Medya Tekes, Gokcem Yigit

We consider the operations of a high-volume emergency department where the waiting times are above the acceptable levels for a significant proportion of the patients. We describe the system by using a simulation model and utilize this model evaluate the impact of various improvement opportunities such as using different policies about the patient flow (e.g., triage method, patient prioritization, patient streaming) and resource allocation (e.g., allocation of staff to shifts and patient groups).

47 - Thresholding Link Weights in Complex Networks as a Percolation Process

Farnaz Zamani Esfahlani, PHD Candidate, State University of New York-Binghamton, 33 Schiller Street, Apt 3N, Binghamton, NY, 13905, United States, fzamani1@binghamton.edu, Hiroki Sayama

Thresholding link weights is a common technique to reduce the complexity and computational time of analyzing complex networks. However, the majority of thresholding techniques alter the properties of weighted networks and therefore influence the results of the analysis. Here we propose a percolation-based thresholding method which can preserve the macro/microscopic properties of the weighted networks more effectively.

48 - A Brain Computer Interface Approach to Examine Changes in Motion Patterns While Walking in a Virtually Infinite World

Rachneet Kaur, Student, University of Illinois at Urbana Champaign, TB 21, Department of Industrial and Enterprise Systems Engineering, 104 S.Mathews Ave, Urbana, IL, 61801, United States, rk4@illinois.edu, Richard Sowers, Ma nuel Hernandez, Daan Michiels

This research focuses on creating virtual reality components of a test bed for understanding responses to visual stimuli and their relation to movement disorders such as Parkinson's disease. With electroencephalography (EEG) as brain-computer interface (BCI), we measure neurological responses of a person walking through a virtual world that elicits nervousness, compute their real time neural state and adapt the virtual world accordingly to diminish fall related anxiety. The objective is to synthesize a self-monitoring and regulated personalized VR environment based on the user's uneasiness that allows to decrease anxiety levels in balance demanding walking conditions.

49 - Modeling Lane Changing Behavior Based on Snowdrift Coordination Game

Saeed Reza Ramezanpour Nargesi, UTA, 500 S Senter St, Apt 117, Arlington, TX, 76010, United States, saeedreza.ramezanpournargesi@mavs.uta.edu

In this research, we are going to model lane changing behavior, using game theoretical approach, to take the interdependency of drivers' decision making into microscopic traffic analysis. The model will include mandatory and discretionary lane changing behaviors in a snowdrift type of coordination game with two players (Target and Lag vehicles), complete information and static setting. Target vehicle aims to gain speed while trying to avoid collision. Lag vehicle tries to maintain its current speed subject to safety constraint.

50 - Machine Learning for Safer Roads

Haridut Athi Shyam Sundar, University of Illinois at Urbana-Champaign, 405 E Stoughton, Apt 20, Champaign, IL, 61820, United States, haridut2@illinois.edu

This research primarily focuses on finding interesting and hugely informative patterns in fatal road accidents. Further, it explores how machine learning can be applied to predict fatalities on the roads given the circumstances of a collision. Our work draws inspiration from Los Angeles' and New York's 'Vision Zero' initiative which aims to achieve zero road fatalities by 2025. Though our initial research is based out of these two city's public data, our larger objective is to build robust machine learning models that could generalize well to most of the cities.

51 - Sustainable Electricity Markets

Mohammad Rasouli, Sustainable Electricity Markets, University of Michigan, 2829 Catalpa Circle, Apt 12, Ann Arbor, MI, 48108, United States, rasouli@umich.edu, Mohammad Rasouli

Electricity policy target in majority of the countries is to achieve sustainable and reliable electricity with efficient prices for uncertain future demand.. We provide a model of the industry with the policy targets propose market-based implementations of the electricity policy targets.

52 - Decoding Nonlinear Brain Dynamics from Human EEG

Miaolin Fan, Northeastern University, 360 Huntington Avenue, Boston, MA, 02115, United States, fan.mi@husky.neu.edu, Chun-An Chou

Decoding EEG activity through pattern recognition helps understand human conscious, perceptions and experiences. However, EEG is a highly complex system driven by nonlinear dynamics. In our study, we characterized the human EEG dynamics based on chaos theory and spectral graph theory. Experiment 1 presents a seizure detection study where graph theoretic method is combined with Recurrence Plots for detecting abnormal state transients using epileptic EEG recordings. In Experiment 2 an emotion recognition task was performed, and we applied RP-based feature extraction method to classify patterns form different emotional states. In conclusion, our method achieved a good accuracy and low latency.

53 - Efficient Algorithms for Some Graph Inverse Problems

Jonathan Celaya, Rice University, 6360 S.Main Street, Houston, TX, 77005, United States, jsc7@rice.edu

Solving the inverse of a weighted graph problem P entails finding the least modification of weights so that X becomes an optimal solution for P. We present polynomial time algorithms for the inverses of the maximum clique and minimum vertex cover problems on bipartite graphs, and also for the former on block graphs. Both under the 1 and infinity norms.

54 - Understanding Consumers' Impulse Buying Behavior in Social Commerce Platforms

Samira Farivar, PhD Candidate, DeGroote School of Business, DSB A211, DeGroote School of Business, McMaster University, 1280 main street west, Hamilton, ON, l8s 4m4, Canada, farivas@mcmaster.ca, Yufei Yuan

Social commerce has identified as a new online commerce platform which enhances users' information contribution and interaction. Thus, social aspects are the main focus of these environments. Nonetheless, the role of social facets in influencing social commerce users' behaviors is not yet fully understood. In this study, we are interested in examining social aspects that exist in the social commerce and their influence on users' buying behavior. Drawing from Latent State-Trait theory, we build our model which suggests that users' personality traits, environmental cues (social factors), and interactions between these two elements drive users to buy impulsively.

55 - Doubling Supply Chain Profits the Theory of Constraints Way: A Case Study

Harshal Lowalekar, Associate Professor, Indian Institute of Management-Indore, Prabandh Shikhar, Rau-Pithampur Road, Indore, 453331, India, lwlherschelle@gmail.com

We describe the implementation of Theory of Constraints (TOC) at a large consumer durables company in India. Using TOC's thinking process the constraints that limited company's performance in production and distribution were identified and eliminated. TOC's unique approach helped in drastic reduction of inventories in the supply chain. Shortage and excess of SKUs in distribution almost vanished. Lead times for make-to-order (MTO) items decreased by 75% while the availability of make-to-stock (MTS) items increased to 100%. ROI for the distributors and retailers on the company's products more than tripled while the profits of the company doubled during the Great Recession of 2008 due to TOC.

56 - Space Efficient Layouts for Block Stacking Warehouses

Shahab Derhami, Postdoctoral Fellow, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30332, United States, shahab.derhami@isye.gatech.edu

In block stacking warehouses, pallets of stock keeping units are stacked on top of one another on the warehouse floor. The arrangement of lanes in the layout of this storage system affects utilization of the storage volume. Existing research that studies space utilization exclusively attempts to find the optimal lane depth and does not address the design of a space-efficient layout. We describe a model for block stacking warehouses that chooses a set of bay depths and arranges them in a layout to minimize wasted space. We use simulation to evaluate performance of the proposed model through an experimental analysis that covers small to industrial-sized warehouses.

■ Tuesday Poster Competition

Exhibit Hall

Tuesday Poster Competition

Competition Poster Session

Chair: Sergiy Butenko, Texas A&M University, 4037 Emerging Technologies Building, Mail Stop 3131, College Station, TX, 77843-3131, United States, butenko@tamu.edu

Co-Chair: Jeffrey W Herrmann, University of Maryland-College Park, Department of Mechanical Engineering, College Park, MD, 20742, United States, jwh2@umd.edu

1 - A Sequential Game of Defense and Attack on Interdependent Systems

Fei He, Texas A&M.University-Kingsville, MSC 191, 700 University Blvd, 700 University Blvd, Kingsville, TX, 78363, United States, fei.he@tamuk.edu, Chiamaka J. Agwuegbo

This research studies the defense strategy of an interdependent system in the face of rational attacks. We propose a sequential game between an attacker and a defender on an interdependent system of systems (SoS) to explore the effect of interdependency on the optimal defense strategy. An algorithm of backward induction is developed to determine the equilibrium path of the game. The attacker is the first mover as he applies an attack strategy on constituent systems that maximize his utility. The defender observes and responds by an optimal defense strategy which maximizes her utility. The utility is evaluated as the difference between a player's reward and the cost of the action. The sensitivity analysis is carried out to compare the effects of different parameters on the attacker and defender's strategies such as the effectiveness of defense, the effectiveness of attack, the unit cost of defense and the unit cost of attack on constituent systems.

2 - Using Drones to Minimize Delivery Time in Disaster Relief Operations

Mohammad Moshref-Javadi, Purdue University, 315 N Grant St., Room 324E, Purdue University, West Lafayette, IN, 47907, United States, moshref@purdue.edu, Lee Seokcheon

Drone is an emerging technology which can be used for distribution of products and services. To benefit from advantagesof drones and deal with their limitations, we design a combined system of drones and trucks in which trucks carry bothsupplies and drones and stop at some points in their routes to launch the drones to deliver supplies. The goal is to minimizethe waiting time of the recipients by deciding about the number of drones, launch locations, victims visited by drones, andsequence of visits. The results of the worst-case analysis and case study in Virginia show that this approach can lead tomore than 58% faster delivery.

3 - Ultra-high Precision Predictive Assembly of Composite Fuselage Joins via Surrogate Model Based Control

Xiaowei Yue, Georgia Institute of Technology, 755 Ferst Drive NW, ISYE, Atlanta, GA, 30332, United States, xwy@gatech.edu, Yuchen Wen

Ultra-high precision predictive assembly is vital for large-scale aircraft production. Passive manual adjustment in current practice is low efficient, non-optimal and experience-dependent. We propose an automated optimal shape control system that can adjust composite parts to an optimal configuration efficiently. The objective is accomplished by (i) building and validating a finite element platform; (ii) developing a surrogate model considering various uncertainties to achieve predictive performance; (iii) conducting feed-forward control to determine the optimal actions. We show the system can significantly reduce assembly time and dramatically improve dimensional quality.

4 - Ranking Alternatives with Partial Information Based on Flexible Interactive Tradeoff

Eduarda Frej, Universidade Federal de Pernambuco, Recife, Brazil, eafrej@gmail.com, Adiel de Almeida

A new approach for ranking alternatives in multicriteria decision making based on the Flexible and Interactive Tradeoff is presented. FITradeoff is a partial information method for elicitation of criteria weights in additive models. The decision aiding is conducted through a structured elicitation process based on tradeoffs, in which the Decision Maker interactively compares consequences by providing strict preference statements, in such a way that less cognitive effort is spent in the decision making process. An application of a supplier selection problem in a food industry is presented in order to show how this method can be applied to solve real-world cases.

5 - Learning in Discrete Optimization

Elias B.Khalil, PhD Student, Georgia Tech, North Avenue, Atlanta, GA, 30332, United States, lyes@gatech.edu

The branch-and-bound algorithm for solving Mixed Integer Programs (MIP) involves decisions that are currently addressed heuristically. Instead, we propose to use machine learning (ML) to make better-informed, input-specific decisions in MIP branch-and-bound. For branching and primal heuristic selection, our ML approaches significantly improve solver performance on heterogeneous MIPLIB instances and certain homogeneous families of instances. For some classical combinatorial problems, we propose a deep graph embedding framework for learning powerful greedy heuristics, and show that the learned heuristics are competitive with existing heuristics for VertexCover, MaxCut and TSP.

6 - An Investigation on Aggregate Production Planning with Flexible Requirement Profiles (FRP) with Stochastic Uncertainty

Setareh Torabzadeh, The University of North Carolina-Charlotte, 9101 Olmsted Dr Apt6, Charlotte, NC, 28262, United States, storabza@uncc.edu, Ertunga C. Ozelkan

This paper investigates production planning problem, using a flexible approach, called: Flexible Requirement Profile, enforcing flexible bounds on production levels in different periods to improve the stability of the production plans. Due to uncertainty of data in the future periods, stochastic programming approach is utilized. We investigate how stochastic FRP aggregate production planning compares with the deterministic FRP aggregate production planning and deterministic and stochastic aggregate production planning. For this aim, we develop chance constraint FRP aggregate production planning model. Results show the FRP models result in better stability and comparable costs.

7 - A Multi-objective Maintenance Strategy through Component Reassignment

Jiangbin Zhao, Northwestern Polytechnical University, 554 Mail Box, No.127 Youyi Western Road, Xi'an, 710072, China, zhaojiangbin@mail.nwpu.edu.cn, Shubin Si, Zhiqiang Cai

System reliability can be improved by corrective maintenance or pro-active replacement, which could be expensive or uneconomical. Reassigning components is a better method to improve the system reliability for linear-consecutive-k-out-of-n systems. We investigate a multi-objective maintenance strategy by seeking the reassignment with the lowest maintenance cost and highest system reliability. A multi-objective optimization model is formulated. A genetic algorithm based on the maintenance cost and system reliability is developed to search for the Pareto solution. The effectiveness is further compared with the popular non-dominated sorting genetic algorithm.

8 - Condition Monitoring of Vessel's Main Engine: A Case Study

Young-Mok Bae, M.S.Candidate, Pohang University of Science and Technology, Nam-gu Chungam-ro 77, Engineering bld 4, Pohang, 37673, Korea, Republic of, ymbae@postech.ac.kr, Min Jun Kim, Kwang-Jae Kim, Chi-Hyuck Jun, Sang-Su Byeon, Kae-Myoung Park

Condition monitoring of a vessel's main engine is a crucial aspect of maintenance since main engine failures may lead to major accident. Recently the advancement of Information and Communications Technologies(ICT) has allowed massive amounts of vessel's condition related data to be collected. The data used in this study comes from a main engine in an actual vessel, collected from recent operations. This study reviews various variables related to the condition of the main engine, and detects abnormalities and their trend. This study is expected to provide a basis for preventive maintenance and proactive management of vessel's main engines.

9 - Minimizing Levelized Cost of Onsite Generation: Towards a Zero Energy Supply Chain

An Pham, Texas State University, San Marcos, TX, 78666, United States, a_p276@txstate.edu, Tongdan Jin, Clara Novoa, Cecilia Temponi

We formulate a linear optimization model to investigate whether it is feasible to operate a net-zero carbon supply chain via 100 percent of onsite wind and solar generation. The study aims to allocate renewable technology, placement and capacity in a three-tier supply chain network with the goal of minimizing the levelized energy cost. The zero-carbon supply chain model is tested on a network comprised of 20 factories, 2 distribution centers, and 30 retail stores under various wind and weather conditions. We also compare the cost effectiveness of onsite generation assuming net metering and variable feed-in-tariff policies, and interesting managerial insights are derived accordingly.

10 - Modeling and Analysis of Sustainable Supply Chain Dynamics

Gang Wang, University of Massachusetts Dartmouth, 285 Old Westport Rd, Room 214, North Dartmouth, MA, 02747, United States, gwang1@umassd.edu, Angappa A.Gunasekaran

This paper studies the dynamic behavior of the interaction between sustainable supply chains and the environment. A mathematical model based on the nonlinear dynamic system is presented to describe the dynamics of the impact of supply chains on the environment while achieving sustainable supply chains. To better understand the dynamic mechanism of this proposed system, performance analysis is conducted with respect to three parameters: (a) design production capacity; (b) environmental cost; and (c) demand rate. Analytical results validate the dynamic interaction of supply chains with the environment and justify the environmental and economic significance of supply chain sustainability.

11 - Budgeting Dredging Projects to Improve Resilience of the Inland Waterway Network

Khatereh Ahadi, PhD Candidate, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States, kahadi@uark.edu

We consider the problem of selecting a budget-limited subset of maintenance actions to maximize the expected tonnage of commodities that can be transported through the inland waterway system. Uncertainty in our model is the budget required at each district for emergency dredging arises from unpredictable conditions. Thus, our main decision is allocating budget to each district to cover the cost of emergency dredging. Then, with the remaining budget routine jobs can be completed. We model this problem as a stochastic programming model, develop solution approaches, and analyze computational results.

12 - Robust Synthetic Control

Muhammad J. Amjad, Massachusetts Institute of Technology, 235 Albany Street, Suite 3121A, Cambridge, MA, 02139, United States, mamjad@mit.edu, Devavrat Shah, Dennis Shen

We present a robust generalization of synthetic control that features a distinguishing data de-noising process via singular value thresholding. Consequently, our method is robust in multiple facets: it automatically identifies a good subset of donors, functions without extraneous covariates (vital to existing methods), and handles missing data (never been addressed). To our knowledge, we provide the first theoretical finite sample analysis for a more general model than previously considered in literature, and show our estimator is asymptotically consistent. We also introduce a Bayesian framework that allows practitioners to quantitatively measure the uncertainty of their estimates.

13 - Sustainable Electricity Markets for Restructured Electricity Industry

Mohammad Rasouli, University of Michigan, 404 Wildwood Avenue, Apt 1, Ann Arbor, MI, 48104, United States, rasouli@umich.edu

We consider emerging electricity technological changes and design electricity markets that are reliable, sustainable and price efficient. We start by modeling an oligopoly of electricity generation companies which interact over the electricity network for a long horizon and have uncertainties with respect to the future. Then we propose efficient capacity, carbon permit, transmission right, and electricity spot markets.

14 - Smart Hospitals: Application and Evaluation of 'Internet of Healthcare Things (IoHT)' in a Hospital Unit

Michael W. Carter, University of Toronto, 5 King's College Road, Toronto, ON, M5S.3G8, Canada, carter@mie.utoronto.ca, Tahera Yesmin

Internet of healthcare things (IoHT) has become an emerging technology which can substantially change the mode of care delivery and therefore improve the care provided. Many researchers have exhibited the working methodology and application of IoHT in various aspects of patient care. However, very few researches have evaluated the outcomes. This research demonstrates the effects of IoHT in one of the hospitals of Ontario, Canada. With the help of various tools of data mining, statistics and industrial engineering this study measures the impact of IoHT. Thus findings of the research indicate the effectiveness of the intervention and hence hold the potential for decision making in care improvement.

Tuesday, 2:00 - 3:30PM

■ TD01

310A

Decision Analysis in Public Policy

Sponsored: Decision Analysis

Sponsored Session

Chair: Jonathan Welburn, RAND Corporation, 4570 Fifth Ave #600, Pittsburgh, PA, 15213, United States, jwelburn@rand.org

1 - Allocating Resources to Account for Multiple Levels of Uncertainty

Lei Yao, Iowa State University, Ames, IA, 50011, United States, lyao@iastate.edu, Cameron MacKenzie

Mathematical models to help public policy decision makers often have a great amount of uncertainty. This uncertainty includes uncertainty about parameters, models, decision maker risk attitudes, and even functional forms in the models. Policy makers may also be skeptical about solely relying on model recommendations with only optimal solutions. A solution to this uncertainty and decision makers' skepticism is to find intervals as model outputs rather than a single optimal solution. This presentation will identify intervals for resource allocation models in which every objective function value evaluated by the interval differs from the minimum objective function value by a predetermined gap.

2 - Supporting Policy Decisions through Text Analytics

Seifu John Chonde, Associate Operations Researcher, RAND Corporation, 1200 South Hayes Street, Arlington, VA, 22202, United States, schonde@rand.org, Timothy Stacey, William Marcellino, Ryan Brown

RAND will discuss lessons learned in the development and application of multilingual text analysis tools to support policy decision makers. In recent work, we created a suite of data storage, natural language processing, and presentation tools. These tools are used across a range of tasks including lexical analysis, stance analysis, topic modeling, text classification, and advanced text clustering. The talk will focus on our latest developments in advanced text clustering. By walking through examples we will illustrate how text clustering is useful in public policy and highlight open research questions for the decision analysis community.

3 - Multinational Direct Investment and Political Uncertainty

Omar Sherif Elwakil, Massachusetts Institute of Technology, 1 Amherst Rd., Cambridge, MA, 02139, United States, oelwakil@mit.edu

Recent developments in the general equilibrium theory of multinationals emphasize the importance of multilateral considerations. Yet, existing explanations and corresponding estimations of FDI patterns have largely limited political and institutional investment impediments to a bilateral framework. Through the application of spatial econometric techniques, I show that the presence of both domestic and regional political uncertainty generate real options effects that lead to the delay or redirection of FDI. The magnitude and direction of these effects is conditional upon the host country regime type and the predominant multinational integration strategies in the region.

4 - Perceptions of Income Tax Evasion and Tax Moral: A Survey to Inform an Agent-based Model

Raffaele Vardavas, RAND Corporation, Santa Monica, CA, United States, rvardava@rand.org

We built an agent-based computational simulation model of income tax evasion. Within the simulation, individuals' compliance behavior changes through an adaptation process based on their past experiences with audits and tax evasion penalties, their perception of the fairness in taxation rates and social interactions with people in their social networks. To inform the model we have conducted a survey on a nationally representative sample on the perceptions of tax fairness. We present how our model was informed by our survey and show some initial model results.

■ TD02

310B

Probability Judgments

Sponsored: Decision Analysis

Sponsored Session

Chair: Asa Palley, Indiana University, Bloomington, IN, 47405, United States, apalley@gmail.com

1 - One-Shot Forecast Aggregation under a Mixture of Measurement Error and Information Diversity

Ville Satopaa, INSEAD, Paris, France, ville.satopaa@insead.edu

In this work, we develop methodology for the "one-shot" prediction environment, where each forecaster predicts a single outcome. Our aggregator arises from a mixture model of measurement error and information diversity, and is therefore, to the best of our knowledge, the first method that addresses both sources of variation simultaneously. Estimation relies on Bayesian statistics, leading to a posterior distribution of the consensus aggregate. Our methodology is illustrated on real-world and synthetic forecasting data.

2 - Quantifying Uncertainty using the Mean and Variance of a Collection of Point Estimates

Asa Palley, Indiana University, 1275 E 10th St, Bloomington, IN, 47405, United States, apalley@gmail.com

The wisdom of crowds—combining information from a collection of individual judgments—offers a useful method for quantifying an unknown variable. Averaging point estimates has proven to be effective in reducing error in the consensus estimate. Often, however, the decision maker requires an assessment of the full distribution. Using a Bayesian model of information, I show that the mean and variance of a variable of interest can be estimated as a function of the mean and variance of a collection of individual judgments, and derive the crowd consensus distribution. This provides a procedure that is easy to implement to estimate a predictive distribution from a collection of point estimates.

3 - A General Method for Addressing Forecasting Uncertainty in Inventory Models

Dennis Prak, University of Groningen, Nettelbosje 2, Groningen, 9747 AE, Netherlands, d.r.j.prak@rug.nl, Ruud Teunter

We derive a framework for addressing the estimation uncertainty, applicable to any inventory model and demand distribution. The (random) estimation errors are modeled and substituted into the inventory model, and the expectation of the objective function is taken with respect to the errors. When estimates are based on 10 observations, relative savings are typically between 10% and 30%. They are larger when estimates are based on fewer observations, when backorders are costlier, and when the lead time is larger. The method applies to any field where forecasts are used in optimization models.

4 - Estimation Error in Portfolio Optimization: Extra Constraints or More Diversification?

Luis Chavez-Bedoya, Universidad Esan, Nestor Bermudez 191, Chorrillos, Lima, LIMA 9, Peru, l.chavezbedoya@northwestern.edu

We study the relationship between extra constraints and diversification when reducing estimation risk in portfolio optimization. By adding a set of linear constraints to the original mean-variance portfolio problem, we prove that the portfolio with the minimum loss caused by parameter uncertainty consists on the combination of two sample portfolio with minimum risk and another one with zero exposure to a set of factors. Also, we claim that the best set of constraints corresponds to statements regarding the sample tangent portfolio. Finally, we give an explanation of the portfolio weights of Kan and Zhou (2007) and the portfolio rule of MacKinlay and Pástor (2000).

■ TD03

310C

Location Models for Emergency Service Applications

Invited: Tutorial

Invited Session

1 - Location Models for Emergency Service Applications

Vladimir Marianov, Pontificia Universidad Catolica de Chile, Department of Electrical Engineering, Vicuna Mackenna 4860, Santiago, 782-0436, Chile, marianov@ing.puc.cl

The term "emergency services" commonly refers to medical, firefighting or police services, although emergency repair can also be included in this category. All these services can be found in both public and private sectors. The design of police services requires mainly districting, dispatching, routing, and scheduling of police beats. Medical and firefighting services, on the other hand, mainly involve locating infrastructure and finding an initial or "idle" site where vehicles wait for an emergency to occur. Thus, the design of medical and firefighting systems benefit the most from the use of location models, and we concentrate in these two types of services. We do not perform a thorough review of the literature related to the application of location models to these services. Rather, we follow some of the successive model innovations that have addressed the main issues and added increasing degrees of reality to the modeling, with a didactic goal. We thus apologize to colleagues who have made significant contributions not included in this chapter.

■ TD03A

Grand Ballroom A

Energy & Uncertainty: Optimization & Control

Sponsored: Applied Probability

Sponsored Session

Chair: Adam Wierman, California Institute of Technology, Pasadena, CA, 91125, United States, adamw@caltech.edu

1 - Distributed Optimization Decomposition for Joint Economic Dispatch and Frequency Regulation

Enrique Mallada, Johns Hopkins University, Baltimore, MD, 21201, United States, mallada@jhu.edu

This work studies the joint problem of co-optimizing economic dispatch and frequency regulation resources in power systems. We provide sufficient conditions under which the joint problem can be decomposed without loss of optimality into slow and fast timescale problems. These problems have appealing interpretations as the economic dispatch and frequency regulation problems respectively. Moreover, the fast timescale problem can be implemented using distributed load and/or generation control. We apply this optimal decomposition to propose an efficient market mechanism for economic dispatch that coordinates with frequency regulation.

2 - Opportunities for Price Manipulation by Aggregators in Electricity Markets

Navid Azizan Ruhi, California Institute of Technology, 1200 E. California Blvd., MC 305-16, Pasadena, CA, 91125, United States, nazizanr@caltech.edu, Krishnamurthy Dvijotham, Niangjun Chen, Adam Wierman

Aggregators are playing an increasingly crucial role in the integration of renewable energy in power systems. However, the intermittent nature of renewables makes market interactions difficult to monitor and regulate, raising concerns about potential market manipulation by aggregators. We study this issue by quantifying the profit an aggregator can obtain through strategic curtailment of generation. We show that, while the problem of maximizing the benefit from curtailment is hard in general, efficient algorithms exist when the topology of the network is acyclic. Further, we highlight that significant increases in profit are possible via strategic curtailment in practical settings.

3 - Cascading Failures in Power Grids: A Large Deviations Approach

Alessandro Zocca, Caltech, Pasadena, CA, United States, zocca.ale@gmail.com, Tommaso Nesti, Bert Zwart

Power grids are increasingly affected by uncertainty due to the intermittent nature of renewable generation. In this talk I will present a stochastic model of power grids under uncertainty, aiming to get insight in the interplay between renewable energy sources and grid reliability. Using the DC approximation and large deviation techniques, we investigate line overload probabilities in a small-noise regime and identify the most likely way for overloads to occur. We also investigate how such overloads and failures lead to cascades. In particular, such cascading failures do not propagate in a nearest neighbor fashion, unlike epidemic models, and we illustrate this analytically in our model.

4 - Interaction Between Retail and Wholesale Electricity Markets: Modeling and Stability Analysis

Thiagrajan Ramachandran, Pacific Northwest National Laboratory, Richland, WA, 99354, United States, thiagarajan.ramachandran@pnnl.gov, Krishnamurthy Dvijotham, Karanjit Kalsi

As power systems cope with increasing amounts of renewable generation, there is an increasing need to engage flexible demand-side resources into power systems operations. Retail markets can facilitate this by providing a platform to aggregate demand-side flexibility and bid the aggregate flexibility into wholesale markets. However, flexible loads have physical dynamics that couples their capacity over time which could have unintended and undesirable consequences. We develop a simple model to capture evolution of load flexibility over time and analyze stability of the market dynamics under this model. We prove that oscillations cannot occur and prices converge to a equilibrium levels quickly.

■ TD03B

Grand Ballroom B

Information Markets and Learning

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ali Makhdoumi, Massachusetts Institute of Technology, 77 Massachusetts Ave. , 32D-640, Cambridge, MA, 02139, United States, makhdoum@mit.edu

Co-Chair: Kimon Drakopoulos, Massachusetts Institute of Technology, Los Angeles, CA, 90066, United States, kimondr@mit.edu

1 - Information Revelation and Consumer Privacy

Alessandro Bonatti, MIT, Cambridge, MA, United States, bonatti@mit.edu, Rossella Argenziano, Gonzalo Cisternas

We develop a dynamic model in which a forward-looking consumer interacts with heterogeneous sellers. In each period, the consumer makes both a purchase decision that is imperfectly observed by future firms. We characterize the amount of information the consumer's equilibrium actions reveal about her true preferences. Because consumers are wary of revealing information through purchases, sellers lower their prices to stimulate demand. These results have implications for privacy regulation that restricts the flows of information.

2 - Learning from Reviews

Ali Makhdoumi, Massachusetts Institute of Technology, 77 Massachusetts Ave. , 32D-640, Cambridge, MA, 02139, United States, makhdoum@mit.edu

Many online platforms present summaries of reviews by previous users. Even though such reviews could be useful, previous users leaving reviews are typically a selected sample of those who have purchased the good in question, and may consequently have a biased assessment. We construct a model of dynamic Bayesian learning and profit-maximizing behavior of online platforms to investigate whether such review systems can successfully aggregate past information and the incentives of the online platform to choose the relevant features of the review system.

3 - Origins and Control of Misinformation

Gad Allon, gadallon@wharton.upenn.edu, Kimon Drakopoulos, Vahideh Manshadi

During the last several years we have witnessed a dramatic change in the way information is being distributed to citizens and consumers: From a market controlled by several key players we moved to a highly fragmented market with many players. The paper is motivated by the the observation that while on the one hand, we see more of these independent news organizations, we also see an increased level of polarization even when it come to agreeing about facts. In order to study this phenomenon, we aim to study the role social networks, and these independent news organization play in discovering and transmitting the real "truth" when the information is discovered sequentially.

4 - Small-loss Online Learning with Partial Information

Thodoris Lykouris, Cornell University, 107 Hoy Rd, Ithaca, NY, United States, teddlyk@cs.cornell.edu, Karthik Sridharan, Eva Tardos

In many applications (online advertising, internet routing, clinical decisions), decisions are based on past experience. Online learning algorithms trade off exploiting knowledge about options chosen in the past and exploring new options to gain useful information for the future. In this talk, we focus on two challenges. First, we discuss the effect of side-information: learners collecting information about options relevant to the ones selected. Second, we consider evolving settings, in which players learn in repeated games where some parameters (e.g. set of opponents) change over time. We provide a black-box framework to make full information learning algorithms robust in both settings.

■ TD03C

Grand Ballroom C

Food Supply Chain Analytics

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Retsef Levi, MIT, Cambridge, MA, 02142, United States, retsef@mit.edu

1 - Network Based Risk Analytics in Global Food Supply Chains

Tauhid R. Zaman, Massachusetts Institute of Technology, MA, United States, zlisto@mit.edu, Amine Anoun, Retsef Levi

We develop a network-based approach to identify high-risk food importing consignees. We illustrate the power of the approach by applying it to consignees of shrimp, a product subject to high food safety and adulteration risks. Using detailed shipment data, as well as F.D.A. site inspection and shipment sampling records, we construct a set of novel network features which predict the risk of individual shrimp consignees failing site inspection. We find that increased supply chain network complexity correlates with increased risk. Our results suggest that network-based risk analytics could significantly improve the effectiveness of regulatory activities related to food supply chains.

2 - Novel Methods for Identifying Shell Companies

Nicholas J. Renegar, Massachusetts Institute of Technology, Cambridge, MA, United States, renegar@mit.edu

Motivated by transshipping networks in the import/export industry, we explored novel methods of identifying shell companies. Using website information and business databases we were able to create an automated method of predicting shell companies. This information will be useful in identifying illegal shipping activity, among many widespread applications.

3 - Inferring the Causes Behind Fresh Food Spending

Elisabeth Paulson, Massachusetts Institute of Technology, Cambridge, MA, United States, epaulson@mit.edu

A growing number of strategies are being proposed and tested to increase consumption of healthy food in poor or underserved neighborhoods. While there is agreement that the food environment is linked to diet and health outcomes, there is surprisingly little agreement about the factors that cause this relationship, due in part to the observational and sparse nature of most data. Thus, arguments in favor of various strategies for increasing healthy food consumption are typically based on tenuous observed relationships. In this paper we analyze the impact of access to grocery stores and value of nutrition on fresh food spending among SNAP households using the Food Acquisition and Purchase Survey (FoodAPS) dataset. Using the methodology of causal inference, we are able to quantify and compare the causal effects of both access and value. We find that the effects of both are significant among certain populations, but that they impact household's decisions differently. Finally, we discuss which strategies for increasing fresh food spending are promising among various populations.

■ TD04

320A

MSOM Sustainable Operations

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Isil Alev, Boston College, Chestnut Hill, MA, 02467, United States, alev@bc.edu

1 - Extended Producer Responsibility in Developing Economies – Design Incentives and Infrastructural Development

Luyi Gui, The Paul Merage School of Business, UC Irvine, University of California, Irvine, Irvine, CA, 92697-3125, United States, luyig@uci.edu

Producers' investment and effort in building recycling infrastructure can be observed in practice especially in developing countries where such infrastructure is missing. Motivated by these examples, this paper studies the cost efficiency and environmental impact such as producers' eco-design incentives when infrastructure investment decisions are endogenized.

2 - An Analysis of Time-based Pricing in Electricity Supply Chains

Asligul Serasu Duran, Kellogg School of Management, 825 W Cornelia Avenue, Apt GDN, Chicago, IL, 60657, United States, a-duran@kellogg.northwestern.edu, Baris Ata, Ozge Islegen

This study builds a framework for the retail electricity market to empirically evaluate the impact of time-based tariffs on the electricity supply chain. We find that optimal time-based tariffs reduce peak demand, but do not change consumers' total demand or electricity bills significantly. Time-of-use tariffs with predetermined rates can capture most of the benefits of real-time prices. The environmental impact of time-based tariffs depends on the characteristics of the electricity market under study.

3 - Fair Labor Practices and Increasing Returns to Scale

Susan A. Slotnick, Cleveland State University, OSM Department, BU 542, Cleveland, OH, 44115, United States, s.slotnick@csuohio.edu, Matthew J.Sobel

This paper investigates the tradeoffs involved in a firm's efforts to ensure that its products are manufactured using fair labor practices. We use a Markov decision process model of a firm that sources from one supplier and decides whether to cut its profit margins and/or expend resources to ensure fair labor practices at the supplier. Retail demand is influenced by reputation: if unfair labor practices come to light, reputation deteriorates, hence demand and profit diminish. Analytical and computational methods yield insights into the firm's profit maximizing behavior, including the result that the firm experiences increasing returns to scale as a function of its reputation.

4 - On Recycling of Post-Disaster Debris

Andriy Shapoval, Georgia Tech, 1449 Willow Lake Dr NE, Apt B, Atlanta, GA, 30329, United States, ashapoval3gt@gmail.com, Pinar Keskinocak, Beril Toktay

This work studies emerging recycling policies regarding post-disaster debris management. We develop a game-theoretic model of sequential decision makers utilizing debris removal funding, including state and local government and recyclers, and analyze the total welfare of policies incentivizing recycling. We determine conditions for effective policies under conflicting stakeholder preferences.

■ TD05

320B

Data Analytics in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Mahboubeh Madadi, Louisiana Tech University, Ruston, LA, 71272, United States, madadi@latech.edu

1 - Bi-level Heterogeneous Degradation Modeling of Functional Performance for the Aging Population

Nazmus Sakib, INFORMS.chapter at University of South Florida, 2319 Campus Lake CT, Apt 204, Tampa, FL, 33612, United States, nsakib@mail.usf.edu, Xuxue Sun, Nan Kong, Hongdao Meng, Mingyang Li

Quantifying heterogeneity among the elderly with functional performance degradation is crucial for effective long-term care planning and delivery. Existing studies mainly model degradation heterogeneity at either sub-population or individual level. This work proposes a bi-level heterogeneity modeling and quantification framework. At sub-population level, a Bayesian non-parametric model is proposed to relax the assumption of pre-specifying the number of sub-populations and realize the joint model estimation and selection. At individual level, functional data analysis tools are considered to extract temporal degradation signatures with risk/protective factors identified.

2 - Identifying Smoking Status from User-generated Content in an Online Community for Smoking Cessation

Xi Wang, University of Iowa, 810 W Benton St B213, Iowa City, IA, 52246, United States, xi-wang-1@uiowa.edu, Kang Zhao

Online communities for smoking cessation are increasingly popular sources of information and support for smokers who want to quit. The ability to automatically find smoking status from user-generated content in such an online community can help to provide better interventions. This study developed a machine-learning-based approach to identify individuals' abstinence from their posts. Augmenting the traditional bag-of-words model, our approach leveraged three new types of features: context-specific features, author-based features, and thread-based features. The evaluation outcomes show that the three types of new features all contribute to the better classification performance.

3 - Detecting Patient-specific Abnormal Synchronization Pattern of Epileptic Seizures

Miaolin Fan, Northeastern University, Boston, MA, United States, fan.mi@husky.neu.edu, Chun-An Chou

In this study, we propose an efficient approach to detecting abnormal synchronization phenomena of epileptic seizures in a multivariate EEG system. The proposed method aims at characterizing the nonlinear dynamics of spatio-temporal EEG recordings using recurrence network and spectral graph theory. We present the computational results for CHB-MIT Scale EEG Epilepsy Database in various experimental settings, which validate the efficiency of detecting seizure onsets, as well as robustness to the noisy EEG data.

4 - Inpatient Discharge-by-Noon: Are Fewer Better Than All?

Pratik Parikh, PhD, Wright State University, Dayton, OH, United States, pratik.parikh@wright.edu, Nicholas Ballester

Discharge before noon has rapidly emerged as an unspoken golden standard in hospitals nationwide. While research has indicated a strong link between earlier inpatient discharges and better patient outcomes, especially upstream patient boarding, quantitative analysis of the expected benefits of discharging all patients before noon is lacking. Building upon our previous work, we explore the expected benefits of discharging fewer or all medically-ready patients by noon. Our findings suggest the law of diminishing returns applies; benefits decrease with an increase in the number of such patients.

■ TD06

320C

Decision-making in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Vishal Ahuja, Southern Methodist University, Dallas, TX, 75275, United States, vahuja@smu.edu

1 - Inferring Doctor Decisions: Post-stent Patient Streaming using Personalized Medicine

Kellas Ross Cameron, Boston University, 62 Bay State Road, Apt. #1, Boston, MA, 02215, United States, kellas@bu.edu, Nitin Joglekar, Nachiketa Sahoo, Jugnu Jain

We develop a structural econometric model to analyze doctors' choice of medication after cardiac stent surgery. The estimated model shows the role of patient's medical, as well as economic conditions in their choice. The model can be used to improve personalized medication processes by streaming those who will benefit the most from a new genomic test-based treatment instead of assigning them to a conventional trial and error process.

2 - Investigating Steroid with drawal Strategies for Kidney Transplant Recipients

Yann Ferrand, Clemson University, Department of Management, 101 Sirrine Hall, Clemson University, Clemson, SC, 29634, United States, yferran@clemson.edu, Christina M.Kelton, Vibha Desai, Teresa M. Cavanaugh, Jaime Caro, Jens Goeble, Pamela C. Heaton

We study long-term complications associated with various steroid withdrawal strategies for kidney transplant recipients. We develop a model calibrated with an econometric study of patient data from a national registry to simulate the long-term course of these patients, and derive patient outcomes based on the characteristics of patient population. We focus part of the investigation on the effect of induction therapy.

3 - Designing Liver Allocation System using Neighborhoods

Sanjay Mehrotra, Northwestern University, Dept of I.E./ M.S.C246 Tech Inst, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States, mehrotra@iems.northwestern.edu

We present approaches used to design a liver allocation system to address geographic disparity in liver transplantation. This design is being considered for public comments. We will also discuss the complexity of national public policy change that is model driven.

4 - An Analytics-driven Approach for Optimal Diabetes Screening Decisions

Michael Hahsler, Southern Methodist University, Bobby B. Lyle School of Engineering, P.O. Box 750123, Dallas, TX, 75275, United States, mhahsler@lyle.smu.edu, Vishal Ahuja, Farzad Kamalzadeh, Michael Bowen

About 10% of the US adult population have diabetes and almost 40% are at risk of developing diabetes. Screening can be used to identify these individuals. Population-based screening is an expensive task and thus prioritizing whom to screen and how often to screen becomes of interest from a decision-making point of view. We develop a Markov Decision Process (MDP) to model disease progression and find the optimal screening policy. For parameter estimation, we suggest the use of Hidden Markov Models. To produce individualized screening recommendations we incorporate predictive diabetes risk modeling. We will present results for electronic health record data from the Parkland Health & Hospital System.

■ TD07

322A

Optimization in Radiation Therapy

Sponsored: Health Applications

Sponsored Session

Chair: David Papp, North Carolina State University, Raleigh, NC, 27695, United States, dpapp@ncsu.edu

1 - DVH-driven Direct Machine Parameter Optimization for Adaptive IMRT and VMAT Radiation Therapy Treatment Planning

Troy Long, University of Texas Southwestern Medical Center, Dallas, TX, United States, troy.long@utsouthwestern.edu, Steve Jiang, Joshua T. Margolis, Weiguo Lu

In conventional fractionated radiation therapy, an overall treatment plan is developed with pre-treatment imaging and then delivered over a number of treatment fractions. However, patient geometry changes between treatment fractions, and physicians often will adapt the existing treatment plan to the new geometry. We study automatically generating adapted IMRT and VMAT plans that (1) attempt to reproduce the original plan's dose-volume histogram (DVH) characteristics and (2) keep the updated machine parameters close to the original plan.

2 - Automated IMRT Treatment Planning using Hierarchical Constrained Optimization

Masoud Zarepisheh, Memorial Sloan Kettering Cancer Center, New York, NY, United States, zarepism@mskcc.org, Linda Hong, James G. Mechalakos, Margie A. Hunt, Gig S. Mageras, Joseph O. Deasy

This study formulates IMRT treatment planning as a hierarchical constrained optimization (HCO) problem (also known as prioritized optimization). HCO prioritizes the clinical goals and optimizes them in ordered steps. We introduce a novel idea to speed up the optimization process by sparsifying the influence matrix and then solving an extra unconstrained optimization problem to compensate for the inaccuracy caused by sparsity. The commercial treatment planning system API is used to automate the entire workflow and our package is currently being used in clinical environment to automate the treatment planning process.

3 - Generating High-quality DMPO Seeds for Single- and Multiple-arc Treatment Plans using a Conformal Arc/VMAT Hybrid Planning Model

Joshua T. Margolis, Clemson University, 277 Freeman Hall, Clemson University, Clemson, SC, 29634, United States, jtmargo@clemson.edu, Scott J. Mason, Weiguo Lu, Steve Jiang, Troy Long

In radiation therapy, conformal arc therapy uses a coplanar moving gantry to continuously deliver radiation to cancerous tissue and has little difficulty in passing post-planning quality assurance. However, plan quality suffers when specific organ-at-risk sparing does not explicitly influence aperture shapes, such as in the more-involved volumetric modulated arc therapy (VMAT). We study a conformal arc/VMAT hybrid planning model use dose volume histogram-driven direct machine parameter optimization (DMPO) to find a locally optimal solution for a given set of apertures. We study how to generate high-quality DMPO seeds for single- and multiple-arc treatment plans.

4 - Optimization of Nonuniformly Fractionated Radiotherapy Treatments with Bounds on the Achievable Benefit

David Papp, North Carolina State University, 3222 SAS.Hall, Campus Box 8205, Raleigh, NC, 27606, United States, dpapp@ncsu.edu, Melissa R. Gaddy, Jan Unkelbach, Sercan Yildiz

Radiotherapy treatments are fractionated, meaning that the radiation dose is delivered over several days rather than in a single session. In current clinical practice, the same dose is delivered on each treatment day. We formulate an optimization model to assess the achievable benefit of altering the dose from day to day. The model is large-scale and nonconvex. Using clinical cases, we show that even locally optimal nonuniform treatments yield a substantial improvement over conventional ones. SDP relaxation bounds show that the computed locally optimal treatments are nearly globally optimal.

■ TD08

322B

Disaster and Emergency Management

Contributed Session

Chair: Damitha Bandara, Albany State University, Albany, GA, United States, damitha.bandara@asurams.edu

1 - Distributionally Robust Optimization of an Emergency Medical Service Station Location Problem

Kanglin Liu, PHD Candidate, Tsinghua University, Tsinghua University, 30 Shuangqing Road, Beijing, 100084, China, lkl15@mails.tsinghua.edu.cn, Zhihai Zhang

Locations and capacities in the emergency medical service (EMS) system are key issues of humanitarian logistics. This paper proposes a distributionally robust model to optimize the location, number of ambulances and demand assignment in an EMS system by minimizing the expected total cost. The model guarantees a high probability of satisfying demand in the entire geographical area by introducing joint chance constraints, and identifies the total expected cost by a data-driven approach. The model is approximated as a tractable second-order cone problem and efficiently solved by an Outer Approximation approach. Extensive numerical results and a real case of Beijing show the validly of the program.

2 - Continuous Location Model for Mobile Fire Fighting Resources
Pablo Escalona, Universidad Técnica Federico Santa María, Av Espana 1680, Valparaíso, 2390123, Chile, pablo.escalona@usm.cl, Monica Lopez-Campos, Mario Navarrete

The Valparaiso region (Chile) has suffered more than 16,000 fires between 1998 and 2015, including a year surpassing 1,300 fires (CONAF, 2015). For its special topographic characteristics, air resources have a high degree of significance. A modified version of the "Queuing Location Problems on the Plane" model (Drezner et al., 1990) has been selected to determine the optimal location of airbases, in an attempt to minimize the amount of burned hectares by wildfires. The computational study determines: the optimum location of the base, which parameters have greater influence in the optimum location, and which parameters have greater influence in the computational times.

3 - A Resource Allocation Model for Large Scale Bio-security Events
Lauren Gardner, Senior Lecturer, University of New South Wales, Kensington Campus, Building H20, Sydney, 2052, Australia, l.gardner@unsw.edu.au, David Rey

Real-time strategies for control are required to minimize the spread of newly emerging infectious diseases at a national and international level. Currently, there is a gap in the literature for optimization-based decision control models that account for the heterogeneous nature of the air travel patterns and infectious disease spreading dynamics. In this work a bi-level optimization model is proposed where the objective is to minimize the risk of a contagion spreading via the air traffic network, where the decision is the allocation of control resources to airports during an on-going event.

4 - Modelling Ambulance Dispatch Systems During Extreme Weather Events
Eric B. DuBois, University of Wisconsin-Madison, Industrial & Systems Engineering, 1513 University Avenue, Madison, WI, 53706, United States, edubois2@wisc.edu, Laura Albert

A moderate, but prolonged increase in patient arrivals, as often occurs during severe weather events, can overwhelm emergency responders and lead to patient queuing and patient health deterioration. To examine this issue we develop a Markov decision process to determine a policy for withholding ambulances from less serious patients in the expectation of more emergent future calls. We further develop heuristics, which capture most of the benefit of the optimal policy while allowing for easier implementation by dispatchers. The results are illustrated with computational examples.

5 - Optimizing Healthcare Facility Locations to Intervene a Fast Spreading Epidemic
Gonca Yildirim, Asst. Prof., Cankaya University, Eskisehir Yolu 29 km Yukariyurtcu Mah., Mimar Sinan Cad. No 4, Ankara, 06790, Turkey, goncayildirim@cankaya.edu.tr, Ayyuce Aydemir-Karadag

Emerging and re-emerging epidemic diseases such as Ebola continue to threaten the global health security. During an outbreak, timely case management is crucial to interrupt chains of transmission and prevent further spread of the infection. The most effective intervention policies are to remove infected individuals from the population by quarantine and provide treatment in healthcare facilities. We consider a fast-spreading epidemic with a short incubation period and take into account forecast models developed for the progression of the outbreak in an environment with scarce resources in an integer programming model to determine locations of healthcare facilities dynamically over time.

6 - Location and Allocation of EMS Vehicles in Dougherty County, Albany, GA
Damitha Bandara, Assistant Professor, Albany State University, 504 College Drive, Albany, GA, 31705, United States, damitha.bandara@asurams.edu

Dougherty County EMS is an advanced life support ambulance service that provides quality pre-hospital medical care and transportation to the citizens of Dougherty County. The contribution of this research towards improving the efficiency of the Dougherty County EMS system is twofold. One is to determine the optimal locations for EMS system stations and the other is to determine the response territory for each EMS vehicle. A mathematical model will be developed to obtain the optimal locations and response boundaries of EMS system in Dougherty County. Computational results will be used to compare the performance of the proposed EMS system as opposed to the existing system.

■ TD09

330A

Learning, Information, and Games

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Kostas Bimpikis, Stanford University, 655 Knight Way, Stanford, CA, 94305, United States, kostasb@stanford.edu

1 - Learning in Repeated Auctions with Budgets: Regret Minimization and Equilibrium
Yonatan Gur, Stanford University, Knight Management Center, 655 Knight Way, Stanford, CA, 94305, United States, ygur@stanford.edu, Santiago Balseiro

We study how budget-constrained advertisers may compete in sequential auctions for available ad slots in the presence of uncertainty about future opportunities and competitors' heterogeneous preferences, budgets, and strategies. We introduce a family of dynamic bidding strategies we refer to as adaptive pacing strategies, in which advertisers adjust their bids throughout the campaign according to the sample path of expenditures. Under arbitrary competitors' bids, we establish through matching lower and upper bounds the asymptotic optimality of this class of strategies. Moreover, we characterize a regime under which these strategies approximate Nash equilibrium in dynamic strategies.

2 - Optimal Learning from Multiple Information Sources
Xiaosheng Mu, Harvard University, Cambridge, MA, United States, xiaoshengmu@fas.harvard.edu, Annie Liang, Vasilis Syrgkanis

Consider a decision-maker who sequentially acquires Gaussian signals from heterogeneous sources for a future decision. Which sources should he choose to observe in each period? In environments that we characterize, it turns out that the dynamically optimal path of signal acquisitions: (1) exactly coincides at every period with the myopic path of signal acquisitions, and (2) achieves "total optimality," so that at every late period, the decision-maker will not want to revise his previous signal acquisitions even if given this opportunity. We show that generically, these properties hold at all sufficiently late times, so that the dynamically optimal path and myopic path are eventually equivalent.

3 - Learning and Efficiency in Games with Dynamic Population
Thodoris Lykouris, Cornell University, 107 Hoy Rd, Ithaca, NY, United States, teddlyk@cs.cornell.edu, Vasilis Syrgkanis, Eva Tardos

We study multi-player game settings (online advertising, internet routing, and bandwidth allocation) where the player set is dynamically evolving over time and participants apply online learning algorithms to adapt to the changing environment. Traditional equilibrium notions require too much information for the players (since they need to form perfect beliefs about the identity and the behavior of other participants) to extend to dynamic settings. In contrast, we show that, in a broad class of games, learning agents that can adapt to the changing environment reach outcomes of high social welfare even when there is a high turnover in the population, extending traditional price of anarchy bounds.

4 - Information Aggregation in Heterogenous Markets
Yaarit Even, Columbia University, 25 Claremont Ave #1c, New York, NY, 10027, United States, yeven18@gsb.columbia.edu, Alireza Tahbaz-Salehi, Xavier Vives

This paper argues that the presence of heterogeneity in traders' trading costs/risk aversion can reduce price informativeness and result in an informational externality. We show that in the presence of heterogeneity, the information content of the price is biased towards the private signals of agents with lower trading costs, thus reducing the informativeness of the price. More importantly, we show that such heterogeneity results in an informational externality with first-order welfare implications.

■ TD10

330B

Role of Transparency and Incentives in Managing Services and Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Damian Beil, University of Michigan, Ann Arbor, MI, 48109-1234, United States, dbeil@umich.edu

1 - Lifting the Veil: the Benefits of Cost Transparency

Ryan Buell, Harvard Business School, Morgan Hall 429, Boston, MA, 02163, United States, rbuell@hbs.edu, Bhavya Mohan, Leslie John

Firms typically treat their costs as tightly-guarded secrets. We test the effect of cost transparency on purchases. We begin with a natural field experiment conducted with an online retailer, in which cost transparency increased sales. We subsequently replicate this field experiment in a controlled lab setting and differentiate cost transparency from other forms of transparency, show that the effect is mediated by consumers' trust in the firm, and demonstrate that cost transparency only boosts purchase interest when it is voluntarily instated by the firm. These results imply that the proactive revelation of costs can improve a firm's bottom line.

2 - Risk Drivers for Economically Motivated Food Adulteration in China's Farming Supply Chains

Yanchong Zheng, Massachusetts Institute of Technology, Cambridge, MA, United States, yanchong@mit.edu, Yasheng Huang, Retsef Levi, Stacy Springs, Shujing Wang

We employ Heckman's sample selection framework to empirically investigate whether and how structural properties of China's farming supply chains (across five industries) and the strength of governance (measured based on factual as opposed to perception data) within the regions in which the supply chains operate jointly influence the risks of economically motivated adulteration (EMA) of food. Our results highlight that both supply chain dispersion and weak local governance are associated with higher EMA risks. Our insights could help food manufacturers, importers, and regulators to proactively and systematically identify, prevent, and mitigate EMA risks.

3 - Performance Based Contracts for Energy Efficiency Projects

Sam Aflaki, Associate Professor of Operations Management, HEC Paris, 1 Rue De La Liberation, Jouy en Josas, 78351, France, aflaki@hec.fr, Liang Ding, Roman Kapuscinski

Energy efficiency projects are often executed by specialised entities, namely energy service companies (ESCOs). A typical ESCO's core business is conducted using performance-based contracts, whereby payment terms depend on the energy savings achieved. This paper studies ESCO contract design issues, focusing primarily on the residential market for energy efficiency. We study the coordination potential of multiple piecewise linear contracts including shared savings contracts, guaranteed savings contracts and 'chauffage' contracts that are used in practice. We show that although coordinating contracts do not exist, simple practical contracts work reasonably well.

4 - Using Transparency to Manage the Sourcing of Complex Non-routine Litigation Services

Jacob Chestnut, University of Michigan, Ann Arbor, MI, United States, jacobpc@umich.edu, Damian Beil

Complex services, such as non-routine litigation (approximately $50 billion in 2015), are often billed on an hourly basis. This arrangement creates opportunities for the supplier (i.e. outside counsel) to drive up costs for the buyer (i.e. general counsel) through the inefficient use of time and resources. A critical hurdle preventing better management and oversight by the buyer is the lack of transparency regarding the work to be done by the supplier. In this paper, we investigate how to achieve this transparency, and what the benefits are of doing so. In particular, we study a buyer who creates a "process map" of litigation, which then serves as the basis for transparency with the supplier.

■ TD11

332A

Healthcare Operations

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Opher Baron, University of Toronto, Toronto, ON, M5S 1L7, Canada, opher.baron@rotman.utoronto.ca

1 - Dynamic Scheduling of Home Care Patients to Medical Providers

Andre Augusto Cire, University of Toronto Scarborough, Department of Management, UTSC, 1265 Military Trail, Toronto, ON, M1C-1A4, Canada, acire@utsc.utoronto.ca, Adam Diamant

Home care aims at providing personalized medical care and social support to patients within their own home. Since 2014, it has been the fastest-growing US industry attending to more than 14 million patients per year. In this work, we propose a dynamic scheduling framework to assist in the assignment of patients to practitioners. Our technique formulates the assignment problem as a discrete-time Markov decision process, which is tackled by a policy improvement heuristic that builds upon the agencies existing assignment strategies. We show numerical results assessing the quality of our policies with data from a Canadian home care provider.

2 - How do Perception and Self Interests of Patients Affect Emergency Department Crowding in Hospitals

Shrutivandana Sharma, Singapore University of Technology and Design, 8 Somapah Road, Singapore, 487372, Singapore, shrutivandana@sutd.edu.sg, Ying Xu, Manu Kumar Gupta

We investigate the crowding problem in hospitals' emergency departments (EDs) from the perspective of demand management. We propose a novel congestion game model that provides the first systematic methodology to simultaneously analyze the effects of ED resource allocation as well as patients' perception and self-interests when they can choose between ED and primary care. We perform extensive numerical experiments to study the impact of perception errors and patients' self-interests on ED demand and resulting crowding, and compare them with optimum social welfare maximizing patient flows.

3 - M/M/C Queues with Two Priority Classes and Abandonment

Jiamfu Wang, Nanyang Technological University, Singapore, Singapore, wangjf@ntu.edu.sg, Tianshu Lu, Opher Baron

In this paper, we consider a system with two priority classes and abandonment. The high-priority customers are infinitely impatient, while the low-priority customers are finitely impatient. This system is modeled as a two-dimensional Markov chain. We show the difficulty in solving this model and propose a new method in finding its steady state distribution. Such a system has many applications in practice, including machine breakdown, network service, call centers, and healthcare. Some management insights are shown for the above applications. The method we develop can be applied to other multi-dimensional Markov chains. We briefly discuss the generalizability of our method.

4 - Effect of Emergency Room Priority Rules on TPIA and LOS

Tianshu Lu, Rotman School of Management, University of Toronto, 105 St George St, Toronto, ON, M5S.3E6, Canada, Tianshu.Lu15@Rotman.Utoronto.Ca, Dmitry Krass, Opher Baron

Excessive waiting in emergency departments, particularly before the initial physician assessment (known as TPIA) can lead to tragic outcomes. One hospital in Ontario has achieved large decreases in TPIA by re-configuring the system and changing the priority rules between new and in-process patients. However, these changes increase variability of waiting time and may increase the average Length of Stay (LOS). Using the empirical data, we estimate the ratio of changes in TIPA and LOS. Our results show that the relative increase in LOS is negligible compared to the decrease in TPIA.

■ TD12

332B

Public Transportation

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Mor Kaspi, École Polytechnique Fédérale de Lausanne (EPFL), EPFL-ENAC-INTER-LUTS, Room GC C2 389, Lausanne, CH-1015, Switzerland, morkaspi@poat.tau.ac.il

1 - Pass Programs and Loyalty Programs for Transit Agencies

Mehdi Nourinejad, Postdoctoral Fellow, University of Toronto, St. George, Toronto, ON, L4B4G6, Canada, mehdi.nourinejad@mail.utoronto.ca, Amir Gandomi, Joseph Y.J. Chow, Matthew Roorda

The proliferation of smart cards in public transportation has paved the way for successful implementation of two prominent discount policies: pass programs and loyalty programs. While pass programs have been around as early as the 1970s, loyalty programs are only becoming popular. In a loyalty program, riders get a discount on their fare if they complete a given number of trips within a time period. In this paper, we derive the optimal pass and loyalty program, and we investigate if one is superior. The pass program is superior for public transit agencies because it offers a higher social welfare, but the loyalty program is better for private agencies because it generates a higher profit.

2 - Optimal Bus Type and Number of Bus Stops in Public Transportation under Random Demand and Sustainability Adoption Levels with in the Community

Elif Elcin Gunay, Iowa State University, Ames, IA, United States, eekabeloglu@gmail.com, Kijung Park, Gul Kremer

This study develops a stochastic optimization model for deciding both the bus size and the number of bus stops to minimize the public transportation cost under randomness of demand and sustainability adoption levels in a community. In addition to transportation costs, we consider social costs, i.e. waiting and riding time of passengers in the model. We model social cost as a factor of the sustainability adoption levels. The number of bus stops and the bus sizes are adapted subject to the fluctuation in demand for different bus lines. In the numerical study, we consider different levels of demand and sustainability adoption levels and conduct a trade-off analysis between decreasing cost and social costs.

3 - A Heuristic Algorithm for Improving the Quality of Service in Paratransit by Considering Schedule Reliability

Chung-Wei Shen, Assistant Professor, National Cheng Kung University, Tainan, Taiwan, cwshen@mail.ncku.edu.tw

With the increasing aging and disabled population and the trend toward on-demand transportation, more and more people are relying on door-to-door shared transportation services. Few studies have been conducted on the quality of service for operating dial-a-ride (DAR) services for elderly/disabled passengers. In this paper, we consider a fundamental feature determining the quality of service of DAR services: the reliability of the trip schedule. An algorithm integrating the measure of schedule reliability will be developed such that it is efficient enough to solve large-sized problems. The objective of this paper is to better understand the tradeoffs between reliability and operational costs.

4 - Designing Lines and Frequencies for Public Transportation using Benders Decomposition

Mor Kaspi, Postdoctoral Researcher, Ecole Polytechnique Federale de Lausanne (EPFL), EPFL-ENAC-INTER-LUTS, Room GC C2 389, Lausanne, CH-1015, Switzerland, mor.kaspi@epfl.ch, Martin Repoux, Nikolas Geroliminis

We formulate an integrated line selection, vehicle assignment and passenger assignment problem for public transportation as an MILP. The quality of service is represented by the total journey time of passengers, composed of riding times and waiting times at origin and transfer stations. The resulting formulation is of high dimensionality. In order to solve large instances, we develop a Benders decomposition approach in which solutions of the sub-problems are obtained in linear time. The effectiveness of our approach is demonstrated using instances derived from a real-world application.

■ TD13

332C

Game Theory

Contributed Session

Chair: Ulas Ozen, Ozyegin University, Istanbul, Turkey, ulas.ozen@ozyegin.edu.tr

1 - A Principal-agent Problem with Heterogeneous Demand Distributions

Wenbo (Selina) Cai, New Jersey Institute of Tech, Mec 308, University Heights, Newark, NJ, 07102, United States, cai@njit.edu, Dashi Singham

Mechanism design problems optimize contract from a principal to agents who have private information about their demands for a product or a service. We study the implications of uncertainty in agents' demands on the principal's contracts. Specifically, we consider the setting where agents' demands follow heterogeneous distributions and the principal offers a menu of contracts stipulating quantities and transfer payments for each demand distribution. We present analytical solutions for the special case of two distributions and a method for deriving analytical solutions from numerical solutions. We show that the optimal solution depends on the ordering of the demand levels across distributions.

2 - Responsible Supplier Selection

Wenqing Zhang, University of Minnesota Duluth, 1318 Kirby Drive, Labovitz School of Business and Economics, Duluth, MN, 55812, United States, zhangwenqing@gmail.com, Jiujiu Shen, Huaping Gong

This paper studies the pricing and sourcing choices in a two-echelon supply chain selling a procure-to-stock product to a price-sensitive and social welfare conscious market. We assume that the manufacturer can decide between two different sourcing options, i.e., insourcing and outsourcing, without friction costs. We illustrate the significance of the social image in a company's sourcing decision. Our results explain, from a managerial point of view, whether or why, if applicable, low manpower cost countries are losing their competitive advantages.

3 - On the Core of M-attribute Cooperative Games

Ulas Ozen, Associate Professor, Ozyegin University, Cekmekoy Campus, Nisantepe District, Orman Street, Istanbul, 34794, Turkey, ulas.ozen@ozyegin.edu.tr, Marco Slikker

We study cooperation between several parties by pooling their m-types of resources to improve overall system performance, i.e., maximize total profit or minimize total costs. This type of cooperation leads to "m-attribute" games whose characteristic function is embedded in an m-dimensional function. We derive the necessary and sufficient conditions on the latter function such that all embedded games have a non-empty core. We also study other important properties of m-attribute games, e.g., convexity.

■ TD14

332D

Patient Flow Management

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States, shi178@purdue.edu

Co-Chair: Nan Liu, Columbia University, New York, NY, 10032, United States, nl2320@columbia.edu

1 - Design and Analysis of Integrated Practice Units

Douglas Morrice, University of Texas at Austin, Irom Department, 2110 Speedway Stop B6500, Austin, TX, 78712-1750, United States, douglas.morrice@mccombs.utexas.edu, Jonathan F. Bard, Karl Koenig

An important strategy for delivering high-value, patient-centered care is for providers to organize into dedicated teams around a patient's condition and provide a full cycle of care in an Integrated Practice Unit (IPU). We discuss the use of simulation and optimization to design and analyze IPUs. We illustrate our work with a Joint Pain IPU example.

2 - Scheduling in Operating Theatres with an Entropic Index
Jin Qi, Hong Kong University of Science and Technology, Room 5559C, Department of Industrial, Engineering and Logistics Management, Hong Kong, Hong Kong, jinqi@ust.hk, Han Ye

In this talk, we propose a simple index to study the scheduling problem in the Operating Theatres (OT). We first use empirical data to explore the features of the scheduling issue in OT. Specifically, many surgeries can start earlier than the scheduled time. Then we formulate the scheduling problem such that the waiting time for each surgery and overtime should meet the service requirement. We propose an index named Entropic Deviation to capture both the variance and skewness of the uncertain surgery time. By simply ranking the Entropic Deviation for each type of surgery, we can make the sequencing decisions and achieve relatively good performance.

3 - Off-placing Patients in Hospital Wards: the Value of Flexibility in Healthcare
Vahid Sarhangian, Univeristy of Toronto, Toronto, ON, Canada, sarhangian@mie.utoronto.ca, Carri Chan, Yuan Zhong

When congestion is high, a common practice used in many hospitals is the off-placement of admitted emergency department (ED) patients to a non-primary inpatient ward (IW). We evaluate and compare the performance of practical flexible designs for routing patients from the ED to IW. We consider a multiclass queueing system with multiple server pools (wards) and allow the customers to be served by servers from a non-primary pool (determined through the flexible design) with a reduced service rate to capture the effect of off-placement.

4 - Inpatient Overflow: An Approximate Dynamic Programming Approach
Pengyi Shi, Purdue University, 403 W. State St, Krannert School of Management, Kran 472, West Lafayette, IN, 47907, United States, shi178@purdue.edu, Jim Dai

Inpatient beds are usually grouped into several wards, with each dedicated to a "primary" medical specialty. However, when a patient waits too long to get a primary bed, hospital managers may assign her to a non-primary bed though it is undesirable. Deciding when to use such "overflow" practice in real time can be challenging. We develop an approximate dynamic programming (ADP) algorithm to aid the decision making. A key step is to choose appropriate basis functions, for which we use a novel combination of fluid control and single-pool approximation. We demonstrate, via experiments in realistic hospital settings, that our ADP algorithm is remarkably effective in finding good overflow policies.

■ TD15

332E

Retail Supply Chain Analytics

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Joline Uichanco, University of Michigan, Ross School of Business, Ann Arbor, MI, 48109-1234, United States, jolineu@umich.edu

1 - The Role of Consumer Return Policies in Omnichannel Operations
Leela Aarthy Nageswaran, Carnegie Mellon University, 308 GSIA, Tepper School of Business, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, lnageswa@andrew.cmu.edu, Soo-Haeng Cho, Alan Scheller-Wolf

We study the pricing and return policy decisions of an omnichannel retailer serving customers who differ in how they realize their valuation for the product — by inspecting in-store before purchase or by purchasing online and possibly returning misfit products. When the salvage value for returned products is low, we find that the firm may prefer full refunds to no refunds, in contrast to prior research showing that full refunds are never preferred at low salvage values in an online-only market. Furthermore, the optimal refund is often larger than the salvage value, which could explain generous refunds seen in practice.

2 - Optimizing SKU Selection for Promotional Display Space at Grocery Retailers
Olga Perdikaki, University of South Carolina, Darla Moore School of Business, 1014 Greene Street, Columbia, SC, 29208, United States, Olga.Perdikaki@moore.sc.edu, Olga Pak, Mark Ferguson, Su-Ming Wu

Promotional displays are a powerful tool to boost consumer engagement. We propose a multi-step methodology to identify a profit-maximizing selection of products for promotional display using grocery store sales transaction data. Our methodology results in a 5% to 23% improvement in profit when compared to an industry benchmark.

3 - Optimizing E-commerce Order Sourcing: A Big Data Analytics and Total Margin Optimization Solution
Ali Koc, IBM.Research, IBM.Research, Yorktown Heights, NY, 10598, United States, akoc@us.ibm.com, Ajay Deshpande, Brian Quanz

As online demand is growing rapidly, retailers are increasingly using their ship from store network with thousands of diverse nodes for online order fulfillment with conflicting business objectives. To overcome these challenges, we have developed a cloud-based solution for order fulfillment utilizing predictive analytics and multi-objective optimization to determine optimal total-margin fulfillment decisions. In this talk, we will present some key aspects of this solution and results.

4 - The Two-Phase Newsvendor Problem with Optimally-Timed Additional Replenishment
Yale Herer, Israel Institute of Technology, Haifa, 32000, Israel, yale@technion.ac.il, Dina Smirnov, Assaf Avrahami

We utilize in-cycle demand information, available from modern information systems, to optimize a newsvendor system with an option of an additional inventory review (AR) and replenishment at an endogenously determined, a priori set time during the period. We jointly optimize the AR timing and order quantities at each ordering opportunity.

■ TD16

332F

Operations Management

Contributed Session

Chair: Xiaojun (Gene) Shan, University of Houston-Clear Lake, Houston, TX, United States, shan@uhcl.edu

1 - Total Cost Effects of the Interaction of Capacity, Periodic Release and Transportation for a Repair Shop
Henny van Ooijen, Dr., Eindhoven University of Technology, P.O. Box 513, Eindhoven, 5600MB, Netherlands, h.p.g.v.ooijen@tue.nl

A repair shop serves industrial customers that operate a commoditized capital good. The shop provides for availability of the capital good. Upon failure of a good, a substitute good, rented from a third party, is installed, and a logistics service provider is informed for transporting good. After arrival at the repair shop the failed good is repaired and returned to the customer; then the rent of the substitute good ends. We are interested under what condition periodic order release at the repair shop leads to cost benefits.

2 - Lean Six Sigma Techniques and a Practise in the Food Company
Harun Karakoç, Industrial Engineer, Erciyes University, Erciyes Teknopark Tekno-3 Binası No: 28, Kayseri, Turkey, harunkarakoc@gmail.com

Keeping the customer satisfaction in a high level and surviving with enough benefit level is getting harder to have at the same time with each passing day. Trading enterprises must minimize their costs while maintaining their certain quality level for completing this task. In this study, firstly Six Sigma and Lean terms have been examined and then integration of lean to six sigma studies has been examined and mentioned. In final part, non-quality reasons in a food company have been eliminated using Six Sigma techniques and optimum production rates have been designated via mathematical model created in Lean logic have been mentioned.

3 - Using Multi-variate Regression and Simulation to Identify a General Formula for Throughput of Flow Manufacturing Lines with Similar Stations
Xiaojun (Gene) Shan, University of Houston-Clear Lake, Houston, TX, 77058, United States, shan@uhcl.edu, Samrawi Berhanu

Accurately estimating throughput of a manufacturing line is important for planning. This paper use simulation and multivariate regression to estimate a generic equation to determine the throughput. Minitab was used to create random data that follow normal distributions: Station Speed, Mean time between failure, Mean time to repair, buffer capacity and line length. One thousand different random manufacturing lines were developed and modeled using PlantSim. The outputs were then used to run a multi-variate regression analysis to find an equation that best fits the data. A regression equation with R2 equal 92% was found. The station speed has the largest impact on throughput.

4 - Outsourcing Maintenance in the Presence of Cyber Threats
Anh Ta, University of North Texas, Denton, TX, 76201, United States, Anh.Ta@unt.edu, Hakan Tarakci, Shailesh S. Kulkarni

Outsourcing minimal repair and preventive maintenance is very important to any system. This study develops a model to maximize the profit of a manufacturer who utilizes an external contractor to maintain its manufacturing system. Later, we extend the study to a system with the existence of cyber threats.

■ TD17

340A

Service Queues

Sponsored: Applied Probability

Sponsored Session

Chair: Rouba Ibrahim, University College London, University College London, London, WC1E 6BT, United Kingdom, rouba.ibrahim@ucl.ac.uk

1 - Choice Models, Queueing Theory, and Delayed Information
Jamol Pender, Cornell University, Ithaca, NY, United States, jjp274@cornell.edu

Many service systems provide queue length information to customers thereby allowing customers to choose among many options of service. However, queue length information is often delayed and is often not provided in real time. Recent work by Dong et al. explores the impact of these delays in an empirical study in U.S. hospitals. In this talk, we prove an appropriately scaled queueing model with customer choice and constant delays converges to a delay differential equation. We analyze these delay differential equations and derive the exact threshold that determines whether the queues have asynchronous dynamics.

2 - Maximizing Ridership in Bicycle Sharing Systems using Empirical Data and Stochastic Models
Pradeep Kumar Pendem, University of North Carolina, Chapel Hill, 110 Mistywood Cir, Apt S, Chapel Hill, NC, 27514, United States, pradeep.pendem@gmail.com, Vinayak V. Deshpande

We analyze the optimal allocation of bikes in a network of stations to improve ridership and service level under non-stationarity demand and station substitution. Our stochastic demand model captures both bike pickups and drop-offs, as well as demand non-stationarity and substitution under stockout. We utilize large datasets on trips, real time inventory information at stations, distances between stations in combination with the model to estimate demand parameters. The optimal allocation of bikes across stations to maximize ridership is determined using a dynamic program. The optimal policy informed by our model could improve ridership and service level by 7.60% and 1.69% to current policy.

3 - Managing Customer Expectations and Priorities in Service Systems
Gad Allon, The Wharton School, Philadelphia, PA, United States, gadallon@wharton.upenn.edu, Qiuping Yu, Achal Bassamboo

We study how to use delay announcements to manage customer expectations while allowing the firm to prioritize among heterogeneous customers. When the firm has information about the state of the system, yet lacks information on customer types, delay announcements play a dual role: they inform customers about the state of the system, while they also have the potential to elicit information on customer types based on their response to the announcements. The tension between these two goals has implications to the type of information that can be shared credibly.

4 - Announcing Delays when the Present Depends on the Future
Rouba Ibrahim, University College London, MS& I.department, UCL, Gower Street, London, WC1E 6BT, United Kingdom, rouba.ibrahim@ucl.ac.uk, Achal Bassamboo

We investigate the accuracy of announcing the waiting time of the Last customer to Enter Service (LES) in a queueing model with multiple customer classes and a priority service discipline. We present ways of exploiting this historical information to design new and improved announcements and supplement our theoretical results with an empirical study.

■ TD18

340B

Joint Session MSOM/APS: Supply Chain and Inventory in Applied Probability I

Sponsored: Applied Probability

Sponsored Session

Chair: Linwei Xin, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, lxin@illinois.edu

1 - Using Multi-stage Stochastic Programs for Inventory Position Coordination in Assemble-to-order Inventory Systems
Qiong Wang, University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, United States, qwang04@illinois.edu, Marty Reiman, Haohua Wan

To manage Assemble-to-Order (ATO) inventory systems efficiently, the inventory positions of components should be aligned with the availability of other components with longer lead times. Independent base stock policies do not feature such a coordination mechanism and existing schemes with proven optimality are only for single-product systems. We have formulated a multi-stage Stochastic Program (SP) and shown its optimal solutions coordinate inventory positions for minimizing inventory cost in multi-product ATO systems with a general Bill of Materials. We will discuss properties of SP solutions that allow their implementation in dynamic ATO systems.

2 - Learning Algorithms in Inventory and Pricing Models
Cong Shi, University of Michigan, 2257 Woodhaven Court, Ann Arbor, MI, 48105, United States, shicong@gmail.com, Xiuli Chao, Boxiao Chen, Huanan Zhang

In recent years, online retailing firms have been experimenting and implementing innovative dynamic pricing strategies and inventory policies to better match demand with supply. In many cases, the decision maker may not know the demand distributional information of a given product a priori, and can only rely on sales data. We propose nonparametric learning algorithms for several fundamental inventory and pricing models with unknown demand functions under censored demand information. We show that the proposed algorithms converge to the clairvoyant optimal policies as the planning horizon increases, and obtain the convergence rate of regret.

3 - Dynamic Pricing and Inventory Control with Large Replenishment Lead Times
Linwei Xin, University of Chicago, 5807 S Woodlawn Avenue, Chicago, IL, 60637, United States, Linwei.Xin@chicagobooth.edu, Xin Chen, Yuanling Gan

We consider a joint pricing and inventory control problem with positive replenishment lead times. Although this problem has been extensively studied in the literature, the structure of the optimal policy remains poorly understood. In this work, we propose a class of so-called constant-order list-price policies. We prove that the best constant-order list-price policy is indeed asymptotically optimal as the lead time grows large, which is exactly the setting in which the problem becomes computationally intractable due to the curse of dimensionality. We also show that the best constant-order list-price policy can be computed effectively.

■ TD19

342A

Wind Power

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Amelia Musselman, Georgia Institute of Technology, Atlanta, GA, 30318, United States, amusselman@gatech.edu

1 - Integrated Predictive Analytics & Optimization for Opportunistic Maintenance and Operations in Wind Farms
Murat Yildirim, Georgia Institute of Technology, 765 Ferst Drive NW, # 415, Atlanta, GA, 30332, United States, murat@gatech.edu, Nagi Gebraeel, Andy Sun

We propose an integrated framework for wind farm maintenance that combines i) predictive analytics methodology that uses real-time sensor data to predict future degradation and remaining lifetime of wind turbines, with ii) a novel optimization model that transforms these predictions into profit-optimal maintenance and operational decisions for wind farms. To date, most applications of predictive analytics focus on single turbine systems. In contrast, this presentation provides a seamless integration of the predictive analytics with decision making for a fleet of wind turbines scattered across multiple wind farm locations.

2 - Considerations for Modeling the Integration of Wind Power in the Electric Power Sector
Kelly Eurek, National Renewable Energy Laboratory, Golden, CO, United States, Kelly.Eurek@nrel.gov

Because wind power is a rapidly growing component of the electricity system, robust representations of wind technologies should be included in capacity-expansion models. This is a challenge because modeling the electricity system—and, in particular, modeling wind integration within that system—is a complex endeavor. This presentation highlights the major challenges of incorporating wind technologies into capacity-expansion models and shows examples of how NREL's Regional Energy Deployment System (ReEDS) model address those challenges.

3 - Optimizing Wind Farm Siting to Reduce Variability Impacts of Wind Power

Amelia Musselman, Georgia Institute of Technology, 1040 Huff Road NW, Apt 1218, Atlanta, GA, 30318, United States, amusselman@gatech.edu, Valerie Thomas, Dima Nazzal

We present a multi-objective optimization model to strategically locate wind farms to reduce wind power variability. In order to model the impact of wind variability without explicitly modeling the full electricity system we develop a metric, which we call demand deficit, to measure the load that the remainder of the system would need to account for under wind fluctuations. By selecting which sites to construct from a set of potential wind farm locations our model minimizes both demand deficit and the maximum change in demand deficit over a given period. We solve our model for a case study of the Southwest Power Pool and develop an efficient frontier to compare the trade-offs between the two objectives.

■ TD20

342B

Information Systems

Contributed Session

Chair: Ozay Ozaydin, Dogus University, Istanbul, Turkey, ozay.ozaydin@gmail.com

1 - Budget Management in International Humanitarian Organizations

Milad Keshvari Fard, ESSEC Business School, 3 Avenue Bernard Hirsch, Cergy, 95021, France, milad.keshvarifard@essec.edu, Felix Papier

Humanitarian Organizations (HO) have to allocate their limited budget to countries and missions at the beginning of each year. Since the budget comes from donations, it is uncertain and may be partly earmarked for specific uses. Considering an HO's objective to improve the social welfare of the beneficiaries and to meet the target fill rates, budget allocation is a challenging problem. We model budget allocation as a two-stage decision process: In the first stage, the HO decides the budget target for each country and in the second stage, the HO determines the optimal allocation of the non-earmarked budget.

■ TD21

342C

Resilient Infrastructure and Community Networks

Invited: InvitedNatural Hazard Planning

Invited Session

Chair: Kash Barker, University of Oklahoma, University of Oklahoma, Norman, OK, 73019, United States, kashbarker@ou.edu

1 - Building Resilience through Redundancy in a Multi-echelon Supply Chain

Jose Emmanuel Ramirez-Marquez, Stevens Institute of Technology, Castle Point on Hudson, School of Systems & Enterprises, Hoboken, NJ, 07030, United States, jmarquez@stevens.edu, Araceli Zavala

Due to the complexity of supply chains (SC) they must increase their resilience to meet demand. A multi-echelon supply chain is analyzed using Discrete Event Simulation (DES) for measuring the effects of disruptions downstream the supply chain - modeled in a probabilistic manner with different impact levels. An experimental design is conducted on multiple input parameters to illustrate the model application and behavior. To lessen the effects of the disruptions, this model considers redundancy as a supply chain capability and aid managers in identifying SC nodes vulnerable to disruptions. SC can increase resilience and a rapid recovery to optimal operation levels.

2 - Analytically Comparing Disaster Resilience across Multiple Dimensions

Christopher Zobel, Virginia Tech, 1007 Pamplin Hall, Dept of Business Info Tech, Blacksburg, VA, 24061-0235, United States, czobel@vt.edu

It is important to be able to compare the resilience of a community to different types of disaster event in order to assess both its vulnerabilities and the opportunities available to address them. Since resilient behavior can be complex and multi-dimensional, however, one must be able to characterize the different ways in which that behavior is actually exhibited in practice. This presentation explores an approach for visualizing and analyzing the relationships between each of the individual resilience dimensions.

3 - Maximal Expected Coverage for Network Restoration and Emergency Response After Disrupted Events

Suzan Afacan, University of Wisconsin-Madison, 27D University Houses, Madison, WI, 53705, United States, iloglu@wisc.edu, Laura Albert

Infrastructure recovery is important for delivering time-sensitive services and commodities after a disaster while also repairing network damage. To examine this issue, we present an extension of the maximal covering problem in the case of extreme events. In the model, we coordinate two types of service providers: (1) recovery crews who repair disrupted roads and (2) emergency responders who deliver services and commodities by relocating emergency service responder between potential locations with restricted access. The objective is to maximize the covered demand with backup coverage over the time horizon. The model is illustrated with a computational example.

4 - An Optimization-based Restoration Approach for Enhanced Interdependent Infrastructure Network Resilience

Yasser Adel Almoghathawi, University of Oklahoma, 1506 E Lindsey St., Apt P, Norman, OK, 73071, United States, moghathawi@ou.edu, Kash Barker

Infrastructure networks such as power, water, and gas are increasingly becoming more interdependent to be functional, potentially making them highly vulnerable to any disruptive event, which makes their restoration more challenging. We propose a resilience-driven solution approach for the restoration problem of interdependent infrastructure networks following a disruptive event. The proposed approach is based on an optimization model considering fixed and variable recovery times for disrupted network components. The proposed approach is illustrated through generated interdependent networks with different sizes and topologies considering different disruption sizes and scenarios.

■ TD22

342D

Innovations in Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Adam Elmachtoub, Columbia University, New York, NY, 10027, United States, adam@ieor.columbia.edu

1 - The Value of Personalization in Limited Information Markets

Michael Hamilton, Columbia University, 500 West 120th Street, New York, NY, 10027, United States, mh3461@columbia.edu, Adam Elmachtoub, Vishal Gupta

We study a one product pricing problem, and quantify the revenue difference between optimal single price strategies and fully personalized ones based on simple summary statistics about the market. Namely using only the mean, range and volatility of the market, we characterize the best and worst case "gaps" between an optimal one price strategy and fully personalized one. As an application of our work we give a simple, distribution-free and near optimal algorithm for market segmentation.

2 - A Joint Framework for Market Segmentation and Price Curve Estimation

Ryan McNellis, Columbia University, New York, NY, 10027, United States, rtm2130@columbia.edu, Adam Elmachtoub

We propose a new methodology for incorporating feature information into price-setting problems. Relevant applications include the recommendation of personalized discounts and customizing bids for advertising exchanges. Our method uses recursive partitioning to segment the feature space into a collection of regions. A probability model involving only the decision variable (i.e., price) is then fit locally in each region. A key strength of our method is its interpretability, as the resulting market segmentation is easily visualized and understood. We explore new training algorithms to ensure scalability in the face of high-dimensional data.

3 - Primal-dual Algorithms for Revenue Management Problems with Unknown Demand Model

He Wang, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, he.wang@isye.gatech.edu

In this talk, we consider a general class of revenue management problems with finite inventory and finite selling horizon. In addition, we assume the customer demand model is unknown prior to the selling season. We propose a primal-dual algorithm that simultaneously estimates the customer demand model and the bid prices associated with inventory constraints.

■ TD23

342E

Revenue Management with Consumer Analytics

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Joline Uichanco, University of Michigan, Ross School of Business, Ann Arbor, MI, 48109-1234, United States, jolineu@umich.edu

1 - Data-driven Pricing for a New Product

Mengzhenyu Zhang, University of Michigan, Ross School of Business, Ann Arbor, MI, 48105, United States, zhenyuzh@umich.edu, Hyun-Soo Ahn, Joline Uichanco

Due to the lack of relevant data, decisions regarding new products are difficult to make, and any mistake has grave consequences to the firm's bottom line. The famous Bass model for new product adoptions requires a priori knowledge on certain parameters which can be determined only after collecting demand data. We study a problem of pricing for a new product under stochastic Bass model when market parameters are uncertain. We propose simple and efficient data-driven pricing approaches and characterize their performances. Our framework is sufficiently flexible to be applied to real time parameter learning in other general diffusion processes along with control reoptimization.

2 - Value of Delayed Incentive: An Empirical Investigation of Gift Card Promotions

Bharadwaj Kadiyala, Univ at Texas-Dallas, 2400 Waterview Parkway, Apt 831, Richardson, TX, 75080, United States, bxk121930@utdallas.edu, Ozalp Ozer, Serdar Simsek

Gift cards have become a popular vehicle for promotional campaigns run by many departmental, consumer electronic, and online retail stores. Using a proprietary data set from a large department store, we investigate how customers respond to these promotions as well as its effectiveness as a promotional vehicle for retailers.

3 - Customer-trends for Personalized Demand Estimation and Targeted Promotions

Kiran Venkata Panchamgam, Oracle America Inc., 78 Kendall Ct, Bedford, MA, 01730, United States, kpanch@gmail.com, Georgia Perakis, Setareh Borjian, Lennart Baardman, Tamar Cohen

Detecting trends in fashion can help retailers determine effective personalized promotion plans more easily. Access to social media data can be important in order to be able to understand these trends. Unfortunately, social data is usually unavailable. We introduce a personalized demand model that captures customer trends and show an efficient method for estimating it from transaction data. Last, we show that the promotion targeting problem is NP-hard to solve exactly, and develop an efficient greedy approach that scales to large datasets and finds provably near-optimal solutions.

4 - A Dynamic Clustering Approach to Data-driven Assortment Personalization

Sajad Modaresi, Duke University, Durham, NC, United States, sajad.modaresi@duke.edu, Fernando Bernstein, Denis R. Saure

A retailer faces heterogeneous customers with initially unknown preferences. The retailer can personalize assortment offerings based on available profile information; however, users with different profiles may have similar preferences, suggesting that the retailer can benefit from pooling information. We propose a dynamic clustering policy that adaptively adjusts customer segments and personalizes the assortment offerings. We test the policy's performance using a dataset from a Chilean retailer.

■ TD24

342F

Ride-sharing Platforms I

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States, ozan.candogan@chicagobooth.edu

Co-Chair: Daniela Saban, Stanford GSB, Palo Alto, CA, 94304, United States, dsaban@stanford.edu

1 - On Pricing and Matching in Ridesharing Systems

Erhun Ozkan, University of Southern California, 3670 Trousdale Pkwy, Bridge Hall, 401, Los Angeles, CA, 90089, United States, erhunozkan@gmail.com, Ramandeep Randhawa, Amy Ward

Ridesharing platforms are two-sided matching markets that pair customers and drivers. The ridesharing company would like to ensure there is always a nearby driver to offer an arriving customer. The difficulty is that drivers choose when to work, how long to work, and where to go to search for customers. The result can be dramatic changes over time in customer demand and driver supply across different locations, which can result in driver shortages. One common operational strategy is to match customers with the closest driver, and to use pricing to incentivize drivers to move to undersupplied locations. This motivates a joint pricing and matching problem, and we discuss steps for its solution.

2 - Ride-hailing Networks with Platform Control

Zhe Liu, Columbia Business School, New York, NY, United States, zliu18@gsb.columbia.edu, Costis Maglaras, Philipp Afeche

We are motivated by the emergence of ride-hailing platforms that match demand (passengers) with service capacity (drivers) over a geographically dispersed network. Drivers are self-interested and can decide whether to join the network and whether to reposition their car when idling at a low demand location. Passenger demand is potentially unbalanced across the network in the sense that the natural passenger flow of cars need not supply sufficient capacity across network locations. The platform can exercise demand-side admission control - which passengers to match to drivers, and supply-side repositioning control - which idling drivers to move (or incentivize to do so) to high demand locations.

3 - Spatial Pricing in Ride-sharing Networks

Ozan Candogan, University of Chicago, Booth School of Business, Chicago, IL, 27708, United States, ozan.candogan@chicagobooth.edu, Kostas Bimpikis, Daniela Saban

We explore spatial price discrimination in the context of a ride-sharing platform that serves a network of locations. Riders are heterogeneous in terms of their destination preferences and their willingness to pay for receiving service. Drivers decide whether, when, and where to provide service so as to maximize their expected earnings, given the platform's prices. Our findings highlight the impact of the demand pattern on the platform's prices, profits, and the induced consumer surplus. In particular, we establish that profits and consumer surplus are maximized when the demand pattern is "balanced" across the network's locations.

4 - Bicycle Redistribution Network Design using Crowdsourcing

Jinjia Huang, Sun Yat-sen University, 135 Xingang Xi Road, Guangzhou, China, jinjiahuang@gmail.com

Jinjia Huang, National University of Singapore, Singapore, Singapore, jinjiahuang@gmail.com, Mabel C.Chou, Linfeng Li, Chung-Piaw Teo

Bicycle redistribution constitutes a major part of the operating cost for bicycle-sharing systems. To economize on the redistribution operations, we aim to incentivize users to take trips that can help to rebalance the network. Considering the feasibility of implementing such a system, we study whether it is enough to encourage trips on certain links of the network. We show that a system with a mix of bicycle redistribution by depot and redistribution on a small set of links suitably chosen from the full network performs almost as well as the fully flexible redistribution system using crowdsourcing.

■ TD25

350A

Innovation/Entrepreneurship

Contributed Session

Chair: Ibrahim Muter, University of Bath, Bath, United Kingdom, i.muter@bath.ac.uk

1 - Investigating the Impact of Digital Business Strategy on Hospitals' Performance

Hossein Kalantar, PhD Student, Business School, University of Colorado Denver, 1475 Lawrence St., Suite 3501, Denver, CO, 80202, United States, hossein.kalantar@ucdenver.edu, Jiban Khuntia, Jahangir Karimi

With the introduction of government mandates in the recent years, the adoption of Information Technology has significantly increased in healthcare organizations. However, not all healthcare organizations can fully leverage IT to enhance their performance. A clear digital business strategy can help these organizations to integrate business capabilities with new IT-based capabilities. In this study, we investigate the impact of hospitals' digital business strategy on their performance. For this study, we conduct hospitals executive survey and combine it with secondary data from the American Hospital Association's (AHA) and the Healthcare Information and Management System Society (HIMSS).

2 - Can We Trust Online Physician Ratings? Evidence from Cardiac Surgeons in Florida

Susan F. Lu, Purdue University, Krannert 441, West Lafayette, IN, 47907, United States, lu428@purdue.edu, Huaxia Rui

Despite heated debate about the pros and cons of online physician ratings, little systematic work has examined the correlation between physicians' online ratings and their actual medical quality. Using the ratings of cardiac surgeons at RateMDs and the patient outcomes of coronary artery bypass graft surgeries in the 2013 Florida Hospital Inpatient Discharge Data, we investigate whether online ratings are informative about physicians' medical quality.

3 - A Big Data Driven Framework for Optimizing the Marketing Mix ROI using Fuzzy Neural Network

Ajay Kumar, Indian Institute of Technology Delhi, Ajay Kumar, Room No - Eb-03,, Girnar Hostel, Iit Delhi , Hauz Khas, New Delhi, 110016, India, ajaytomar.dce@gmail.com, Ravi Shankar

This study aims to investigate the contributions of promotional marketing activities as predictors and develops a big data driven framework for optimising marketing mix ROI using fuzzy neural network.Companies want to sense demand signals and shape future sales using historical demand, price, promotion and others economic factors so that they can react immediately to customer's orders.This study improves the quality of sales forecasts using historical demand and sales data combined with advertising effectiveness,promotions and marketing events data,and provides important implications for practitioners as they can better understand how promotional marketing can influence product sales.

4 - Game-theoretic Analysis of Zero-rating Plans: The Importance of Context

Neena Pandey, Doctoral Candidate, Indian Institute of Management, Bangalore, India, neena.alok@gmail.com, Manaswini Bhalla

Considering the contrasting implications that zero-rating plans in the Internet domain are argued to have on society, we study the role of context (extent of digital divide) on these implications. Contrary to the belief that Internet Service Providers will allow only the content providers (CPs) with higher revenue generating capability to zero-rate their data and hence act as a gate-keeper to the Internet access, we find that the ISP will have the incentive to choose the different options (none, one or both CPs) in different context. We provide further direction to policymakers by analysing and comparing consumer and total surplus in each of the cases.

5 - Incorporating Diversity in Recommender Systems using Optimization Approaches

Ibrahim Muter, Dr., University of Bath, Bath, United Kingdom, i.muter@bath.ac.uk

Recommender systems have become one of the main components of web technologies, which helps people to cope with the information overload. These systems are based on the analysis of past behavior of users to develop user models that can filter items according to users' likes and interests. Two of the most important metrics used to analyze the performance of these systems are accuracy and diversity of the recommendation lists which emerges in various forms such as aggregate diversity and individual diversity. In this study, we integrate these objectives using multi-objective optimization approaches and solve them using scalable optimization approaches.

■ TD26

350B

Getting Funded by NSF: Proposal Preparation and the Merit Review Process

Invited: NSF

Invited Session

Chair: Irina Dolinskaya, National Science Foundation, Herndon, VA, 20170, United States, irina.s.dolinskaya@gmail.com

1 - Getting Funded by NSF: Proposal Preparation and the Merit Review Process

Irina Dolinskaya, National Science Foundation, Herndon, VA, 20170, United States, irina.s.dolinskaya@gmail.com, Georgia-Ann Klute

So, you think you have a great research idea, now how do you get funding from the National Science Foundation (NSF) to do the work? A well-scoped and written proposal is instrumental to successful submission. This session targets junior faculty and researchers who might be new to NSF and describes detailed guidelines and practical advice for proposal preparation. The presenters will go over NSF review process and Intellectual Merit and Broader Impacts criteria, as well as share most common mistakes made by the PIs when submitting a proposal. Question-and-answer session will follow the presentation.

■ TD27

350C

Social Media Analytics II

Invited: Social Media Analytics

Invited Session

Chair: Karthik Kannan, karthikbabu.nk@scheller.gatech.edu

1 - Bias in Online Reviews: Variety and Atypicality in Online Gaming

Pranay Jinna, Emory University, Atlanta, GA, United States, pjinna@emory.edu

In this paper, I study self-selection bias in online reviews which can occur because the propensity of certain segments of users to opt in to review a product is different compared to other segments. Using a unique data set of 1.4 million individuals and their playing history across more than 3900 games, I find that high variety seeking consumers are more likely to post reviews compared to consumers who are low variety seeking. Further, these high variety seeking consumers have a different appeal for atypical games compared to low variety seeking consumers. I also find that users who have more friends on the platform are more likely to opt in to review.

2 - An Investigation of Information Technology and Complementarities in Innovation

Patricia Angle, Georgia Institute of Technology, Atlanta, GA, United States, Patricia.Angle@scheller.gatech.edu, Chris Forman

This study is an investigation into complementarities between IT and a firm's intellectual property (IP) protection strategy, in the context of product innovation. An IP protection strategy is the way a firm protects its innovations from being appropriated for outside interests. Whether IT is complementary with an open strategy, such as the use of patents, or a closed strategy, such as trade secrets, is unclear. This early-stage research represents a novel investigation into the relationship between IT investments and a firm's innovative strategy.

3 - Big Data Location Analytics - Predicting Purchase Location with Mobile Location Data

Karthik Babu Nattamai Kannan, Scheller College of Business, Georgia Tech, 800 West Peachtree NW, Atlanta, GA, 30308, United States, karthikbabu.nk@scheller.gatech.edu, Sridhar Narasimhan

We work with a leading national mobile carrier in the USA to explore how its customers choose the location of brick-and-mortar store to purchase or upgrade wireless service. We explore how understanding people's travel patterns is helpful in choosing the optimal number of stores in a given market based on maximum coverage model. We explore literature on firm expansion and franchising to develop a machine learning based heuristic solution procedure (work in progress).

4 - Public Reaction to Supply Chain Glitches: A Twitter Sentiment Analysis

David Wuttke, EBS.University, Burgstr. 5, Oestrich-Winkel, 65375, Germany, david.wuttke@ebs.edu, Christoph G. Schmidt, H. Sebastian Heese

Supply chain glitches have become an inherent business risk and bad news spreads quickly through social media and can negatively affect sales. Our study investigates whether and how supply chain glitches evoke public reaction on Twitter in terms of attention and sentiment. We apply the event study method to 126 glitches, analyzing sentiments using machine learning. We find that public attention triples in response to glitches, and sentiments turn to negative. To examine the drivers of public reaction, we use attribution theory, and find that sentiment shifts are stronger when glitches result from stable, internal, and specific causes; thus helping managers to allocate resources more efficiently.

■ TD28

350D

Approximation in Auctions

Invited: Auctions

Invited Session

Chair: Rakesh Vohra, University of Pennsylvania, rvohra@seas.upenn.edu

1 - A Duality Based Framework for Bayesian Mechanism Design

Yang Cai, 65 Sherbrooke Est, Apt. 1711, Montreal, QC, H2X1C4, Canada, cai@cs.mcgill.ca, S. Matthew Weinberg, Nikhil Devanur

It is well-known by now that the simple mechanisms used in practice are rarely, if ever, optimal. Recent work has aimed to understand this through the lens of approximation and has successfully shown that while virtually never optimal, these simple mechanisms are often approximately optimal. Still, the techniques used to prove these claims were setting-specific and therefore limited their applicability to broad settings. We provide a principled approach to design and analyze these simple mechanisms based on duality theory. Our approach unifies and improves previous results, and greatly extend known settings where simple mechanisms are approximately optimal.

2 - Robust Mechanisms under Common Valuation

Songzi Du, Simon Fraser University, Burnaby, BC, Canada, songzid@sfu.ca

We study robust mechanisms to sell a common-value good. We assume that the mechanism designer knows the prior distribution of the buyers' common value but is unsure of the buyers' information structure about the common value. We use linear programming duality to derive mechanisms that guarantee a good expected revenue for all information structures and all equilibria. Our mechanism maximizes the revenue guarantee when there is one buyer. As the number of buyers tends to infinity, the revenue guarantee of our mechanism converges to the full surplus. We numerically demonstrate that the revenue guarantees of our mechanisms are generally close to optimal when there are two buyers.

3 - Informationally Robust Optimal Auction Design

Benjamin Aaron Brooks, University of Chicago, Becker Friedman Economics, 1126 E.59th Street, Chicago, IL, 60637, United States, ppivoriu@uchicago.edu

A single unit of a good is to be sold by auction to one of two buyers. The good has either a high value or a low value, with known prior probabilities. The designer of the auction knows the prior over values but is uncertain about the correct model of the buyers' beliefs. The designer evaluates a given auction design by the lowest expected revenue that would be generated across all models of buyers' information that are consistent with the common prior and across all Bayesian equilibria. An optimal auction for such a seller is constructed, as is a worst-case model of buyers' information. The theory generates upper bounds on the seller's optimal payoff for general manyplayer and common-value models.

■ TD29

350E

Manufacturing

Contributed Session

Chair: Jorge Fresneda, Drexel University, Philadelphia, PA, United States, jef78@drexel.edu

1 - Online Reputation Analysis by Social Network

Jing Luo, University of Pittsburgh, 5712 Beacon Street, Pittsburgh, PA, 15217, United States, JIL204@pitt.edu

The goal of this study is to find a way to detect the real reputation of the online business roles. We will use network science methods to find the real reputation of the supplier and customer by their previous purchase history. From the network, we will see the change of strong links and weak links by each group. Then we will study the change of network structure to find the reputation of the roles. We could find how the previous data could work for the future purchase. Then this network result could help to set the current transaction cost.

2 - Predicting Fashion Branding Effects using User Generated Brand Network

Tawei Wang, DePaul University, 1 East Jackson Blvd, DePaul Center 6028, Chicago, IL, 60604, United States, wang131@gmail.com, Yusan Lin

Social media increases the visibility of young designer fashion brands but makes the competition more fierce due to the proliferation of social media channels. However, the branding effects of fashion brands on social media are challenging to capture due to the domination of major national brands' marketing campaigns. In order to understand the branding effects among various types of fashion brands, this study examines and predicts the branding effects of fashion brands on a user generated brand network by using network analysis. Our findings demonstrate that both network information and brand preferences can improve our understanding of the choice of posting outfits with different brands.

3 - The Effect of a Front-of-pack Nutrition Labeling System to Promote Healthier Purchase Decisions

Jeremy C. Young, Professor, Pontificia Universidad Javeriana, Bogota, Colombia, jeremyyoung@javeriana.edu.co, Claudio Mora, Luisa Fernanda Tobar, Pamela Elizabeth Vallejo

Our intervention aims to study if food purchasing decisions can be improved by using a simple, informative, front-of-package label. In contrast to previous studies, our design uses controlled randomization that can disentangle whether the label itself or the information on the label is causing behavior change in a real-world setting. Our paradigm utilizes the 5-Color Nutrition Label, which exploits the nutritional information of products to inform consumers about each products' nutritional contents in an easy-to-understand manner that promotes product comparison. We utilize all sales data and intervene in the 21 cafeterias and shops run by Food Services at Pontificia Universidad Javeriana.

4 - All That Glitters is Not Gold: Extracting Product Information from Online Consumer Reviews

Jorge Fresneda, Drexel University, 3220 Market Street, Philadelphia, PA, 19104, United States, jef78@drexel.edu

This study shows empirically that Online Consumer Reviews (OCR) may be understood as composed of three main elements: information, emotions, and how accessible each OCR was for consumers. This approach allows academic researchers and practitioners to develop a better classification of OCRs regarding their information content -as this article test empirically- and gain a more accurate knowledge of consumers' opinions in the electronic marketplace. But this approach can benefit consumers as well, since making more helpful information accessible can assist them better in making purchase decisions and overcome information overload, especially for very popular products with hundreds of reviews.

■ TD30

350F

Tutorial Erlang Queueing Models

Sponsored: Applied Probability

Sponsored Session

1 - Tutorial on Erlang – A Queueing Dynamics

Jamol Pender, Cornell University, 206 Rhodes Hall, Ithaca, NY, 14850, United States, jamol.pender@gmail.com, William A. Massey

Since 2017 is the 100th anniversary for the Erlang-B formula, we consider the Erlang-A queueing model. It is defined to be a Markovian multi-agent, infinite buffer service system that permits customer abandonment. We also assume non-homogenous Poisson arrivals with exponentially distributed service and abandonment times. We use dynamical systems to analyze the transient dynamics of this queue. We obtain dynamic performance metrics for the queueing process and customer delays. Also, these differential equations motivate dynamic optimization methods for new service staffing control algorithms.

■ TD31

351A

Risk Analysis

Contributed Session

Chair: Chanjoo Lee, InterContinental Hotels Group, Atlanta, GA, United States, chanjoo.lee@ihg.com

1 - Evolution of Revenue Management System at IHG

Chanjoo Lee, Manager Revenue Optimization, InterContinental Hotels Group, 3 Ravinia Drive, Suite 100, Atlanta, GA, 30346, United States, chanjoo.lee@ihg.com

IHG's PERFORM Price Optimization project started in 2005 to drive key strategic priorities such as brand performance enhancement and excellent hotel returns. The project was the first large-scale enterprise implementation of price optimization in the hospitality industry and provided a 2.7% increase in revenue as verified in the IHG 2009 Annual Report. In this talk, we will discuss how the IHG Revenue Management Systems including PERFORM Price Optimization evolved to increase user acceptance from the hotels and drive revenue improvement over the years.

2 - Pull and Push Contracts in a Decentralized Assembly System with Random Component Yields
Yanling Feng, Beihang University, Haidian District, Xueyuan Road No. 37, Beijing, 100191, China, fengyanling.1@163.com

This paper investigates how random component yields could influence the pricing and production decisions. Both suppliers' yields are assumed to be random and all information is symmetric. The equilibrium solutions are studied under pull and push contracts. Compared results show that under the push contract the suppliers always achieve the first mover advantage, but this may not be true for the manufacturer under the pull contract. Sensitivity analysis are also performed to study the impact of random yields and the retail price on the equilibrium solutions. We then extend our analysis to a more general case of n suppliers.

3 - Assortment Optimization Considering Consumers Heterogeneity
Shunichi Ohmori, Assistant Professor, Waseda University, Room 0903A, Okubo 3-4-1, Shinjuku, Tokyo, Japan, ohmori0406@gmail.com, Kazuho K. Yoshimoto

We propose an assortment optimization model in which customer heterogeneity is considered. We used id-pos data to estimate parameters of a demand model, considering brand loyalty of each customer heterogeneity. We build an optimization model to maximize total revenue.

4 - Determine the Customer Compensation for an Overbooked Flight
Lijian Chen, Assistant Professor, University of Dayton, 300 College Park Ave, Dayton, OH, 45469-0001, United States, lchen1@udayton.edu

We study the monetary impact of denying customers to board an overbooked flight. Overbooking has been a common practice of major airlines for decades to minimize the spoilage, i.e., the empty seats caused by no-shows. The airlines demand a quantitative measure to determine the monetary impact and we model the seat allocation problem with overbooking as a chance-constrained optimization. We compare our model with the seat allocation models without overbooking to gain insights regarding the benefit of overbooking and the related cost of denying economy customers. In addition to our analysis, we also present numerical results to support our conclusions.

■ TD32

351B

Supply Chain, Shipping and Transportation

Contributed Session

Chair: Yuhong Li, Virginia Tech, Blacksburg, VA, United States, yuhongli@vt.edu

1 - Host National Strategy Impact on Supply Chains: Consequences of Gaining Legitimacy via Supplier Development
Remi Charpin, PhD Candidate, Clemson University, 250 Elm Street, Apt 501, Clemson, SC, 29631, United States, rcharpi@clemson.edu, Erin Powell, Aleda Roth

The recent protectionist and nationalist waves coupled with the renaissance of industrial policies have pushed foreign firms to reconsider the role played by host governments.This study intends to understand how host policies impact foreign firms' operations strategy. We use a grounded theory approach to explore how foreign managers' sensemaking of the host national strategy towards foreign entities impact their decision-making. We extend the legitimacy-based view theory to the operations and supply chain fields and find that firms implement supplier development programs to increase their legitimacy in the host country at the risk of enabling their own competition.

2 - Performance Assessment of Traditional Inventory Policies as Resilience Strategy.
Weimar Ardila, University of South Florida, Tampa, FL, United States, weimar@mail.usf.edu, Alex Savachkin, Daniel Romero

One of the resilience improvement strategies widely referenced in the literature is inventory redundancy, which basically consists of maintaining high levels of inventory to respond adequately to failures presented in the operation. The main problem with these types of strategies is the difficulty of its implementation, since it is an alternative that against the reduction of costs and efficiency. Therefore, this work aims to evaluate the performance of different traditional inventory policies, and to determine which one offers the best balance between resilience and efficiency.

3 - The Impact of Supply Chain Risk Announcements on Stock Market Performance
Laharish Guntuka, Robert H. Smith School of Business, University of Maryland, 4335 Rowalt Drive, # 301, College Park, MD, 20740, United States, lguntuka@rhsmith.umd.edu, Xiaodan Pan, Thomas M. Corsi, Curt Grimm

We explore the effects of supply chain risks with major emphasis on plant- and labor-related risks on the stock market reaction. Focusing on main upstream manufacturing industries, we collected data on day-to-day basis for a period of 1 year (2015) by using "early monitoring system" created by Lexis Nexis which collects and scores risk announcements. We find the stock market reaction is notably negative in the face of plant- and labor-related risks.

4 - Cash Hedging in a Supply Chain
Yixuan Xiao, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong, yixuxiao@cityu.edu.hk, Panos Kouvelis, Xiaole Wu

We study hedging cash flow risks in a bilateral supply chain. Hedging reduces expected cost for firms due to the convexity of production cost in capital investment, while not hedging provides the flexibility for firms to adjust their operational decisions in response to different cash flow realizations. We quantify the tradeoff between the cost reduction effect and the flexibility effect of hedging, and characterize the firms' hedging decisions in the supply chain.

5 - Network Characteristics and Supply Chain Disruption Resilience
Yuhong Li, Virginia Tech, 301 Piedmont Street, Apt 8, Blacksburg, VA, 24060, United States, yuhongli@vt.edu, Christopher Zobel, Onur Seref

Inspired by the growing needs to understand supply chain network structure and its impact on supply chain resilience, this study focuses on investigating the relationships between network characteristics and supply chain resilience. Specifically, we select the key influential characteristics and study how they influence network resilience. Then we conduct a case study to show how practitioners can use these characteristics to gain a knowledge of supply chain resilience and support decision making.

■ TD33

351C

Empirical Research on Air Transportation

Sponsored: Aviation Applications

Sponsored Session

Chair: Milind Sohoni, Indian School of Business, Hyderabad, 500032, India, milind_sohoni@isb.edu

1 - An Analytical Approach to Predicting Airline Planned Maintenance Inspections
Shervin Beygi, Boeing, 441 Smith Avenue, Seattle, WA, 98109-2155, United States, shervin@umich.edu

Airlines regularly perform major planned maintenance inspections on their fleet. Predicting such events is key for providers of spare parts and technical services to predict future demand. We present a data-driven model to determine airlines' past maintenance logic and use it to predict future events. The model uses flight leg data to find gaps in the flight schedule of each airplane. A statistical model is used to determine if the detected gaps can be attributed to scheduled maintenance events, and then predicts when the next check will occur, for each tail number, up to three years before the actual event. Test cases illustrate that the proposed model can successfully predict major scheduled checks.

2 - Network Design and Fleet Management for Air Cargo Operations
Timothy L. Jacobs, Amazon, 415 W. Larona Lane, Tempe, AZ, 85284, United States, tljacobs61@gmail.com, Hoda Parvin, David Michael

Amazon's Middle Mile Planning and Research Science (PROS) team is responsible for the design and implementation of optimization models and algorithms to design the air network and better utilize the Amazon air transportation assets. In 2017, PROS developed a network design and fleet assignment model to plan the air network for fall 2017 and beyond. The model uses a mixed integer programming approach that simultaneously builds the flight schedule, assigns fleets to flights, and determines how best to flow all air packages throughout the network. This model provides both tactical and strategic solutions taking into account available aircraft, station and hub capacity, the use of point to point and hub and spoke configurations, and other operational restrictions. Amazon uses the model to help select new stations, determine operating strategies at the hub, and to evaluate network topology. This talk will describe the major components of the model and our general solution approach.

3 - Analyzing How Individuals Filter and Screen Alternatives for Discrete Choice Modeling Applications
Virginie Lurkin, Ecole Polytechnique Fédérale de Lausanne, Route Cantonale, Lausanne, 1015, Switzerland, vlurkin@ulg.ac.be, Laurie Garrow

There has been little research into whether state of the art consumer welfare models accurately capture consumers' decision-making process. Both the itinerary choice and welfare estimation literatures generate a "complete" set of itineraries and assume individuals look at and evaluate all itineraries in the choice set. This may not be a realistic assumption. We designed an online experiment to capture how individuals filter and screen alternatives for discrete choice modeling applications. We present preliminary results analyzing screening rules that have been used by respondents.

4 - Quantile Regression Based Estimation of Statistical Contingency Fuel

Mark M. Hansen, University of California-Berkeley, 114 McLaughlin Hall, Berkeley, CA, 94720, United States, mhansen@ce.berkeley.edu

We use quantile regression to estimate statistical contingency fuel based on the specific circumstances of a given flight, and the fuel savings that could result from using this approach compared to current practice.

■ TD35

351E

Supply Chain Optimization

Contributed Session

Chair: Vinay Gonela, Texas A & M University, Killeen, TX, United States, vinay.gonela@tamuct.edu

1 - Mixed-fleet Sizing and Routing with Electric Vehicles for Maximum Profit

Isil Koyuncu, Teaching and Research Assistant, The University of Alabama, Alston Hall Box 870226, Tuscaloosa, AL, 35487, United States, ikoyuncu@crimson.ua.edu, Mesut Yavuz

This talk presents a maximum profit mixed-fleet electric VRP with traditional and electric vehicles. A set of customers are willing to pay an EV premium to reduce their supply chain carbon footprint. We investigate the exact solution of the problem via Branch and Price Algorithm and compare with heuristic algorithms.

2 - Potential Revenue of Wasted Plastic Bottle Auction in Japan

Kazuaki Okubo, Associate Professor, Ehime University, 3 Bunkyo machi, Matsuyama city, Matsuyama, 790-8577, Japan, okubo@cee.ehime-u.ac.jp

This study explores the potential revenue of municipalities, who collect and sell waste plastic bottles to recycling firms on auctions. I use the auction data in Japan to estimate potential bids and formulated a mixed integer programming model to derive the optimal combination of municipalities and recycling firms that maximizes municipalities' revenue. I found that the revenue in the optimal combination is larger than in the observed combination, especially in Kanto region where there are relatively many recycling firms. The distances between municipalities and recycling firms become smaller in the optimal combination to reduce transportation cost.

3 - Carbon Emission Reduction Strategies for Two Competing Firms under Cap and Trade Regulation with Consumers Preference

Tao Li, Santa Clara University, 2730 Park Ave, Apt 3, Santa Clara, CA, 95050, United States, tli1@scu.edu

This paper develops price and low-carbon competition models between one socially responsible manufacturer and one regular manufacturer under the influences of consumers' low-carbon preference. We assume that the responsible manufacturer is a pioneer in low-carbon market. Our research questions address how the regular manufacturer's low-carbon production choice is affected by factors such as cap-and-trade policy and competitive environment.

4 - Improving Environmental Sustainability within Emission Control Areas in Liner Shipping: Review and Analysis of Different Regulations

Maxim A. Dulebenets, Florida A&M.University-Florida State University, 2300 Bluff Oak Way, Apt. 8408, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Ren Moses, Eren Erman Ozguven, Thobias Sando

Emissions produced by oceangoing vessels negatively affect the environment and living organisms. Several regulations were released by the International Maritime Organization (IMO) to alleviate negative externalities from maritime transportation. Certain polluted areas were designated as "Emission Control Areas". This study aims to perform a comprehensive review of the existing IMO regulations and conduct the assessment of advantages and disadvantages from introducing restrictions on the emissions produced within "Emission Control Areas".

5 - Designing a Sustainable Biomass Based Electricity Supply Chain

Vinay Gonela, Assistant Professor, Texas A.& M.University, FH 218K, 1001 Killeen Place, Killeen, TX, 76549, United States, vinay.gonela@tamuct.edu, Iddrisu Awudu

This paper focuses on designing a sustainable biomass based electricity supply chain (BESC) under uncertainties. All the three economic, environmental and social aspects of sustainability are considered. A Multi-objective stochastic mixed integer linear programming model is developed that aims to design optimal BESC under carbon tax and unemployment rate considerations. The result provides strategic BESC decisions. In addition, sensitivity is conducted to determine the impact of various factors on the BESC design.

■ TD36

351F

Project Management

Contributed Session

Chair: Homayoun Khamooshi, George Washington University, 2201 G Street NW, Funger 415, Washington, DC, 20052, United States, hkh@gwu.edu

1 - Multi-mode Resource-constrained Project Scheduling with Uncertain Activity Cost

Fang Xie, Shandong Technology and Business University, Shandong Province Yantai I City Laishan District #191, Yantai, 264005, China, xiefangmm@163.com, Haitao Li, Zhe Xu

In this paper, we study the multi-mode resource-constrained project scheduling problem under uncertain activity cost. A nonlinear integer programming model with the minimum risk of project cost overrun is formulated. To overcome the computational challenge of solving large instances, several heuristic algorithms are proposed and implemented to obtain quality solutions in reasonable computational time. Through extensive computational experiments, the effectiveness of our algorithms are demonstrated. Furthermore, related conclusions are also discussed.

2 - Reactive Scheduling Procedures for Project Resource Leveling with Uncertain Activity Durations

Hongbo Li, Assistant Professor, Shanghai University, Baoshan District, Shangda Road 99, Shanghai University, Shanghai, 200444, China, ishongboli@gmail.com

Recent research in the area of project resource leveling has paid attention to robust resource leveling, which aims at obtaining a robust baseline schedule by considering both resource leveling and activity start time stability. However, such a schedule may still not fully protect a project from disruptions in uncertain environments. Therefore, we study reactive scheduling procedures for resource leveling. We try to repair a disrupted schedule, such that the recovered schedule deviates as little as possible from the original one while maintaining a leveled resource usage. Extensive computational experiments on benchmark instances are conducted to evaluate the proposed procedures.

3 - The Integration of Resource Allocation and Time Buffering for Bi-objective Robust Project Scheduling

Yangyang Liang, Huazhong University of Science and Technology, Wuhan, Hubei , P.R. China, China, yangliang0419@sina.com, Nanfang Cui

In this paper, we aim at constructing a proactive schedule that is not only short in time but also less vulnerable to disruptions. Firstly, a bi-objective scheduling model is proposed in the presence of activity duration variability. Then a two-stage algorithm is developed which deals with a robust resource allocation problem in the first stage and optimally determines the position and the size of time buffers using a simulated annealing algorithm in the second stage. Finally, an extensive computational experiment demonstrates the superiority of the combination between resource allocation and time buffering.

4 - Solution Approaches for a Project Scheduling Problem with Multiple Modes and a Single Nonrenewable Resource

Cansu Altintas, Research Assistant, Middle East Technical University, Odtu Kampusu Endustri Muhendisligi, Oda136, Ankara, 06800, Turkey, cansubulutaltintas@gmail.com, Meral Azizoglu

We study a project scheduling problem with multiple activity modes where mode is defined by an activity duration and resource consumption amount. We assume that there is a single nonrenewable resource and it is released in scheduled times at specified quantities. Our problem is to select the modes and activity timings to minimize the project makespan. We give an efficient mathematical formulation and propose an alternative combinatorial solution approach. We discuss and compare the efficiencies of both methods, mathematical formulation and combinatorial algorithm.

5 - Managing Service Systems via Disguised Queues

Eren Basar Cil, University of Oregon, Lindquist College of Business, Eugene, OR, 97403-1208, United States, erencil@uoregon.edu

Touristic attractions, such as observatory decks, boat tours, museums, have recently started to manage their operations via disguising parts of their waiting lines. If customers are not aware of the hidden queues, the firm can easily boost its revenues by engaging in queue disguising behavior. Our goal in this paper is to investigate the impacts of strategic customer behavior on the firm's queue disguising decisions and profits. We show that the firms can significantly benefit from disguised queues if customers act strategically, especially when the queue disguising is harmful under non-strategic customers.

6 - An Integrated Model for Assessing Project Performance
Homayoun Khamooshi, Associate Professor, George Washington University, 2201 G Street NW, Funger 415, Washington, DC, 20052, United States, hkh@gwu.edu

Project performance assessment traditionally is focused on measuring schedule performance index and cost performance index. These two measures do not provide a full picture of performance of a project. A two dimensional model is developed for assessing the performance of a project by focusing on project success and project management success. For assessing the performance of a project from delivery perspective, time, cost, quality, scope and risk measures are used whereas for business case success (project success) the business objectives realization (benefit realization) is evaluated. The integration of the two dimensions provide an overall assessment of the performance of the project.

■ TD37

352B

Introducing Editor's Cut: Transforming Retailing through Analytics

Sponsored: Service Science

Sponsored Session

1 - Introducing Editor's Cut: Transforming Retailing through Analytics
Paul R. Messinger, University of Alberta, Faculty of Business, 3-20e Faculty Of Business Bldg, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca

This session introduces the INFORMS Editor's Cut on Transforming Retail through Analytics. This panel will discuss the pros and cons of the print and digital materials included in the collection, including key research papers from the past 20 years, industry reports and podcasts, and what leading retail managers in video interviews perceive as new issues in data measurement, analysis, and management. Panelists will also identify materials that should be added to the collection and give their views on topics meriting future research attention. See pubsonline.informs.org/editorscut/retail

2 - Panelist
Roland T.Rust, University of Maryland, Robert H. Smith School of Business, University of Maryland, College Park, College Park, MD, 20742, United States, rrust@rhsmith.umd.edu

3 - Panelist
James D.Hess, University of Houston, Dept of Marketing & Entrepreneurship, 334 Melcher Hall, Houston, TX, 77204-6021, United States, jhess@uh.edu

■ TD38

352C

Models for Multicriteria Group Decision and Negotiation - Joint Session of MCDM and GDN Sections.

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Danielle Costa Morais, Universidade Federal de Pernambuco, Rua Conselheiro Portela, 169/701, Espinheiro, Recife, 52020-030, Brazil, dcmorais@cdsid.org.br

Co-Chair: Adiel Teixeira De Almeida, PhD, Universidade Federal de Pernambuco, Recife, Brazil, almeida@cdsid.org.br

1 - Multicriteria Group Decision using FITradeoff for Preference Elicitation
Adiel Teixeira De Almeida, Federal University of Pernambuco, Cx Postal 7462, Recife PE, 50630-970, Brazil, adielta@gmail.com, Eduarda Asfora

One of the most relevant tasks in multicriteria group decision process is preference elicitation of Decision Makers (DMs). The facilitation process demands contributions in the intersection of many topics, such as: analytical normative models, cognitive process of individuals and the social interaction of a DMs' group. This work deals with the use of FITradeoff (Flexible and Interactive Tradeoff) method for preference elicitation in this kind of problem, using partial information for additive models in MAVT scope. This method reduces DM's cognitive effort, contributing for reducing inconsistences in the elicitation process.

2 - Negotiation Model to Aid a Brazilian Retail Company with Logistics Problems
Jose Leao Silva Filho, Universidade Federal de Pernambuco, Brazil, zeleao@gmail.com, Danielle Morais, Thomas Gonçalo

The retail industry is characterized by extreme competition among various retailers and requires much efficiency in its processes. Selecting and negotiating with transport suppliers, in turn, is a very complex process because of the great number of suppliers available. Consequently, a negotiation support system is proposed to guide decision making in the selection of hauliers that meet the transportation demands of a retail organization. A numerical application was developed for the case of a major Brazilian retail

3 - A Group Decision Model to Establish a Preventive Maintenance Policy for a Low-income Water Supply System
Danielle Costa Morais, Universidade Federal de Pernambuco, Rua Conselheiro Portela 130A, apt. 1402, Espinheiro, Recife - PE, 52020-212, Brazil, dcmorais@cdsid.org.br,
Adiel T. De Almeida-Filho, Madson B. Monte

Water supply system aging cause failures and then, demand imbalance. It becomes unable to supply all users continuously, emphasizing the role of maintenance. This study presents the process for defining the optimal preventive maintenance interval considering a group of stakeholders, including population, in a multicriteria decision process. The criteria were described by maintenance engineering variables and the individual preferences were aggregated trough a voting procedure. The result is the best-poised alternative for the group's views and shows the impact of contemplating population opinion, being this approach quite adequate for this type of decision.

■ TD39

352D

Entrepreneurs in Advanced Analytics and Operations Research

Sponsored: The INFORMS Section on Practice

Sponsored Session

Chair: G. Jack Theurer, G. Theurer Associates, Inc., New York, NY, 10025, United States, theurer@aol.com

1 - Entrepreneurs in Advanced Analytics and Operations Research
G. Jack Theurer, G. Theurer Associates, Inc., 215 West 92nd Street, Suite 7F, New York, NY, 10025, United States, theurer@aol.com

This session is the new format of the Isolated Practitioner Workshop that so many have attended at national meetings over the years. Topics in this series address timely issues of interest to the entrepreneur community of Advanced Analytics/OR/MS ("Lone Ranger" practicing the profession independently or within a large organization) while also having a universal appeal to a broader audience of practitioners from all walks of life in the profession. This is the 34th in the series of workshops sponsored by the Practice Section of INFORMS since the first one at the 1992 fall meeting in San Francisco. The workshops have spanned a spectrum of topics from the serious ("Business as an Independent Practitioner " - 2008) to the timely ("The Lone Ranger of OR/MS and Surviving the Great Recession" - 2009) to the cutting edge ("Current Technology Trends and Future Growth of the Optimization Market" - 2012) to the cross-cultural ("Doing Business in Japan" - 1998) and much in between ("Experiences Consulting in the Healthcare Industry Dos and Don'ts" - 2011) including lighter entertaining fare. This year's session with speakers (TBA) continues a new format for the workshops. It is now presented as part of the technical session program rather than the previous evening session with reception.

■ TD41

352F

Health Care, Public Health

Contributed Session

Chair: Farbod Farhadi, Roger Williams University, Bristol, RI, United States, ffarhadi@rwu.edu

1 - Proactive Inpatient Bed Reservations for Admissions from Emergency Department
Seung-Yup Lee, PhD Candidate, Wayne State University, 4815 Fourth, Room 1070, Detroit, MI, 48201, United States, seung.lee@wayne.edu, Ratna Babu Chinnam, Evrim Dalkiran, Seth Krupp, Michael Nauss, Michael Welchans

One of the main factors driving Emergency Department (ED) crowding is boarding delay, where admitted patients are held up in an ED while waiting for inpatient beds to be identified and prepared. We propose a queueing network model that allows for the development of 'proactive' coordination strategies. In particular, under the proposed setting, the inpatient bed preparation process precedes ED patient disposition, and beds are reserved for ED patients. Model also accounts for the performance of the predictive analytics model in predicting disposition decisions. We present analytical results and insights through experiments motivated by a large Midwest healthcare facility.

2 - Confirmatory Data Analytics to Reduce Excess Days in Hospitals
Shaghayegh Norouzzadeh, Program Manager, Northwell Health, 1 Fairhaven Mall, Apt B83, Mineola, NY, 11501-8517, United States, snorouzzad@northwell.edu, Christina Mouradian

The objective of this study is to determine and reduce the frequency and reasons for medically unnecessary hospital days also contributing to excess days. Additional length of stay creates risk for communication errors and hospital acquired adverse events. This study focuses on reducing the turnaround time (TAT) from when patient is medically ready to be discharged to actual discharge. A staged configuration is designed to integrate the qualitative and quantitative data analysis for administrative decision making in two inpatient units. The results indicate that the average TAT and variation improved by minimum of 21% and 26% respectively. Correspondingly, excess days decreased by 45%.

3 - Service and Price Design for Healthcare Information Service Platform
Shifu Pan, PhD Candidate, University of Southeast, No. 2, Southeast University Road, Jiangning D, Nanjing, 211189, China, shifupan@outlook.com

In order to study the sustainable operation mechanism of health information service platform, we construct a supply chain consisting of medical data providers, health information service platforms and medical information demanders. We design the service content of health information service platform and discuss pricing strategies for health information service platforms that maximize the supply chain revenue.

4 - Weighted Yield Bundle to Quantify Patient Experience in Hospitals
Shaghayegh Norouzzadeh, Program Manager, Northwell Health, 1 Fairhaven Mall, Apt B83, Mineola, NY, 11501-8517, United States, snorouzzad@northwell.edu, Nancy Riebling, Ryan Cowan, Christina Mouradian, Eric Chen, George Reeder

Strategies to target patient experience typically rely on a random sample of post-discharge satisfaction surveys and Likelihood to Recommend (LTR) scores. This study's purpose is to enhance the patient experience by reducing the avoidable defects in hospital service delivery. This study presents an innovative two-stage approach. A patient experience bundle© development with a weighted yield model to quantify the qualitative parameters in the process and concurrently measure patient experience, followed by specification of process inefficiencies for improvement. Overall bundle compliance improved on average by 41% with a relative LTR improvement of 5.8%ile.

5 - A Markov Chain Analysis for Medical Resource Allocation for Disease Outbreaks
Farbod Farhadi, Roger Williams University, 1 Old Ferry Road, Bristol, RI, 02809, United States, ffarhadi@rwu.edu

We encounter many disease outbreaks around the world every year. In year 2016 alone, there were 136 disease outbreaks with variety of impacts recorded by the World Health Organization (WHO). Every disease outbreak affects populations and economies negatively in multiple dimensions. For instance, the Ebola outbreak of West Africa in 2014 caused over 28 thousand suspected cases and more than 14 thousand deaths. In this study, we develop a markovian chain process to propose an efficient allocation of medical resources for disease outbreak containment.

■ TD42

360A

Transportation Issues in Smart Cities

Sponsored: Public Sector OR

Sponsored Session

Chair: Leila Hajibabai, Ph.D., Stony Brook University (SUNY), Stony Brook, NY, 11794, United States, leila.hajibabaidizaji@stonybrook.edu

1 - Optimal Control Logic for Intersection Management in an Autonomous Vehicle Environment
Amir Mirheli, Stony Brook University, 30 Piedmont Dr. Apt 9, Stony Brook, NY, 11776, United States, amir.mirheli@stonybrook.edu, Leila Hajibabai, Ali Hajbabaie

This research presents an optimal control logic to minimize travel delay while upholding safety constraints. The problem is formulated into a dynamic programming model, where vehicular information is obtained from neighboring intersection approaches. A stochastic look-ahead model is developed based on Monte Carlo Tree Search algorithm to determine the optimal vehicle trajectories that prevent movement conflicts. Numerical results confirm that reliable coordination between connected autonomous vehicles can effectively address the consequences of traffic signals.

2 - Real-time Dynamic Traffic Metering in Connected Urban Street Networks
Rasool Mohebifard, Washington State University, 1630 NE Valley Road, Apt B204, Pullman, WA, 99163, United States, rasool.mohebifard@wsu.edu, Ali Hajbabaie

This study develops a real-time optimization algorithm to determine dynamic metering rates at entry gates to urban street networks. The proposed approach decomposes the problem into smaller sub-problems with the objective of reducing the computational complexity while creating effective coordination among them to improve the quality of the solutions. The proposed approach was tested on a realistic case study network and found dynamic metering rates in real-time that improved network performance.

3 - Dynamic Speed Harmonization in Connected Urban Transportation Networks
Mehrdad Tajalli, Washington State University, 210 SE McKenzie St, Pullman, WA, 99163, United States, mehrdad.tajalli@wsu.edu, Ali Hajbabaie

This study develops a mathematical linear program for dynamic speed harmonization in connected transportation networks. The solution algorithm decomposes the network to several sub-networks to reduce computational complexity of the problem and improve its runtime. At the same time, the decisions of various sub-problems are coordinated to push the solutions towards optimality. The results show that the proposed algorithm finds real-time solutions in networks of various scales that significantly reduce the number of stops and travel time while increasing the number of completed trips.

4 - Distributed Coordination and Optimization for Optimal Signal Control under Various Connected Vehicle Penetration Rates
S.M. Islam, Washington State University, Pullman, WA, United States, smabinal.islam@wsu.edu, Ali Hajbabaie

This research presents distributed coordination and optimization algorithms for real-time optimal signal control with various connected vehicle penetration rates. The algorithm distributes the optimization to the intersection-level to improve the run-time and scalability, and creates effective coordination between neighboring intersections to push solutions towards optimality. Besides, we developed an algorithm to incorporate point detector data and car following models to predict the location of unconnected vehicles. The results indicated significant improvement in network performance under various connected vehicle penetrations rates compared to solutions found by VISTRO.

■ TD43

360B

Prevailing Issues in Public Sector OR

Sponsored: Public Sector OR

Sponsored Session

Chair: Ebru Korular Bish, Virginia Tech, Blacksburg, VA, 24060, United States, ebru@vt.edu

Co-Chair: Hrayer Aprahamian, ahrayer@vt.edu

1 - Robust Prevalence Rate Estimation under Limited Resources
Ngoc Nguyen, Virginia Tech, Blacksburg, VA, 24060, United States, ntn@vt.edu, Ebru Korular Bish

Prevalence rate estimation is essential to surveillance studies in public health, and is normally conducted via pooled testing. However, as the optimal pooling design relies on the true and unknown prevalence rate, it is often determined under uncertainty. We take a robust optimization approach to prevalence rate estimation by minimizing the maximal regret in the estimate mean squared error, given an interval in which the true prevalence is presumed to be. We then compare the numerical results from the robust optimization model to those obtained from an expectation-based pooling design model to demonstrate the benefits of robust optimization in pooling design for prevalence estimation.

2 - Resource Allocation Policies for Post-disaster Relief Operations with Explicit Consideration of Human Choice Behavior
Xinchang Wang, Assistant Professor, Mississippi State University, 324C McCool Hall, Marketing Department, P.O. Box 9582, Mississippi State, MS, 39762, United States, xwang@business.msstate.edu

It has been seen that disaster-affected victims choose to visit a point of distribution (POD) to acquire life-sustaining commodities from a set of alternatives after disasters. We study a variety of post-disaster resource allocation models with victim choice to minimize the total unmet demand. These models are non-differentiable and non-convex due to nonlinear utility functions capturing the reality that no informed victim would visit a POD with no inventories. We fully characterize the optimal policies for these models under a homogeneous case. For a general non-homogeneous case, we provide a partial characterization of the optimal policies and propose a search method to find optimal policies.

3 - Benefits of Optimal Testing Schedules for Sequential Adaptive Clinical Trials

Alba Rojas-Cordova, Assistant Professor, Southern Methodist University, Caruth Hall 339, Dallas, TX, 75205, United States, alba@smu.edu, Ebru Korular Bish

Existing sequential analysis methodologies can be applied to sequential clinical trials with interim analyses to preserve the statistical significance and power levels of a fixed sample size trial. These methodologies, however, do not prescribe the number of patients that need to be recruited and analyzed every period, nor incorporate financial constraints, and do not allow for learning. We utilize a stochastic dynamic programming model with Bayesian updates to derive an optimal testing schedule and an optimal futility threshold, which can be combined with a wide range of sequential stopping methodologies that address stopping for benefit.

4 - Optimal Post-donation Nucleic Acid Testing of Donated Blood Considering Viral Load Growth Curves and Donor Characteristics

Hadi El-Amine, George Mason University, 4310 Cotswolds Hill Ln, Fairfax, VA, 22030, United States, helamine@gmu.edu, Ebru Korular Bish, Douglas R. Bish

Blood product safety, in terms of being free of transfusion-transmittable infections (TTIs), is crucial. Nucleic Acid Testing (NAT) technology enables earlier detection of infections but is more expensive, hence, most blood centers administer NAT to pools of blood samples from multiple donors. Since some donor characteristics are uncertain, we develop a chance-constrained model that determines the optimal NAT pool sizes for various TTIs, considering both non-universal (where first-time donors undergo more extensive screening), and universal (i.e., common testing for all donors) strategies, so as to minimize the TTI risk, while remaining within the testing budget with a high probability.

■ TD44

360C

Operations Management/Marketing Interface

Contributed Session

Chair: Lauri Saarinen, University of Lausanne, Lausanne, Switzerland, lauri.saarinen@unil.ch

1 - Simulation of Inventory Systems with Unknown Input Models

Canan Gunes Corlu, Assistant Professor, Boston University, 808 Commonwealth Avenue, Boston, MA, 02215, United States, canan@bu.edu, Alp Akcay

Assuming the availability of limited demand data, we consider the stochastic simulation of an inventory system with unknown demand distributions. Building on a nonparametric Bayesian approach, we propose a simulation replication algorithm that estimates a service level for the inventory system without making any assumptions on the functional form of the demand models. We illustrate our approach in a single-product inventory simulation.

2 - Newsvendor Problem and Approximate Solutions under Price Dependent Intensity

Ahasan Harun, University of North Texas, 316 Fry Street, Apt 203, Denton, TX, 76201, United States, MdAhasanUddin.Harun@unt.edu

Approximate solutions have been proposed to the newsvendor problem when the demand is a compound Poisson and with price dependent intensity. The distribution of the selling time may not necessarily follow an exponential distribution as is typically assumed. The normal distribution provides a good empirical fit for fast moving items. However, in practice, only the first two moments may be known. Examining approximations and the optimal price for order quantity items under limited information about distributions may provide insights into new guidelines for modeling this complex problem.

3 - Skill-based Performance Model of Heterogeneous Multi-skilled Workers in Seru Production Systems

Yin Gai, Dongbei University of Finance & Economics, 217 Jianshan Street, Shahekou District, DaLian, 116025, China, gaiyin@dufe.edu.cn

Effective cross-training for multi-skilled workers is viewed as a critical factor when it comes to enhancing the performance of seru production system (SPS). Responding to this importance, we develop a skill-based analytical model of the performance of heterogeneous multi-skilled workers accounting for individual learning/forgetting curves in different types of serus. The proposed analytical model has been successfully applied to a practical case using a discrete event simulation model, and the result justifies incorporating skill-based modeling into cross-training of SPS results in an accurate analyses and informed decisions of actual and future workforce performance.

4 - Operations Research in the Management of Linen in Indian Railways

Balaraman Rajan, Assistant Professor, California State University East Bay, 25800 Carlos Bee Blvd, Hayward, CA, 94542, United States, balaraman.rajan@csueastbay.edu, Ravichandran Narasimhan

Indian railways operates 12,000 trains a day ferrying 23 million passengers a day. About 9,000 couches use linen and 1.8 million pieces are washed everyday by Indian railways. The infrastructure includes 41 mechanized laundries and estimated expense of Rs. 36 per linen set. This paper traces the life cycle of a linen, outsourcing options, capacity and their location, inventory, and flow management. It reviews the existing practice and identifies modelling opportunities to improve operations.

5 - Retailer's Efforts on Quality Assurance under Manufacturer Encroachment

Mao Yuan, Huazhong University of Science and Technology, Luoyu Road 1037, Wuhan, 430074, China, myuan@hust.edu.cn, Wanjiang Deng, Shihua Ma

We study a two-echelon supply chain where a manufacturer produces and distributes products through an independent retailer or direct channel. The production may yield defective units, and the retailer conducts an inspection to assure quality. We exam the impact of manufacture encroachment on retailer's quality assurance level, and the results show that manufacturer encroachment will induce the retailer to enhance quality assurance level,and the manufacturer may decrease the wholesale price. We also find that the encroachment may lead to win-win outcomes and lose-lose outcomes for the manufacturer and the retailer.

6 - Using Simulation to Bridge the Theory-practice Gap

Lauri Saarinen, University of Lausanne, Lausanne, Switzerland, lauri.saarinen@unil.ch, Kyle D.Cattani, Katariina Kemppainen, Suzanne de Treville

Scheduling a production facility around a product portfolio that combines products varying in time sensitivity makes it possible to combine responsiveness with effective deployment of capacity. This volatility-portfolio theory emerges from quantitative finance: Typical managers lack the background to carry out the calculations so hesitate to implement the theory, which is nonlinear and counterintuitive. We describe use of simulation modeling in two companies to help managers get comfortable with implementation. Managers then suggested additions to the model that gave insight into boundary conditions of the theory.

■ TD45

360D

Retail Management

Contributed Session

Chair: Sajjad Farahani, University of Wisconsin-Milwaukee, Milwaukee, WI, United States, farahani@uwm.edu

1 - Production Planning of a Remanufacturing System with Variable Quality Returns in Reverse Logistics Environment

Sajjad Farahani, PhD Candidate, University of Wisconsin Milwaukee, WI, 53211, United States, farahani@uwm.edu, Wilkistar A.Otieno

In this paper, proposed a general framework for a remanufacturing environment and a mathematical model to maximize the profit by optimally deciding the quantity of products to be remanufactured and number of products disassembled or disposed.

2 - Optimization of Warranty Period and Product Price for Remanufactured Products using Mathematical Method

Amir Kordijazi, Teaching Graduate Assistant, PhD Candidate, University of Wisconsin-Milwaukee, 1133 E Pleasant St, Apt # 103, Milwaukee, WI, 53202, United States, kordija2@uwm.edu, Yuxi Liu, Wilkistar A.Otieno

Warranty is an important factor in building a good manufacturer—consumer relationship. Manufacturers pursue to minimize warranty costs and at a same time they try to offer a warranty which promises acceptable product quality and reliability. This study considers a remanufactured electrical product under a tiered warranty policy and try to presents an optimal warranty period from the perspective of a manufacturer to maximize the total expected profits, while ensuring sustained consumer relation. Real data from a local company with a global supply chain was used to provide a numerical example.

3 - Pricing in Remanufacturing Operations
Akshay Mutha, Pennsylvania State University, Smeal College of Business, 454 Business Building, University Park, PA, 16802, United States, axm536@psu.edu, Saurabh Bansal, V. Daniel R. Guide

We consider a firm that can remanufacture products after the demand is realized. We analyze the effect of postponing remanufacturing operations on the pricing decisions of a firm. We show the application of our model using industry data.

4 - Optimal Core Pricing and Financing Strategies at Different Stages for Remanufacturing Products under Different Quality Levels
Qianru Li, Southeast University of China, Nanjing, China, 230169156@seu.edu.cn, Weida Chen

This paper studies an acquisition pricing and financing problem in the payback period or production period in a remanufacturing system under independently uncertain demand and capital constraints, where the remanufacturer acquires and produces high- and low-quality cores in a single period setting. The acquisition pricing is viewed as a convex optimization problem, which is formulated by a nonlinear programming model. Finally, numerical experiments are conducted to show that through some key parameters, the optimal decisions can be determined to improve profits of the remanufacturer.

5 - A Two Stage Stochastic Programming Approach for Capacity and Inventory Planning for A Manufacturing Remanufacturing System
K. Nageswara Reddy, Research Scholar, Indian Institute of Technology Kharagpur, Academic Area, Kharagpur, West Bengal, 721302, India, knreddy@iitkgp.ac.in, Akhilesh Kumar

In this paper, we developed a two-stage stochastic model to optimize capacity and inventory decisions jointly while considering demand, supply and yield uncertainties. We have considered a scenario where new and remanufactured products don't compete with each other and sold in primary and secondary markets respectively.

■ TD46

360E

Teaching Project Management 1

Invited: Project Management and Scheduling

Invited Session

Chair: Nicholas G. Hall, Ohio State University, Columbus, OH, 43210-1144, United States, hall.33@osu.edu

1 - Design of a Graduate Business Elective in Project Management
Nicholas G.Hall, Ohio State University, 658 Fisher Hall, 2100 Neil Avenue, Columbus, OH, 43210-1144, United States, hall.33@osu.edu

This presentation describes in detail the development of a graduate business elective course in project management. Among the components discussed are: lecture content, online simulations, integration of guest speakers, in-class games and exercises, business cases, case reports and presentations, and class participation. Course objectives and learning outcomes are also discussed.

2 - Teaching Project Management's Four Letter Word: Risk
Theodore D. Klastorin, University of Washington, ISOM Department, Box 353226, Seattle, WA, 98195-3226, United States, tedk@u.washington.edu, Gary Mitchell

Arguably, the most important concept in project management is risk: studies have shown that risk management is a project manager's most important responsibility. In this talk, we discuss ways to teach PM risk management, including the management of a complex project that operates under the threat of a possible disruptive event that will stop all work on the project although overhead/indirect and possible penalty costs will continue to accrue. We describe a short case that illustrates these concepts and relates risk management to standard PM time-cost trade-offs.

3 - Web-based Applications and Games in a Quant Project Management Course
Rainer Kolisch, Technical University of Munich, Arcisst 21, Munich, 80333, Germany, rainer.kolisch@tum.de

I have been teaching an undergraduate course in project management using operations research models and methods for several years. Recently I introduced the web-based applications RESCON and Project Management Team Builder (PTB) as well as the Marshmallow Game into the course. I will be sharing my experience with the course, its new elements and their alignment with quantitative topics.

4 - Teaching Agile Project Management
Enno Siemsen, University of Wisconsin-Madison, Wisconsin School of Business, 975 University Avenue, Madison, WI, 53706, United States, esiemsen@wisc.edu

Agile project management has become more prevalent in practice; yet it is not clear how to effectively teach agile project management in the classroom. In this session, I will report on an exercise using Legos that helps students understand the differences between traditional and agile project management.

■ TD47

360F

Risk Management and Cybersecurity

Sponsored: EBusiness

Sponsored Session

Chair: Jingguo Wang, PhD, The University of Texas at Arlington, Arlington, TX, 76019, United States, jwang@uta.edu

1 - Using Machine Learning to Improve Phishing Detection Training
Zhe Shan, Univeristy of Cincinnati, shanze@ucmail.uc.edu, Andrew Harrison

Fraudulent phishing attacks cost firms and consumers billions of dollars annually. Despite the widespread use of automated classification systems developed to stop phishing attacks, phishing has evolved and continues to pose threats to people and organizations. To fight these dynamic malicious behaviors, researchers have called for better integration of behavioral factors into antiphishing efforts. Our research is motivated to combine the insights gleaned through automated detection systems with behavioral training methods to improve people's abilities to detect deception.

2 - Information Security Investment with Externalities and Heterogeneous Firms – Theory and Government Policies
Jie Zhang, University of Texas at Arlington, Arlington, TX, United States, jie.zhang2@mavs.uta.edu, Kay-Yut Chen, Jingguo Wang

How to ensure business entities spend enough effort to protect their information assets has been a challenge for regulators. In this paper, we investigate how externalities and firm heterogeneity impact firms' level of information security investment . Consistent with prior studies and practical observations, our results indicate that firms tend to under-invest if they make independent, self-interested decisions without any government interventions. We explore two possible governmental policies such as mandatory security investment standard and subsidies that can help alleviate the under-investment problem.

3 - Evolution of Intellectual Structure of Cybersecurity within the Last 25 Years
Rahul Dwivedi, PhD Student, University of Texas, 701 S Nedderman Drive, Arlington, TX, 76019, United States, rahul.dwivedi@mavs.uta.edu, Sridhar P.Nerur, Jingguo Wang

Cybersecurity is an area of predominant research both for academicians and practitioners. With organizations scrambling to keep up with growing cybersecurity concerns, we see a tremendous growth in the number of articles published in this area. The purpose of this research is to examine the conceptual foundations of the field of cybersecurity based on detailed analysis of research articles published within the last 25 years (1992 - 2015). Using a combination of citation analysis and text analysis techniques, our study aims to identify the most discussed topics, their relationships and evolution over time.

4 - Multilateral Contracts in Information Security Outsourcing
Ming Zhao, University of Houston, 334 Melcher Hall 290F, C.T. Bauer College of Business, Houston, TX, 77204, United States, mzhao@bauer.uh.edu

We present a comprehensive investigation of multilateral contracts, and analyze the influence of externalities and breach probabilities on contingent payments. The results show that a normalized externality, the ratio between a firm's externality and its investment efficiency, dictates the levels of contingent payments in multilateral contracts.

5 - Bringing Cyberinsurance and Managed Security Services to ISPS: A Game Theoretic Analysis
Yun-Sik Choi, University of Texas at Austine, Austin, TX, United States, yunsik@cs.utexas.edu, Jin Hyuk Choi, Gene Moo Lee, Andrew B.Whinston

We propose a new business model for Internet Service Providers (ISPs), which providing managed security service and cyberinsurance in addition to the traditional Internet service. We develop a dynamic game model to build a theoretical foundation of this business model. The Bayesian Nash equilibrium of the game characterizes the strategic interaction between an attacker and a defender. The analysis of the model implies that the defender's role of updating suspicion level and blocking suspicious users are crucial as the attacker's capacity increases. These observations support our claim that the ISPs are in the suitable position to provide managed security service and cyberinsurance.

■ TD48

361A

Social and Environmental Responsibility in Supply Chains: Behavioral Insights

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Karen Donohue, Carlson School of Management, University of Minnesota, Minneapolis, MN, 55455, United States, donoh008@umn.edu

1 - The Effect of Visibility on Consumer Trust of Social Responsibility Disclosures

Leon Matias Valdes, MIT.Sloan School of Management, 77 Massachusetts Avenue, E62 - 459, Cambridge, MA, 02139, United States, lvaldes@mit.edu, Tim Kraft, Yanchong Zheng

We conduct an incentivized human-subject lab experiment to investigate the role of supply chain visibility on consumer trust of firms' social responsibility (SR) communications. Specifically, we analyze via a three-player game how consumer trust and firm trustworthiness are affected by the quality of the information that the firm has about its supplier's SR practices. Our results suggest that consumer trust, as measured by their willingness-to-pay for a product, is higher when the firm has better visibility into its supplier's SR. Furthermore, consumer players who demonstrate a high prosocial orientation display a lack of trust under low visibility.

2 - Randomness and Correlations in Willingness-to-Pay for Remanufactured Products

Anton Ovchinnikov, anton.ovchinnikov@queensu.ca, James Duane Abbey

This paper questions a common assumption in modeling consumer behavior in purchasing remanufactured products: that the willingness-to-pay (WTP) for such products is perfectly correlated to that for the new products. We present experimental evidence suggesting that there is a degree of randomness in WTP. We then build a model to explicitly account for such randomness and, show that, surprisingly the firm benefits from uncertainty in WTP. We finally characterize the correlation structures that enhance versus reduce such benefit.

3 - Sustainable Operations Versus Corporate Social Responsibility: A Cross-country Analysis of Value Chain Transparency

Basak Kalkanci, Georgia Institute of Technology, 3151 Stillhouse Creek Dr SE, Apt 25517, Atlanta, GA, 30339, United States, basak.kalkanci@scheller.gatech.edu, Ryan Buell

We conduct experiments to study the effect of transparency into a company's internal sustainable operations initiatives (such as paying living wages or reducing emissions) relative to transparency into external CSR initiatives (such as contributing to social causes or offsetting emissions) on customers and prospective employees in the US and India. Although transparency boosts consumer choice, not all initiatives perform equally well. Internal sustainability initiatives lead to higher purchase intentions and are perceived as more sincere in the social domain. However, consumers perceive internal and external initiatives to be substitutable in the environmental domain.

4 - Encouraging Energy Efficiency Investment in a Supply Chain: A Behavioral Investigation

Karen Donohue, University of Minnesota, SCO.Department, 321 19th Street Avenue S, Minneapolis, MN, 55455, United States, donoh008@umn.edu, Jason Nguyen, Behrooz Pourghannad

While there are different mechanisms from both buyers and third-party organizations to assist suppliers in investing in Energy Efficiency (EE) improvements, suppliers' propensity to accept this assistance and undertake investments can be elusive. Through a series of controlled behavioral experiments, we study how the source of external assistance, contract framing and characteristics of the investment, including the initial assessment costs and uncertainty of returns, influence the supplier's propensity to perform the initial assessment and subsequently invest in EE improvements.

■ TD49

361B

Practice/Healthcare II

Contributed Session

Chair: Yajun Ding, Baylor College of Medicine, One Baylor Plaza, Houston, TX, 77030, United States, Yajun.Ding@bcm.edu

1 - The Impact of EMR on Patient Care Evidence from LOS Reduction for HF Patients in Developing Countries

Yazan Alnsour, Assistant Professor, University of Illinois Springfield, Springfield, IL, 62703, United States, yalns2@uis.edu, Mohammad Alsharo

Researchers are arguing that EMR systems have a positive impact on healthcare especially in reducing unnecessarily cost. In this paper, we examine the impact of using EMR systems on healthcare cost in one of the developing countries. We argue that EMR help providers in reducing hospital length of stay (LOS). Our findings show that EMR systems can reduce unnecessary hospital LOS which subsequently reduce cost and the risk of hospital-acquired conditions. We empirically examine and find support for the hypothesized relationships using an archival data set for1,979 cognitive heart failure (CHF) patients. We discuss the practice implications and contributions of the findings.

2 - Family Medicine Resident Rotation Schedule Design using a Sequential Optimization Method

Allison Koram, Health Systems Engineer, Mayo Clinic, Jacksonville, FL, United States, koram.allison@mayo.edu, Yu Li Huang

Scheduling Family Medicine (FM) residents is a multifaceted task when considering the required amount of other medical services for each year of residency, the schedule flexibility of these services, the policies of FM resident and advisor staffing requirements as well as required shifts and patient volumes. The study proposed a sequential optimization model to determine the combinations of medical services in each year of residency so that the family medicine training policies can be met. The model produces a year of rotation schedule template for FM residents at an academic medical facility.

3 - Effective and Equitable Appointment Scheduling in Rehabilitation Centers

Idil Arsik, Georgia Institute of Technology, 391 17th St NW. Apt. 4054, Atlanta, GA, 30363, United States, idilarsik@gatech.edu, Pinar Keskinocak, Jennifer Coppola, Kirthana Hampapur, Yitong He, Haozheng Jiang, Dani Regala, Nick Tailhardat, Kristin Goin

Appointment scheduling in rehabilitation centers is a complex process; unlike in a primary care clinic setting, patients need a combination of services to be scheduled over multiple days and time slots with different providers. The goal in scheduling is to provide the ideal care to patients with different needs while efficiently utilizing resources. In a collaborative project between Shepherd Center, a rehabilitation institute for patients with brain injuries, and Georgia Tech, we developed a decision support-tool which employs heuristics and mixed integer programming models for efficient and effective scheduling.

4 - Simulation Based Evaluation for Point of Care Testing

Reed Harder, Dartmouth College, 14 Engineering Drive, Hanover, NH, 03755, United States, reed.haseltine.harder.TH@dartmouth.edu, Keji Wei, Vikrant Vaze, James Stahl

In order to compare Point-of-Care Testing, Central Lab Testing and Point-of-Care Sample Acquisition testing regimes in a clinical environment, we develop a computer simulation of a primary care clinic. Using data on clinic workflow, test cost and test performance characteristics, we simulate a clinical workflow over the course of a year in different settings, including clinics in rural, retail/semi-public, outpatient, and hospital based scenarios. We then analyze system performance in terms of time, economic cost, staff utilization and treatment effectiveness, and analyze trade-offs between testing regimes in different scenarios.

5 - Using GIS and Optimization for Optimal Organ Allocation for Heart Transplant

Monica Gentili, University of Louisville, JB Speed Building, Room 304, Louisville, KY, 40292, United States, monica.gentili@louisville.edu, Fatemeh Karami, Mehdi Nayebpour, Naoru Koizumi

Heart transplantation is the definitive therapy for the end-stage heart failure patients with the post-transplant survival rate of over 70%. However, the number of transplants has been limited by a growing supply-demand mismatch, and geographic disparity in access to heart transplant has been reported as one of the significant problems. The proposed research will explore different heart allocation boundaries derived from our mathematical optimization models and evaluate them by means of simulation models

6 - Discrete-event Simulation of HIV Drug Resistance from Antiretroviral Therapy in South Africa

Ume Abbas, Baylor College of Medicine, Houston, TX, United States, Ume.Abbas@bcm.edu, Yajun Ding, Robert Glaubius

Expanded access to antiretroviral therapy (ART) for HIV raises concern about drug-resistance spread. We developed a novel discrete-event simulation model of the HIV epidemic in KwaZulu-Natal, including ART and drug-resistance mutations, and evaluated HIV drug-resistance by 2030. Our model predicts that if access to second-line ART is limited, resistance to current first-line ART will increase, with potential decrease in efficacy.

■ TD50

361C

Fleet and Marketplace Optimization for Mobility-on-Demand (MoD) Systems with Ridepooling

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Samitha Samaranayake, Cornell University, Ithaca, NY, 14853, United States, samitha@alum.mit.edu

1 - Large-scale On-demand Micro-transit and Integration with Mass-transit Systems

Samitha Samaranayake, Cornell University, School of Civil & Environmental Engineering, 220 Hollister Hall, Ithaca, NY, 14853, United States, samitha@alum.mit.edu

This presentation will discuss two approaches for improving the scalability of on-demand ridesharing systems. The first approach is a micro-transit system that serves passenger demand using a fleet of high capacity shuttles, while still assigning passengers to vehicles and routing vehicles in real-time. A novel solution framework is used to solve the problem at scale. The second approach considers integrating on-demand ridesharing with mass-transit. Large-scale simulations of both approaches, using real taxi trip data from NYC, demonstrate the efficiency gains made possible by these systems.

2 - Pricing and Optimization in Shared Vehicle Systems

Siddhartha Banerjee, Cornell University, 229 Rhodes Hall, Ithaca, NY, 14853, United States, sbanerjee@cornell.edu, Daniel Freund, Thodoris Lykouris

We develop a framework for optimizing shared-vehicle systems, modeled using closed queueing networks. Our approach gives the first efficient algorithms with rigorous guarantees for several common demand-supply balancing controls, including pricing, rebalancing and matching, in the process simplifying and extending several recent results. Moreover, our framework, which is based on a novel convex relaxation coupled with a new infinite-projection and pullback technique, may prove useful for proving approximation bounds in other settings.

3 - Estimating Willingness to Carpool at Uber

Peter Frazier, Cornell University, School of Operations Research, and Information Engineering, Ithaca, NY, 14853, United States, pf98@cornell.edu

We consider estimation of a rider's willingness to use rideshare-based carpooling as a function of inconvenience created by carpooling, price of the carpool product, and the price of a non-carpool alternative. Such estimates are critical for pricing rideshare based-carpooling, and for designing the matching algorithm and constraints that determine inconvenience. We present estimation methodology and insights from applying this methodology at Uber.

4 - Enhancing Urban Mobility: Integrating Ride-sharing and Public Transit

Niels Agatz, Erasmus University, Rotterdam School of Management, Burg. Oudlaan 50, Rotterdam, Netherlands, nagatz@rsm.nl, Mitja Stiglic, Martin W. P.Savelsbergh

Seamless integration of ride-sharing and public transit may offer fast, reliable, and affordable transfer to and from transit stations in suburban areas thereby enhancing mobility of residents. We investigate the potential benefits of such a system, as well as the ride-matching technology required to support it, by means of an extensive computational study. Our study shows that the integration of a ride-sharing system and a public transit system can significantly enhance mobility and increase the use of public transport.

■ TD52

361E

Energy

Contributed Session

Chair: Amandeep Gupta, Cornell University, Ithaca, NY, United States, ag729@cornell.edu

1 - A Building Thermal Model for Humidity Prediction

Jingyang Xu, Innovative Decisions & Analytics LLC, 6991 Brescia Way, Orlando, FL, 32819, United States, jxu7@buffalo.edu, Daniel Nikolaev Nikovski

In this talk, we'll show you a grey-box model to predict temperature and humidity in a building with active control of HVAC (heating, ventilation and air conditioning) systems. Various factors are considered, such as weather, human activity, radiation, moisture absorption/desorption, ventilation, condensation, etc. Accurate prediction results are obtained using data collected from a physical building. The prediction time step is 5 mins, which is much short than existing models and made it possible for the model to support optimal control of HVAC for better thermal comfort and energy consumption.

2 - Bioenergy Facility Location: A Dynamic Problem to Address Electricity Demand and Supply Gap

Raza Ali Rafique, Assistant Professor, Lahore University of Management Sciences (LUMS), Sector 'U', DHA, Lahore Cantt., Lahore, 54792, Pakistan, raza.ali@lums.edu.pk, Mohsin Nasir Jat

In this research, the optimal locations of bioenergy facilities are sought. We propose a mixed integer linear programming (MILP) approach for minimization of energy gap (between demand and supply) at district levels with defined biofuel potential and targeted electricity capacity. Our study is based on real data collected across 135 districts of Pakistan. The proposed optimization tool can assist policy makers for strategic planning and development of biofuel energy in Pakistan.

3 - Planning for Electric Taxi Charging System from the Perspective of Transport Energy Supply Chain- A Data Driven Approach

Yinghao Jia, PhD Candidate, Tsinghua University, Beijing, 100084, China, jyh12369@126.com

Yinghao Jia, PhD Candidate, Sparkzone Research Group, Beijing, China, jyh12369@126.com, Ziyang Guo, Zhuying Jiang, Yu Xin, Yide Zhao, Fang He

Administration in big cities is strongly promoting electric taxis (ETs) by providing purchasing subsidies, public charging facilities and many other encouraging policies. However, how to allocate the limited resources to optimize the benefits brought by ETs remains a headache for most researchers. Applying data mining technology, this research gathers real-time vehicle trajectory data of 39,053 urban conventional taxis (CTs) and 408 suburban ETs in Beijing for 4 weeks to extract the model of customers' travel demand and ET driving patterns. Based on the transport energy supply chain derived from GPS data, we develop a data-driven method to design ET charging infrastructure in the near future.

4 - Storage Dam and RUF off River Hydroelectric Power Generation and Distribution Planning

Govind Joshi, Colorado School of Mines, Golden, CO, United States, gobndjoshi@gmail.com, Ebisa Wollega

We present power delivery planning problem for integrated storage dam and run-off-river (ROR) hydroelectric power plant projects under supply uncertainties. We formulate the problem as a two-stage stochastic program, where the storage dam projects are considered as a first stage, the ROR projects are considered as the second stage of the program. Numerical comparisons of stochastic solution, expected value solution, and wait and see solution are made to provide the economic dispatch of generators and optimal delivery plan that the power system operators can use to coordinate, control, and monitor the hydroelectric power generation and distribution system.

5 - Bus Ranking Method for Robust Optimization

Amandeep Gupta, Cornell University, 316 Highland Road, Ithaca, NY, 14850, United States, ag729@cornell.edu, Lindsay Anderson

Interest in efficient and flexible stochastic methods for unit commitment has been growing steadily in answer to increasing renewable energy resources on the grid. This work describes a statistical bus ranking methodology that identifies the most critical buses based on criteria such as economic dispatch cost, or ramping needs to provide a robust unit commitment solution. The method is illustrated via a case study on the IEEE 30-bus system and compared to other established approaches to demonstrate the efficacy of obtained solutions. Results show that the bus ranking method performs as well as the best of these methods, with the provision of additional flexibility and potential for parallelization.

■ TD53

361F

Hazardous Materials Transportation

Invited: TSL, Intelligent Transportation Systems (ITS)

Invited Session

Chair: Pirmin Fontaine, Technical University of Munich, Arcisstrasse 21, LST Minner, Munich, 80333, Germany, pirmin.fontaine@tum.de

1 - Simulation and Analyzing the Hazardous Materials Transportation Interdependent Network

Peng Hu, Southwest Jiaotong University, Erhuanlu Beiyiduan No. 111, Chengdu, 610031, China, hupengbaby@163.com, Bin Shuai, Zhenyao Wu

Hazardous Materials Transportation Network has very tightly coupling with Traffic Flow Network of Hazmat Transportation. We build the interdependent system for the two networks. We build the interdependent system and analyze it through simulation method for knowing the robustness of the interdependent transportation network.

2 - Managing Rail-truck Intermodal Transportation for Hazardous Materials: A Scenario-based Robust Optimization Model

Ginger Yi Ke, Memorial University of Newfoundland, St. John's, NL, Canada. gke@mun.ca, Arifusalam Shaikh

Combining multiple transportation modes, intermodal transportation has been widely used in shipping hazardous materials (hazmat). But the corresponding research is still limited, especially when the planning environment contains uncertainties. Herein we propose a bi-objective robust optimization approach to determine the best shipment plan for transporting hazmat in intermodal networks. Both minmax and regret based techniques are applied and compared to find robust solutions. Managerial insights are generated through discussions of the effectiveness and efficiency of our model.

3 - Fair Risk Distribution for the Multi-mode Hazmat Transport Network Design Problem

Pirmin Fontaine, Technical University of Munich, Munich, 80333, Germany, pirmin.fontaine@tum.de, Teodor Gabriel Crainic, Michel Gendreau, Stefan Minner

To fairly distribute the risk in hazardous material shipment, we propose a population-based risk definition that evaluates the risk in each population center. Moreover, we propose different objective functions for equilibrating the risk and extend the bilevel Hazmat Transport Network Design Problem by considering several transportation modes. We show that both objectives have a positive convex correlation and therefore a significant improvement in risk distribution can be achieved at the cost of just a small increase in total risk. The cities with high risk benefit from the risk redistribution in the beginning. However, strong equilibrations just penalize cities with low risk.

4 - Considering Dangerous Goods in Container Stowage Problems

Kiros Kebedow, PhD Student, Hawassa University, Ethiopia, Hawassa University, 05, Hawassa, 05, Ethiopia, kirosmaths@gmail.com, Johan Oppen

Container stowage problems are rich optimization problems with both high economic and environmental impact. These problems are typically decomposed into a master bay planning phase, which distributes containers to bay sections of the vessel, and a slot planning phase, which assigns a specific slot within the bay section to each container. In this talk, we extend existing models for slot planning by considering containers with dangerous goods and containers of length 45'. We show that our model can be solved to optimality in reasonable time using standard software.

■ TD54

362A

Waste and Hazardous Material Routing

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Roger Chen, Rochester Institute of Technology, 111 Lomb Memorial Drive, 81-2178, Rochester, NY, 14623, United States, rbcgis@rit.edu

1 - Conditional Value at Risk Model for Rail Transportation of Hazardous Material with Demand Due Date

Ginger Yi Ke, Associate Professor, Memorial University of Newfoundland, Faculty of Business Administration, Memorial University of Newfoundland, St. John's, NL, A1B 3X5, Canada, gke@mun.ca, Kan Fang, Tingting Cheng

The conditional Value-at-Risk (CVaR) model is employed to generate route choices for the multi-trip rail transportation of hazardous materials, where each demand has an associated due date and each train can run at various train speeds. We investigate the structural properties of the corresponding CVaR model, and provide analytic methods to determine optimal scheduling and routing plans as well as the train speed at each arc, such that the total transportation cost is minimized.

2 - Economic Analysis of Residential Garbage Collection Operations: Case of the City of Kingsville

Sachinkumar Prajapati, Texas A&M.University-Kingsville, 1414, W Santa Gertrudis, Apt#702, Kingsville, TX, 78363, United States, prajapatisachin11@yahoo.com, Joon Yeoul Oh, Amir Gharehgozli

The quantity of residential garbage increases every year. Along with that, the cost and time of garbage collection increase. The objective of this research is to find an effective yet efficient way to collect residential garbage. To achieve this goal, first, data on the current garbage collection operations is collected and analyzed. Second, Arena simulation is used to improve the operations for the city of Kingsville. Finally, an economic analysis is performed to compare the current and proposed garbage collection operations. The results show that the proposed garbage collection method is 35%-40% less costly compared to the current method.

3 - A Meta-heuristic for the Vehicle Routing Problem with Crossdocking

Changsheng Wu, Student, New York Institute of Technology, Manhattan, NY, 10023, United States, cwu25@nyit.edu, Birasnav Muthuraj

This study focuses on developing a meta-heuristic for routing vehicles operated by third party logistics service providers to pick up hazardous materials from manufacturing companies and to deliver these materials to customers through crossdocking facility. This study compares the solutions of this meta-heuristic with the solutions derived from exact methods.

4 - Expected Value of Perfect Information of Demand in Propane Distribution Problem

Nichalin S. Summerfield, Assistant Professor, University of Massachusetts Lowell, One University Avenue, Lowell, MA, 01854, United States, nichalin_summerfield@uml.edu, Moshe Dror

Recent advancement in sensors allows companies to remotely monitor propane levels in customers' tanks and plan their daily distribution operations. In this work, we study the expected value of perfect information (EVPI) of demand in Propane Distribution Problem (PDP) to decide if it is profitable to install the sensors. Specifically, we compare the solution cost when the levels of propane are known, against the solution cost when customers' consumption levels are forecasted. In our setting, split deliveries are allowed and any stockout is replenished by a costly special delivery. We use a state-of-the-art heuristic solution for PDPs that minimizes the expected replenishment costs per year.

5 - Organic Waste Recovery: Routing, Siting and Blending

Roger Chen, Assistant Professor, Rochester Institute of Technology, 111 Lomb Memorial Drive, 81-2178, Rochester, NY, 14623, United States, rbcgis@rit.edu, William Armington

In the US, an estimated 63 million tons of food product is discarded annually, leading many regions to consider diverting food waste from landfills towards other more sustainable technology alternatives. Heterogeneity and inconsistency in the food waste composition, combined with technology constraints require trade offs in optimizing the recycling process, including the routing of organic waste streams. Within this context, this work considers three class of problems: (i) vehicle routing of organic waste streams; (ii) facility location decisions for organic waste recycling technologies; and (iii) waste blending and composition balance.

■ TD55

362B

Topics In Finance II: Behavioral Finance and Economics

Sponsored: Financial Services

Sponsored Session

Chair: Xuedong He, The Chinese University of Hong Kong, Hong Kong, xdhe@se.cuhk.edu.hk

Co-Chair: Nan Chen, Chinese University of Hong Kong, Shatin N T, Hong Kong, nchen@se.cuhk.edu.hk

1 - A New Preference Model that Allows for Narrow Framing

Xuedong He, The Chinese University of Hong Kong, Room 609 William M.W. Mong Engineering Bldg, Shatin, Hong Kong, xdhe@se.cuhk.edu.hk, Jing Guo

Barberis and Huang (2009) propose a preference model that allows for narrow framing and apply it to explain individuals' attitudes toward timeless gambles and high equity premia in the market. To uniquely define the utility process in this preference model and to yield a unique solution when the model is applied to portfolio selection problems, one needs to impose some restrictions on the model parameters, which are too tight for many financial applications. We propose a modification of Barberis and Huang's model and show that (i) the modified model admits a unique utility process and a unique solution in portfolio selection problems and (ii) it is more tractable than Barberis and Huang's model.

2 - Naive Behavior in Continuous-time Mean-variance Model

Lin Chen, Columbia University, New York, NY, 10025, United States, lc3110@columbia.edu, Xunyu Zhou

This project is concerned with the naive behavior in continuous-time mean-variance model. The objective is obtain the wealth process and portfolio process if we redo naive behavior at each time. By cutting the time interval into many equal length parts and in each part we use the precommitted strategy. By doing so, we can obtain the corresponding wealth process and portfolio process. When the number of cutting parts goes to infinity, we prove that, under some bounded conditions, both of the wealth process and portfolio process will converge. We also find the limits of both processes.

3 - Limited Foresight Strategy in Multi-period Mean-variance Framework

Xiangyu Cui, Shanghai University of Finance and Economics, School of Statistics and Management, Room 2218, Shanghai, 200433, China, cui.xiangyu@mail.shufe.edu.cn, Duan Li

In multiperiod mean-variance framework, the investor suffers time inconsistency. The current solution schemes either assume the investor does not possess any foresight or assume the investor possesses unlimited foresight. However, in reality, the investor often has limited foresight and can only influence his own investment behaviors over a relative short time interval. Thus, we integrate the limited foresight of the investor into the model and formulate the problem as a planner-middleman-doer game. We derive the explicit expression of the equilibrium strategy, which is called limited foresight strategy, and analyze the properties of the equilibrium strategy.

4 - Stock Trading with Realization Utility in a Regime-switching Model

Shengcheng Shao, The Chinese University of Hong Kong, Hong Kong, scshao@se.cuhk.edu.hk, Xuedong He

We consider a stock trading model in which the stock price follows a regime-switching process with observable regimes. The agent buys and sells the stock sequentially to maximize her terminal wealth utility and realization utility, where the latter is derived from the realized gains and losses at the sale times. We solve the optimal strategy in closed form and show that the agent holds the stock at a deep loss even in the bear market but sells the stock at a gain even in the bull market. We find that the more the agent weights the realization utility, (i) the more frequently she trades and (ii) the lower the expected terminal wealth.

■ TD56

362C

Logistics

Contributed Session

Chair: Jihyun Jo, Pennsylvania State University, University Park, PA, United States, JZJ5077@psu.edu

1 - Dual Channel Warehouse with Uncertain Demands

Guoqing Zhang, University of Windsor, Dept of MAME, 401 Sunset Avenue, Windsor, ON, N9B 3P4, Canada, gzhang@uwindsor.ca

With the emergence of online sales channels, a warehouse has come to commonly fulfil demands for both offline and online channels. To optimize operations, such a warehouse is usually divided into two areas: one for the process of fulfilling online orders and one for storing products and filling offline orders. This paper discusses multi-item product inventory policies with both stochastic online and offline demands for a dual-channel warehouse. Such a discussion has not been addressed in existing literature. Both a mathematical model and a solution approach are proposed. The impacts of uncertainty and the warehouse space have been analyzed.

2 - Robust Optimization of Biomass Logistics Supply Chain Design

Babak Badri Koohi, PhD Candidate in Operations Research, Virginia Tech, Blacksburg, VA, 24061, United States, babakbk@vt.edu, Subhash C. Sarin

Optimizing the design of biomass logistics supply chain plays a crucial role in utilizing biomass as a source of renewable energy. Nevertheless, there are some uncertainties associated with biomass logistics such as availability of necessary equipment, and the amount of seasonal or periodical supply and demand. In this research study, we address these uncertainties using a robust optimization approach.

3 - Identifying Noise Level in Military Logistics under Anti-access/Area-denial Environment

Rosemonde Ausseil, University of New Haven, West Haven, CT, United States, rauss1@unh.newhaven.edu, Ridvan Gedik, Amy Bednar, Mark Cowan

In modern warfare, the US military is increasingly faced with anti-access/area-denial challenges, which threaten its power projection operations. By analyzing the US military's logistics, adversaries could infer and anticipate the US military's mission objectives. Identifying which factors are predominant in determining these intentions leads us to develop a denial and deception technique of introducing noise into the US military's movements, with the aims of obscuring its logistics activities and disrupting the adversary's decision-making process. The mathematical model quantifies the noise and gives greater insight into what is a sufficient noise level for adversary deception.

4 - Heuristic Algorithm for Megacity Vehicle Routing Problem

Jihyun Jo, Pennsylvania State University, 234 Leonhard Building, University Park, PA, 16802, United States, JZJ5077@psu.edu, Soundar Kumara, Venky Shankar

The main objective of this study is generating the daily delivery routes under the conditions of m depots and n vehicles in urban transportation network and some other restrictions. Considering these characteristics, we first create the cost matrix of this routing problem using google maps API to adapt the current road conditions of the operating area. To solve the problem, we generate the delivery sequence of entire network like TSP by using genetic algorithm and the we distribute the vehicle routes with the given resource and time constraints. To speed-up the TSP solution generating process, we generate and solve the multiple subnetworks problem and then link the subnetwork solutions.

■ TD57

362D

Scheduling

Contributed Session

Chair: David Johnson, Purdue University, West Lafayette, IN, United States, davidjohnson@purdue.edu

1 - Using Cluster Analysis to Develop a Risk Taxonomy for Small Unmanned Aircraft System

Dothang Truong, Professor, Embry-Riddle Aeronautical University, 600 S.Clyde Morris Boulevard, Daytona Beach, FL, 32114, United States, truongd@erau.edu

The growing demand for Small Unmanned Aircraft System (sUAS) in the past two years has increased the number of sUAS encounters with manned aircraft or airports, raising the risk of collision. The purpose of this research is to develop a taxonomy of risk factors for sUAS operations in National Airspace System. Specifically, this research presents a process of analyzing the sUAS sighting data using cluster analysis to classify sUAS encounter incidents into different groups based on a set of selected variables in the dataset. The taxonomy will allow authorities to understand the nature, characteristics, and risk factors for each group of sUAS encounter incidents.

2 - Team Based Task Assignment for Air Cargo Operations

Yong-Hong Kuo, Assistant Professor, The University of Hong Kong, Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, yhkuo@hku.hk, Janny M. Y. Leung

Our work is motivated by a real-world task assignment problem when managing air cargo operations. The tasks are assigned to teams based on considerations such as manpower requirements, team shift times, workload balance, and meal and rest break requirements. We have developed an optimization tool to aid decision-making.

3 - A Railroad Track Geometry Life Analysis

Behnam Rahimikelarijani, Lamar University, Department of Industrial Engineering, Beaumont, TX, 77710, United States, brahimikelar@lamar.edu, Maryam Hamidi

This paper analyses railroad track geometry degradation based on the data gathered by geometry cars. The life data is used for reliability analysis of the track. A Weibull distribution whose scale parameter is assumed to be a function of stress factors is fitted. Accumulated tonnage and average running speed are considered as the stress factors affecting degradation of the track. The analysis can next be used in minimizing life cycle cost of tracks by determining the optimal maintenance schedule. By predicting track failure and proactively maintaining them, our methodology avoids considerable costs such as revenue loss, costs of damage to other parts, and random failures.

4 - Estimating the Potential for Cost Effective Nonstructural Flood Risk Reduction in Coastal Louisiana

David Richard Johnson, Assistant Professor, Purdue University, 315 N.Grant St, West Lafayette, IN, 47907-2023, United States, davidjohnson@purdue.edu, Zening Chen

Louisiana's 2017 coastal Master Plan allocates $6.1B for nonstructural flood risk reduction measures, such as elevating homes and floodproofing commercial properties. We outline the methods used to estimate the cost effectiveness of these options and present results from the Master Plan projects. We also derive the maximum potential for nonstructural risk reduction across the coast and compare optimal standards to the current standards used for flood insurance, which are based on FEMA's estimate of the "100-year" flood depth, and to the standards used by the Master Plan. Uncertainty in future conditions is also considered.

■ TD58

362E

TSP/VRP Generalizations

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Ibrahim Capar, Bowling Green, OH, United States, icapar@bgsu.edu

Co-Chair: Burcu Keskin, bkeskin@cba.ua.edu

1 - A Steiner Zone Heuristic for the Close-Enough Traveling Salesman Problem

Xingyin Wang, Singapore Univeristy of Technology and Design, 8 Somapah Road, #05-101, Singapore, 487372, Singapore, xingyin_wang@sutd.edu.sg, Bruce L.Golden, Edward Andrew Wasil

In the close-enough traveling salesman problem (CETSP), a truck starts at a depot and serves all customers on a Euclidean plane before it returns to the depot. The truck only has to get close enough to a customer to make a delivery. The objective is to minimize the total distance traveled by the truck. The CETSP has real-world applications including meter reading. We develop a heuristic based on Steiner zones that identifies regions close enough to multiple customers and connects them by the shortest route. When compared to existing algorithms on benchmark instances, our heuristic produces results of comparable quality with much shorter computation times.

2 - The Mothership and Drone Routing Problem

Stefan Poikonen, University of Maryland-College Park, 3406 Tulane Dr., Apt 22, Hyattsville, MD, 20783, United States, spoikone@math.umd.edu, Bruce L.Golden

The mothership and drone problem (MADP) considers the use of two vehicles: a large "mothership" and a small "drone". It is assumed both mothership and drone are free to move by the Euclidean metric. There exists a set of targets ("buoys") that must be visited. The drone is launched from the mothership, visits a buoy, and returns to the mothership. The original objective is to minimize the total time required to visit all buoys and return the drone to the mothership. A branch and bound method is used and a second order cone program defines a lower bound at each node. Modified objective functions and a "close-enough" variation for signals collection will also be presented.

3 - Dynamic Discretization Discovery Approach for Deliveryman Problem with Time Windows

Minh Duc Vu, Quinlan School of Business, Loyola University Chicago, 16 E.Pearson St, Chicago, IL.60611, Chicago, IL, 60611, United States, dvu3@luc.edu, Mike Hewitt

In this talk, we study the Delivery Man Problem with Time Windows (DMPTW), a problem belonging to the Traveling Salesman Problem with Time Windows (TSPTW) and its variants. Unlike TSPTW and its counterpart Delivery Man Problem (DMP), research works for DMPTW are quite scarce. We present the first exact method based on Dynamic Discretization Discovery approach and partially time-expanded networks to solve the problem. Experiments on a set of 310 instances indicate that the algorithm is capable of finding good feasible solutions with 251 optimal or close-to-optimal solutions. Based on insights from the computational experiments, we conclude with future research directions.

4 - Attractive Orienteering Problem with Proximity and Timing Interactions

Ibrahim Capar, Bowling Green State University, Department of ASOR, 355 Business Administration Building, Bowling Green, OH, 43403, United States, icapar@bgsu.edu, Nickolas K. Freeman, Burcu B. Keskin

We consider an attractive orienteering problem for planning entertainment events that seeks to determine the profit maximizing tour among a fixed set of candidate locations over a fixed planning time. The profit contribution for each stop depends on a time-varying measure that accounts for the attraction of the event's location and the presence of events nearby, in location and time. We formulate an MIP model and develop two heuristics; local search and scatter search. The heuristics find optimal solutions for small test instances and for large instances, they provide a 32% improvement over the best feasible solution returned by a commercial solver.

5 - Demand-resilient Electric Vehicles Sharing System Design

Xin Wang, University of Wisconsin-Madison, 8916 Red Beryl Drive, Middleton, WI, 53562-4278, United States, xin.wang@wisc.edu, Yikang Hua, Dongfang Zhao, Xiaopeng Li

Electric vehicle sharing advances the green city development, but faces challenges in practical operations like infrastructure deployment and vehicle rebalancing. We build a multi-stage stochastic model to reduce the customer queueing under demand-shock scenarios. Our model incorporates uncertain customer demand arrival together with the daily fleet dispatch and rebalancing decisions.

■ TD59

362F

New Directions for Product Assortment and Recommendation

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Clark C. Pixton, Massachusetts Institute of Technology, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, cpixton@mit.edu

1 - Long Tail or Blockbuster: Product Variety in Industries with Network Effects

Ming Hu, University of Toronto, Rotman School of Management, 105 St. George Street, Toronto, ON, M5S.3E6, Canada, ming.hu@rotman.utoronto.ca, Yinbo Feng

We provide a theory unifying the long tail theory and blockbuster phenomenon.

2 - Online Product Demand and Strategy in the Presence of Social Influence

Clark C. Pixton, Massachusetts Institute of Technology, 292 Vassar Street, Apt D-5, Cambridge, MA, 02139, United States, cpixton@mit.edu

We explore the demand patterns observed in product categories of online retailers, and add to the modeling literature explaining these effects. We provide managerial implications for new product introduction and demand estimation.

3 - Analytics for a Hotel Property: Demand Prediction and Optimization of Pricing and Capacity Allocation Decisions

Rui Sun, Massachusetts Institute of Technology, 77 Massachusetts Avenue, MIT.Bldg. E18-436, Cambridge, MA, 02139, United States, ruisun@mit.edu, Eduardo Candela, David Simchi-Levi

We present our work with a hotel company as an example of how machine learning techniques can be used to improve the demand predictions of a hotel property as well as its pricing and capacity allocation decisions. We first build a random forest model to predict the number of price-sensitive bookings and then feed these predictions into a mixed integer program to optimize prices and capacity allocations. We prove that the mixed integer program can be equivalently solved as a linear program. Finally, numerical results show that the optimized decisions are able to generate an increase in revenue compared to the historical policies.

4 - Assortment Optimization under a Mixture of Multinomial Logits with Nested and Interval Consideration Sets

Jacob Feldman, Olin Business School, United States, jbfeldman@wustl.edu, Huseyin Topaloglu

We study assortment problems when customers choose under the multinomial logit model with various consideration set structures. In this choice model, there are multiple customer types and a customer of a particular type is interested in purchasing only a particular subset of products. We use the term consideration set to refer to the subset of products that a customer of a particular type is interested in purchasing. We develop novel approximation schemes for the assortment problem under nested and interval consideration set structures.

■ TD60

370A

Improving STEM Education

Sponsored: INFORMEd

Sponsored Session

Chair: Kingsley Anthony Reeves, University of South Florida, 4202 E Fowler Avenue, ENB118, Tampa, FL, 33620, United States, reeves@usf.edu

1 - Practices to Improve Engineering Engagement in Rising 9th Graders: A Case Study on Advanced Manufacturing

Justin Yates, Francis Marion University, Florence, SC, 29501, United States, jyates@fmarion.edu, Karen Fries, Meredith Love, Tracy Meetze-Holcombe, Matthew Nelson

This project is a collaboration among The School of Education, the Industrial Engineering Program, and the Center of Excellence for College and Career Readiness at Francis Marion University. Curriculum and student exercises were created for a one-day short course targeted at improving engagement in rising 9th graders with risk factors that inhibit their pursuit of college. We present pre and post data and discuss the short-term outcomes of this short course. We also discuss novel ways in which students from Industrial Engineering and the School of Education supported the planning and implementation of this short course.

2 - Teaching and Learning of Economic Decisions for Uncertain and Complex Projects

K. Jo Min, Iowa State University, 3004 Black Engineering, Department of Industrial &, Ames, IA, 50011-2164, United States, jomin@iastate.edu, John Jackman, Michelle Zugg

Economic decisions for projects that are complex and facing uncertainties are inherently difficult. In this paper, based on simple principles of stochastic optimal control, we show such subject can be taught and learned in an undergraduate course. Empirical statistical analysis of student learning outcomes as well as insights from experience will be presented.

3 - Fun and Innovative Ways to Teach Computer Programming Concepts

Stephany Coffman-Wolph, Lecturer, The University of Texas-Austin, 2880 Donnell Drive, Round Rock, TX, 78664, United States, scoffmanwolph@utexas.edu

Although most college students are familiar with computers, almost all stem majors must take one or more introductory computer courses. Teaching these classes can be challenging as students are unaware of what being a computer scientist really entails. The activities presented are designed to be extremely cost-effective, easily portable, require minimum preparation, and do not require a lab or prior computer experience. The end goal of these activities is to introduce various computer science topics using familiar everyday experiences and fun physical activities.

4 - Reimagining the Engineering Textbook: Learning-centered Textbook Design

Kingsley Anthony Reeves, Associate Professor, University of South Florida, 4202 E. Fowler Avenue, ENB118, Tampa, FL, 33620, United States, reeves@usf.edu, Grisselle Centeno, Garrett Bowleg, Brittany Clift

We present the initial results of a design effort to reimagine the engineering textbook. The goal was to develop a Probability and Statistics for Engineers textbook that was designed with the needs of instructors, the needs of students, and learning theory in mind. The resultant design features will be displayed along with their explicit connection to best practices as identified in the teaching and learning literature.

■ TD61

370B

Joint Session SpORts/Practice: Sports Analytics IV

Sponsored: SpORts

Sponsored Session

Chair: Walter DeGrange, CANA Advisors, Chapel Hill, NC, 27517, United States, wdegrange@canallc.com

1 - Rank and Score: Athlete-event Assignment Optimization

Matthew Bailey, Bucknell University, Bucknell University, Taylor Hall, Lewisburg, PA, 17837, United States, matt.bailey@bucknell.edu, Maciek A.Nowak

With over 16,000 programs and one million secondary school athletes annually, track and field is second only to football in national participation. For coaches managing these large teams the focus is often solely on the training and development of athletes. As a result, coaches may overlook and underappreciate the competitive advantage of strategically assigning athletes to events to maximize their team's points in a meet. Building upon previous work, we present a generalization and extension of an assignment problem where we simultaneously assign, rank, and score athletes in events to maximize the expected total team points scored under a variety of scenarios, league rules, and preferences.

2 - Sports Analytics: Viable Career Path or Something Really Smart People Made up to Try to Get in the Game

Walter DeGrange, Cana Advisors, Chapel Hill, NC, 27517, United States, wdegrange@canallc.com, Jesse McNulty

With the recent success of sports teams heavily using analytics (Cubs, Patriots, Penguins, Warriors, Leicester City F.C.), does this mean that analytics has gained a foothold in the sports world? And if so, is there a career path that a high school student can use to become a sports analytics professional? This presentation attempts to answer both of these questions and summarizes all the areas of the application of analytics in sports.

3 - Predicting Collegiate Lacrosse Play Performance at the U.S. Major League Lacrosse Level

Walter DeGrange, CANA Advisors, 6727 Falconbridge Rd, Chapel Hill, NC, 27517, United States, wdegrange@canallc.com, Jesse McNulty, Harrison Schramm

Predicting the performance of amateur athletes at the professional level is challenging in any sport. Very few of the players get the opportunity to play professionally. In this presentation we will show the results of using machine learning and traditional techniques on a data set of over 45,000 collegiate lacrosse players that covers a three year period. The predictors are Major League Lacrosse shooting and defending data sets. Being able to connect data such as school, team strength of schedule, shooting, goal tending, and historical performance of professional players allows insight into the potential for a collegiate player's performance at an elite level.

4 - Using Machine Learning to Improve Football Play Calling Effectiveness

Jonathan David Lonski, Student, Clemson University, Clemson, SC, 29634, United States, jdlonsk@g.clemson.edu

Using past data from NCAA football games, we developed a tool that assists coaches with making in-game decisions regarding plays to call. Historical data describing the down, distance to gain a first down, field position, offensive formation, defensive front, and other key indicators. Our tool's objective is to recommend the play that has the highest expected average gain and the highest probability of achieving a first down, based on the situation and defensive formation being faced.

■ TD62

370C

Developments in Bayesian Data Analysis

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907, United States, sabbaghi@purdue.edu

1 - A Missing Data Perspective for Modeling Deformations in 3D Printed Products

Sobambo Sosina, PhD, Deloitte University, MD, United States, bambososina@gmail.com

In the past decade, additive manufacturing (AM), a layer-by-layer approach for printing 3D objects, has attracted a lot of attention from manufacturers. However, dimensional accuracy control currently poses a challenge in AM, often due to deformations resulting from phase changes in the printing material. Building on work done by Huang et al. (2015) on the minimization of deformations, we explore a missing data approach for understanding deformations, subsequently utilizing Bayesian models in the estimation of deformation, and compensation plan design for minimizing the deformation effect

2 - Designing for What's Important: Combining Bayesian and General Weighted Optimality Criteria

Jon Stallings, North Carolina State University, jwstalli@ncsu.edu

How one compares experimental designs depends heavily on the analysis goals (minimizing estimation variance, estimation bias, prediction variance, etc.). If one decides to focus on minimizing estimation variance, there is still the question of what has to be estimated and whether some effects are more important to estimate. DuMouchel and Jones (1994) tackled this issue with factorial experiments through a Bayesian framework assigning relative importance through prior variances. The Bayesian optimal design minimizes a summary of posterior variances and hence focuses on efficient estimation of effects with large prior variance. Stallings and Morgan (2015) introduced a class of general weighted optimality criteria that also allows the experimenter to assign relative importance to model effects through weighted variances. In this talk I compare the relative advantages and disadvantages of the two approaches in terms of their interpretability and utility for tailoring experiments to a researcher's goals. I then present a new criteria function that combines the two and demonstrate the resulting designs under multiple cases of different types of factorial experiments.

3 - A Bayesian Analysis of Communication Activity on Social Media Networks

Vinayak Rao, PhD, Purdue University, West Lafayette, IN, 47907, United States, varao@purdue.edu

Modeling communication activity among individuals on email, social media and citation networks is a topic of recent interest in statistics and machine learning. We examine such activity through the lens of two models: latent space models, where communication between individuals is determined by latent "interests", and reciprocal models, where this is a function of previous communication. We find both such models are inadequate for a variety of real-world communication data sets, and propose new models that address these limitations. Approaches we describe incorporate message content, include hierarchies of senders and receivers, and well as latent spaces that modulate reciprocal behavior.

4 - Automated Learning of Geometric Shape Deformation Models in Additive Manufacturing

Raquel Ferreira, Purdue University, West Lafayette, IN, 47907, United States, rdesouz@purdue.edu, Arman Sabbaghi, Qiang Huang

A major challenge in quality control for 3D printing is the specification of geometric shape deformation models. The current practice of constructing tailor-made deformation models for each combination of computer-aided design model, 3D printer, material, and machine setting, is impractical for general application. We propose an automated model building method based on extreme learning machines that does not require detailed knowledge of the underlying system. We illustrate promising benefits of our methodology for real-life case studies. Comparisons with current tailor-made models demonstrate the potential of our automated approach to yield similar results in a more systematic manner.

■ TD63

370D

Transportation, Public

Contributed Session

Chair: Nishanth Mundru, Massachusetts Institute of Technology, Operations Research Center, E40, Cambridge, MA, 02139, United States, nmundru@mit.edu

1 - Reliable Spatial Districting

Siyang Xie, U. of Illinois at Urbana-Champaign, 205 N Mathews Avenue, 3150 Newmark Lab, Urbana, IL, 61801, United States, sxie13@illinois.edu, Yanfeng Ouyang

Traditional districting problems focus on partitioning an area into districts under operational criteria, e.g., contiguity, compactness, workload balance, etc. In many real-world applications, each district is associated with a facility, thus involving additional location and assignment decisions. We develop a facility districting framework to combine the facility and districting considerations, with possible facility disruptions. We formulate the problem as a set-covering based reliable network partitioning model and design a column generation algorithm to effectively solve it. Numerical case studies are conducted to demonstrate the framework and to draw managerial insights.

2 - Electric Vehicle Routing Problem under the Limited Energy Supply

Shinichi Maeda, Osaka University, Suita, Japan, shinichi.maeda@ist.osaka-u.ac.jp, Hiroshi Morita

In recent years, the development and diffusion of Electric Vehicles have been advanced. For the delivery companies, electric vehicles are expected not only for means of transportation and delivery but also energy management systems by using vehicle storage batteries. Particularly, in cooperation with the smart grid or virtual power plant, which has recently undergone reforms, it is expected to minimize energy usage and reduce electricity bills. In this research, we will develop a delivery plan by electric vehicles according to changes in energy supply in future electric power systems.

3 - A Modern Optimization Approach for the Robust Airlift Planning Problem for the United States Transportation Command

Nishanth Mundru, Massachusetts Institute of Technology, Operations Research Center, E40, Cambridge, MA, 02139, United States, nmundru@mit.edu, Dimitris Bertsimas, Allison An Chang, Velibor Misic

The United States Transportation Command (USTRANSCOM) plans missions globally, the majority traveling by air. These missions are challenging to plan and are subject to uncertainty in travel times and cargo weights. We propose a solution approach based on local search methods, robust and mixed-integer optimization, and column generation, and show that it provides high quality solutions in practical times.

■ TD64

370E

Supervised Learning Models and Applications

Sponsored: Data Mining

Sponsored Session

Chair: Ali Dag, Ali.Dag@usd.edu

1 - A Supervised Learning Approach for Matched Case-control Study

Nooshin Shomal Zadeh, Arizona State University, Tempe, AZ, United States, nshomalz@asu.edu, Sangdi Lin, George Runger

Matched case-control study is commonly used in the field of public health to detect important variables that affect an outcome. One of the challenges in this study is to determine the relationship between the variables and the outcome in the presence of large number of variables whose interactions can affect the outcome. Another challenge is that the relationships can be nonlinear and some are difficult to model by traditional approaches. In addition, handling both numerical and categorical variables remains an important and yet difficult problem. In this research, we propose a supervised learning approach which can address these challenges and handle both categorical and numerical variables.

2 - A Novel End-to-end Deep Learning Model for Time Series Classification

Sangdi Lin, Arizona State University, AZ, United States, Sangdi.Lin@asu.edu, George Runger

Time series classification is an important task in many domains such as manufacturing and finance. It is gaining more attention in health care as the wearable devices become popular, and more health-related time series data is recorded. In this presentation, we introduce a novel deep learning model which can be generally applied to time series classification tasks in various domains. The proposed deep learning model can be trained in an end-to-end fashion without the need of the traditional exhausting feature engineering step. Our deep learning model not only produces accurate classification results, but also obtains some insights and understanding about the time series data.

3 - Predicting the Survival of Breast Cancer Patients via Supervised Machine Learning Algorithms

Eyyub Kibis, PhD, The College of Saint Rose, Albany, NY, United States, eyyubyunus@gmail.com, Esra Buyuktahtakin, Ali Dag

Breast cancer is the second leading cause of death after lung cancer in the U.S. There are many reasons that impact the life time expectancy of patients. In this study, given a set of explanatory variables that include demographics, health conditions, and cancer treatment regimens of patients, our objective is to determine patient specific survival scores ten years after the initial breast cancer diagnosis. We use data mining methods and information fusion technique to determine the key features for breast cancer survivability as well as the patient specific survival score. Our results can help practitioners for adjusting the aggressiveness of treatments based on the survival scores of patients.

■ TD65

370F

Applications in Freight Transportation and Logistics

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Hakan Yildiz, Michigan State University, Department of Supply Chain Management, 632 Bogue St., East Lansing, MI, 48824, United States, yildiz@msu.edu

1 - Reliable Synchromodal Transportation Networks

Rob A. Zuidwijk, Professor, Ports in Global Networks, Erasmus University-Rotterdam, RSM.Erasmus University, P.O. Box 1738, Rotterdam, 3000 DR, Netherlands, rzuidwijk@rsm.nl

This paper studies planning of container transport services on port hinterland networks where various transport resources are deployed in a flexible way. Two aspects receive particular attention. First, the sourcing of transport capacity to provide these services. Second, the reliability of the door-to-door services based on the reliability of the scheduled services of the various modes.

2 - Drone-assisted Delivery: A Practical Approach

Iman Dayarian, Georgia Institute of Technology, School of Industrial and Systems Engineering, 765 Ferst Dr NW, Atlanta, GA, 30318, United States, iman.dayarian@isye.gatech.edu, Martin W. P.Savelsbergh

Unmanned aerial vehicles, drones in particular, have recently seen an increased level of interest as their potential use in same-day home delivery has been promoted by large retailers and courier companies. We introduce the vehicle routing problem with drone resupply in which a delivery vehicle makes deliveries in a certain area and is regularly resupplied by a drone. Resupply can take place at specific meeting locations, where the drone will land on the roof of the delivery vehicle. We explore and compare different decision-making strategies and provide insights resulting from a comprehensive computational study.

3 - Transportation and Process Planning for Beverage Container Recycling

Hakan Yildiz, Michigan State University, Department of Supply Chain Management, 632 Bogue St., East Lansing, MI, 48824, United States, yildiz@msu.edu, Robert Wiedmer

Empty beverage containers are mostly returned to retail stores, which are then picked up and transported to processing facilities. The routes and schedules of pickup vehicles are mostly done based on forecasts, which makes this problem a variant of Vehicle Routing Problem with Stochastic Demand. We analyze data and develop methods to optimize the pick-up and processing operations.

4 - Routing and Scheduling Optimization in Road Transport Operations

Onur Can Saka, Optimization & Analytics Unit Manager, Borusan R&D, Istanbul, Turkey, osaka@borusan.com
Onur Can Saka, Optimization & Analytics Unit Manager, Koc University, Istanbul, Turkey, osaka@borusan.com, Sibel Salman

The aim of this study is to develop a methodology to optimize the daily planning of road transport operations of a third-party logistics provider. The problem is represented on a time-space network and time windows are imposed on both pick-ups and deliveries, while synchronization requirements arise at cross-docks. We propose a construction algorithm that generates routes considering predefined rules for distinct vehicle types. The resulting set of routes is then inserted into a comprehensive mixed-integer linear programming model to find the least-cost assignment of orders to routes and vehicles satisfying problem constraints. We test and validate our model using real-life data of the company.

■ TD66

371A

Best Dissertation

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Lavanya Marla, U. of Illinois at Urbana-Champaign, 104 S Mathews Avenue, Room 216E, Urbana, IL, 61801, United States, lavanyamarla@cmu.edu

1 - Best Dissertation Finalists

Halit Uster, Southern Methodist University, Dallas, TX, United States, uster@smu.edu

Finalists and winner(s) of the best dissertation award, announced in the TSL Business Meeting on Monday, will present their dissertation work.

■ TD67

371B

Design and Analysis of Experiments with Heterogeneous and Functional Responses

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Lulu Kang, Illinois Institute of Technology, Chicago, IL, 60616, United States, lkang2@iit.edu

1 - A Sequential Split-conquer-combine Approach for Gaussian Process Modeling in Computer Experiments

Ying Hung, Rutgers State University of New Jersey, 110 Frelinghuysen Road, 501 Hill Center Busch Campus, Piscataway, NJ, 08854-8019, United States, yhung@stat.rutgers.edu

Gaussian process (GP) models are widely used in the analysis of computer experiments. However, two critical issues remain unresolved. One is the computational issue in GP estimation and prediction where intensive manipulations of an n-by-n correlation matrix are required and become infeasible for large sample size n. The other is how to improve the naive plug-in predictive distribution which is known to underestimate the uncertainty. In this talk, we introduce an unified framework that can tackle both issues simultaneously. The proposed framework is demonstrated by a data center example based on tens of thousands of computer experiments generated from a computational fluid dynamic simulator.

2 - An Empirical Adjustment of the Uncertainty Quantification in Gaussian Process Modeling

Ran Yang, Northwestern University, Dept. of Industrial Engineering, Rm C230, 21, Evanston, IL, 60208, United States, ranyang2011@u.northwestern.edu, Daniel Apley

Gaussian process (GP) models is the standard surrogate models for deterministic computer response surfaces, due in part to their built-in mechanism for providing uncertainty quantification (UQ) in the form of prediction intervals on the response. However, their parameter estimation methods tend to favor good prediction at the expense of poor UQ. We develop a post-processing method that takes a fitted GP model and its training data, and empirically adjusts the built-in GP UQ so that it is in better agreement with the actual uncertainty in the predictions. We show that it substantially improves the accuracy of the UQ, especially for nonstationary response surfaces that have more complex behaviors.

3 - Practical Heteroskedastic Gaussian Process Modeling and Design for Large Simulation Experiments

Mickaël Binois, University of Chicago, Chicago, IL, United States, mbinois@uchicago.edu, Robert B. Gramacy, Michael Ludkovski

We present a unified view of likelihood based Gaussian progress regression for simulation experiments exhibiting input-dependent noise. Replication plays a key role in that context as it allows to perform inference for all parameters, bypassing full-data sized calculations. We then borrow a latent-variable idea from machine learning to address heteroskedasticity, leveraging both the computational and statistical efficiency of designs with replication. We further propose to create and sequentially enrich designs with a tunable degree of replication.

■ TD68

371C

Quality Engineering Invited Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Murat Caner Testik, Hacettepe University, Ankara, 06800, Turkey, mtestik@hacettepe.edu.tr

1 - An Economic Off-line Quality Control Approach for Unstable Production Processes

Rong Pan, Arizona State University, School of Computing Informatics & Decison Sys, P.O. Box 878809, Tempe, AZ, 85287-8809, United States, rong.pan@asu.edu, Zhenlu Chen, Lirong Cui

An economic off-line inspection/disposition approach is proposed, which incorporates manufacturing variation. This approach includes a new inspection algorithm for inspections based on cost minimization and utilizes a specified confidence level for identifying in-control items.

2 - A Discrete Spatial Model for Wafer Yield Prediction

Kaibo Wang, Tsinghua University, Department of Industrial Engineering, Tsinghua University, Beijing, 100084, China, kbwang@tsinghua.edu.cn

Yield analysis is one of the key concerns in the fabrication of semiconductor wafers. In this paper, we propose a novel discrete spatial model based on defect data on wafer maps for analyzing and predicting wafer yields at different chip locations. More specifically, based on a Bayesian framework, we propose a hierarchical generalized linear mixed model, which incorporates both global trends and spatially correlated effects to characterize wafer yields with clustered defects. Both real and simulated data are used to validate the performance of the proposed model.

3 - Charting Methods to Address Unknown Weights and Autocorrelation with Cyber Security Applications

Theodore T. Allen, Ohio State University, 210 Baker Systems, 1971 Neil Ave, Columbus, OH, 43210-1271, United States, allen.515@osu.edu

Literature relating to demerit and other multinomial charting methods is reviewed. A novel Bayesian charting method generalizing with convergence properties is introduced. Its applications to two problems in cyber security monitoring and addressing false positives are explored.

4 - ERLDAT2: X-bar Analysis Enhancements to the EWMA Run Length Distribution Analysis Tool

Hiram Moya, University of Texas, McAllen, TX, 78501, United States, hiram.moya@utrgv.edu, Douglas Timmer

ERLDAT provided quality practitioners an easy-to-use web-based tool to evaluate the on-target and off-target run length performance of the EWMA control chart. Performance metrics implement in ERLDAT included the average run length, variance of the run length and user-specified quantiles of the run length distribution. Seven options were provided to users to help design and evaluate EWMA control charts. ERLDAT2 extends the original ERLDAT application by providing the run length performance information for a comparable X-bar control chart versus EWMA control charts.

■ TD69

371D

FSS Student Paper Competition

Sponsored: Financial Services

Sponsored Session

Chair: Tim Siu-Tang Leung, University of Washington, Dept of Applied Mathematics, University of WA, Lewis Hall #202, Seattle, WA, 98195-3925, United States, timleung@uw.edu

1 - Clearinghouse Default Waterfalls: Risk-sharing, Incentives, and Systemic Risk

Allen Cheng, Columbia University, New York, NY, 10027, United States, wc2232@columbia.edu

We model the clearinghouse waterfall, explain empirical capitalization differences, and provide regulatory insights.

2 - Portfolio Construction by Mitigating Error Amplification: The Bounded-Noise Portfolio

Long Zhao, UT McCombs Business School, 2110 Speedway Stop B6500, CBA 5.334 B, Austin, TX, 78712-1277, United States, longzhao@utexas.edu

By dissecting covariance estimation error, a new portfolio achieves great performance in both simulation and real data.

3 - Default Risk Premia and a Non-Linear Asset Pricing Model

Yi Marco Zhang, University of Chicago, Booth School, Chicago, IL, United States, marco.y.zhang@chicagobooth.edu

The value of an equity investment can be framed as an embedded call option on a firm's assets, and losses given default create discontinuities in the value of these options. In this paper, we introduce a non-linear equity pricing model that includes these aspects of potential default consequences.

4 - A Dynamic Network Model of Interbank Lending

Xu Sun, Columbia University, 363 W 123rd St Apt 4R, New York, NY, 10027, United States, xs2235@columbia.edu

We develop a dynamic model of interbank borrowing and lending activities in which banks are organized into clusters, and adjust their monetary reserve levels to prescribed target. We model the transactional dynamics through a set of interacting measure-valued processes and establish the weak limit of the interacting measure-valued processes as the number of banks grows large.

■ TD70

371E

Data Mining

Contributed Session

Chair: Kyungduck Cha, SAS Institute Inc, Cary, NC, United States, Kyungduck.Cha@sas.com

1 - One-class Relaxed Support Vector Machines

Petros Xanthopoulos, Stetson University, 421 Woodland Blvd, DeLand, FL, 32723, United States, pxanthopoulos@stetson.edu, Orestis P. Panagopoulos, Athanasios A. Panagopoulos, Talayeh Razzaghi, Onur Seref

In this work, a new novelty detection method called One-Class Relaxed Support Vector Machines (ORSVMs) is proposed for datasets with outliers. ORSVMs are formulated using a quadratic loss function and are solved with sequential minimal optimization. Their performance is measured on several publicly available datasets and are compared to other state-of-the-art one-class classification methods.

2 - Lexicographic Multiobjective Programming (LMOP) Models for Feature Selection in LAD

Cui Guo, Associate Professor, Shantou University, 243 Da Xue Road,, Shantou, Guangdong Province, 515063, China, cguo@stu.edu.cn, Kedong Yan, Peihua Zhao

The bianrization step of Logical Analysis of Data(LAD) replaces each numerical attributes with a set of binary variables. This introduces large amount of binary features, which increases the complexity of subsequent pattern generation procedure. A feature selection method based on set covering was proposed to minimize the number of binary variables. In practice, however, it's also expected to reduce the number of real attributes. In this presention, we'll introduce LMOP models to select the optimal sets of variables w.r.t. to different lexicographic preferences. Theories and their proofs will be given. And the utilities of the propsed models will be demonstrated on various benchmark datasets.

3 - Classification of Intracardiac Electrogram During Atrial Fibrillation using Hidden Markov Models and Gaussian Mixture Models

Lianning Zhu, Texas Tech University, 2500 Broadway, Lubbock, TX, 79409, United States, lianning.zhu@ttu.edu, Dongping Du

This talk presents a new classification algorithm to identify electrical triggers in Atrial Fibrillation using hidden Markov models(HMM) and Gaussian mixture models(GMM). Activations of multi-lead Intracardiac Electrogram(IEGM) are detected based on the variance equality test. Wavelet transform is used to denoise and extract features to train HMMs. HMMs are developed for each lead of signal and used to calculate the log-likelihood of each activation in the IEGM. Computer simulation is performed to generate modeled IEGM for model testing and validation. The accuracy and sensitivity of this diagnosis system are relatively high.

4 - Robust Principal Component Analysis in Cloud-based Run-time Environment

Kyungduck Cha, SAS.Institute Inc, Sas Campus Drive, Cary, NC, 27513, United States, Kyungduck.Cha@sas.com, Seunghyun Kong, Zohreh Asqharzadeh, Arin Chaudhuri

Robust Principal Component Analysis (RPCA) is an enhanced statistical procedure to perform the principal component analysis in the presence of noisy data. Principal component analysis is widely used in data mining and machine learning. RPCA aims to recover a low rank matrix from grossly corrupted observations. RPCA has been applied in many areas, including image processing, latent semantic indexing, ranking and recommendations, and anomaly detection. The RPCA techniques have been implemented in SAS Viya platform, the cloud-based run-time environment for data management and analytics. We present the advantage of the distributed computing and how to use clients other than SAS, such as Python

5 - A Data Framework of Financial Deterioration Detection for Chinese Firms

Jun Huang, assistant professor, San Angelo State University, San Angelo, TX, United States, jun.huang@dusty.tamiu.edu, Haibo Wang

Firm level credit risk prediction, such as financial deterioration detection or financial distress prediction, is used to mitigate the risk of non-performing loans. The objectives of this study include: (1) Identify most efficient model in predicting the financial deterioration of Chinese firms based on different statistical and machine learning algorithms; (2) Use the model(s) to establish a warning mechanism to detect financial deterioration in an early stage; (3) Identify effective financial indicators for the prediction model by using a feature selection technique; (4) Test whether discretization of financial ratios improve the prediction performance of this classification problem.

■ TD71

371F

2:00 - 2:45 SAS/ 2:45 - 3:30 JMP, a Division of SAS

Invited: Vendor Tutorial

Invited Session

1 - Building and Solving Optimization Models with SAS

Edward P. Hughes, SAS.Institute, Inc., Sas Campus Drive, Cary, NC, 27513, United States, ed.hughes@sas.com, Rob Pratt

SAS provides a broad and deep array of data and analytic capabilities, including data integration, statistics, data and text mining, econometrics and forecasting, and operations research. The SAS optimization, simulation, and scheduling features coordinate easily and fully with other SAS strengths in data handling, analytics, and reporting. OPTMODEL from SAS provides a powerful and intuitive algebraic optimization modeling language and unified support for building and solving LP, MILP, QP, NLP, CLP, and network-oriented models. And because the OPTMODEL optimization modeling language is contained within the OPTMODEL procedure, a SAS software module, it integrates seamlessly with the entire family of SAS functions, procedures, and macros. We'll demonstrate how you can use OPTMODEL to solve both basic and advanced problems, highlighting its newer capabilities and its support for both standard and customized solution strategies.

2 - JMP Pro: Top Features That Make You Say "Wow"!

Mia L. Stephens, SAS.Institute Inc, P.O. Box 290, York Harbor, ME, 03911, United States, mia.stephens@jmp.com

JMP is data visualization, analysis and modeling software from SAS for Mac or Windows. Come see the top 10 features in JMP Pro 13 that JMP users are raving about, including Text Explorer (for preparing and analyzing unstructured text data), the JMP Query Builder (for generating queries and writing SQL code directly in JMP), the Formula Depot (for comparing predictive models, scoring new data and generating C, Python, SAS, SQL and JavaScript code), dashboards, interactive web reports, and the latest visualization techniques in the drag-and-drop Graph Builder.

■ TD72

372A

Optimization, Nonlinear Programming

Contributed Session

Chair: Ragheb Rahmaniani, Université de Montréal, Montréal, QC, Canada, Ragheb.rahmaniani@gmail.com

1 - Team Orienteering Problem with Stochastic Profits and Risk Constraints

Hadi Feyzollahi, SUNY University at Buffalo, Department of Industrial Eng., 316 Bell Hall, Buffalo, NY, 141260, United States, hadifeyz@buffalo.edu, Jose Luis Walteros

We proposed a dynamic programming approach to tackle the Team Orienteering Problem over graphs with stochastic profits and risk constraints. We study both discrete and continuous probability distributions to model the profits and test different approaches to compute their convolutions. We further presented a case study to illustrate the results.

2 - The Multiperiod Network Design Problem

Ioannis Fragkos, Rotterdam School of Management, Burg. Oudlaan 50, Rotterdam, 3062 PA, Netherlands, fragkos@rsm.nl, Jean-Francois Cordeau, Raf Jans

We devise decomposition methods to solve large-scale instances of multi-period network expansion problems. For capacitated networks, we devise a custom heuristic procedure combined with arc-based Lagrange relaxation. For uncapacitated networks, we employ Benders decomposition, where the subproblems are decomposable per period and per commodity. We formulate the problem of generating Pareto Optimal cuts, and based on structural properties of optimal solutions we devise an improve approach to solve it, thereby improving the original Benders cuts. Computational results demonstrate the efficiency of this approach.

3 - Self Charging Path Problem with Node Visiting

Dincer Konur, Missouri University of Science and Technology, 206 Emse, 600 W. 14th Street, Rolla, MO, 65409, United States, konurd@mst.edu

In this study, we analyze a shortest path problem with node visiting constraints such that the path should be self-charging. A self-charging path is defined as a path, on which the vehicle traveling charges the energy consumed on the path. This requires using wireless charging and we model integrated design and path decisions. The resulting model is a bi-objective mixed-integer programming model and we propose solution methods to generate Pareto efficient solutions after characterizing important properties of such solutions. A demonstration is also presented.

4 - A Sample Average Approximation Approach for a Network Evacuation Model with Joint Chance Constraints Considering Social Influence

Hyeong Suk Na, PhD Candidate, Pennsylvania State University, 234 Leonhard Building, University Park, PA, 16802, United States, hxn144@psu.edu, Necdet Serhat Aybat, Soundar Kumara

We consider a network evacuation problem with stochastic traffic demand, where the departure time decision-making behavior of evacuees is affected by social influence. Since it is difficult to characterize the departure behavior due to the inherent uncertainty, we study the evacuation process using the cell transmission model with joint chance constraints (JCCs). To resolve the intractability of JCCs, we adopt a sample average approximation method to handle JCCs. Numerical experiments are implemented to validate the performance of the proposed approximation method.

5 - Packages Delivery Optimization with On-demand Drivers

Farzad Daneshgar, University of Maryland, 4324 Rowalt Dr, 302, College Park, MD, 20740, United States, farzadd@umd.edu

Nowadays, purchases are made online more than ever and minimizing the delivery time is significantly essential to satisfy customers. Inspired by new innovations such as ride-hailing services, this research aims to develop a mathematical formulation to optimize packages delivery by on-demand drivers. We present a mixed-integer model to determine the scheduling for one-demand drivers by considering elements such as demand volume and operation costs.

6 - Parallel Benders Decomposition Method for Two-stage Stochastic Integer Programs

Ragheb Rahmaniani, Universite de Montreal, Pavillon Andre-Aisenst, CIRRELT, P.O. Box 6128, Montreal, QC, H3T.1J4, Canada, Ragheb.rahmaniani@gmail.com, Teodor Gabriel Crainic, Michel Gendreau, Walter Rei

In this talk, we discuss parallelization strategies for the Benders decomposition method. The existing parallel variants of the method rely heavily on the synchronization requirement between the master and subproblems. We describe an asynchronous parallel framework for this method. Relaxing the synchronization requirements, however, entails various theoretical and numerical difficulties that will be addressed in this presentation. We present numerical results and provide guidelines regarding how and when to use the proposed parallelization strategies and mention several fruitful research directions.

■ TD73

372B

Traffic Management

Contributed Session

Chair: Yuri Yatsenko, Houston Baptist University, Houston, TX, United States, yyatsenko@hbu.edu

1 - Technology Opportunity Discovery through Extracting Opinion Trigger Based on Word2Vec and Natural Language Processing (NLP)

Taeyeoun Roh, First Author, Dongguk University, Seoul, Korea, Republic of, nty92@dongguk.edu, Yujin Jeong, Byungun Yoon

Some needs cannot be satisfied in technology same as needs due to there is no specify object that must be satisfied and some object is not related to their technology fields. To solve this problem, this research proposes an approach to discovering new technology opportunity related to opinion trigger(OT). OT is defined as object that users express a feeling. First, OT and their sentimental value are defined through natural language processing and naïve base classifier. Second, OTs and patent keywords which have similar meaning in context are clustered as needs and technology related to needs based on Word2Vec. Finally, technology which can be satisfied needs is derived as technology opportunity.

2 - Investigating Knowledge Management Enablers-a Case Study

Hamdy Elwany, Professor of Industrial Engineering and Operations, Alexandria University, 678 El Horreya Ave., Louran, Aexandria, 21532, Egypt, hamdy@elwany.com

This study investigates the relationship between Knowledge Management Enablers KMEs and Knowledge Management Success KMS in Middle East and North Africa region MENA industrial companies. Data was collected through an online self-administered questionnaire from 251 respondents in several industries/business sectors in MENA region. The findings of this research proved the existence of the relationship between KMEs and KMS. Also job satisfaction can be considered as KM enabler by having a positive impact on KMS. The organizational culture has a full mediating effect on the job satisfaction and KMS, and a partial mediating effect between organizational structure and IT support.

3 - Technology Adoption in Firm Networks

Wei Zhang, University of Hong Kong, Pokfulam Road, Hong Kong, 0050, Hong Kong, zhangw.03@gmail.com

We study how firms influence each other when adopting a new technology. Using real data from the semiconductor industry and survival analysis, we show that the chance of a firm adopting a new technology is a U-shaped function of the number of firms that have adopted the technology. In addition, the adoption decision of some firms would positively influence others while some firms would negatively influence others. We use the model to predict the demand of a new technology.

4 - Patent Technical Information Retrieval System Based on Natural Language Processing

Wan Wook Ki, Postech, Pohang, Korea, Republic of, wwki86@postech.ac.kr

With the development of text mining and natural language processing technology, it became possible to extract desired technical information from the each section of the patents. In this study, we developed a system that can semantically search technical information based on machine learning that can directly help technology planning such as technical function, context, components, purpose, and fusible technology in patents. This enables user to semi-automatically search and analyze patent information, which should have relied on the know-how of existing patent and technology domain experts.

5 - Optimization of Sustainable Capital Lifetime under Environmental Uncertainty

Yuri Yatsenko, Professor, Houston Baptist University, 7502 Fondren Road, Houston, TX, 77074, United States, yyatsenko@hbu.edu, Natali Hritonenko

Serial replacement of a single capital asset is analyzed under uncertain operating cost and uncertain technological improvements. A modification of classic Economic Life method is suggested and compared to popular asset replacement approach based on real options and dynamic programming. It is shown analytically and numerically that both techniques deliver similar results when the cost volatility is small. The constructed algorithm works equally well for any age-distribution of stochastic operating cost, while the real options technique is developed for geometric and linear cost age-profiles only. The algorithm is illustrated on replacement data for medical imaging devices.

■ TD74

372C

OR and Computational Biology

Sponsored: Computing

Sponsored Session

Chair: Allen Holder, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803, United States, holder@rose-hulman.edu

1 - Modeling Cellular Metabolism as a Hypergraph Flow

Paul Brooks, Virginia Commonwealth Univ., Dept of Stat. Sci. and OR, P.O. Box 843083, Richmond, VA, 23284, United States, jpbrooks@vcu.edu

Optimization-based models of metabolism are a widely used tool in systems biology for generating predictions in medical and engineering applications. We explain how this modeling paradigm is essentially a study of flows in hypergraphs. We then demonstrate how optimal flux distributions can be decomposed into flows along pathways in a manner that enhances model interpretation. The method is applied to study the virulence of an infection-causing strain of Salmonella.

2 - Mixed-Integer Program and Heuristics for Monogamous Relationship Inference

Chun-An Chou, Northeastern University, Boston, MA, United States, ch.chou@northeastern.edu, Daehan Won, Tanja Berger-Wolf, W. Art Chaovalitwongse

In this study, we infer the relationships of parents and offspring in monogamous mating process. The inference of monogamous relationships is a NP-Hard combinatorial problem with the objective to minimize the number of parents, subject to the biological constraints (i.e., Mendelian laws). A heuristic approach is proposed to find the best monogamous parent information.

3 - Inferring New Protein Function with DEA

Allen Holder, Rose-Hulman Institute of Technology, Department of Mathematics, Terre Haute, IN, 47803, United States, holder@rose-hulman.edu

Proteins are classified into functionally similar classes called families. However, proteins probably don't have unique functionality, and hence, they likely share membership with families other than their original classification. We use a robust, inverse DEA model to help infer new functional relationships.

4 - New Density-based Optimization Formulations and Algorithms to Identify Fixations in Gaze Data

Wen Liu, Doctoral Student, Worcester Polytechnic Institute, 100 Institute Rd., Worcester, MA, 01609, United States, wliu3@wpi.edu, Andrew C.Trapp, Soussan Djamasbi

Eye tracking is an increasingly common technology with a variety of practical uses. Gaze data can be categorized into two main events: fixations, which represent attention, and saccades, which occur between fixations. We develop new optimization formulations to recover densest fixations, extending earlier work that identifies fixations using a novel density metric. We discuss related complexity results and demonstrate a polynomial-time algorithm exists if the number of fixations is apriori fixed, and very small. We conclude with encouraging computational results and insights on real data sets.

■ TD75

372D

Optimization for large-scale data analysis

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Mert Gurbuzbalaban, Rutgers University, 77 Massachusetts Avenue, Building 32, Room D632, Cambridge, MA, 02139, United States, mg1366@business.rutgers.edu

1 - Optimal Design of Efficient Rooftop Photovoltaic Arrays

Madeleine Udell, Cornell University, 207 Hoy Road, Ithaca, NY, 14850, United States, udell@cornell.edu, Alp Yurtsever, Joel Tropp, Volkan Cevher

In this talk, we consider a fundamental class of convex matrix optimization problems with low-rank solutions. We show it is possible to solve these problem using far less memory than the natural size of the decision variable when the problem data has a concise representation. Our proposed method, SketchyCGM, is the first algorithm to offer provable convergence to an optimal point with an optimal memory footprint.

2 - Large Gaps Between Cyclic Coordinate Descent and Randomized Versions

Ruoyu Sun, UIUC, 104 S Mathew Ave, Urbana, IL, 61801, United States, ruoyus@illinois.edu

A simple idea for solving large-scale computational problems is to iteratively solve smaller subproblems, which appeared in, e.g., Gauss-Seidel (G-S), Kaczmarz, coordinate descent (CD). We prove that for all these methods, there are large gaps between the deterministic cyclic versions and the randomized versions. In fact, we show an (up to) O(n^2) gap in the convergence rate for CD/G-S/Kaczmarz methods. There are examples showing cyclic CD (C-CD) can be much slower than randomized coordinate descent (R-CD), but there also exist practical examples where C-CD is faster. We show that C-CD indeed can be O(n^2) slower than R-CD in the worst case, by establishing a lower bound that matches the upper bound.

3 - Surpassing Gradient Descent Provably: A Cyclic Incremental Method with Linear Convergence Rate

Aryan Mokthari, University of Pennsylvania, 220 South 33rd Street, 107 Towne Building, Philadelphia, PA, 19104, United States, aryanm@seas.upenn.edu

The coordinate descent (CD) methods have seen a resurgence of recent interest because of their applicability in machine learning as well as large scale data analysis and superior empirical performance. CD methods have two variants, cyclic coordinate descent (CCD) and randomized coordinate descent (RCD) which are deterministic and randomized versions of the CD methods. In light of the recent results in the literature, there is the common perception that RCD always dominates CCD in terms of performance. In this paper, we provide problem classes for which CCD (or CD with any deterministic order) is provably faster than RCD in terms of asymptotic worst-case convergence.

4 - When Cyclic Coordinate Descent Beats Randomized Coordinate Descent

Mert Gurbuzbalaban, Researcher/Postdoctoral Associate, Rutgers University, Cambridge, MA, 02139, United States, mg1366@business.rutgers.edu

The coordinate descent (CD) methods have seen a resurgence of recent interest because of their applicability in machine learning as well as large scale data analysis and superior empirical performance. CD methods have two variants, cyclic coordinate descent (CCD) and randomized coordinate descent (RCD) which are deterministic and randomized versions of the CD methods. In light of the recent results in the literature, there is the common perception that RCD always dominates CCD in terms of performance. In this paper, we provide problem classes for which CCD (or CD with any deterministic order) is provably faster than RCD in terms of asymptotic worst-case convergence.

■ TD76

372E

Mixed Integer Programming with Applications

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Haochen Luo, Texas A&M University, College Station, TX, 77840, United States, hcluo@tamu.edu

1 - Chance Constrained Combinatorial Optimization with a Probability Oracle

Hao-Hsiang Wu, University of Washington, Seattle, WA, United States, hhwu2@uw.edu, Simge Kucukyavuz

A chance-constrained combinatorial optimization problem (CCOP) aims to find a minimum cost selection of binary decisions, which satisfies a constraint with high probability. Suppose that we have an oracle that can compute the probability of satisfying the constraint exactly. Using this oracle, we propose a general method for solving CCOP exactly. In addition, if CCOP is solved by a sampling-based approach, the oracle can be used as a tool for checking and fixing the feasibility of the resulting solution. To demonstrate the effectiveness of the proposed methods, we apply them to an NP-hard probabilistic set covering problem, which admits a polynomial-time exact probability oracle.

2 - Preventive Maintenance Scheduling with Shared Set-ups

Eric C. Blair, University of Florida, 25 SW 5th Terrace, Apt. 4506, Gainesville, FL, 32601, United States, ecblair@ufl.edu, Yongpei Guan

We present a formulation of a preventive maintenance scheduling problem with shared set-ups. Maintenance jobs have a time-variant interval which they must be performed within, and some jobs share set-ups, so scheduling these jobs together can reduce set-up costs. The problem is modeled as an integer program, and can be relaxed to a linear program without sacrificing integrality when excluding complicating capacity constraints. We explore and discuss approaches that can be used to generate solutions for large-scale instances of the problem with all constraints included.

3 - On Knapsack Problems Over Time

Yuri Faenza, Assistant Professor, Columbia University, 500 West 120th Street, New York, NY, 10025, United States, yf2414@columbia.edu, Igor Malinovic

The time-Invariant Incremental Knapsack problem (IIK) has been introduced by Bienstock et al. [2013] as a generalization of the classical Maximum Knapsack to a discrete multi-period setting. At each time, the capacity increases and items can be added, but not removed, from the knapsack. The goal is to maximize the sum of profits of items over all times. IIK naturally models scenarios where resources (e.g. money, labor force) augment over time in a predictable way, allowing an expansion of our portfolio. In this talk, we give algorithmic and structural results on this and, if time permits, on related problems.

4 - A Regularized Cutting Plane Algorithm for Inverse Mixed Integer Programming Problems

Vishnu Vijayaraghavan, Texas A.& M.University, 400 Nagle Street, College Station, TX, 77840, United States, vishnunitr@tamu.edu, Kiavah Kianfar, Andrew J.Schaefer

An inverse optimization problem is to minimally perturb the cost function of an optimization problem with respect to some Lp-norm, so as to make a given feasible solution the optimal one. Inverse optimization for mixed integer problems is particularly challenging. Wang (2009) proposed a cutting plane algorithm to solve inverse mixed integer problems under a weighted norm. We present an improved version of this cutting plane algorithm by regularizing the addition of more effective cutting planes. Our computational results demonstrate significant gains over the previous approach, more profoundly for problems in large dimensions.

■ TD77

372F

Optimization, Integer Programming

Contributed Session

Chair: Hyeoncheol Baik, Auburn University, Auburn, AL, United States, hbaik@auburn.edu

1 - Bundle Pricing and Inventory Planning for a Multi Products Newsvendor Problem

Nooshin Hamidian, University of Tennessee-Knoxville, 5 11Q John D. Tickle Engineering Building, 851 Neyland Dr, Apt A5, Knoxville, TN, 37996, United States, nhamidia@vols.utk.edu, Rupy Sawhney

The multi-product newsvendor problem is studied. The objective is to maximize expected revenue while both the selling prices and ordering quantities are decision variables. The demand for all products and bundles are additive stochastic and cross-elastic. The mathematical model for the problem is developed. A two-stage algorithm is proposed in order to solve the mathematical model. The proposed algorithm is based on multi-directional search and Nest Partitioning algorithm and has both methods' advantageous. Sensitivity analysis is presented to obtain managerial insights.

2 - Biased Random-key Genetic Algorithm for Balanced Edge Partitioning

Larissa P.G. Petroianu, PhD Student, University of Washington, 3900 E Stevens Way NE, Mechanical Engineering Building, Seattle, WA, 98195, United States, lpetroia@uw.edu, Mauricio G.C. Resende, Wanpracha Art Chaovalitwongse

Vertex partitioning in graphs has received more attention in the literature than edge partitioning. In this talk, we consider an edge-partitioning problem with applications in page-rank computation and delivery routing. We develop a Biased Random-Key Genetic Algorithm (BRKGA) that finds optimal or near-optimal solutions to this problem. We present experimental results, comparing our algorithm with other approaches.

3 - Automatic Design of Algorithms for Knapsack Problems

Victor Parada, Dr Sc, Universidad de Santiago de Chile, Av. Ecuador 3659, Departamento de Ingeniería Informática, Santiago, Chile, victor.parada@usach.cl

Automatic design of algorithms for combinatorial optimization problems can generate new procedures from existing heuristics. We generated algorithms for the 0-1 binary knapsack and for the multidimensional knapsack problems that efficiently and competitively solve a set of typical problem instances. The automatically constructed algorithms are generated by genetic programming as a result of exploring the heuristic combinations space.

4 - Unmanned Aircraft System Path Planning for Inspecting Electric Transmission Towers

Hyeoncheol Baik, Auburn University, 3331 Shelby Center, Auburn, AL, 36849, United States, hbaik@auburn.edu, Jorge F.Valenzuela

Electric utilities inspect transmission towers by dispatching line crews and helicopters. This method has high operation costs and safety concerns. To mitigate these issues, the utilities are using unmanned aircraft system to accomplish this task. We have developed a particle swarm optimization based algorithm to find an efficient flight route for a UAS to inspect a transmission tower. The proposed model contains three sub-objectives: to minimize the total flight distance, maximize the inspection coverage, and maximize the image resolution. We have tested our model and make recommendations for the actual use of a UAS in the field.

■ TD78

381A

Market-based Management of Future Electricity Grids

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Wolfgang Ketter, University of Cologne, Cologne, Germany, ketter@wiso.uni-koeln.de

1 - Pricing Mechanisms to Coordinate EV Charging: A Variable Charging Speed Approach

Konstantina Valogianni, Assistant Professor, IE Business School, VAT.# ES.B-82334319, Maria de Molina 13, Madrid, 28006, Spain, konstantina.valogianni@ie.edu, Wolfgang Ketter, John Collins, Gediminas Adomavicius

We present a decision support system (DSS) that coordinates electric vehicle (EV) charging. It combines the benefits of a decentralized decision making approach with a top-down control mechanism. This hybrid approach creates a less volatile aggregate power demand curve, and therefore a better match between the output of renewable energy sources and overall demand. Our mechanism is based on price signals to individual EV owners. We prove that are sufficient to motivate self-interested EV owners to approach a desired profile, given a range of user preferences. We prove the analytical properties of the mechanism in order to induce desired charging profiles and evaluate its outcome on real-world data.

2 - Risk-neutral and Risk-averse Methods for Bidding in the Energy Market

Daniel Jiang, University of Pittsburgh, Pittsburgh, PA, 15261, United States, drjiang@pitt.edu, Warren B. Powell

The talk is centered on developing optimal trading/bidding policies for the energy market in the presence of storage. In the context of this application, we describe two general methodological contributions: approximate dynamic programming for monotone value functions and for risk-averse sequential problems.

3 - Implement Real-time Pricing with Regret-based Learning Games

Zibo Zhao, PhD Candidate, Purdue University, West Lafayette, Grissom Hall, 315 N Grant Street, West Lafayette, IN, 47907, United States, zhao438@purdue.edu

The situation where price-responsive consumers determine what to do in the near future (such as when to charge their PEVs) forms a dynamic and incomplete-information game, in which the consumers' collective actions will impact electricity prices, which in turn affect their payoffs. We propose a multi-armed bandit (MAB) game framework in which each consumer plays an MAB problem to minimize the cumulative regret, as opposed to naively responding to day-ahead prices. Numerical results show very fast convergence to a steady-state of the MAB game with much reduced price volatility than the naïve-response case.

■ TD78B

380B

Technology Management

Contributed Session

Chair: Aditya Kulkarni, Virginia Tech, Blacksburg, VA, United States, aditya88@vt.edu

1 - Generating Large Size Social Networks

Xu Dong, Research Assistant, University of Miami, 1251 Memorial Drive, Coral Gables, FL, 33145, United States, x.dong3@umiami.edu, Nazrul I.Shaikh

Researchers conduct various tests on simulated social networks, because of the infeasibility of testing certain conditions (e.g. node removal, link adding, etc.) and processes (e.g. spread of diseases, opinions, influence, etc.) that take place in real-world social networks. However, the existing social network models are only able to recover small social networks with few members in it. In this work, we focus on generating large-scale networks with desired social network topologies, such that they can serve as the test beds for modeling specified social processes and activities.

2 - Blockchain for Security of Cyber Physical Systems

Leili Soltanisehat, Research Assistant, Old Dominion University, Norfolk, VA, United States, lsolt001@odu.edu

In recent decades, along with various cyber attacks to some important settings, security of cyber-physical systems (CPS) has become a challenging issue. In this paper, we are analyzing the implications of Blockchain Technology in boosting the security of CPS. General idea is that CPS will be more secure and resilient if both information and physical security are controlled. Using the concept of cryptography and decentralization, Blockchain technology enables the cyber system with a very high degree of certainty and reliability. Certainty and reliability ensure the integrity and accuracy of information.

3 - Analyzing the Economic and Environmental Impacts of Cloud Computing

Chialin Chen, Professor, National Taiwan University, College of Management, National Taiwan University, Taipei, Taiwan, cchen026@ntu.edu.tw, Xiaodan Pan

Cloud computing has fundamentally changed the way today's companies use information technology. We use Systems Dynamics to construct a simulation model to analyze the economic and environmental impacts of cloud computing. On the demand sides, we classify customers in different market segments for cloud computing, and then characterize their specific demand patterns and preferences. On the supply side, we identify different infrastructure and network costs as well as different sources of energy consumption associated with cloud computing. By observing the dynamic systems behaviors, we identify the key determinants of the economic and environmental risks and benefits of cloud computing.

4 - A Decision-theoretic Approach to Verification in Systems Engineering

Aditya Umesh Kulkarni, Virginia Tech, 250 Durham Hall, 1145 Perry Street, Blacksburg, VA, 24061, United States, aditya88@vt.edu, Christian Wernz, Alejandro Salado

Verification is a key step in the development of a complex system. Multiple decision-making agents across multiple firms are involved in verification activities. A comprehensive and rigorous mathematical framework for computing optimal verification strategies in this multi-agent and multi-firm environment has not yet been developed. We propose a new approach that builds upon principal-agent modeling, partially observable Markov decision processes and multiscale decision theory. Using this new approach, we identify incentive and information exchange mechanisms that allow for better verification at lower cost.

■ TD80

381C

Urban Operations: Towards Livable Cities

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Tim Williams, University of Michigan, Ann Arbor, MI, 48104, United States, tgw@umich.edu

Co-Chair: Tom M. Logan, University of Michigan, Ann Arbor, MI, 48109, United States, tomlogan@umich.edu

1 - The Role of Behaviour in Undermining the Effectiveness of Adaptive Measures in Reducing Long-term Vulnerability to Natural Hazards

Tom M. Logan, Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI, 48104, United States, tomlogan@umich.edu, Seth Guikema, Jeremy Bricker

How to defend the world's cities from natural hazards is the subject of intense debate. Allegedly, some adaptive measures increase vulnerability to unforeseen events. Here, we develop a cellular automaton model to quantitatively examine the effect of alternative adaptive strategies in reducing a community's risk over time when subject to repeated natural hazards (tsunamis). We find that while hard measures (sea walls) protect against expected events, they increase vulnerability to future, larger events. Actions to avert development from risk zones appear more effective. These results demonstrate hard-adaptive measures can result in maladaptation, thus challenging current practice.

2 - How Accessible Are Our Cities? A Cross-sectional Analysis of Access to Green Space

Tim G. Williams, Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI, 48104, United States, tgw@umich.edu, Tom Logan, Connie Zuo, Kevin Liberman, Seth Guikema

Adapting our cities requires us to resolve the contentious issue of social justice in service access. Green spaces provide a wide range of benefits, and their access has been subject to much analysis. However, the generalizability of many existing conclusions is limited by both scope and resolution of analysis. Here, we evaluate access to green space in multiple US cities to: a) Investigate whether systemic inequity exists across US cities; and b) Assess the sensitivity of these conclusions to measures of amenity quality. This large-scale, fine-resolution analysis incorporates uncertainty and enables us to draw enhanced insights to answer these questions, essential to designing livable cities.

3 - Using Machine Learning to Predict Building Level Waste Generation and Recycling Rates

Constantine Kontokosta, ckontokosta@nyu.edu, Boyeong Hong

New York City generates approximately 3.2 million tons of waste each year at a cost of over $1.5 billion. This paper develops a machine learning model to predict building-level waste generation at daily and weekly timescales for over 800,000 residential properties, and uses the results to evaluate the impact of incentive and regulatory measures designed to change household behavior. We use NYC Department of Sanitation daily waste collection data over eight years at the individual truck level, which account for more than 5,000,000 observations, and integrate these with weather, socioeconomic, and land use characteristics. We apply multiple approaches to validate our model output.

4 - Urban Analytics: A Case Study in Philadelphia

Shane Jensen, Wharton School, University of Pennsylvania, Philadelphia, PA, United States, stjensen@wharton.upenn.edu

Urban data analysis has been recently improved through publicly available high resolution data, allowing us to empirically investigate urban design principles of the past half century. We are currently using safety as a measure of the health of a neighborhood and exploring how it relates to local neighborhood features, including land use zoning, business locations and activity as well as economic measures and population density. I will discuss matching analyses of the relationship between vibrancy and safety and spatial modeling of the change in safety over the past decade. Philadelphia is an interesting case study for this work with its recent population growth and substantial urban development.

■ TD81

382A

Dynamic Optimization: Theory and Applications

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Vineet Goyal, Columbia University, Columbia University, New York, NY, 10027, United States, vgoyal@ieor.columbia.edu

1 - Improvement of Linear Decision Rules in Robust Optimization by Lifted Uncertainty Sets

Frans de Ruiter, Tilburg University, H.R.Holststraat 48, Tilburg, 4103 VB, Netherlands, f.j.c.t.deruiter@uvt.nl

We design a new class of nonlinear decision rules for robust optimization and approximate this class of decision rules using lifted uncertainty sets. The new decision rules on the lifted uncertainty set are linear again and strictly improve on the classical linear decision rules and existing lifting methods. We show that the resulting model with our new decision rules on the lifted uncertainty set are not more difficult from a computational standpoint than the models that use classical linear decision rules. The power of our new decision rules is shown on existing applications taken from the literature on adjustable robust optimization.

2 - Stochastic Dynamic Programming using Optimal Quantizers
Anna Timonina-Farkas, Postdoctoral Researcher, EPFL, RAO, Rue Saint-Laurent 33, Lausanne, Switzerland, anna.farkas@epfl.ch

Multi-stage stochastic optimization is a well-known quantitative tool for decision-making under uncertainty. Theoretical solution of stochastic programs can be found explicitly only in very exceptional cases due to the problems complexity. Therefore, the necessity of numerical solution arises. In this work, we deal with numerical approximation methods for the solution of multi-stage optimization problems, which enhance both accuracy and efficiency of the solution. We preserve accuracy of the estimation by the use of optimal distribution discretization techniques on scenario trees, as well as we enhance efficiency of numerical algorithms by the combination with the dynamic programming.

3 - On the Optimality of Affine Policies for Budget of Uncertainty Sets
Omar El Housni, oe2148@columbia.edu, Vineet Goiyal

The performance of affine policies for two-stage adjustable robust optimization problem under a budget of uncertainty set. This important class of uncertainty sets provide the flexibility to adjust the level of conservatism in terms of probabilistic bounds on constraint violations. The two-stage adjustable robust optimization problem is hard to approximate within a factor better than $\Omega(\log n)$ even for budget of uncertainty sets where n is the number of decision variables. We show affine policies provide the best possible approximation of $O(\log n)$ for budget of uncertainty sets. We discuss performance of affine when the uncertainty set is given by intersection of budget constraints.

■ TD82

382B

Recent Advances in Risk Averse Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Gabor Rudolf, Koc University, Koc University, Istanbul, 34450, Turkey, grudolf@ku.edu.tr

1 - Optimization with Incomplete Information About Risk Measures
Jonathan Yu-Meng Li, Telfer School of Management, University of Ottawa, 55 Laurier Avenue East, Ottawa, ON, K1N 6N5, Canada, jonathan.li@telfer.uottawa.ca, Erick Delage

New risk theories have been developed recently that formalize measures that reasonably capture ones' risk preferences. The problem, however, of applying these theories is that in reality only limited information about ones' risk preferences is available. In this talk, we present a unified framework, preference robust optimization, that allows one to apply principles established by the latest risk theory to measure risk even when the preference information is incomplete and to generate solutions that are robust in terms of one's true risk preferences. Our main result is to show that most optimization problems under uncertainty can be tractably solved even with incomplete preference information.

2 - Acceptability Pricing of Contingent Claims under Model Ambiguity using Stochastic Optimization
Martin Glanzer, PhD Student, University of Vienna, Oskar-Morgenstern-Platz 1, Vienna, 1090, Austria, martin.glanzer@univie.ac.at, Georg Ch. Pflug

Optimal bid and ask prices for contingent claims can be found by mathematical optimization. The traditional strategies find the optimal prices under the constraint that all risks are shifted to the resp. counterparty. We weaken this assumption by introducing risk (acceptability) functionals in the stochastic optimization framework. Moreover, we consider the associated ambiguity problem, where we replace the single probability model by a nonparametric set of models. We show that weakening the acceptability constraint leads to a shrinking bid-ask spread while considering model ambiguity makes it even larger. We discuss algorithmic solution methods and present some illustrative examples.

3 - A Decomposition Algorithm for ASD Risk Measure for Stochastic Programs with 0-1 Variables
Saravanan Venkatachalam, Wayne State University, 4815 Fourth St., Detroit, MI, 48377, United States, saravanan.v@wayne.edu, Lewis Ntaimo

Due to the lack of block-angular structure, stochastic programs with ASD risk measure pose computational challenges. In this talk, we propose a decomposition algorithm to ASD risk-measure and computational results are presented for a supply chain application.

4 - Optimization with Stochastic Preferences Based on a General Class of Scalarization Functions
Gabor Rudolf, Koc University, Koc University, Istanbul, 34450, Turkey, grudolf@ku.edu.tr, Nilay Noyan

We consider problems where a decision leads to multiple uncertain outcomes, and decision makers' preferences are incorporated via risk measures or via dominance constraints. Scalarization functions are a common tool to combine multiple outcomes. While the stochastic multi-objective literature largely relies on linear scalarization, a variety of other functions are used in deterministic settings. We incorporate a general class of scalarizations into multi-criteria decision models with stochastic preference constraints, and develop a theoretical background along with tractable solution methods.

■ TD83

382C

Optimization, Robust

Contributed Session

Chair: Shunichi Ohmori, Waseda University, Tokyo, Japan, ohmori0406@gmail.com

1 - A Robust Optimization Approach in Dynamic Pricing with Online Demand Learning
Maryam Zokaeinikoo, Graduate Research Assistant, Pennsylvania State University, Department of Industrial and Manufacturing Engineering, 364 Leonhard Building, University Park, State College, PA, 16802, United States, mzz30@psu.edu, Janis Terpenny, Tao Yao, Xue Wang

We consider dynamic pricing problem in revenue management where the goal is to maximize revenue from multiple products with limited inventory over a finite time horizon. The demand function is unknown and should be learned from the sales data. We can formulate this problem as a multi-armed bandit problem to address the challenge of exploration-exploitation tradeoff. Through exploration, the retailer attempts to learn the demand at different prices and set a price that maximizes revenue over the remainder of the selling season (exploitation). We use robust optimization in this problem and show that the regret bound achieves near optimal performance compared to an oracle that knows all the parameters.

2 - Many-objective Evolutionary Approach to Scenario-based Optimization Problems
Hayrullah Mert Sahinkoc, Bogazici University, Istanbul, Turkey, hmertsahinkoc@gmail.com, Umit Bilge

We propose to approach optimization problems under scenario-based uncertainty by transforming them into multi-objective optimization problems where each scenario is considered as a separate objective. Solving the multi-objective counterpart provides optimal solutions with respect to different robust performance measures in a Pareto optimal set. To overcome the challenges posed by more than three scenarios, we resort to an emerging research area called many-objective optimization. The proposed many-objective evolutionary algorithm strategically combines several features and yields promising results on scenario-based 0-1 Knapsack problem compared to a set of existing algorithms.

3 - Optimization Problem for the Most Robust Preference
Jian Hu, Assistant Professor, University of Michigan-Dearborn, 4901 Evergreen Rd., Dept. of IMSE,, Dearborn, MI, 48128, United States, jianhu@umich.edu

We propose an optimal model with most robust preference. This problem is to seek a valid option most robustly preferable to benchmark. We develop an approximation approach based on Bernstein polynomials, and a cut-generation algorithm to solve the approximation problem. A financial portfolio investment problem has been used to illustrate the effectiveness of this model.

4 - A Heuristic Method for Stochastic Optimization
Shunichi Ohmori, Assistant Professor, Waseda University, Room 0903A, Okubo 3-4-1, Shinjuku, Tokyo, Japan, ohmori0406@gmail.com

We studied stochastic non-convex optimization problem. We proposed an analysis framework using stochastic dynamical system and analyze stability of algorithm. By doing so, we can adjust the balance between diversification and convergence.

■ TD84

GB Prefunction Area

Joint session RAS/Practice: RAS Poster Session

Sponsored: Railway Applications

Sponsored Session

Chair: Andy Yoon, Norfolk Southern Corporation, Suwanee, GA, 30024, United States, andy.yoon@nscorp.com

1 - RAS Poster Session

Andy Yoon, Norfolk Southern Corporation, 867 Village Manor Pl, Suwanee, GA, 30024, United States, andy.yoon@nscorp.com

The RAS poster session provides an interactive way to share knowledge and state-of-the-art research in railroad applications. Poster presenters will have the opportunity to show case research or projects that are at early stages of development, and benefit from the interactive critique, suggestions, and encouragement from colleagues working in the area of railroad business analytics and optimization.

Tuesday, 3:40 - 4:30PM

■ Tuesday Keynote

GBCC- General Assembly A, Level 3

Keynote: Edelman Reprise

Invited Session

Chair: Carrie Beam, Carrie Beam Consulting, 200 Gregory Lane, Suite B-203, Pleasant Hill, CA, 94523, United States, carrie@carriebeamconsulting.com

1 - Revenue Management Delivers Significant Revenue Lift for Holiday Retirement

Ahmet Kuyumcu, Prorize, LLC, Atlanta, GA, United States, akuyumcu@prorize.com

Revenue Management (RM) is a business discipline leveraging management science and information technology to drive bottom-line profitability. Holiday Retirement (Holiday) is the largest private owner and operator of independent living communities for seniors in the United States with over $1 billion annual revenue. Holiday partnered with Prorize LLC to change its pricing process completely using advanced revenue management (RM) algorithms starting 2011. Since it fully deployed the state-of-the-art system in 2014, Holiday has increased its revenue from new rentals by $88 million, or approximately 9 percent.

■ Tuesday Keynote

GBCC- Grand Ballroom B, Level 3

Keynote: Looking to the Future by Celebrating the Past: Operations Research and Revenue Management in the Travel Industry

Invited: Keynote

Invited Session

1 - Looking to the Future by Celebrating the Past

Andy Boyd, University of Houston

Poker has been a challenge problem in game theory, OR, and AI for decades. No program had been able to beat top players in large poker games. In January 2017, our AI, Libratus, beat a team of four top specialist pros in the main benchmark, heads-up no-limit Texas hold'em, which has 10^161 decision points. Libratus is powered by new algorithms in each of its three main modules:1) computing approximate Nash equilibrium strategies before the event, 2) endgame solving during play, and 3) fixing its own strategy to play even closer to equilibrium based on what holes the opponents have been able to identify and exploit. The algorithms are domain-independent and have applicability to a variety of imperfect-information games such as negotiation, strategic pricing, cybersecurity, auctions, finance, and steering biological adaptation and evolution (e.g., for medical treatment planning). Joint work with my PhD student Noam Brown.

■ Tuesday Keynote

GBCC- General Assembly C, Level 3

Keynote: Super-Human Strategic Reasoning: Libratus Beats Top Pros in Heads-Up No-Limit Texas Hold'em

Invited: Keynote

Invited Session

1 - Super-Human Strategic Reasoning

Tuomas Sandholm, Carnegie Mellon

Poker has been a challenge problem in game theory, OR, and AI for decades. No program had been able to beat top players in large poker games. In January 2017, our AI, Libratus, beat a team of four top specialist pros in the main benchmark, heads-up no-limit Texas hold'em, which has 10^161 decision points. Libratus is powered by new algorithms in each of its three main modules:1) computing approximate Nash equilibrium strategies before the event, 2) endgame solving during play, and 3) fixing its own strategy to play even closer to equilibrium based on what holes the opponents have been able to identify and exploit. The algorithms are domain-independent and have applicability to a variety of imperfect-information games such as negotiation, strategic pricing, cybersecurity, auctions, finance, and steering biological adaptation and evolution (e.g., for medical treatment planning). Joint work with my PhD student Noam Brown.

■ Tuesday Keynote

GBCC- General Assembly B, Level 3

Keynote: Optimization and Analytics Applications in the Oil and Gas Industry

Invited: Keynote

Invited Session

1 - Optimization and Analytics Applications in the Oil and Gas Industry

Cassandra McZeal, Exxon-Mobil

The oil and gas industry is going through transformational times as reflected in the shale revolution, the gradual increase of the use of non-renewables, the recent drop in the oil prices, and the increasing efficiency in energy uses. With such changes, the industry is faced with several challenges in achieving its goals of efficient and environmentally responsible operations, production optimization, and capital cost reduction. The oil and gas industry is often divided into three sectors: upstream, midstream and downstream. The upstream is mainly focused on activities related to the exploration and production of hydrocarbons. Such activities include searching for subsurface accumulation of hydrocarbons, drilling wells, and the production of those resources. On the other hand, the downstream sector is mainly concerned with the conversion of produced raw hydrocarbons into useful and useable products. Downstream activities include refining of petroleum crude oil, the processing of natural gas, and the distribution of refined products, such as gasoline, jet fuel, diesel oil, heating oil, fuel oils, lubricants, and many other petrochemicals products. The midstream sector comprises the transportation, storage, and marketing of crude oil, refined petroleum products, natural gas and petrochemicals. Transportation and logistics for the various products are carried out through a variety of modes including pipelines, rail, barges, oil tankers and trucks. Optimization and analytics technologies are currently playing a vital role in enabling the oil and gas industry to achieve the above objectives. In this talk, I will review selective applications of optimization technology in the Oil and Gas Sector with focus on problem modeling and algorithmic development in all three sectors.

■ Tuesday Keynote

GBCC- Grand Ballroom A, Level 3

2017 Daniel Wagner Prize Winner

Invited: Keynote

Invited Session

1 - 2017 Daniel Wagner Prize Winner

The Daniel H. Wagner Prize is awarded for a paper and presentation that describe a real-world, successful application of operations research or advanced analytics. The prize criteria emphasize innovative, elegant mathematical modeling and clear exposition. The competition sessions will be held Monday, October 23, in the George R. Brown Convention Center, Room 352E beginning at 11am.

Tuesday, 4:35 - 6:05PM

■ TE01

310A

Judgments and Forecasting

Sponsored: Decision Analysis

Sponsored Session

Chair: Kenneth Nguyen, University of Southern California, 8211 Somers Drive, Anaheim, CA, 92841, United States, hoangdun@usc.edu

1 - Comparing Verbal and Numeric Forecasts: New Findings and Implications

Kenneth Nguyen, University of Southern California, 8211 Somers Drive, Anaheim, CA, 92804, United States, hoangdun@usc.edu, Richard S.John

This research compares verbal and numeric forecasts of subjective probability estimates. A sample of 118 NFL football experts was recruited to participate in the study. The experts were randomized into one of the two experimental conditions that differ in the modes of the response scale. Verbal responses were later transformed into numbers using a method based on Savage's conceptualization of subjective probabilities. Results showed that verbal forecasts were not statistically significant from numerical predictions in terms of the overall accuracy. However, numerical judgments were more discriminatory and more biased than verbal judgments.

2 - Quantifying the Accuracy of Subjective Probability Estimates: A Meta-analysis

Kenneth Nguyen, University of Southern California, 8211 Somers Drive, Anaheim, CA, 92804, United States, hoangdun@usc.edu, Matthew Baucum, Richard S. John

We attempted to address the question whether subjective probability estimates are actually better than random guesses, and explored the effects of various methodological and substantive factors. A comprehensive database search returned 466 records, and 84 of these met the study's inclusion criteria. Preliminary data analyses suggest that subjective probability estimates were better than chance. In addition, experts' judgments were significantly better than laypeople's judgments. Yet, there was remained large heterogeneity in the effect size, suggesting the roles of other moderators beyond expertise. Data analyses are ongoing, and a full report is expected by September.

3 - The One Man Show: the Connection Between Overconfidence and Joint Decision-making

Dominik Piehlmaier, Doctoral Student, University of Wisconsin-Madison, 1300 Linden Dr, Madison, WI, 53706, United States, piehlmaier@wisc.edu, Dee Warmath, Cliff Robb

Verbal and nonverbal interactions as well as social networks enable humans to profit from the knowledge and skills of others (Harvey and Fischer, 1997). Advice seeking and taking are integral parts of such interactions and help to increase calibration in one's decision-making process (See et al., 2011). This study explores the connection between shared decision-making and overconfidence. We draw from a dataset of 2,000 investors (45 % female) and find that individuals who include household members and/or financial advisors in their investment decisions are significantly more calibrated in their financial judgments and less overconfident in terms of monetary expectations towards future growth.

4 - Judgement Error in Lottery Play: When the Hot Hand Meets the Gambler's Fallacy

Qingxia Kong, Assistant Professor, Erasmus University, Rotterdam, Netherlands, q.kong@rsm.nl, Chung-Piaw Teo, Nicolas Lambert

We use two sets of naturally occurred data to show that both the gambler's fallacy and hot-hand fallacy can exist in lottery games. The existence of hot-hand fallacy is surprising, as previous works have documented instead the presence of an opposite effect, the gambler's fallacy, in the US lottery market. Some literature also suggest that gambler's fallacy prevails when random numbers are generated by mechanical devices such as in lottery games. We show that our empirical findings are consistent with the classical optimal Bayesian learning model, which allows us to investigate some conditions in the lottery game design that determine which phenomenon will dominate.

■ TE02

310B

Decision Analysis, Game Theory, Homeland Security, and Disaster Management, Part II

Sponsored: Decision Analysis

Sponsored Session

Chair: Jun Zhuang, University at Buffalo, SUNY, Buffalo, NY, 14260, United States, jzhuang@buffalo.edu

1 - Mapping Terrorist Networks with Graphical Databases

Alexander Gutfraind, Uptake, Inc., 600 W. Chicago Avenue, Chicago, IN, 60654, United States, sasha.gutfraind@uptake.com

Open datasets about terrorist networks are scarce, small, and frequently suffer from incomplete data. To address this problem, we developed a system for recording data on terrorist events based on open media sources using graphical databases, and applied it to ISIS networks in Europe. We found robust differences between covert ISIS networks and Al-Qaida's networks from the earlier generation of Islamist terrorism. We suggest that graphical databases promise to enable more robust and reproducible analysis of covert networks.

2 - Evaluating the Resilience of Subway Systems under Simulated Attacks

Jose Emmanuel Ramirez-Marquez, Stevens Institute of Technology, Castle Point on Hudson, School of Systems & Enterprises, Hoboken, NJ, 07030, United States, jmarquez@stevens.edu, Gabriela Noemi Gongora Svartzman

After the attacks on 9/11 the government of USA took extra effort into tracking potential terrorist threats to their country. Around the world public transportation systems have been a popular target for terrorists. This work shows the effect of a possible attack on the subway system of NYC, measuring alternatives and resilience of the system itself. The stages of resilience measured include the reliability of the system before an attack, the vulnerability and adaptability after an event. The data is drawn from daily crimes reported at subway stations, inflows and outflows, and census data. A discrete event simulation of the subway system is modeled and used to evaluate an attack on the subway.

3 - Decision Analytic Techniques in Practice for Homeland Security Problems

Julia A. Phillips, Argonne National Laboratory, Oswego, IL, United States, phillipsj@anl.gov

This discussion presents an overview of decision analytic techniques that have been deployed for use in the homeland security and resilience operational space. This dialogue will also cover several tools that are currently in use based off these decision analytic techniques.

4 - Deductible-based Public Assistance Program

Allison C. Reilly, Assistant Professor, University of Maryland, College Park, MD, United States, areilly2@umd.edu, Gina Tonn, Seth Guikema, Hamed Ghaedi

Recently, FEMA proposed establishing a deductible-based approach for its Public Assistance (PA) Program. The new rule is designed to encourage States to engage in pre-disaster planning and mitigation by offering targeted reductions to their deductible. This change represents a seismic shift in how post-disaster money is allocated and has the potential to change the hazard environment. This talk will review the proposed rule and discuss how States should best respond given different objectives.

5 - Staying Ahead of the Game: Adaptive Robust Optimization for Dynamic Allocation of Threat Screening Resources

Sara McCarthy, University of Southern California, Los Angeles, CA, United States, saramarm@usc.edu, Phebe T. Vayanos, Milind Tambe

We consider the problem of dynamically allocating screening resources at checkpoints to successfully avert an attack. Previous work in this area operates under the unrealistic assumption that screenee arrival times are perfectly known. We thus propose a novel framework that explicitly accounts for uncertainty in arrival times. We model the problem as a multistage robust optimization problem and propose a tractable solution approach using compact linear decision rules combined with robust reformulation and constraint randomization. We show that our approach is scalable and outperforms previous state of the art in terms of both feasibility and optimality.

■ TE03

310C

Competition in Multi-Echelon Systems

Invited: Tutorial

Invited Session

1 - Competition in Multi-Echelon Systems

Awi Federgruen, Columbia University, New York, NY, United States, af7@gsb.columbia.edu

Around the start of this new millennium, scholars in the operations management/operations research field started to make important contributions to the study of price competition models. In this tutorial, we review these contributions, and partition them into five broad areas. Most of the tutorial is devoted to the last and most recent category: price competition models for multi-echelon supply chains with an arbitrary number of competing firms and products at each echelon.

■ TE03A

Grand Ballroom A

Joint Session APS/SIM:Simulation and Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Shane Henderson, Cornell University, Ithaca, NY, 14853, United States, sgh9@cornell.edu

1 - High Volume Traffic Modeling: Simulation and Statistics

Zeyu Zheng, Stanford University, 94 Thoburn Ct. 110#, Stanford, CA, 94305, United States, zyzheng@stanford.edu, Peter W. Glynn

Many service system applications require the ability to adequately model and statistically characterize high volume traffic. Most prior work with focus at the inter-arrival time scale may fail to identify non-stationarities, correlations and non-Poisson behavior that may only manifest over longer time scales. Existing limit theory shows that system performance is primarily affected by arrival behavior over time scales that are at the order of service time. We develop a "top-down" modeling toolbox to capture the statistical characteristics of incoming traffic that have a primary impact on performance. This talk describes our modeling perspectives and tools. This work is joint with Peter Glynn.

2 - Robust Multivariate Extreme Event Analysis

Xinyu Zhang, Columbia University, New York, NY, United States, xz2691@columbia.edu, Henry Lam

We discuss an approach to estimate extremal quantities from data under multivariate settings, based on estimated marginal information such as density estimates and tail probability masses, and conjectured geometric constraints such as monotonicity and convexity that aim to reduce estimation conservativeness. The approach utilizes optimization over probability distributions to obtain extremal bounds with statistical confidence guarantees. We discuss our solution techniques that generalize some classical mixture representations for convex sets of probability measures, and the implications of our results in rare-event simulation.

3 - Combined Acceptance-rejection and Importance Sampling Methodologies for Perfect Sampling from Gibbs Point Processes

Sarat B. Moka, Visiting Fellow, Tata Institute of Fundamental Research, HB Raod, Colaba, Mumbai, 400005, India, sarathmoka@gmail.com, Sandeep Juneja, Michel Mandjes

We consider generating perfect samples from spatial Gibbs processes and associated unbiased estimation problem. Traditionally, the former problem is addressed using coupling from the past based methods. We focus on acceptance-rejection with and without importance sampling for generating perfect samples. We illustrate the efficacy of proposed methods relative to existing ones in a simpler setting of hard sphere models that we analyze in asymptotic regime where the number of spheres generated increases to infinity while the sphere radius decreases to zero at varying rates. Our analysis identifies the large deviations rates of no overlap probability of spheres when centers form a Poisson process.

4 - Estimating the Probability that a Function Observed with (simulation) Noise is Convex

Shane Henderson, Cornell University, School of ORIE 230 Rhodes Hall, Cornell University, Ithaca, NY, 14853, United States, sgh9@cornell.edu, Nanjing Jian

Consider a real-valued function that can only be observed with stochastic simulation noise at a finite set of design points. We wish to determine whether there exists a convex function that goes through the true function values at the design points. We develop an asymptotically consistent Bayesian sequential sampling procedure that estimates the posterior probability of this being true. In each iteration, the posterior probability of convexity is estimated using Monte Carlo simulation. Of 3 variance reduction methods — change of measure, acceptance-rejection, and conditional Monte Carlo, numerical experiments suggest that conditional Monte Carlo should be preferred.

■ TE03B

Grand Ballroom B

Choice Models and Assortments

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Sumit Kunnumkal, Indian School of Business, Hyderabad, 500032, India, sumit_kunnumkal@isb.edu

1 - Learning to Rank an Assortment of Products

Kris Johnson Ferreira, Harvard Business School, Morgan Hall 492, Boston, MA, 02163, United States, kferreira@hbs.edu, Shreyas Sekar

A large product variety makes it impractical for consumers to browse all products before purchasing, making product ranking an important decision. Best practice is to rank products in decreasing order of popularity. However, its optimality assumes that consumers know their expected utility for all products a priori. When this assumption does not hold, consumers must form an expectation of their utility of unseen products. We identify the optimal product ranking in light of this and propose and test an online algorithm that learns consumer preferences and converges to the optimal ranking.

2 - Relating the Fixed Cost and Space Constrained Assortment Problems

Jacob Feldman, Olin Business School, United States, jbfeldman@wustl.edu, Alice J.Paul

In the assortment optimization problem, a retailer seeks the revenue maximizing set of products to offer to each arriving customer. In effort to make the problem more realistic, there have been a number of extensions to this classic version. For example, the space constrained assortment problem places a limit on the total space consumed by the set of offered products. The fixed cost assortment problem associates a stocking cost with each offered product. Combinatorially, the two problems are drastically different, however, in both problems, there is a "penalty" of sorts for offering a product. The goal of this research is to link the two problems.

3 - Assortment Optimization with Product Costs and Constraints

Sumit Kunnumkal, Queen's University, 465 Goodes Hall, Kingston, ON, K7L2G8, Canada, sk162@queensu.ca, Victor Martinez de Albeniz

We consider the assortment optimization problem under the MNL model with product fixed costs and constraints. We propose a new method to obtain an upper bound on the optimal expected profit. We show that our method is tractable and has provable performance guarantees for some common types of assortment constraints.

■ TE03C

Grand Ballroom C

Empirical Operations Management

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Eduard Calvo, ecalvo@iese.edu

Co-Chair: Weiming Zhu, IESE Business School, Avenida Pearson 21, Barcelona, 08034, Spain, zhuwm923@gmail.com

1 - The Incentive Game under Target Effects: Evidence from the Ride Sharing Market

Liu Ming, University of Maryland, 9530 Baltimore Avenue, Apt 603B, College Park, MD, 20740, United States, mldshg@gmail.com, Xirong Chen, Zheng Li, Weiming Zhu

Ride sharing platforms usually provide monetary incentives to keep registered drivers active. To theoretically and empirically analyze the incentive game under target effect, we model platform's bonus scheme and driver's working hours at equilibrium. We derive theoretically how driver's target effects shape their willingness to drive. We then structurally probe the existence of target effect and derive the optimal bonus strategy.

2 - A Computer Plays the Beer Game: A Deep Reinforcement Learning Algorithm for Inventory Optimization

Lawrence V. Snyder, Lehigh University, Mohler Lab 200 West Packer Avenue, Bethlehem, PA, 18015-1582, United States, lvs2@lehigh.edu, Afshin Oroojlooy Jadid, Mohammadreza Nazari, Martin Takac

We propose an algorithm to play the beer game with "teammates" that are humans or other algorithms. The beer game is a multi-agent serial supply chain in which agents attempt to minimize network cost while each agent only observes its local information. We develop a Deep Q-Network algorithm to solve this problem. We show that our algorithm outperforms approaches from literature and unlike the majority of them does not impose restrictions on the problem parameters, and also provides good solutions even if other agents do not follow rational policies. The algorithm can be extended to any decentralized multi-agent cooperative game with partial information, which is a common situation in supply chains.

3 - Stress on Operational Risk: Empirical Evidence from Commercial Bank

Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, United States, lillian.xyq@gmail.com, Fangyun Tan, Serguei Netessine

Operational risk is now one of the three most important risks in the financial services industry. This paper studies how workload affects bank operational risk events frequency and severity. To achieve this goal, we use a unique operational risk event data set from a commercial bank that contains 1441 operational risk events in two years. We find that workload has a U-shape impact on operational risk frequency. We then proceed to discuss bank capital allocation on staffing level among branches so as to reduce operational risk losses. We compare our optimal staffing policy with bank's original policy with both in-sample and out-of-sample studies.

■ TE04

320A

Renewable Energy and Energy Efficiency

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: afak Yücel, safak.yucel@georgetown.edu

1 - Business Models for Off-Grid Energy Access at theBottom of the Pyramid

Bhavani Shanker Uppari, INSEAD, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, BhavaniShanker.Uppari@insead.edu, Ioana Popescu, Serguei Netessine

One in every five people people does not have access to electricity, relying mostly on kerosene for light. Solar technologies are healthier and offer greater value, yet they require significant one-time investments which are not affordable to people living on 2 USD per day. Even though cheaper rechargeable lighting technologies are available, their adoption is low and some consumers still use kerosene. We develop a consumer behavior model that accounts for income variability and liquidity constraints specific to impoverished markets, and investigate alternative business models, based on a case study in Rwanda.

2 - Investments in Renewable and Conventional Sources: The Role of Operational Flexibility

Safak Yucel, Georgetown University, Georgetown University, 3700 O St. NW, 523 Hariri Building, Washington, DC, 20057, United States, safak.yucel@georgetown.edu, Gurhan Kok, Kevin Shang

We study capacity investments of a utility firm in renewable and conventional energy sources with different levels of operational flexibility, i.e., the ability to quickly ramp up or down the output of a generator. We consider supply characteristics of conventional and renewable sources and derive the optimal capacity investment portfolio. We find that inflexible sources (e.g., nuclear energy) and renewables are substitutes; flexible sources (e.g., natural gas) and renewables are complements.

3 - Utility Ownership of Decentralized Combined Heat and Power

Eric Webb, PhD Student, Indiana University, 2915 W. Winterberry Ct., Bloomington, IN, 47404, United States, eric.michael.webb@gmail.com, Owen Wu, Gilvan Souza

Combined heat and power (CHP) plants generate electricity and capture excess heat for space heating, water heating, or industrial processes. CHP plants reach 70-80% efficiency, improving on the 40-50% efficiency of natural gas combined cycle or the 30-35% efficiency of coal. A CHP plant, located at a firm with large heating needs, may provide reliability benefits by continuing to operate during a grid outage. Despite these benefits, CHP plants are rarely owned by utilities in the United States. We study the economics of utility ownership of CHP, determining when it is valuable to the utility, to the on-site firm, and to society. We examine which regulatory policies encourage CHP ownership by utilities.

4 - Strategic Forward Trading and Technology

Heikki Peura, Imperial College Business School, South Kensington Campus, London, SW7 2AZ, United Kingdom, h.peura@imperial.ac.uk, Derek W. Bunn

Motivated by the electricity industry's transition towards renewable power, we analyze how operational factors of production, such as its flexibility and reliability, can influence market prices indirectly through altering the balance of spot and forward trading. We show, for example, that increasing the capacity of intermittent renewable electricity generation, despite its lower marginal production cost, may not necessarily reduce power prices.

■ TE05

320B

Data-Driven and Dynamic Decision-Making for Healthcare Policies

Sponsored: Health Applications

Sponsored Session

Chair: Alireza Boloori, Arizona State University, Tempe, AZ, 85283, United States, aboloori@asu.edu

1 - Optimal Scheduling of Medical Diagnostics

Arkajyoti Roy, Northwestern University, Evanston, IL, 60208-3119, United States, aroy@bgsu.edu, Omid Nohadani

In medical decision making, clinical information on patient is collected from a history or physical examinations. To refine and to track the progression of care, often one or more diagnostic tests are conducted during the treatment. The timing of these tests affects the understanding and influences the efficacy of decisions. In this work, we provide a framework for optimal schedules via robust optimization by modeling an evolving uncertainty set in time. We apply the approach to cancer radiation therapy. The findings are general and relevant to a broad range of applications, e.g., maintenance scheduling.

2 - Using a Branch-and-bound Scheme with Multi-fidelity Models to Optimize Hepatitis C Screening and Treatment Policies under a Budget Constraint

TingYu Ho, University of Washington, Industrial and Systems Engineering, Box 352650, Seattle, WA, 98195-2650, United States, tyhotw@uw.edu, Shan Liu, Zelda B.Zabinsky

We propose an efficient algorithm for Hepatitis C (HCV) screening and treatment allocation problem with disease progression, budget constraint, and population evolution. We first present a low fidelity model by approximating future disease progression with a stationary Markov model. We then design a combined rollout algorithm embedding the low fidelity model into a high fidelity model with disease progression to efficiently identify a good incumbent policy. Lastly, we incorporate the incumbent and a theoretical upper bound into a branch-and-bound scheme.

3 - Optimal Breast Cancer Diagnostic Decisions Based on Disease Subtypes to Reduce Overdiagnosis

Sait Tunc, University of Chicago, Chicago, IL, United States, sait.tunc@chicagobooth.edu, Oguzhan Alagoz, Elizabeth S. Burnside

Mammography, which reduces breast cancer mortality, has several negative effects such as overdiagnosis. Overdiagnosis may be reduced if indolent breast cancer subtypes can be identified and followed with noninvasive imaging. We develop a large-scale MDP to optimize the post-mammography diagnostic decisions based on disease subtypes. We present an efficient and easily implementable algorithm to find the exact optimal solution. We reduce the computational complexity of the algorithm by obtaining feasible upper bounds for the optimal decision thresholds using dimension reduction.

4 - Operational Policy Recommendations for Treatment Protocol Restrictions at a County Hospital: A Process-based Case Study

Olga Bountali, Southern Methodist University, 4210 Fairmount Street, Apartment 3063, Dallas, TX, 75219, United States, obountali@smu.edu, Farnaz Nourbakhsh, Sila Cetinkaya, Vishal Ahuja

County hospitals serving the indigent are subject to treatment protocol restrictions under which the uninsured are admitted only if the patient's clinical condition is evaluated as life threatening. The underlying goal of such restrictions is improved oversight and efficiency. Motivated by clinical observations, we present a process-based case study and offer analytical and numerical results for a comparative analysis of the impact of protocol restrictions on patient- and systems-level metrics. Counterintuitive to the common belief, protocol restrictions may be myopic.

5 - Data-driven Management of Post-transplant Medications: An APOMDP Approach

Alireza Boloori, Arizona State University, 505 W. Baseline Rd, Apt 2158, Tempe, AZ, 85283, United States, aboloori@asu.edu, Soroush Saghafian, Harini A. Chakkera, Curtiss B. Cook

Patients after organ transplantations receive high amounts of immunosuppressive drugs (e.g., tacrolimus) to reduce the risk of organ rejection. However, this practice has been shown to increase the risk of New-Onset Diabetes After Transplantation (NODAT). We propose an ambiguous POMDP framework to generate effective medication management strategies for tacrolimus and insulin. Our approach increases the patient's quality of life while reducing the effect of transition probability estimation errors. We also provide several managerial and medical implications for policy makers and physicians.

■ TE06

320C

Kidney Exchange

Sponsored: Health Applications

Sponsored Session

Chair: Burhaneddin Sandikci, University of Chicago, Chicago, IL, 60637, United States, burhan@chicagobooth.edu

1 - Incentives in Kidney Exchange

Itai Ashlagi, Stanford University, Department of Management Sci. and Engr., Stanford, CA, 94305, United States, iashlagi@stanford.edu

We provide empirical evidence for the inefficiency resulting in the current kidney exchange marketplace in the US and propose a novel mechanism that can implement the first best in equilibrium.

2 - Operation Frames and Clubs in Kidney Exchange

Tuomas W. Sandholm, Carnegie Mellon University, Gates Center for Computer Science, Pittsburgh, PA, 15213, United States, sandholm@cs.cmu.edu, Gabriele Farina, John Dickerson

Kidney exchanges use 2-cycles, 3-cycles, and chains. We propose generalizations. We allow more than one donation in exchange for an organ. We also support a donor willing to donate if any of a number of patients receive organs. We generalize these notions to organ clubs that are willing to donate outside if the club receives organs from outside according to specifications. We introduce operation frames for sequencing operations across batches. We present IP formulations for the clearing problems for these exchanges. Experimentally, in the single-donation setting, operation frames improve planning by 34%-51%. Allowing up to two donors to donate in exchange for an organ increases welfare further.

3 - A Non-asymptotic Approach to Analyzing Kidney Exchange Graphs

Christopher Ryan, University of Chicago, 5807 S Woodlawn Ave, Chicago, IL, 60637, United States, chris.ryan@chicagobooth.edu, Yichuan Ding, Dongdong Ge, Simai He

We propose a novel methodology to study kidney exchange. Taking the random graph model of kidney exchange introduced in Ashlagi, Gamarnik, Rees and Roth (2012), we propose a non-asymptotic approach based on a two-phase procedure where random walks are used to allocate chains, followed by allocation in cycles. Random walks preserve the probabilistic structure of residual graphs, greatly facilitating analysis. Our results complement previous findings in large (limit) graphs and also shows how prioritizing chains over easy-to-transplant cycles improves performance and we provide analytical bounds on the associated benefits.

4 - Matching and Thickness in Dynamic Markets

Maximilien Burq, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States, mburq@mit.edu, Vahideh Manshadi, Itai Ashlagi, Patrick Jaillet

We study dynamic matching in an infinite-horizon stochastic networked market, in which some agents are a priori more difficult to match than others. Agents can match either bilaterally or indirectly through chains. We study the effect of varying the composition of the market. Counter-intuitively, we show that increasing the market size does not always result in less waiting for hard-to-match agents. We also provide precise bounds that allow us to theoretically and numerically compare different matching policies and priority schemes.

■ TE07

322A

Personalized Medical Decision-Making

Sponsored: Health Applications

Sponsored Session

Chair: Gian Gabriel P. Garcia, University of Michigan, Ann Arbor, MI, 48105, United States, garciagg@umich.edu

1 - Mobile Health for Chronic Disease Management: A Change Point Detection Approach

Anthony Bonifonte, Georgia Institute of Technology, 5940 Water Oaks Dr, Austell, GA, 30106, United States, ABonifon@gatech.edu

Wearables and other mobile health devices have the potential to revolutionize the management of chronic disease. We present a Bayesian changepoint detection algorithm that indicates when a health characteristic has exceeded a threshold value. We demonstrate the performance of this algorithm on realistically simulated blood pressure data, and show improvement over baseline policies and simpler, more general changepoint procedures. This work demonstrates the enormous improvement in chronic disease screening and monitoring that can be achieved using data from mobile health technologies.

2 - Designing Personalized Weight Loss Interventions with Behavioral Analytics

Yonatan Mintz, UC Berkeley, 1822 Francisco St., Apt 10, Berkeley, CA, 94703, United States, ymintz@berkeley.edu, Anil Aswani, Philip Kaminsky, Elena Flowers, Yoshimi Fukuoka

In this talk, we develop a behavioral analytics framework which uses patient data to effectively design personalized weight loss interventions. Our framework utilizes a utility maximization model for patient behavior which combined with integer programming and Bayesian prediction allows us to create several personalized interventions, as well as aggregate these interventions into a cohort weight loss program. We then present simulation results which show that our method maintains efficacy while potentially reducing the associated person hours and cost of the intervention.

3 - A Stochastic Programming Approach to Determine Decision Boundaries for Medical Diagnosis

Gian Gabriel P. Garcia, University of Michigan, 1823 Pointe Crossing Street, Apt 204, Ann Arbor, MI, 48105, United States, garciagg@umich.edu, Mariel Sofia Lavieri, Ruiwei Jiang, Steven P. Broglio, Michael McCrea, Thomas W. McAllister

We use stochastic programming to determine decision thresholds for medical diagnosis risk models under uncertain data samples from a fixed population. These thresholds maximize sensitivity and specificity under constrained false positive and false negative rates. We show that sample average approximation solutions for these models are consistent estimators. We apply our method to concussion assessment and show that our thresholds dominate single decision thresholds under multi-criteria evaluation.

4 - Value and Design of Clinical Decision Support Systems in the Presence of Bias in Imaging-based Decisions

Mehmet U.S. Ayvaci, University of Texas at Dallas, 800 W. Campbell Rd, Sm33, Richardson, TX, 75080-3021, United States, mehmet.ayvaci@utdallas.edu, Mehmet Eren Ahsen, Srinivasan Raghunathan

A patient's clinical risk information could bias a radiologist's assessment of a mammogram. We examine the design and value of a clinical decision support system (CDSS) in the breast cancer diagnosis context. The CDSS assists a caring physician in her follow-up recommendation to a patient based on the radiologist's assessment. We show that the CDSS can eliminate the adverse impact of bias if there is no variability associated with the bias-induced error in radiologist's assessment. Using point estimates based on mammography practice and the medical literature, we show that a bias-aware CDSS can significantly improve the expected patient life years or the accuracy of decisions based on mammography.

■ TE08

322B

Disaster and Emergency Management

Contributed Session

Chair: Sandeep Grover, YMCA University of Science & Technology, Faridabad, India, groversandeep@hotmail.com

1 - Optimal Recovery Strategy for the Power Grid after a Cascading Failure

Yan-Fu Li, Tsinghua University, N410, Shunde Building, Haidian District, Beijing, 100084, China, liyanfu@tsinghua.edu.cn, Yi-Fei Yuan

Although heavily protected, electric power grids fail more frequent than expected. Severe failures, e.g. cascading failure, often result to significant damages to our society. Therefore it is of great importance to quickly repair the damaged power grid in the immediate aftermath of such failures. Whereas, the repair actions are cost-associated. In this study, we formulate an optimization problem for repair activity planning with the objective to minimize the total cost during recovery process, which includes the expense of repair actions and the economic loss due to load shedding. The proposed model is demonstrated on a Chinese provincial power grid.

2 - Network Planning Model for Food Aid Distribution During Chennai Floods: A Big Data Analytic Approach

Ravi Shankar, Indian Institute of Technology Delhi, Department of Management Studies, Vishwakarma Bhavan, Shaheed Jeet Singh Marg, New Delhi, 110016, India, ravi1@dms.iitd.ac.in, Ashish Kumar Kaushal

In this paper we design an effective last-mile food aid distribution network using big data analytics. We present location models to determine a set of distribution centres, where the food is directly distributed to the beneficiaries, during Chennai floods, 2015 in India. Our models take into account the consideration of all key stakeholders involved in the response system.

3 - Understanding Strategies Governing the Use of Social Data in a Disaster Response Operation

Justin Taylor, University of Arkansas, 4207 Bell Engineering Center, 1 University of Arkansas, Fayetteville, AR, 72701, United States, jlt025@email.uark.edu, Ashlea Bennett Milburn

The use of social data during disaster response has the ability to provide more information to emergency responders quickly, however the data is not guaranteed to be accurate. As such, responders are likely to have concern over the incorporation of social data and may limit the use of it by organizational policies or personal preferences. The research aims to help define what the current social data collection strategies are through interviews with emergency managers, as well as characterize the social data that are used during a disaster response operation.

4 - A Decision Support System for Location of Warehouses During the Preparedness Phase

Ravi Shankar, Indian Institute of Technology Delhi, Delhi, India, ashishkiitd89@gmail.com, Ashish Kumar Kaushal

This study integrates the fuzzy DEMATEL and goal programming model for solving the warehouse location problem during preparedness phase for effective disaster response. The managerial usefulness of this proposed method is that it allows decision makers to set multiple aspiration levels for the decision criteria.

5 - Early Forecasting of Flood Response Requirements for American Red Cross Mass Care Services

Sanjeev Goyal, Assistant Professor, YMCA University of Science & Technology (Faridabad, India), NH-2, Sector 6, Mathura Road, Faridabad, 121006, India, goyalsanjeev@pitt.edu, Kiatikun Louis Luangkesorn, Sandeep Grover

In the United States, after a disaster resources are sent based on needs assessed at the local level. However, this local assessment can take time while local resources are preoccupied with immediate response activities. This delays the mobilization of personnel, resources, and supplies into the disaster area. We develop a machine learning method to estimate the required American Red Cross sheltering and feeding resources using data that would be readily available to disaster response managers on the first day of a flood. This enables more rapid mobilization and deployment and more effective provision of services to those affected by disaster.

■ TE09

330A

Machine Learning in Healthcare

Sponsored: Health Applications

Sponsored Session

Chair: Yingfei Wang, Princeton University, Princeton, NJ, 08540-5233, United States, yingfei@princeton.edu

1 - The Behavior of Value of Information Policies in the Presence of a Locally Quadratic Belief Model

Nana Kwabena Aboagye, Princeton University, Sherrerd Hall, Charlton Street, Apartment A, Princeton, NJ, 08544, United States, aboagye@princeton.edu, Warren B.Powell

We study the problem of learning the unknown parameters of an expensive function where the true underlying surface can be well-approximated by a quadratic polynomial. We demonstrate that the well-known behavior of many learning policies for lookup table belief models no longer apply, and that the behavior when using a quadratic belief model exhibits a very special structure. This is the first paper to identify and exploit the behavior of learning policies in the presence of parametric belief models. We derive a simple rule that is much simpler to compute than a knowledge gradient policy that maximizes the one-step value of information and demonstrate its performance empirically.

2 - Machine Learning in Healthcare

Nilakantan Sundara Raman Narasinganallur, K.J. Somaiya Institute of Management Studies & Research, B.602 Tulip Rachna Garden, Mulund Colony, Mumbai, 400082, India, nilakantan@somaiya.edu

Healthcare is one of the new areas with potential for data analytics. With the generation of voluminous data, the use of big data analytics is essential for reaching useful conclusions in medical research. While past efforts in data analytics have been more in the area of statistical methods based on assumptions of linear data structures, machine learning provides an alternate basis to analyse for nonlinear relationships. The presentation will provide an overview of the use of machine learning in healthcare.

3 - Estimating the Cost-savings of Preventive Dental Services by Unsupervised Learning

Ilbin Lee, Assistant Professor, University of Alberta, 3-23 Business Building, Edmonton, AB, T6G 2R6, Canada, ilee79@gatech.edu, Sean Monahan, Nicoleta Serban, Paul Griffin, Scott L. Tomar

Dental caries is the most common chronic disease among U.S. children. Preventive services have been shown to be effective in preventing caries, but little is known about how the use of preventive services affects downstream care expenditures. We followed dental care utilization of nearly a million Medicaid children for 7 years and classified them using an unsupervised clustering algorithm. The results showed that expenditures were much lower for children who received preventive care than those who did not, and thus, preventive dental care can have substantial return on investments while also improving oral health outcomes.

4 - Adapting Kernel Mean Matching to Balance Observational Data in Health Care

Martin Cousineau, PhD Candidate, McGill University, 1001 Sherbrooke St W, Montreal, QC, H3A 1G5, Canada, martin.cousineau@mail.mcgill.ca, Susan A. Murphy, Joelle Pineau, Vedat Verter, Gustavo Turecki

We propose the use of kernel mean matching to compute a causal effect from observational data. We also propose an improved tuning procedure for kernel mean matching.

5 - Approximation Methods for Markov Decision Processes with Application to Clinical Trial Design

Vishal Ahuja, Southern Methodist University, Cox School of Business, P.O. Box 750333, Dallas, TX, 75275, United States, vahuja@smu.edu, John R. Birge

Multi-armed bandit problems, typically modeled as Markov decision processes (MDPs), exemplify the exploration vs. exploitation tradeoff. For many practical problems of interest, the state space is intractably large, rendering exact approaches to solving MDPs impractical. We propose a novel approximation approach that combines the strengths of multiple methods - grid-based state discretization, methods to improve approximation accuracy, and simulation, to obtain near-optimal policies for large scale MDPs with minimal added computational burden. Our numerical analysis shows our design to be almost as good as a fully optimal design and superior to existing heuristics.

■ TE10

330B

New Trends in Pricing and Revenue Optimization

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Gustavo Jose Vulcano, Universidad Torucato di Tella, New York University, New York, NY, 10012, United States, gvulcano@stern.nyu.edu

1 - Large-scale Bundle Size Pricing: A Theoretical Analysis

Tarek Abdallah, New York University, Stern School of Business, New York, NY, United States, tabdalla@stern.nyu.edu, Arash Asadpour, Joshua Reed

Bundle size pricing (BSP) is a multi-dimensional selling mechanism where the firm prices the size of the bundle rather than the different possible combinations of bundles. In BSP, the firm offers the customer a menu of different sizes and prices. The customer then chooses the size that maximizes his surplus and customizes his bundle given his chosen size. In this talk, we provide a simple and tractable theoretical framework to analyze the large-scale BSP problem. Solving the BSP problem is in general hard, however we show that for large numbers of products, the BSP problem transforms from a hard multi-dimensional problem to a simple multi-unit pricing problem.

2 - Randomized Pricing, Fulfillment, and Product Ranking for Ecommerce Retailers

Stefanus Jasin, University of Michigan, 2836 Barclay Way, Ann Arbor, MI, 48105, United States, sjasin@umich.edu, Yanzhe Lei, Joline Uichanco, Andrew Vakhutinsky

We consider an etailer selling multiple products to customers from multiple regions. Products are stored at multiple warehouses and the decisions are price, fulfillment (i.e., from which warehouse to ship the request), and products display ranking (i.e., how we should order the products—ordering affects product visibility, which in turn affects purchase probability). The deterministic version of the problem can be solved as an MILP, however it may have a large number of binary variables. We propose a different approach: We first relax the problem (turning the MILP into an LP) and then we construct a randomization strategy that guarantees the optimal performance under the relaxed LP in expectation.

3 - Demand Learning and Earning with Online Bundle Recommendations

Anna M. Papush, Massachusetts Institute of Technology-ORC, 411 Norfolk Street, Apt 2C, Somerville, MA, 02143, United States, apapush@mit.edu, Pavithra Harsha, Georgia Perakis, Divya Singhvi

Product recommendation systems have grown to become a necessity in the vast majority of online retail businesses. However, most existing literature focuses on efficient design under the assumption that consumer demand is known. In this work we propose and discuss an approach for online pricing and recommendation of product bundles that makes strategic offers in order to learn consumer demand efficiently over time while maximizing profits and balancing inventory. We test our algorithm's performance and provide theoretical guarantees against optimal offline approaches with known demand.

4 - Customized Individual Promotions: Model, Optimization, and Prediction

Dmitry Mitrofanov, NYU. Stern, 44 West 4th Street, 8th Floor, New York, NY, 10012, United States, dm3537@stern.nyu.edu, Srikanth Jagabathula, Gustavo Jose Vulcano

We consider the problem of predicting individual responses to a product promotion using historical transaction data, tagged by customer ID. In our proposal, we model each individual through a partial-order that embeds promotion information. Then, we calibrate a multinomial logit model over the partial orders and quantify their prediction power on out-of-sample transactions. Then, we use this information to optimize personalized promotions, obtaining a remarkable performance.

■ TE11

332A

Operations in Delivery Services

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Long He, National University of Singapore, Singapore, 119245, Singapore, longhe@nus.edu.sg

Co-Chair: Wei Qi, McGill University, Montreal, QC, 1, Canada, qiwei@berkeley.edu

1 - Zoning for Last Mile Delivery: A Data-driven Approach

Sheng Liu, University of California, Berkeley, 2249 Bonar Street, Unit C, Berkeley, CA, 94702, United States, lius10@berkeley.edu, Long He, Zuo-Jun Max Shen

In this study, we propose a data-driven approach for strategic zoning planning in last mile delivery services. Using historical data to calibrate driver behaviors, we construct a practical routing distance prediction model. We then develop a mixed integer linear program as a sample average approximation model and show significant delay reductions from the benchmark model in numerical studies.

2 - Efficiency-fairness Trade-offs: the Case of the Federated Locker System

Guodong Lyu, National University of Singapore, 1 Business Link, BIZ2 Building, Singapore, 117592, Singapore, guodong.lyu@u.nus.edu, Chung-Piaw Teo

We study the efficiency-fairness trade-offs in a class of last mile delivery problems, using automated parcel lockers. We show that the concerns on reduction in efficiency can be mitigated with the proper choice of the scale of the system. To see this, we develop a locker choice model and calibrate the parameters to predict the volume of parcels that the system can attract based on location decisions. Contrary to conventional wisdom, our model does not place lockers near areas with peak usage because of endogeneity issues in existing demand data.

3 - Managing a Portfolio of Self-scheduling Workers

Kaitlin Daniels, Olin Business School, Washington University in St. Louis, Saint Louis, MO, United States, k.daniels@wustl.edu

Self-scheduling workers value their ability to decide for themselves how much they work. However, granting this flexibility costs the coordinating platform its ability to directly control its capacity. We study a system of heterogeneous workers who decide how much to work in response to incentives offered by a platform. In this setting, the platform may elect to place restrictions on a worker's decision. We study how the resulting portfolio of working-behaviors changes as workers make costly demands of the firm (e.g. expense reimbursement, overtime pay, minimum wages), like those made by Uber drivers in recent lawsuits.

4 - Shared Mobility for Last-mile Delivery: Design, Operational Prescriptions and Environmental Impact

Wei Qi, McGill University, Montreal, QC, Canada, qiwei.0216@gmail.com, Lefei Li, Sheng Liu, Zuo-Jun Max Shen

We evaluate the prospect where shared mobility of passenger cars prevails throughout urban areas for home delivery services. We develop logistics planning models that characterize drivers' responses to wages, optimal open-loop routes, interactions with the ride-sharing market and service zone design. Then we prescribe several scenarios where this business model is economically and environmentally favorable.

■ TE12

332B

Models for Evolving Public Transportation Systems

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Nicholas E. Lownes, University of Connecticut, 261 Glenbrook Road, Unit 3037, Storrs, CT, 06269-3037, United States, nlownes@engr.uconn.edu

1 - Research on Integrated Development Plan for the Urban Rail Transit Station with the Concept of Linkage Development of Station and City

Xinmei Chen, Southwest Jiaotong University, Chengdu, China, siyu.tao@okstate.edu

Xinmei Chen, National United Engineering Laboratory of Integrated and Intelligent Transportation, Chengdu, China, siyu.tao@okstate.edu, Qiyuan Peng, Siyu Tao, Yida Li

Expanding the city function blindly around the transit stations led to the contradiction between the traffic jams and land use. For linkage development of the urban rail station and city, multi-goal programming model was used to determine the final integrated development plan of the station and land, considering the investment risk, economic benefit, traffic impact of real estate for the layout of the connection channel between the station and city.

2 - On-demand Public Bus Service on a Multimodal Travel Corridor
Jie Zhang, PhD Student, Nanyang Technological University, N1-B4-B06, 50 Nanyang Avenue, Singapore 639798, Singapore, 639798, Singapore, jzhang049@e.ntu.edu.sg, Zhiwei Wang

On-demand Public Bus (ODPB) service, a new type of public transport service, has emerged in many big cities. This study analyzes the provision of ODPB by applying analytical approaches based on demand analysis and network modeling. Several alternative travel modes are considered. The choices of mode and route/service are taken into account simultaneously in logit-type formula. The resultant traffic equilibrium condition is expressed as a variational inequality (VI) problem. Numerical analysis from one idealized corridor indicates that the introduction of ODPB service could effectively bring a significant impact on mode shift, especially for the long distance trip.

3 - Design Optimal Strategy of On-demand Mobility Allowance Shuttle Transit (MAST) Service
Dahye Lee, Texas A&M.University, 3135 TAMU, College Station, TX, 77843-3135, United States, dahyelee1991@tamu.edu, Luca Quadrifoglio, Kai Yin

We adopt the Markov Decision Process (MDP) with empirical dynamic programming algorithms to design optimal strategies for Mobility Allowance Shuttle Transit (MAST) service with demand uncertainties. The MAST allows vehicles to deviate from fixed routes to serve customers at their desired pick-up and drop-off locations within the service area. The main objective of this study is to then obtain the optimal policy of vehicle routing strategy that minimizes the total cost subject to the vehicle distance traveled and the number of served customers, and evaluate the quality of solutions with numerical studies.

4 - Bus Fleet Turnover Strategies to Optimize Life-cycle Costs and Carbon Emission Reductions
Nicholas E. Lownes, University of Connecticut, 261 Glenbrook Road, Unit 3037, Storrs, CT, 06269-3037, United States, nicholas.lownes@uconn.edu, Adrita Islam

The increasing competitiveness of battery electric bus (BEB) technology is prompting transit agencies across the globe to consider a transition to a BEB fleet. In most cases, this transition will occur over a number of years, depending on the age composition of the bus fleet. BEB stand to generate substantial mobile GHG savings and are seen as increasingly cost competitive with standard diesel hybrid buses, with cost parity anticipated to occur sometime within the next decade. This paper presents a fleet turnover optimization model that considers life-cycle costs and potential GHG reductions. An application on the Connecticut bus fleet is presented to illustrate results of the model.

■ TE13

332C

Decision Support Systems

Contributed Session

Chair: Majed Al-Shawa, Strategic Actions, Waterloo, ON, Canada, malshawa@strategic-actions.com

1 - An Integrated Feedback and Optimization Approach for Healthcare Services
Soumyajyoti Datta, Indian Institute of Management Indore, Indore, India, f14soumyajyotid@iimidr.ac.in, Rohit Kapoor

This work addresses an integrated service quality and multi objective optimization problem in the context of healthcare delivery. Feedback on the experience in the hospitals concerning the clinical and process parameters have been collected. Machine learning techniques have been applied to recommend a healthcare delivery. Moreover, we feel that an integrated approach involving feedback and healthcare operational process parameters more scientifically reflect the quality of care. Hence an optimization problem involving the operational parameters has been studied using evolutionary intelligence.

2 - An Analysis of Pricing Models Between Online Medical Service and Traditional Hospital
Donghui Yang, Southeast University, Sipailou 2, Nanjing, 210096, China, dhyang@seu.edu.cn

With new developments related to online technologies and environments, medical online is much more a feasible venue for physicians and patients. In this work, three scenarios (online consulting, see a doctor online or in a hospital, see a doctor online or in a hospital with drug purchasing option) are compared to help a patient to make a good decision. Meanwhile, a game between online medical and a hospital is constructed to optimize their profits.

3 - Approximation of Max Min Fairness of Bandwidth Allocation in Multicommodity Flow Networks
Hamoud S. Bin Obaid, PhD candidate, University of Oklahoma, 1526 E.Lindsey Street, Apt I, Norman, OK, 73071, United States, hsbinobaid@ou.edu, Theodore B.Trafalis

A bi-objective LP model to find the max min fair flow vector in multicommodity flow networks is proposed. The overall throughput is maximized in the first objective, and the sum of absolute deviations among commodities is minimized in the second objective. The model is capable of solving large-scale networks with low computational time producing a quality solution. The model is tested on real and random networks.

4 - RISKMETER: An Interactive Tool for Integrating Public Preferences into Long-range Electricity Supply Planning
Georgios Xexakis, ETH Zurich, Universitatstrasse 22, K76.1, Zurich, CH-8092, Switzerland, georgios.xexakis@usys.ethz.ch, Sandra Volken, Evelina Trutnevyte

Finding consensus pathways for transforming national electricity supply systems is a challenge due to multi-dimensional policy priorities and complexity of public preferences. We use a linear optimization model EXPANSE with Modeling to Generate Alternatives (MGA) to quantify 500 electricity supply scenarios for Switzerland in 2035. We then assess the scenarios in terms of health, safety, built and natural environment impacts and use an interactive tool RISKMETER to visualize the impact tradeoffs. Ultimately, we conduct an online survey (N=200) with non-experts to empirically evaluate the RISKMETER's usability, collect public preferences, and integrate these with the EXPANSE scenarios.

5 - Modelling and Analyzing Stabilities and Equilibrium Strengths of Strategic Non-cooperative Conflicts using the Constrained Rationality Framework
Majed Al-Shawa, Strategic Actions, Waterloo, ON, N2V 2V8, Canada, malshawa@strategic-actions.com

We discuss the theory of moves and counter-moves of decision making agents that Constrained Rationality proposes for strategic multi-agent non-cooperative conflicts, and define four different stability and equilibrium solution concepts to analyze such conflicts. These concepts will guide the stability analysis of the conflict's states, for each agent. Then, we define the stability strength for each solution concept and the strength of the equilibrium that could result from it. To demonstrate the effectiveness of the framework, we model and analyze the Cuban Missile Crisis, and show why the sequence of events observed in reality was the most rational sequence of events for the conflict to take.

■ TE14

332D

Modeling to Improve Healthcare System Performance

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Bryan A. Norman, University of Pittsburgh, University of Pittsburgh, Pittsburgh, PA, 15261, United States, banorman@pitt.edu

1 - A Technical Note on (r,s,q) Inventory Control Systems in Hospitals
Bryan A. Norman, University of Pittsburgh, Department of Industrial Engineering, 1006 Benedum Hall, Pittsburgh, PA, 15261, United States, banorman@pitt.edu, Nazanin Esmaili, Jayant Rajgopal

We develop discrete time Markov chain models of (R,s,Q) inventory control systems which are used at Point of Use Locations (POU) in hospitals and characterized by limited storage capacity, stochastic demand, periodic reviews with fractional lead times, expedited delivery when stocking out, and very high service level requirements. We present a novel approach that locally decomposes the state space for this specific class of inventory systems and use this to reduce the number of equations that must be solved by at least a factor of two. The result is that the overall computational effort required for finding the optimal replenishment policy parameters is significantly reduced.

2 - Wait Time Announcements at Hospital Emergency Departments
Marco Bijvank, University of Calgary, 2500 University Dr. NW, Calgary, AB, T2N.1N4, Canada, marco.bijvank@haskayne.ucalgary.ca, Zhankun Sun

A number of Canadian hospitals have started publishing live emergency department (ED) wait times online in an effort to provide patients with expectations on how long they will have to wait to be seen for non-urgent care after initial assessment by a triage nurse. We accurately predict the state-dependent wait times at emergency departments based on a busy-period analysis for a multi-class, multi-server priority queue with delayed feedback. We illustrate the robustness and impact of the predictor on patient flow and patient care with a case study at four major hospitals in the Calgary area.

3 - Predicting Patient Treatment Deferrals/no-shows to Improve Chemotherapy Pre-Mix Policies

Donald B. Richardson, University of Michigan, 2753 IOE Building, 1205 Beal, Ann Arbor, MI, 48109-2117, United States, donalric@umich.edu, Amy Cohn

In collaboration with the University of Michigan Comprehensive Cancer Center, we have developed a predictive model to determine the probability that a patient will not show for or defer treatment on a given day. This information can then be used in our proposed expected drug waste cost functions to aid outpatient chemotherapy centers in deciding which drug to make-ahead. We test a wide range of predictive models including Generalized Linear models (GLM), tree-based methods, Neural Networks, and various Ensemble models. This work complements our optimization model which determines the superior set of drugs to make ahead to reduce patient waiting time in the outpatient cancer center.

4 - Sequencing Patients for Ancillary Service in an Inpatient Unit

Pratik Parikh, Associate Professor, Wright State University, Dayton, OH, 45435, United States, pratik.parikh@wright.edu, Nicholas Ballester, Nan Kong, Jordan Peck

Ancillary service providers on an inpatient unit, such as social workers, care managers, and physical and occupational therapists, play crucial roles in the inpatient discharge process. However, these providers are also responsible for other patients besides those to be discharged. There is a paucity of research suggesting an optimal patient sequencing strategy for these providers. We model this problem similar to a stochastic single machine sequencing problem with side constraints. Using a simulation-optimization approach, we derive near-optimal policies and benchmark industry practice.

■ TE15

332E

Sustainable Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Basak Kalkanci, Georgia Institute of Technology, Atlanta, GA, 30339, United States, basak.kalkanci@scheller.gatech.edu

1 - Voluntary vs. Compulsory Supplier Sustainability Assessments in Supplier Selection

Karca Duru Aral, Assistant Professor, Syracuse University, 721 University Avenue, Syracuse, NY, 13244, United States, kdaralwa@syr.edu

In order to make an informed supplier selection during a total-cost procurement auction, the buyer can choose to make sustainability assessments compulsory for the competing suppliers. However, this would negatively affect competition as some suppliers can drop out of the auction given the assessment costs. The buyer can instead make assessments voluntary - but would then risk making a less informed selection. We analyze this trade-off and identify how the buyer should set her assessment policy.

2 - Worker Flexibility Training and Production Autonomy

Evan Barlow, Weber State University, Goddard School of Business & Economics, 1337 Edvalson St, Ogden, UT, 84408, United States, evanbarlow@weber.edu, Gad Allon, Achal Bassamboo

We explore the interaction between worker production autonomy and workers' decisions on training to become flexible resources. Research on flexible resources is prevalent in the operations management literature. Human resources, however, are decision makers and have rights to decide on their own training levels. Many firms, however, have also given workers some production autonomy. We show how workers' training decisions are affected by the identity of the production decision maker.

3 - When to Source from a Competitor?

Eda Kemahlioglu Ziya, North Carolina State, Poole College of Management, Campus Box 7229, Raleigh, NC, 27695-7229, United States, ekemahl@ncsu.edu, Olga Perdikaki

We study the outsourcing decisions of an original equipment manufacturer (OEM). One option is to source from an independent supplier and the other is to source from an integrated firm who is also a competitor of the OEM in the consumer market. However, the advantage of the latter option is that the independent supplier can achieve lower production cost by exploiting the manufacturing synergies between the two products. We also study how/if the OEM's decision is impacted by the type of contract between the OEM and it's supplier.

4 - Selling Off-grid Light to Liquidity Constrained Consumers

Bhavani Shanker Uppari, INSEAD, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, BhavaniShanker.UPPARI@insead.edu, Ioana Popescu, Serguei Netessine

A large proportion of the world's population has no access to electricity and so relies on noxious kerosene for their lighting needs. As an alternative, there are business models relying on rechargeable light bulbs that are sold at a subsidized price (which renders them affordable) and require regular micropayments for recharges (which eases liquidity constraints). These bulbs provide a cheaper and healthier light source than kerosene, yet their adoption is lower than expected and some consumers continue to use kerosene. This paper explores the potential drivers of such preferences and proposes strategies to alter them.

■ TE16

332F

Operations Management

Contributed Session

Chair: Xiaojing Feng, Shanghai Jiao Tong University, Shanghai, China, fengxj89@sjtu.edu.cn

1 - How Market Power Impacts Invest in Supply Chain

Jingjie Su, University of Texas at Arlington, 2508 Mustang Drive, Arlington, TX, 76001, United States, jingjie.su@mavs.uta.edu

Consider a supply chain network with two players, one is original equipment manufacturers and another is contract manufactures.. OEM and CM have relationships both as downstream supplier and competitor in the market. In this supply chain network, when OEM is deciding about making an investment to lower the cost of the product, based on different investment cost and market power, the Nash Equilibrium theory predicts the different decision. We conduct a series of experiments, varying the investment cost and market power, and find out that the experiment data varies from theory. We then apply behavior models to explain these difference.

2 - Prescriptive Analytics for Optimizing the Scheduling of Maintenance Operations

Stefan Feuerriegel, University of Freiburg, Platz der alten Synagoge, Freiburg, 79098, Germany, stefan.feuerriegel@is.uni-freiburg.de, Niklas Goby, Dirk G. Neumann

Maintenance of industrial components frequently occurs upon failure, thereby incurring costs from down-times. A remedy is given by preventive maintenance, for which we propose a prescriptive methodology that schedules maintenance events in order to minimize the service-related costs. This approach consists of two stages: first, we predict the time-to-service of machines based on sensor data using machine learning. In the second stage, we identify the optimal timing of maintenance operations. Here the key ingredient of this work is the fusion of prediction and optimization. We demonstrate the effectiveness of our approach in a case study with real-world data from a large wind park operator.

3 - An Investigation of the Impacts of Nurse Slack on Care Quality and Operating Costs

Xiaosong (David) Peng, Associate Professor, University of Houston, 511 Somerset Dr, Sugarland, TX, 77479, United States, xpeng@bauer.uh.edu, Yuan Ye, Xin Ding

As value-based purchasing (VBP) and patient-centered care take the center stage in today's healthcare environment, healthcare organizations including hospitals are in an ongoing quest to improve both clinical quality and (patient) experience quality while containing rapidly rising costs. To improve and control clinical quality and experiential quality, hospitals must carefully determine the level of nurse slack, defined as the amount of nurse capacity relative to the amount of work performed. This research seeks to identify the fine-grained relationships between nurse slack and clinical quality, experiential quality, and operating costs.

4 - In-house vs Outsourcing: the Effect of Volume-based Learning on Quality Competition

Yanni Ping, PhD Candidate, Drexel University, 3220 Market Street, Philadelphia, PA, 19104, United States, yp86@drexel.edu, Seung-Lae Kim

This paper considers an original equipment manufacturer (OEM) who outsources finished products from an contract manufacturer (CM) where the CM, by adopting existing technology, achieves cost reduction and quality improvement through learning-by-doing. Besides the role of upstream partner, the CM also acts like a downstream competitor. We study the OEM's outsourcing strategy dynamically when competition exists and does not exist. We construct a two-period model and explore the interplay of learning, quality and cost and identify the condition under which pure outsourcing, partial outsourcing or non-outsourcing outplays the others.

5 - Decision Conflict in the Newsvendor Game
Ilkka Leppanen, Dr, Loughborough University School of Business and Economics, Epinal Way, Loughborough, LE11 4NZ, United Kingdom, i.leppanen@lboro.ac.uk

We argue that decision conflict between the pecuniary motive of profit maximization and the nonpecuniary motive of satisfying demand is the driving force behind non-normative behavior in the newsvendor game. We find in behavioral experiments that the previous round situation affects current round decision time such that "intermediate" situations where demand was not satisfied and the decision was not normative produce more decision conflict and deliberation in the current round than "extreme" situations where either demand was satisfied or/and the decision was normative. We demonstrate that decision conflict between pecuniary and nonpecuniary motives can affect newsvendor behavior.

6 - Is the Optimal Suggestion the Best for Managerial Decision Making? A Laboratory Investigation of the Newsvendor Problem
Xiaojing Feng, PhD Candidate, Shanghai Jiao Tong University, 2nd Yanjiusheng Building 1519, Huashan Road 1954, Shanghai, 200031, China, fengxj89@sjtu.edu.cn, Ying Rong, Tianjun Feng

Decision makers often tend to choose the inferior humans' forecasts rather than the superior algorithms' forecasts, although algorithms outperform humans in most cases. So, how to design an efficient decision support system (DSS) that helps people to make better forecasts and decisions becomes our concern. We investigate how the suggestions of different DSSs affect humans' order decisions in the classical newsvendor settings. Through laboratory experiments, we find that the introduction of DSS induces human newsvendors to exhibit algorithm aversion and regret aversion. We identify the most efficient DSS which eliminates human newsvendors' pull-to-center bias.

■ TE17

340A

Service Systems in Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Jing Dong, Northwestern University, Evanston, IL, 60208, United States, jing.dong@northwestern.edu

1 - A Fluid Model for Service Systems with Dependent Service and Waiting Times
Chenguang Allen Wu, Northwestern University, Evanston, IL, United States, allenwu@u.northwestern.edu, Ohad Perry, Achal Bassamboo

We consider a large service system in which the service time of each customer depends on his waiting time. Specifically, there can be two types of dependence: either a customer's patience depends on his individual service requirement, or the actual service requirement changes in response to the delay in queue. To study the two cases, we develop a unified fluid model that captures those two types of dependencies, and demonstrate its accuracy via simulations. We prove qualitative results for the stationary and transient behavior of the fluid model, which reveal the fundamental differences between the two dependence structures.

2 - Multi Queue Service Systems with Dynamic Customer Choice
Yichuan Ding, University of British Columbia, University of British Columbia, 6333 Larkin Drive, Vancouver, BC, V6T.1C3, Canada, daniel.ding@sauder.ubc.ca, Mahesh Nagarajan, Zhe Zhang

We study a stochastic service system with multiple servers and dynamic consumer choice., where service providers of heterogeneous quality are distributed at different locations. An arriving customer chooses a service provider to obtain service by observing the service reward and length of each queue. Many real life queueing systems can be accommodated by this model. We study this system using both fluid and diffusion approximations. We prove the existence of the unique equilibrium customer queue-length vector of the service providers.We show that the system can be approximated by a multi-dimensional reflected Ornstein-Uhlenbeck process centered at that equilibrium.

3 - Central Limit Theorems for Bike-sharing Networks
Jamol Pender, Cornell University, jjp274@cornell.edu

Bike-sharing is an emerging mode of eco friendly transportation in many cities. In this talk, we prove central limit theorems for a bike-sharing stochastic model. These central limit theorems allow us to move beyond mean field behavior and describe the fluctuations around the mean field limit. Moreover, we are able to derive new Gaussian approximations for various performance measures such as the probability that a station has no bikes or is at capacity.

4 - Optimal Policy in Single-server Multi-class Queuing Systems with Abandonment
Sina Ansari, Northwestern University, Evanston, IL, United States, SinaAnsari2013@u.northwestern.edu, Seyed Iravani, Laurens G. Debo

We study a multi-class queuing system with a single server and customer abandonment. We fully characterize the structure of the server's optimal scheduling policy that minimizes the total average customer abandonment cost.

■ TE18

340B

Queueing Systems and Approximations

Sponsored: Applied Probability

Sponsored Session

Chair: John Hasenbein, University of Texas-Austin, Austin, TX, 78712-0292, United States, jhas@mail.utexas.edu

1 - An Asymptotically Optimal Control Policy for a Multiclass Many Server Queue with General Reneging Distributions
Amy R. Ward, University of Southern California, Marshall School of Business, Bridge Hall BRI 401H, Los Angeles, CA, 90089-0809, United States, amyward@marshall.usc.edu, Amber L. Puha

We consider a multiclass many-server queue with general interarrival, service, and reneging distributions. For reneging distributions with bounded, nonincreasing hazard rates, we find that static priority may not be asymptotically optimal on fluid scale. We propose a new class of policies, called Random Buffer Selection, and prove their asymptotic optimality. We further identify the fluid approximation to the limiting cost as the optimal value of a certain optimization problem.

2 - Operational Benefits of Free Trials in Large Scale Service Systems
Yasar Levent Kocaga, Sy Syms School of Business, Belfer Hall Room # 403/A, 2495 Amsterdam Ave, New York, NY, 10033, United States, kocaga@yu.edu, Chihoon Lee

We consider a firm that is serving price and delay sensitive customers and that has the option of offering a free trial service to a new market of customers. We first show that it is optimal for the revenue maximizing firm to operate in the QED heavy traffic regime and provide tractable and accurate expressions for the optimal price and revenue. Then, we use these expressions to identify conditions under which offering free trials is beneficial to the firm.

3 - Stability and Tail Asymptotics in a Multiclass Queue with State-dependent Arrival Rates
John Hasenbein, University of Texas-Austin, 1 University Station Stop C2200, Department of Mechanical Engineering, Austin, TX, 78712-0292, United States, jhas@mail.utexas.edu, Philip Ernst, Soren Asmussen

We analyze a multiclass single-server queueing system in which the arrival rates depend on the current job in service. The system is characterized by a matrix of arrival rates. Using fluid models, we obtain the necessary and sufficient conditions for stability. Utilizing the natural connection with the multitype Galton-Watson processes, we derive the Laplace-Stieltjes transform of busy periods. We conclude with tail asymptotics for the busy period for heavy-tailed service time distributions for the regularly varying case.

4 - Naor's Model with Heterogeneous Customers and Arrival Rate Uncertainty
Chengcheng Liu, 2815 Rio Grande Street, Austin, TX, 78705, United States, liuchengcheng2011@gmail.com, John Hasenbein

This research examines extensions of Naor's queueing model in which the arrival rate is not known with certainty by either customers or system managers. The arrival rate is considered as a non-degenerate random variable. In view of a social optimizer and a revenue maximizer, we investigate both static and state-dependent pricing policies in the presence of customer heterogeneity in their economic characteristics. Two cases are considered: the observable case and the unobservable case. This work is also an extension of the study of Chen and Hasenbein on a related model in that their model only considers homoge- neous customer populations.

■ TE19

342A

Production and Scheduling

Contributed Session

Chair: Rajitha Meka, University of Texas at San Antonio, San Antonio, TX, United States, rajitha.meka@utsa.edu

1 - Minimizing the Warehouse Order Picking Costs Considering Probabilistic Risk

Atieh Madani, University at Buffalo (SUNY), 308 Bell Hall, Buffalo, NY, 14260, United States, atiehmad@buffalo.edu, Rajan Batta, Mark Henry Karwan

The expansion of online shopping and supply chain in today's world makes the warehouses as one of the main element of trading network. In this research first we give a brief review on different aspects of warehousing and in continue we present the order picking as one of the most common problems in this area. In our research we have focused on the problem of minimizing order lateness and picking cost by deciding on the number of pickers and the probabilistic risk of batching. This cost includes customer loyalty, internal transportation, and etc. We have used queuing theory to create an algorithm in order to produce an optimal or near optimal decision for batching and workforce level.

2 - A Comparison of Construction Productivity Ratings

Mostafa Ghandehari, Senior Lecturer, University of Texas-Arlington, Civil Engineering, Univ. of Texas at Arlington, Arlington, TX, 76019, United States, ghandeha@uta.edu

Labor utilization rating model is used to calculate labor rating factor. Chi-square distribution is used to compare productivity ratings of three or more construction crews. Statistical test of hypothesis for proportions is utilized to decide if proportions of productive times between crews are equal or not.

3 - Reducing Manufacturing Electricity Costs by Controlling Dependence Between Production Parameters

Hyun Woo Jeon, Assistant Professor, Louisiana State University, 3272X Patrick F. Taylor Hall, Mechanical and Industrial Engineering, Baton Rouge, LA, 70803, United States, hwjeon@lsu.edu

Manufacturing electricity costs are charged for energy consumption (EC in kWh) and peak demand (PD in kW). To model the costs accurately, EC and PD need to be considered together, but a model investigating the two factors has not been thoroughly studied. This study introduces a novel approach to estimating and reducing the costs by applying a multivariate probability model. The proposed model as a joint probability distribution characterizes important production parameters, and then EC and PD are evaluated from the model. From various examples, the proposed model provides a strategy to reduce the costs (EC + PD) by adjusting the production parameters and their dependence.

4 - An Active Learning Approach for Gaussian Processes

Rajitha Meka, Graduate Student, University of Texas at San Antonio, 15801 Chase Hill Blvd, Apt 104, San Antonio, TX, 78256, United States, rajitha.meka@utsa.edu, Adel Alaeddini

Gaussian process regression is a well-known non-parametric regression method that provides the estimate of uncertainty along with the predictions. Having the initial fit of the model with the points observed, active learning method helps to choose a promising point that improves the Gaussian process model. For the design space with large number of unobserved points, the main aim is to provide a good model with less number of evaluations by learning information about the design space at each evaluation.

■ TE20

342B

Empirical Research in Innovation

Sponsored: Technology, Innovation Management & Entrepreneurship

Sponsored Session

Chair: Tian Chan, Emory University, tian.chan@emory.edu

1 - Exploring the Affect of Idea Sources on the Successful Evaluation of Ideas

Nilam Kaushik, University College-London, London, United Kingdom, nilam.kaushik.13@ucl.ac.uk, Bilal Gokpinar

In this project we explore the factors affecting the successful evaluation of ideas on a crowdsourcing platform. In particular we are interested in understanding how the diversity, semantic distance of source ideas from the problem domain and the ways in which sources recombine affect the likelihood of idea success. In this work, we leverage text mining techniques and information retrieval methods to understand the recombination process.

2 - Structural Anatomy and Evolution of Supply Networks: A Multi-method Approach

Hyunwoo Park, The Ohio State University, Columbus, OH, 43210, United States, park.2706@osu.edu, Marcus A. Bellamy, Rahul C. Basole

We investigate the evolutionary dynamics of supply networks with a focus on the influence of structural, firm-, and industry-specific mechanisms. We characterize the dynamic relationship between the structural mechanisms on a longitudinal dataset of 2,221 unique firms and 13,668 firm-year observations. We find empirical support for negative crossover effects between two key structural mechanisms inherent in supply networks, a positive moderation of a firm's absorptive capacity and a negative moderation of industry growth on the structural reinforcement.

3 - Engaged Scholarship and Co-Creating Knowledge: A Design Science Approach to Operations Management Research

Aravind Chandrasekaran, Associate Professor, The Ohio State University, 600 Fisher Hall, 2100 Neil Avenue, Columbus, OH, 43210, United States, chandrasekaran.24@osu.edu, Joan Ernst Van Aken, Bradley R. Staats, Andrew H. Van de Ven

We question whether the decline in business education is partly due to the research approach adopted by operations management scholars. We show how co-creating knowledge with practice through a design science approach can derive dual benefit of relevance and rigor through several examples. We also offer suggestions on when and how to use this research approach.

4 - Unpacking the Value of Novelty in Design

Tian Chan, Emory University's Goizueta Business School, 1300 Clifton Road, Atlanta, GA, 30322, United States, tian.chan@emory.edu

We study how novelty in product form influences its economic value. We exploit a confidentiality feature specific to the design patent and use stock market reactions in the days subsequent to patent grant to estimate the private value of individual design patents granted to firms publicly listed in the US. We use the construct of styles—categories of product designs that are similar in form—to build various measures of novelty relative to designs of the same style, thus taking into account the context in which novelty is perceived. We show how different kinds of novelty positively or negatively affect value. Our results have implications on how firms should rely on novelty to seek value.

■ TE21

342C

Information Systems

Contributed Session

Chair: Feng Li, University of Science and Technology of China, 96 Jinzhai Road, Anhui, 230026, China, lfeng90@mail.ustc.edu.cn

1 - Sourcing Uncertain Product Quality: Competition, Learning, and Volume Postponement

Alexander Rothkopf, Julius-Maximilians-University Wuerzburg, Carla-Henius-Straße 9, Wuerzburg, 97070, Germany, alexander.rothkopf@uni-wuerzburg.de, Felix Lauton

Global-health buyers seek to introduce competition by incenting new generics suppliers with uncertain performance/quality to enter the market. We investigate the benefits of postponing a portion of the procurement volume to learn entrant's performance and how the dynamics of learning and competition depend on the size of the postponed volume.

2 - A Method for Location, Allocation and Distribution of Critical Supplies After a Natural Disaster

Ricardo Giesen, Associate Professor, Pontificia Universidad Catolica de Chile, Vicuna Mackenna 4860 Macul, Casilla 306 Cod. 105, Santiago, 7820436, Chile, giesen@ing.puc.cl
Ricardo Giesen, Associate Professor, CIGIDEN, Santiago, 7820436, Chile, giesen@ing.puc.cl, José Ignacio Olave, Juan Carlos Herrera

Humanitarian logistics after a natural disaster is normally characterized by lack of coordination, material convergence and shortage of critical supplies. This work proposes a mathematical programming method for location, allocation and distribution of critical supplies considering demand forecasting per item, operational costs and social costs including deprivation costs. Different scenarios are compared in terms of costs, considering water, food and shelter items.

3 - Resource Allocation Decisions to Manage Material Convergence
Merve Ozen, Research Assistant, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States, mozen@wisc.edu, Ananth Krishnamurthy

The large flow of donated items, both solicited and unsolicited, immediately after a major disaster, lead to the material convergence problem. Inefficient resource allocation can cause significant wastage of donated goods as well as deprivation of critical items for victims affected by the disaster. Using transient queuing models, we model this phenomenon to quantify material convergence and assess the impact of staffing strategies that improve efficiency.

4 - A Preposition and Allocation Model for Disaster Relief Inventories with Explicitly Considering Demand Risk
Feng Li, PhD, University of Science and Technology of China, NO. 96, JinZhai Road, Baohe District, Hefei, Anhui Province, 230026, China, lfeng90@mail.ustc.edu.cn

In humanitarian operations management, the relief organizations always have incomplete information on the beneficiaries. As a result, there would exist an estimation error between the estimated demand and real demand for relief supplies. In this paper, we propose a preposition-allocation model for disaster relief inventories by considering a demand risk parameter. We will investigate the impacts of demand risk on decisions of humanitarian logistics and human sufferings of beneficiaries. A cooperative strategy is also developed to cover the demand risk and to reduce human sufferings. Further, the proposed model will be demonstrated using the real case of Rammasun Typhoon in Hainan Island.

■ TE22

342D

Novel RM Models for Loyalty Programs

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ang Li, PROS, Inc., Houston, TX, 77002, United States, ali@pros.com

1 - Allocation Priority Tiebreakers for Frequent Flyer Seat Allocation Optimization
Shigeru Tsubakitani, PROS, Inc., 43360 Hillpark Street, South Riding, VA, 20152-2597, United States, stsubakitani@pros.com

Three approaches for breaking ties of alternative solutions for a frequent flyer seat allocation optimization model are discussed. The tiebreakers help generate solutions more desirable for airline companies by eliminating randomness and allocating frequent flyer seats more evenly among flights when there are many $0 bids exist in a market.

2 - Which Customers are More Valuable in a Dynamic Pricing Situation?
Anton Ovchinnikov, Queen's School of Business, 143 Union Street, Kingston, ON, K7L.3N6, Canada, ao37@queensu.ca, Jue Wang

We consider a firm that dynamically price its inventory and examine whether customers who purchase at higher prices indeed add higher marginal value to the firm. We present modeling and computational results which are calibrated on a unique data set from a major airline. We show that in some situations a customer's value can be independent of the price paid.

3 - Predicting Customer Retention using Cart Models
Pratik Mital, Senior Consultant, Operations Research, Revenue Analytics, Inc., 300 Galleria Parkway, Suite 1900, Atlanta, GA, 30339, United States, pmital@revenueanalytics.com

Predicting customer retention is an important problem in airlines, cruise lines, and any other industry where demand has a tendency to go higher than capacity. This allows the planners to optimally book more than the capacity, depending upon how many customers are expected to cancel. The margin for error in predicting customer retention can be quite low, since a wrong prediction can lead to either a denied boarding or an empty seat cost. The following are the key areas that will be covered during the talk: 1. Overview of customer retention and CART models 2. Customer attributes that can be utilized in the models 3. A real-world example 4. Accuracy metrics to evaluate the accuracy of the models

■ TE23

342E

Joint Session RMP/APS: Data-driven Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Will Ma, willma353@gmail.com

Co-Chair: David Simchi-Levi, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Dslevi@mit.edu

1 - Data-driven Dynamic Pricing with Model Misspecification and Endogeneity Effect
He Wang, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, he.wang@isye.gatech.edu, Milashini Nambiar, David Simchi-Levi

We study a dynamic pricing problem with contextual information where the seller may assume an incorrect demand model. The seller sequentially observes demand, estimates model parameters, and then chooses price. In this setting, model misspecification can cause price endogeneity, which in turn leads to inconsistent estimation of price elasticity and bad pricing decisions, a phenomenon known as the "spiral-down effect" in revenue management. To address the endogeneity effect we propose a "Random Price Shock" algorithm that dynamically generates independent price shocks to estimate price elasticity while maximizing revenue.

2 - Learning with Abandonment
Sven Peter Schmit, Stanford University, 729 Escondido Rd, Apt 224, Stanford, CA, 94305, United States, schmit@stanford.edu, Ramesh Johari

Consider a seller that repeatedly sets a price for a subscription product to the same customer. The seller would like to raise the price to the maximum the customer is willing to pay, but if it exceeds this value the customer abandons forever. Therefore, the learner has to be conservative in its policy.We propose a general thresholded learning problem that models such scenarios. The goal is to maximize the sum of discounted rewards based on a activity level set at discrete times. However, the process stops if the activity level exceeds an unknown threshold. We show that simple policies perform well under fairly general conditions.

3 - Data-driven Promotion Planning with Multiple Forms of Cannibalization
Hanwei Li, MIT, Cambridge, MA, United States, hanweili@mit.edu, Will Ma, David Simchi-Levi, Jinglong Zhao

We study the problem of promotion planning given data from a distributor which sells multiple products through multiple retailers. While planning these promotions, three cannibalization effects must be taken into consideration: across products, across retailers, and across time. We also analyze the effects of competing SKU's from other distributors.

4 - Continuous Assortment Optimization with Incomplete Information
Arnoud den Boer, University of Amsterdam, Postbus 94248, Room Number F3.33, Amsterdam, 1090 GE, Netherlands, A.V.denBoer@uva.nl

We study the classical assortment optimization problem with multinomial-logit type choice probabilities and finite capacity, but with a continuous instead of discrete set of products. We discuss how to determine an optimal assortment, how to estimate the choice probabilities from data, and how to apply these in an online-learning setting.

■ TE24

342F

Topics in Revenue Management, Choice Modeling and Assortment Optimization

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Vineet Goyal, Columbia University, Columbia University, New York, NY, 10027, United States, vgoyal@ieor.columbia.edu

1 - Revenue Management with Dynamic Customer and Assortment Selection
Adam Elmachtoub, Columbia University, 500 W. 120th St., New York, NY, 10027, United States, adam@ieor.columbia.edu, Vineet Goyal, Roger D. Lederman

We provide algorithms that select customers dynamically, each with their own choice model, in order to maximize revenue from a limited supply of inventory. We propose constant factor approximations when assortments may be chosen dynamically, and for a constrained setting where the set of offered products can only decrease over time.

2 - A Dynamic Learning Approach to Assortment Selection
Vashist Avadhanula, Columbia University, 3022 Broadway, 4th Floor West, New York, NY, 10027, United States, vavadhanula18@gsb.columbia.edu, Shipra Agrawal, Vineet Goyal, Assaf Zeevi

We consider a dynamic assortment selection problem where customers choose according to a multinomial logit (MNL) choice model. The retailer observes this choice and the objective is to dynamically learn the model parameters, while optimizing cumulative revenues over a selling horizon of length T. We present an efficient algorithm that simultaneously explores and exploits, achieving performance independent of the underlying parameters. The algorithm can be implemented in a fully online manner, without knowledge of the horizon length T. Furthermore, the algorithm is adaptive in the sense that its performance is near-optimal in both the "well separated" case and the general parameter setting.

3 - The Limit of Rationality in Choice Modeling: formulation, Computation, and Implications
Srikanth Jagabathula, NYU. Stern School of Business, 44 W. 4th St, Kmc Rm 8-74, New York, NY, 10012, United States, sjagabat@stern.nyu.edu, Paat Rusmevichientong

We focus on quantifying the limit of rationality (LoR) in choice modeling applications, defined as the "cost" of approximating the observed choice fractions from a collection of offer sets with those from the best fitting probability distribution over rankings. Computing LoR is intractable in the worst case. We express the complexity in terms of structural properties of an appropriately defined graph and exploit the graph structure to compute LoR efficiently for a large class of applications. Using real-world grocery sales data, we identify product categories for which going beyond rational choice models is necessary to obtain acceptable performance.

■ TE25

350A

Innovation/Entrepreneurship

Contributed Session

Chair: Pelin Atahan, Ozyegin University, Istanbul, Turkey, pelin.atahan@ozyegin.edu.tr

1 - How do IT Infrastructure and Human Resources Impact Operational Adjustment Agility
Peiran Gao, Huazhong University of Science and Technology, 1037 Luoyu Road, Wuhan, China, gaopeiran@hust.edu.cn, Jinlong Zhang, Yeming Gong, Shan Liu

This study proposes that two types of IT resource(i.e, IT infrastructure and human resources) enhance operational adjustment agility by facilitating structural IT capabilities, and that the magnitude of facilitation depends on the level of CEO support of IT. We test these relationships based on data from a multi-industry survey. Our results demonstrate that IT infrastructure and human resources do enhance operational adjustment agility through the mediated effects of structural IT capabilities, and that CEO support of IT differentially affects these relationships.

2 - Spatial Patterns and Socioeconomic Dimensions of Shared Accommodations: the Case of Airbnb in Los Angeles
Avijit Sarkar, Professor, University of Redlands, 1200 E.Colton Avenue, Redlands, CA, 92373, United States, avijit_sarkar@redlands.edu, Mehrdad Koohikamali, James B. Pick

This study examines spatiotemporal aspects and socioeconomic dimensions of shared accommodations within the broader context of the sharing economy. Specifically, we examine how socioeconomic attributes of Airbnb hosts moderated by hosts' attitudes towards trust and greener consumption influence participation in the sharing economy. Spatial bias in sharing economy participation rates is examined and policy implications for the supply side of shared accommodations are discussed along with generalizability of results.

3 - A Study of Mixed Reality Feature Utilization within Social Networking Applications
Alsius David, Doctoral Student in IT, University of North Texas, 1155 Union Circle #311277, Denton, TX, 76203, United States, alsiusdavid@my.unt.edu, Daniel A.Peak

Mixed reality (MR), where both real and virtual worlds are mixed, has been trending in social networking applications. MR enhances communication by integrating a virtual experience into the users' current environment. Taking the user's perspective, this study identifies whether personality, quality, and environmental characteristics influence feature utilization on the reality-virtuality continuum employed by SnapChat and Facebook Messenger.

4 - The Effect of Emotional Support by Conversational Assistants on Information Disclosure by Users
Kambiz Saffarizadeh, Georgia State University, 35 Broad Street, Suite 900, Atlanta, GA, 30303, United States, ksaffarizadeh1@gsu.edu, Maheshwar Boodraj, Tawfiq Alashoor

The main objective of this research is to investigate interaction behaviors between CAs and users. Specifically, we will examine how CA-based emotional support can influence users' satisfaction and disclosure behavior. We will draw upon interpersonal communication theories to develop and test a research framework in an experimental setting using a conversational assistant. We are interested in examining how CA-based emotional support can facilitate higher trust and lower privacy concern toward sharing personal information, which in turn influence the relationship between the user and CA in terms of service satisfaction and users' disclosure behavior.

5 - A Duopoly Model of Competition in Cloud Computing Services
Pelin Atahan, Assistant Professor, Ozyegin University, Nisantepe Mah Orman Sok Cekmekoy, Istanbul, 34794, Turkey, pelin.atahan@ozyegin.edu.tr, Basak Altan, Okan Orsan Ozener

In this paper, we investigate the price, quality of service and capacity decisions of 'Cloud Computing' service providers. We present a model where customers vary in their valuation of quality and in the quantity they demand. We study a duopolistic market, where the incumbent firm enjoys lower costs in later periods as a result of learning. We study how the service offerings change and how the entrant firm positions itself under two scenarios. In the first case, the incumbent firm does not consider future competition, whereas, in the second case, the incumbent firm anticipates future competition and acts strategically to deter entry in the first period.

■ TE26

350B

Cyber Analytics and Optimization

Sponsored: Social Media Analytics

Sponsored Session

Chair: Les Servi, The MITRE Corporation, The MITRE Corporation, Bedford, MA, 01730-1420, United States, lservi@mitre.org

1 - Multifirm Models of Cybersecurity Investment and Competition vs. Cooperation and Network Vulnerability
Anna B. Nagurney, University of Massachusetts Amherst, Isenberg School of Management, Dept of Operations & Information Mgmt, Amherst, MA, 01003, United States, nagurney@isenberg.umass.edu, Shivani G. Shukla

We develop and compare three distinct models for cybersecurity investment in competitive and cooperative situations to safeguard against potential and ongoing threats. We utilize game theory and optimization theory. We then apply the framework to two case studies on retailer and financial services and recommend a course of action.

2 - Scheduling and Training Multi-skilled Analysts under Uncertainty
Doug Altner, MITRE Corporation, 7515 Colshire Drive, M/S.H617, McLean, VA, 22102, United States, daltner@mitre.org, Erica Mason, Les Servi

This talk introduces a shift scheduling problem with unknown demand, multiple job types, and multi-skilled employees who can be trained to complete additional jobs. We provide a stochastic integer programming formulation of this problem and demonstrate that this formulation can be directly fed into Gurobi to solve instances with as many as 50 employees and 50 scenarios per day without any decomposition techniques. Finally, we present a local search heuristic that consistently produces good solutions for instances that are too large for a direct feed into a commercial solver.

3 - A Methodology to Measure and Monitor Level of Operational Effectiveness of a Cybersecurity Operations Center (CSOC)
Rajesh Ganesan, George Mason University, Fairfax, VA, United States, rganesan@gmu.edu, Ankit Shah, Sushil Jajodia, Hasan Cam

There are a number of disruptive factors that can adversely impact the normal operating conditions of a cybersecurity operations center (CSOC) such as 1) higher alert generation rates from a few IDSs, 2) new alert patterns that decreases the throughput of the alert analysis process, and 3) analyst absenteeism. The impact of all the above factors is that the alerts wait for a long duration before being analyzed, which impacts the readiness of the CSOC. It is imperative that the readiness of the CSOC be quantified and measures taken to maintain it, which in this talk is defined as the Level of Operational Effectiveness (LOE) of a CSOC.

4 - Deriving Global Criticality Conditions from Local Dependencies
Les Servi, The MITRE Corporation, M/S.M230, 202 Burlington Road, Bedford, MA, 01730-1420, United States, lservi@mitre.org, Paul R. Garvey

To assure greater resilience in a richly connected cyber network from exploited vulnerabilities, it is necessary to identify critical nodes and links that, without which, could compromise the ability of the system to operate as required. This talk provides a new near linear time way to find the globally critical nodes and links from local dependencies between elements that comprise the system.

■ TE27

350C

Social Media Analytics III

Invited: Social Media Analytics

Invited Session

Chair: Sriram Somanchi, University of Notre Dame, Notre Dame, IN, 46556, United States, somanchi.1@nd.edu

1 - Apply Text Mining Technology to Assist Design of Mobile Game Pokémon Go
Shih-Hsien Tseng, Chung Yuan Christian University, 200 Chung Pei Road, Chung Li District, Taoyuan City, 32023, Taiwan, tsengsh@mail2000.com.tw, Hsiao-Ying Chen, Chung-Yu Lao

With the prevalence of Mobile Games, numbers of Games Developers and the players are growing significantly. Many players like to discuss experiences and suggestions at the forum, and therefore online reviews from users become an important source of information for the game developer. In this research, we apply LDA Topic Model to analyze the opinions from users of Mobile Game Pokémon Go on PTT which is the largest forum in Taiwan to help game developers enhance the design quality.

2 - Opinion Dynamics with Bounded Openness to Ideas
Youzong Xu, Xi'an Jiaotong-Liverpool University, 111 Ren'ai Road, Business Building 423B, Suzhou, 215123, China, xu.youzong@wustl.edu, Bo Li

We study opinion dynamics with agents who have bounded openness to ideas. We characterize necessary and sufficient conditions under which agents with bounded openness to ideas can reach a consensus, or become segregated groups that never listen to each other. We then apply our findings to show why, when social media is providing a platform that people can easily be connected with each other, social media may lead to segregation and even polarization of people's opinions.

3 - Exploring the Social Media Prevalence and Consequence of "Sharing without Reading"
Frank Zheng, Doctoral Student, UT-Austin, Austin, TX, United States, jianqing.zheng@mccombs.utexas.edu

Extant research on social contagion assumes that information spreads as sharers deliberately process external information, then decide whether or not to share it; as each sharer processes this information, s/he is "infected" with new knowledge. However, emerging evidence suggests that this is not always the case; for example, 16.2% of shared links on Twitter have more retweets than clicks (Zarrella, 2013). We propose that "sharing without reading" represents a distinct phenomenon in which information "carriers" spread content without being infected by it. Evidence from four studies suggests that sharing without reading leads to increases in subjective, but not objective, knowledge.

4 - Exploring Social Influence from Social Opinion to Social Network
Shu-Ping Tsai, Graduate Student, National Sun Yat-Sen University, No. 70, Lienhai Rd., Kaohsiung, 80424, Taiwan, Kaohsiung, Taiwan, m054020017@Student.nsysu.edu.tw

With the rapid development of social Web and electronic commerce, the potential consumers seek for product-related information before making a purchase decision from various online resources. Among all kinds of online resources, customer review provides critical product features and discussion posts play a vital role for peer communication. However, there is a lack of integration of these rich online resources. This study particularly investigates customer review and interpersonal information from discussion boards and explores how these two social resources associated with each other to improve the insight into each user's preference with a social role they act.

■ TE28

350D

Mechanism Design and Pricing

Invited: Auctions

Invited Session

Chair: Gabriel Weintraub, Stanford Graduate School of Business, Stanford, CA, 94304, United States, gweintra@stanford.edu

1 - Evaluating Strategic Forecasters
Rahul Deb, University of Toronto, 150 St George Street, Toronto, ON, M5S.3G7, Canada, rahul.deb@utoronto.ca

Motivated by the question of how one should evaluate professional election forecasters, we study a novel dynamic mechanism design problem without transfers. A principal who wishes to hire only high quality forecasters is faced with an agent of unknown quality. The agent privately observes signals about a publicly observable future event, and may strategically misrepresent information to inflate the principal's perception of his quality. We show that the optimal deterministic mechanism is simple and easy to implement in practice: it evaluates a single, optimally timed prediction. We study the generality of this result and its robustness to randomization and noncommitment.

2 - The Scope of Sequential Screening with Ex-post Participation Constraints
Gabriel Weintraub, Stanford Graduate School of Business, Knight Management Center, Stanford University, 655 Knight Way, E364, Stanford, CA, 94304, United States, gweintra@stanford.edu, Dirk P. Bergemann, Francisco Javier Castro

We study the classic sequential screening problem with the additional constraint that the seller is required to satisfy the buyer's ex-post participation constraints. This setting arises in several practical applications, such as the market for display advertising. First, we provide a necessary and sufficient condition under which the static contract (buyers are not sequentially screened) is optimal for general distributions. When this condition fails, we fully characterize the optimal dynamic contract, which randomizes the low type buyer and exhibits other novel properties.

3 - Understanding and Pricing on a Network with Latent Agents
Alexandre Belloni, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708, United States, abn5@duke.edu, Baris Ata, Ozan Candogan

A recent literature on social networks has focused on understanding how a seller can use the available social network information to improve decisions. This paper investigates how a seller estimates the impact of the social network on agents' consumption and makes pricing decisions when there are additional latent agents which are not observed by the seller. These latent agents can purchase the same product from a different channel and can influence the agents in the observable part of the network. We establish structural results, compute optimal pricing rules based on observable quantities, and estimate the effective latent network.. Variants with and without random shocks are considered.

4 - Local Computation Mechanism Design
Shai Vardi, California Institute of Technology, Pasadena, CA, United States, svardi@caltech.edu

Local computation mechanisms (LCMs) are game theoretic mechanisms that produce small parts of a solution extremely quickly, without any pre-processing. LCMs reply to queries in time sub-linear in the input size, so that the replies to different queries are consistent with a single global solution that satisfies some required game-theoretic properties. LCMs are useful in scenarios when the market is so big that mechanisms that require access to all of the input and produce the entire output are impractical. We design local computation mechanisms for several classical game-theoretical problems: stable matching, job scheduling and unit-demand combinatorial auctions.

■ TE29

350E

Manufacturing

Contributed Session

Chair: David Richardson, Illinois Institute of Technology, Chicago, IL, United States, david.richardson@stuart.iit.edu

1 - Measuring Large-scale Market Responses from Aggregated Sales: Regression for High-dimensional Sparse Data

Nobuhiko Terui, Professor, Tohoku University, Kawauchi Aoba-Ku, Sendai, 980-8576, Japan, terui@econ.tohoku.ac.jp

We propose a regression model for high-dimensional sparse data from store-level aggregated sales. The modeling comprises two sub-models—topic model and hierarchical factor regression model—that are applied sequentially not only for accommodating high dimensionality and sparseness but also for managerial interpretation. First, the topic model is applied unusually to aggregated data to decompose the aggregated sales volume of a product into sub-sales for several topics by allocating each unit sale in a day into one of topics based on joint purchase information. Then, we construct a topic-wise market response function by hierarchical factor regression based on canonical correlation analysis.

2 - In Store Customer Experience Creation in the Retail Industry

Trisha D. Anderson, Texas Wesleyan University, 1201 Wesleyan Street, Fort Worth, TX, 76105, United States, trdanderson@txwes.edu

This paper examines the impact of the right mix of atmospheric factors used to create the in-store customer experience in a retail market that includes ambience factors (volume of music, type and strength of aroma, level of lighting), interaction with sales people, and store display, on the in-store customer experience, the customer's emotional state, and customer shopping behavior.

3 - Do Marketing Talents Matters its Relationship to Marketing Capability and Performance

YiChun Liu, National Taiwan University, Room 1116, No 30, Sec 3, Taipei, 10668, Taiwan, d02724003@ntu.edu.tw

The discussion of marketing capability on firms' performance has been well documented for the last two decades. Most of the previous studies regarding the measurement of marketing capability are based solitary on the attitude of top managers. However, employees' marketing talents are rarely discussed. This study investigates a new construct of marketing capability and the measurement of individual employee's marketing talents. A preliminary questionnaire was developed to conduct an empirical study, of which over 2,000 employees were surveyed. This study identified the positive impact of employee marketing talent and managerial marketing capability to organizational performance.

4 - Peer Effects in the Adoption of a New Social Program

Claudio Mora, Pontificia Universidad Javeriana, Carrera 7 #40b-36, Piso 4, Bogota, Colombia, claudio_mora@javeriana.edu.co

Launching a new program is challenging for organizations because their potential clients have to learn its unknown quality. This is the first paper to empirically study how adoption by high school classmates and coworkers affects each peer's adoption of a new employment subsidy during implementation stages. Identification comes from a discontinuity in the subsidy assignment rule inducing exogenous variation in a neighborhood around the worker's wage eligibility cutoff. Using a unique set of administrative records, we find that: coworkers strongly influence one's adoption, classmates do not; peer effects decrease over time. Hence, information diffusion can explain adoption in the short run.

5 - The Power of Social Networks in Predicting Noncontractual Customer Activity Evidence from Venmo

Pantelis Loupos, PhD Candidate, Kellogg, Northwestern University, 2800 N Lakeshore Dr, Apt 2913, Chicago, IL, 60657, United States, louposp@gmail.com

There is a shift away from the subscription-based business model to on-demand (OD) services. We focus on predicting customer activity (CA) in OD settings in the presence of social network (SN) data. Data comes from Venmo, a P2P payment application. We: 1) Conduct a dynamic analysis to quantify the effect of user and SN metrics on CA and find that SN metrics help achieve a significant increase in predictive accuracy during the beginning of a customer's lifetime. 2) Evaluate our models in the task of CA-based customer segmentation and find that we can identify customers segments with high accuracy. 3) Identify structural differences among the different customer segments.

6 - Controlling Endogeneity in Event Studies: Valuing Movie Product Placements using Prediction Market Data

David Richardson, Assistant Professor of Marketing, Illinois Institute of Technology, Chicago, IL, 60605, United States, david.richardson@stuart.iit.edu

Abstract: Event studies are widely used in marketing to value intangible investments using abnormal returns as measured by equity markets. Two objections; omitted variables which are endogenously related to event timing may bias estimates, and researcher flexibility in choosing the event window allows for cherry picking results. We use data from the Hollywood Stock exchange (HSX) to control for these effects in a study of product placement of automobiles in films. We evaluate individual placements using regression on panel data and compare the results with the conclusions from a standard event study approach to shed light on potential endogeneity bias in such studies.

■ TE31

351A

Finance

Contributed Session

Chair: Nadja Younes, University of Konstanz, Konstanz, Germany, nadja.younes@uni-konstanz.de

1 - Analyst Coverage, Board Monitoring, and Firm Value. Evidence from a Natural Experiment

Torsten Twardawski, University of Konstanz, Universitaetsstr. 10, Konstanz, 78467, Germany, Torsten.twardawski@uni-konstanz.de, Iana Zborshchyk

In this paper, we estimate a causal impact of analyst coverage on the long-term value of a company. Using two established quasi-natural experiments, we find that exogeneous coverage reductions decrease long-term firm value. We show that the reduction in firm value is linked to a decline in fundamental value and stronger if a board has weak monitoring power. Conditional on their initial internal monitoring quality, firms try to offset the negative effect by improving their internal governance mainly through getting more independent boards. Overall, our results confirm that analysts create value through their governance role, which interacts with preexisting internal monitoring.

2 - The Role of Sentiment-driven Institutional Investors in IPO Pricing

Bo Liu, University of Electronic Science and Technology of China, No. 2006, Xiyuan Ave, West Hi-Tech Zone, Chengdu, 611731, China, b.liu07@fulbrightmail.org, Jingbin He

In this paper, we take advantage of the unique setting and big data of Chinese auction-based IPO process to examine the role that sentiment institutions play in the pricing of newly listed stocks. We find that underwriters may "strategically" use positive/negative language to manipulate the writing style in the premarket Valuation Report to influence bidder's pricing and hence the final offer prices of IPO. This is one type of "agency problem", which leads to substantial losses of both retail and institutional investors and more volatile post-IPO stock prices. The results suggest that sentiment institutional investors deteriorate the pricing of newly listed stocks.

3 - Financial Assets and Demand Estimation

Murat Tiniç, PhD Candidate, Bilkent University, Ankara, Turkey, tinic@bilkent.edu.tr

In this study, I propose to model the investment decisions of an investor as a discrete choice action, and estimate the demand for a financial asset through the underlying structure of the investor's utility.

4 - The Impact of a CEO's Status as High Quality Board Director , on Personal and Organizational Outcomes: Evidence fro CEO Awards

Nadja Younes, University of Konstanz, Universitaetsstr. 10, Konstanz, 78467, Germany, nadja.younes@uni-konstanz.de, Torsten Twardawski

In this paper we examine the extent to which a CEO's status as high quality board director impacts economic outcomes. We use a unique data set of CEO awards to measure positive second-order status shocks to CEOs, who serve on an award-winning CEO's board. Around the awarding, we find negative and significant stock-price reactions for the CEOs' focal firms. We show that affected CEOs accept more board positions and receive higher compensation. Corporate governance has a moderating effect on the investigated outcomes. Our findings suggest that CEOs with reputable board positions become busy with firm-unrelated activities, dedicate less time and effort to their firms, and destroy shareholder wealth.

■ TE32

351B

Supply Chain, Design & Services

Contributed Session

Chair: Huajiang LUO, Lingnan University, Hong Kong, Hong Kong, huajiangluo@ln.edu.hk

1 - Dynamic Pricing Competition of Fresh Produces under Vertical Product Differentiation

Chang Xu, East China University of Science and Technology, Shanghai, China, 947319206@qq.com

This paper study the dynamic pricing competition between two firms respectively offering vertically differentiated fresh produces of which freshness is decrease over time without considering fresh-keeping effort. Then, through taking into account the freshness-keeping effort, we deepen the analysis of the problem. We show that the retailer would mark down its price when its decay rate promote comparing to its rival and , accordingly, its accumulated discount income would decline. And we also find it would be profitable for the retailer to trade off between the gains from the depressing the decay rate and the losses from rising the price for the compensation of the cost of freshness-keeping effort.

2 - Cost of Information Sharing in Group Purchasing

Gilles Merckx, University of Namur, Rempart de la Vierge, 8, Namur, 5000, Belgium, gilles.merckx@unamur.be, Wenli Peng, Aadhaar Chaturvedi, Philippe Chevalier

We investigate through a Cournot model whether group purchasing could be attractive for competing firms, when the next period market demand and firms' product quality are uncertain. In this context, group purchasing offers the firms a higher negotiation power with the supplier, but also requires to reveal some sensitive information to the competitor, as the quantity desired (which is a signal of a firm's product quality and market demand estimation), in order to negotiate as a single buyer with the supplier. Hence it is not clear whether firms should agree on doing group purchasing. We find that different types of uncertainty can lead the firms to select opposite purchasing strategies.

3 - Price Competition and Quality Competition: National Brand vs. Store Brand

Tulika Chakraborty, Research Associate, John Molson School of Business, 1450 Rue Guy, Montreal, QC, H3H2L5, Canada, jum.tulika@gmail.com, Satyaveer S. Chauhan, Xiao Huang

We consider a supply chain in a market segment where a national brand competes with a retailer's private label product with respect to not only price but also quality. We use the game theoretic model to focus the impact of different channel leadership of quality-setting stage on optimal decisions.

4 - Strategic Timing of New Product Release with Information Leakage under Competition

Huajiang LUO, PhD Student, Lingnan University, Hong Kong, Hong Kong, huajiangluo@ln.edu.hk, Tian Li, Weixin Shang

We consider a model in which two firms plan to sell substitutable new products to a uncertain market. Each firm makes two decisions (release timing decision and quantity decision) based on its private information. The late firm can infer the early one's information via its quantity. We find that the late firm will commit a higher quantity, and hence early releasing doesn't necessarily translate into a bigger market share. When the competition is not intense, the equilibrium is that the more-informed firm releases later than the less-informed one. With private information, sequentially releasing new product dampens the quantity competition, and firms benefit from the differentiation of release time.

■ TE33

351C

From the Center to the Terminal: Methods for Managing Airspace and Airport Operations

Sponsored: Aviation Applications

Sponsored Session

Chair: James Calvin Jones, University of Maryland, College Park, MD, United States, jonesjc1@gmail.com

1 - An Optimization Framework for Trajectory Based Operations in Air Traffic Flow Management

Guglielmo Lulli, Lancaster University, Lancaster, LA1 4YX, United Kingdom, g.lulli@lancaster.ac.uk, Veronica Dal Sasso, Franklin Djeumou Fomeni, Giuseppe Murgese, Konstantinos G. Zografos

In this talk, we present a mathematical framework - developed within the activities of the SESAR ER project OptiFrame - to optimally configure and assess the performance of the Trajectory Based Operation (TBO) concept. The existence of multiple and sometimes conflicting objectives, reflecting the views and expectations of the different airspace stakeholders, naturally lead to multi-objective optimization. To evaluate the tractability of the proposed model, a computational performance analysis on a set of realistic instances will be presented.

2 - Capacity Scenarios for Multiple Airport Regions and their Application for Regional Air Traffic Management

Ang Li, angli@berkeley.edu, Mark M. Hansen

We identify multiple airport regions (MARs) in the United States based on the temporal distance between airports. Clustering analysis is implemented to identify daily capacity scenarios in 2015 for the airports for the New York MAR. Using the scenarios, we formulate a mixed-integer linear programming model to reschedule and reassign flights into the New York MAR to minimize the total cost of delay and inter-airport flight shifting.

3 - Evaluating Capacities of New York-area Airports Combining Empirical Data with Enveloping Methods

Jeremy Eckhause, RAND Corporation, 1200 S. Hayes St., Arlington, VA, 22202, United States, eckhause@rand.org, Kenneth Kuhn, Candice Miller

We present a capacity estimation method that combines large amounts of ASPM data with published capacity studies and methods in the literature for estimating capacity envelopes at the three New York-area airports. Based on this approach, will illustrate how existing capacity values may not provide sufficient flexibility tradeoff in off-nominal conditions. As a result, we provide suggested alternative capacities to reflect those additional data points, to provide inputs into models that assess the delay performance under certain GDP procedures.

4 - Models for Setting Airport Capacities

James Calvin Jones, University of Maryland-College Park, 223 Concord Turnpike, Apt 206, Cambridge, MA, 02140, United States, jonesjc1@gmail.com

In this presentation we propose a supervised learning method for predicting airport capacity as well as the uncertainty associated with those predictions. We also discuss a chance-constrained programming model that leverages the uncertainty from these predictions to select the planned airport capacity.

■ TE34

351D

Optimization and Military Applications

Sponsored: Military Applications

Sponsored Session

Chair: Keith DeGregory, USMA, West Point, NY, Keith.Degregory@usma.edu

■ TE35

351E

Supply Chain Optimization

Contributed Session

Chair: Ziyu Zhai, Huazhong University of Science and Technology, Wuhan, China, zhaiziyu000@126.com

1 - An Analytical Model for Low Carbon Supplier Development

Chiranjit Das, Indian Institute of Management Rohtak, MD University Campus, Rohtak, Haryana, Rohtak, 124001, India, fpm02.003@iimrohtak.ac.in, Sanjay Jharkharia

This paper deduces a set of association rules of firm's investment and collaboration decisions for low carbon supplier development through fuzzy-c-means (FCM) clustering algorithm and fuzzy formal concept analysis. Firstly, suppliers are classified based on carbon performances through FCM algorithm and finally fuzzy formal concept lattice structure and implication rules for relative investment and collaboration decisions are deduced through the help of next closure algorithm and implication operator. Lastly, the model is illustrated through a case study of an Indian apparel manufacturing firm.

3 - EU Effect and the Adoption of Environmental Practices Among Apparel and Textile Firms in Developing Economies

J. Shubham, Indian Institute of Management Raipur, GEC Campus, Raipur, 492015, India, shubham.1913@gmail.com, L.S. Murty

This paper analyses the linkage between international trade and environmental issues. We examine how the commitments of Annexe I countries to Kyoto Protocol has impacted the reduction in carbon dioxide emission(CO_2) levels of top apparel and textile exporting developing countries? We found that trade with the European Union has helped in significantly reducing emissionCO_2 levels among developing countries. Thus, this paper acknowledges the strength of European Union as a formidable trade power and presence of "EU-effect" in the area of environmental governance.

2 - The Impact of Buyer Pressure on Supplier Transparency
Suvrat Dhanorkar, Assistant Professor, Pennsylvania State University, 466 Business Building, University Park, PA, 16802, United States, ssd14@psu.edu, Veronica H.Villena

We explore conditions under which buyer pressure may succeed or fail to drive greater supplier transparency. To test the hypotheses, we combine data from the Carbon Disclosure Project's (CDP) supply chain program and ASSET 4 on a sample of 700+ suppliers over the 2013-2015 period. The results show that the degree of influence exerted by buyer pressure is significantly lower when suppliers have in place internal environmental structures (i.e., an environmental strategy, a dedicated board representative and managerial incentives).

4 - The Optimal Incentive Supervision Contract for Ewaste Recycling with Retailers Self Interest Behavior
Ziyu Zhai, Huazhong University of Science and Technology, Wuhan, China, zhaiziyu000@126.com

We adopted the principal agent theory to explain this phenomenon and study the impact of incentive supervision contract on the self-interest behavior of retailers. Pure supervision and penalty on retailers does not always avoid the self-interest behavior of retailers, even when the revenue from selling recycled E-waste to individual is low and the producers have ability to control the recycling market; the hidden number of retailers recycling is weakly correlated with the supervision level and penalty degree, furthermore only the supervision level and penalty degree reach to be a certain threshold, self-interest behavior of retailers can be effectively avoided;

■ TE36

351F

NSF Funding Opportunities for Service System Researchers Converging with Social, Behavioral and Cognitive Sciences

Sponsored: Service Science

Sponsored Session

Chair: Alexandra Medina-Borja, NSF/ UPRM, NSF/ UPRM, Falls Church, VA, 22046, United States, amedinab@nsf.gov

1 - NSF Funding Opportunities for Service System Researchers Converging with Social, Behavioral and Cognitive Sciences
Alexandra Medina-Borja, PhD, US.National Science Foundation, 4201 Wilson Blvd., Arlington, VA, 23330, United States, alexandra.medinaborja@upr.edu

Dr. Alexandra Medina-Borja, Program Director in the Directorate for Engineering at the National Science Foundation will provide an overview of the agency's emerging funding opportunities for operations researchers and data scientists in programs that draw engineering and computer science researchers in collaboration with cognitive and behavioral scientists to study human-technology partnerships in service settings. Other funding opportunities for engineering and computer science departments as well as in graduate and undergraduate education will also be discussed followed by an open discussion and Q&A.

■ TE37

352B

Modeling to Inform Science Policy

Sponsored: Service Science

Sponsored Session

Chair: Maryam Alsadat Andalib, Virginia Institute of Technology, Virginia Institute of Technology, Blacksburg, VA, 24060, United States, maryam7@vt.edu

1 - System Dynamics and Operations Research: A New Synergy for Policy Modeling
Richard C. Larson, Massachusetts Institute of Technology, E40-233, Cambridge, MA, 02139, United States, rclarson@mit.edu, Navid Ghaffarzadegan

We offer a methodological hypothesis that many traditional OR models can be modified with SD feedback loops driven by forces outside of the traditional OR modeler's universe. We argue that such models, even if simple and approximate, will be powerful and effective for policy modeling. We present examples of our recent models. These cases benefit from both schools of modeling. We think the fields of SD and OR can significantly benefit from collaboration. We further discuss the first steps towards integration of queueing models and feedback loop models: endogenous queueing models.

2 - The Network of Cross-disciplinary Research in Health: Neuroscience Bridging Scientific Disciplines
Ran Xu, Virginia Tech, Blacksburg, VA, 24060, United States, ranxu@vt.edu, Navid Ghaffarzadegan

We map the progression of cross-disciplinary research studies in biological and health sciences by examining the topics of doctoral dissertations from US institutions. Examining dissertations from the past two decades, we analyze the changes in frequency of subjects that appear in each discipline, as well as how subjects co-appear in the same dissertations. We further conduct a topic-network analysis of the dissertations and examine emerging topics and links between the topics. Results show that behavioral sciences and engineering fields are playing an increasingly important role in biological and health sciences research. There are also important new bridges emerging around neuroscience.

3 - Modeling Long-term Success and Innovation in Career of Scientists in Academia
Arash Baghaei Lakeh, Virginia Tech, 1145 Perry Street, 250 Durham Hall (0118), Blacksburg, VA, 24061, United States, arashb@vt.edu, Navid Ghaffarzadegan

Success and innovation in a scientist's career depend on multiple organizational factors such as availability of funding, resource allocation, capacity development, and learning through exploration. In this project, we investigate the dynamics of innovation and success in a scientist's career through a system dynamics model. By capturing the important feedback mechanisms in the process of science production and modeling the stochastic nature of scientific inquiry, we study the conditions under which scientists can be successful and follow innovative projects in their careers.

■ TE38

352C

Multi-Objective Methods for Infrastructure Analysis

Sponsored: Multiple Criteria Decision Making

Sponsored Session

Chair: Kash Barker, University of Oklahoma, Norman, OK, 73019, United States, kashbarker@ou.edu

1 - Vehicle Routing Formulation for Infrastructure Network Recovery
Nazanin Morshedlou, University of Oklahoma, 1135 E.Brooks Street, Apt 2, Norman, OK, 73071, United States, nazanin.morshedlou@ou.edu

This research proposes an extension of the vehicle routing problem with a comprehensive formulation that accounts for scheduling work crews to recover an infrastructure network after a disruptive event. In this problem, work crews are routed from depots to disrupted network components to maximize the cumulative flow in the network in a desired time horizon. As disrupted network components possess different characteristics (e.g., level of disruption, the rate of recovery), we develop the formulation to address (i) different levels of requirements for disrupted components and (ii) the possibility of assigning more than one work crew to a single link to change its recovery rate.

2 - Integrated Performance Modeling of Water and Transportation Infrastructures with Physical-socioeconomic Interdependencies
Shima Mohebbi, University of Oklahoma, Norman, OK, United States, mohebbi@ou.edu, Mingyang Li, Qiong Zhang, Qing Lu, E. Christian Wells

This study develops an integrated performance modeling and decision framework to maintain and improve the operations of water and transportation infrastructures by considering their physical-socioeconomic interdependencies. We first develop system level performance measures to evaluate the vulnerability. Based on failure scenarios heuristically simulated, we then examine their consequences on system performances and characterize the degree of interdependency. A two-stage stochastic mathematical model is further developed to investigate the cost-effective maintenance and rehabilitation decisions. A case study will be demonstrated in the City of Tampa, FL.

3 - Optimizing Interdependent Infrastructure Resilience under the Dynamics of Individuals and Organizations
Andres David Gonzalez, The University of Oklahoma, Norman, OK, United States, andres.gonzalez@ou.edu, Camilo Gómez-Castro, Hiba Baroud

Most research on infrastructure resilience assumes a centralized decision maker with a single well-defined objective function. In this work, we propose a model that incorporates a multi-objective societal layer to analyze and optimize the resilience of interdependent infrastructure networks. The proposed approach enables modeling how human and organizational aspects (e.g., biases, risk preferences, multiple interests, and decentralization, among others) influence infrastructure risk and resilience management decisions on the stakeholders involved in their use and operation, and how these impact the overall performance and resilience of infrastructure systems.

4 - Resilience-based Freight Transportation Infrastructure Network Design

Mohamad Darayi, Pennsylvania State University-Great Valley, 201-F Wadsack Dr., Malvern, PA, United States, mud415@psu.edu, Nazanin Morshedlou, Kash Barker

Improving freight transportation infrastructure network design (i) by the addition of capacitated links/nodes or (ii) by increasing the capacity of current network components are explored as options to strengthen the functionality of the network and its effect on the multiple industries relying upon it. Considering different disruption scenarios, this research addresses a network completion decision making problem with respect to the network resilience, as well as multi-industry impacts.

■ TE39

352D

The Analytics of Modern Political Campaigning

Sponsored: The INFORMS Section on Practice

Sponsored Session

Chair: Douglas Alan Samuelson, InfoLogix, Inc., Annandale, VA, 22003-3807, United States, samuelsondoug@yahoo.com

1 - Polling, Psychology and Propaganda in Forecasting Electoral Outcomes

Dimitris Vayenas, Metapoll, London, United Kingdom, dimitris@metapoll.co.uk

Having predicted the outcomes of recent elections the session addresses the underlying theories that are calling for a re-evaluation of political campaigning. By utilising formal models developed to quantify transparency in many-to-many communications, accurate forecasting is attainable based on the motives of the population as addressed by the campaigns; in the case of Brexit with a 0.1% deviation one month before the elections. The shortcomings of polling methodologies and how analytics can help mitigate the impact of unreliable responses are also addressed. Models of human socialty and motivators are employed in the mapping of quantifiable sentiments and reactions to propaganda.

2 - Voting Access and Delay

Theodore T. Allen, Ohio State University, 210 Baker Systems, 1971 Neil Ave, Columbus, OH, 43210-1271, United States, allen.515@osu.edu

Election officials are often poor users of waiting line analyses including simulations. As a result, they often fail to account for longer ballots in certain locations requiring more resources. Also, they can fail to provision enough ballots so that lines are uniform and minimal. Evidence from elections in New Mexico and North Carolina is discussed. In both cases, there is evidence that one party in power used lines (with somewhat unclear intentionality) to improve its own election results likely, for some elections, changing the outcomes.

3 - Targeting and Virtual Tribalism

Douglas Alan Samuelson, InfoLogix, Inc., 8711 Chippendale Court, Annandale, VA, 22003-3807, United States, samuelsondoug@yahoo.com

Recent US elections and marketing data indicate that the country is evolving toward a form of virtual tribalism. Virtual tribes are defined by shared values and perceptions rather than kinship, but they work the same way: mutual reinforcement of information and opinions, excluding outsiders. Several political campaigns have exploited this tribal structure to target selected groups of voters with focused messages, especially via non-traditional media. We review these methods and phenomena and discuss some of their implications.

■ TE40

352E

Operations/Finance Interface

Contributed Session

Chair: Haitao Li, Univ of Missouri-St Louis, St Louis, MO, United States, lihait@umsl.edu

1 - Bank's Effect on Entry of Capital-constrained Firm

Guanmei Liu, PhD, Shanghai Jiao Tong University, 1954 Huashan Roda, Shanghai, 200030, China, lgmei2006@sjtu.edu.cn

This paper studies the effect of finance on new entry in industry market, when an entrant and an incumbent both need to borrow money from a common bank. We derive two firms' optimal production quantities and bank's optimal interest rate in two scenarios: monopoly without entry and competition with entry. We find that bank may not deter entry in one of three cases: 1)two firms are symmetric, 2)incumbent only has advantage in working capital, 3)incumbent has advantage in market size or production cost or both but with more working capital. Interestingly, only when incumbent has no or a little working capital, his larger market size or lower production cost advantage could make bank deter entrant.

2 - The Newsvendor with Uncertain Accounts Receivable

Emre Berk, Bilkent University, Faculty of Business Administration, Ankara, 06800, Turkey, eberk@bilkent.edu.tr

I revisit the classical newsvendor with different customer segments having different likelihoods of not being able to pay for the purchases they have already made. Under various collection scenarios, analytical results are obtained on the optimal production, marketing (promotion) and financial (collection) decisions. Basic trade-offs are discussed via illustrative examples.

3 - Effects of Overconfident Coos on Inventories.

Jaeseok Na, KAIST, Seoul, Seoul, 082, Korea, Republic of, jsna@kaist.ac.kr, Bowon Kim, Jeong Eun Sim

This study investigates the effects of overconfident Chief Operating Officers (COO) on the corporate inventory strategy of a large number of U.S. manufacturing companies. Overconfident managers tend to overestimate future outcomes; thus we hypothesize that overconfident COOs set their operational strategy more aggressively expecting to increase their sales. Using option-based proxies for the overconfidence, we find that such firms fail to maintain lean strategy. In addition, we suggest the relationship is moderated by market structure. We therefore conclude that understanding the behavioral aspects of managers provides valuable insights in managing inventories.

4 - Optimal Supply Chain Financing Strategies with Loss Aversions: Financing vs. Investment

Ye Liu, Central University of Finance and Economics, Beijing, China, yeliuaug@gmail.com, Nina Yan

This paper designs two supply chain financing schemes for the capital-constrained retailer, namely, supplier financing and supplier investment. Considering the retailer's loss aversions, we comparatively analyze the optimal strategies for all participants under these two schemes and investigate the optimal financing choices for the retailer in different cases.

5 - Optimal Commodity Selling using Spot and Forward Markets

Behzad Ghafouri, Graduate Research Assistant, University of Western Ontario, 1151 Richmond Street, Western Science Centre, Room 262, London, ON, N6A 5B7, Canada, b.ghafouri@gmail.com, Matt Davison, Somayeh Moazeni

During contango oil markets, the offshore crude oil storage trade in which cheaper spot oil is purchased for higher forward sale is popular. The optimal sale of a commodity stored in a rental tanker over a finite horizon is studied. At each time step, the quantity of inventory sold at spot and the forward contract maturity for the remaining inventory are decided. Using the short/long-term Schwartz-Smith price model, the problem is formulated and analyzed as a Markov Decision problem. Approximate dynamic programming policies are investigated. The value of dynamic selling in the forward market and adaptively adjusting the forward maturities are compared to initial spot selling.

6 - A Bilevel Programming Approach to Optimize Credit Term Decisions in Supply Chains

Haitao Li, Univ of Missouri-St Louis, College of Business Administration, 229 Express Script Hall, St. Louis, MO, 63121-4400, United States, lihait@umsl.edu

We present a new game-theoretic framework to model the problem of optimizing credit-term in a supplier-buyer supply chain. The interaction between supplier's credit term decision and buyer's order decision is captured in a Stackelberg game, where the supplier is the leader who determines credit terms for the transaction anticipating certain order quantities from the buyer; then the buyer reacts with its order quantity decision as a follower. A real world case study is presented to show benefit of our optimal credit term solution comparing with two fixed heuristic solutions.

■ TE41

352F

Health Care, Other

Contributed Session

Chair: Anna Paula Galvão Scheidegger, Texas A&M University, College Station, TX, United States, apscheidegger@tamu.edu

1 - Preliminary Integrated Approach to Modeling the Prescription and Illicit Opioid Epidemic

Jacqueline Garrahan, Healthcare Systems Engineering Institute, Northeastern University, Boston, MA, 02115, United States, j.garrahan@northeastern.edu, Iulian Ilies, James C. Benneyan

We formulated a differential equations model of the prescription and illicit opioid co-epidemic and parametrized this model for Massachusetts aggregate and county-level populations as case studies. We optimized parameter values to reproduce historic overdoses by using a grid search approach, identified a prior systemic change leading to increased prevalence, and simulated the consequences of potential interventions. Results identified chronic prescribing and the prescription-to-illicit use pipeline as major drivers of epidemic growth, providing avenues for future research and model expansion.

2 - Maximizing Social Welfare in Vaccine Procurement for Multiple International Group Buying Entities with or with out Cooperation

Bruno Alves Maciel, Rochester Institute of Technology, 5000 Nathaniel Rochester Hall 248, Rochester, NY, 14623, United States, ba8641@rit.edu, Kushal Mehta, Ruben Proano

This study models the global vaccine market for a set of antigen bundles from different manufacturers. Those are sold to international group-buying entities (GAVI, PAHO, etc.) and/or individual countries organized as markets that may or may not cooperate. Through a sequence of optimization problems, vaccine prices and allocations are compared in different scenarios of cooperation to maximize social welfare and ensure profit for the manufacturers.

3 - Assessing Decisions in Medical Referral Networks from Empirical Data

Mojtaba Araghi, Wilfrid Laurier University, 438 King Street W, Apt 1208, Toronto, ON, M5V. 3T9, Canada, maraghi@wlu.ca, Michael Pavlin

Informal referral networks are central to the allocation of medical resources in many healthcare systems. In this paper we assess decisions in a cataract surgery referral network. The system is modeled as a bipartite queueing network and empirical techniques are developed to estimate decision making parameters from aggregate data.

4 - Application of Kolmogorov-sinai Entropy for Estimating Uncertainty in Infectious Disease Spread Model

Anna Paula Galvão Scheidegger, Texas A&M.University, College Station, TX, 77843-3131, United States, apscheidegger@tamu.edu, Amarnath Banerjee

Kolmogorov-Sinai (KS) entropy has been widely applied for image texture and biological signal analyses. Consequently, it has been proposed as an alternative tool to diagnose chronic diseases such as epilepsy and Parkinson. Despite the similarities between chronic and infectious diseases with respect to complexity, uncertainty and dynamic components, to the best of our knowledge KS entropy has not yet been applied to infectious diseases. Therefore, the goal of this study is to use KS entropy to investigate whether infectious disease spread models are sensitive to initial conditions and to quantify the average amount of uncertainty in the model.

■ TE42

360A

Military Applications

Contributed Session

Chair: Tulay Flamand, Colorado School of Mines, Division of Economics and Business, Engineering Hall 816 15th Street, Room 313, Golden, CO, 80401, United States, tulayvarol@gmail.com

1 - Distinguishing Temporal Associations from Coincidences

Thomas R.Willemain, Senior VP, Smart Software, Inc., 4 Hill Road, Belmont, MA, 02478, United States, tomw@smartcorp.com

Consider two binary time series. In some time periods, both series will be "on" simultaneously. How do we use this type of data to distinguish between associations and mere coincidences? The answer has operational significance in logistics and other military functions. We review several alternative technical approaches to this problem and outline an application to spare part logistics.

2 - Social Networks and Life Satisfaction: the Interplay of Cultural Orientation and Network Density

Jacob Do-Hyung Cha, Seoul National University, Room 204, 935-Dong, Family Housing, SNU, Seoul, 150-742, Korea, Republic of, research.dohyung@gmail.com, Yun Ha Cho

We present that an individual's cultural orientation moderates the influence of social network density on life satisfaction. Study 1 demonstrates that high collectivism effectiveness participants report higher life satisfaction when embedded in a high-density network, whereas high individualism effectiveness participants report lower life satisfaction in the same condition. Study 2 elaborates the underlying mechanism; a high-density network facilitates interdependent self-oriented goals pursuits while it hampers independent self-oriented goals pursuits. We discuss the implications for studying the interplay among social networks, cultural psychology, and positive psychology.

3 - A Branch-and-price Algorithm for the Optimal Deployment Problem

Tulay Flamand, Colorado School of Mines, Division of Economics and Business, Engineering Hall 816 15th Street, Room 313, Golden, CO, 80401, United States, tflamand@mines.edu, Mohamed Haouari, Ghaith Rabadi

We address the problem of deploying multiple types of commodities or assets from various origins to various destinations across a network of multiple modes of transportation. Applications of this problem exist in military, commercial and humanitarian contexts. A B&P algorithm is proposed for this hard problem to minimize the total travel time.

■ TE43

360B

Proactive Planning Against Natural Disasters

Sponsored: Public Sector OR

Sponsored Session

Chair: Ozlem Ergun, Northeastern University, Boston, MA, 02115, United States, o.ergun@neu.edu

Co-Chair: Mahsa Ghanbarpour, mahsa.ghanbarpour@gmail.com

1 - Considering Disaster Volunteer Behavior in Management Decisions During Relief Events: A Simulation Approach

Abdelwahab Alwahishie, Clemson University, Clemson, SC, United States, aalwahi@g.clemson.edu, Kevin M. Taaffe

Following disasters, non-governmental organizations (NGOs) rely heavily on their volunteers to provide assistance to the impacted communities. While their main goal is to serve community needs, NGOs should not ignore disaster volunteer's dissatisfaction and intention to quit. We propose a simulation that models a volunteer's behavior and a manager's decisions through the effects of job mismatch, workload and group conflict. Embedding a volunteer's in the NGO's decisions can reduce volunteer dissatisfaction and intention to quit while not negatively impacting the level of unmet community needs. The model information is based on survey data from two relief organizations in the US.

2 - A Robust Chance Constraint Programming Approach for Evacuation Planning under Uncertain Demand Distribution

Ayda Darvishan, University of Houston, Houston, TX, United States, ayda.darvishan@gmail.com, Gino Lim, Mukesh Rungta, Mohammad Reza baharnemati@gmail.com

We consider an evacuation planning problem where the demand (the number of evacuees) is uncertain and use a chance-constrained model to ensure a reliable evacuation plan. In the context of mass evacuation, we make the assumption that only partial information of the demand distribution, such as moment, support, or symmetry information is known. A distributionally robust chance-constrained model is proposed that ensures the demand constraints are satisfied for any probability distribution consistent with the known properties of the underlying unknown demand. Numerical experiments suggest that our model provides excellent results in terms of solution feasibility and robustness.

3 - Evaluating the Hurricane Decision Simulator

Cameron MacKenzie, Iowa State University, 3029 Black Engineering, Ames, IA, 50014, United States, camacken@iastate.edu, Eva D.Regnier, Anna Prisacari, Sophia Hetherington

We previously developed the Hurricane Decision Simulator to help the U.S. Marine Forces Reserve in New Orleans train to make decisions in advance of a hurricane. In the simulation, a user must decide when and which preparatory decisions to make (e.g., evacuating the headquarters). This presentation will provide the results of a behavioral study in which college students trained using the simulation. We assess how their decisions change after practicing with the simulation. Users believe their decisions improve after practicing with the simulation, and training on the simulation makes users more likely to wait to evacuate.

4 - Proactive Surgery Cancellation Based on Weather Forecasts

Mahsa Ghanbarpour, Northeastern University, Boston, MA, 02115, United States, ghanbarpourmamagh.m@husky.neu.edu, Ozlem Ergun

Severe weather such as hurricanes and snowstorms can dramatically disrupt the delivery of many essential services within a community, including healthcare services. This study introduces proactive surgery cancellation planning due to impending snowstorms and considers weather forecast updates as time progresses. Since weather events can be predicted more accurately closer to the event, the framework we develop is a decision support system for the evaluation of the tradeoff between making better decisions later due to more accurate forecasts and the increased cost of cancellations as the event gets closer. This tradeoff is captured by a dynamic planning approach over particular time horizons.

5 - Cooperative Strategies for Emergency Services under Resource Constrained Settings

Lavanya Marla, University of Illinois, Urbana, IL, lavanyam@illinois.edu, Jungeun Shin

We consider a case where emergency medical services compete as well as collaborate to serve a population. Settings like these are inspired from the cases of mutual aid between neighboring counties, and from emerging economies, where multiple EMSs have to interact strategically and tactically. We aim to understand the cooperative and competitive impacts when EMS agencies interact and share resources or information. We embed simulation-optimization frameworks into game-theoretic settings to understand the impact of such cooperative and competitive interactions.

■ TE44

360C

Operations Management/Marketing Interface

Contributed Session

Chair: Pin Zhou, HUST School of Management, HUST, Wuhan, China, zhoupin@hust.edu.cn

1 - Competitive Equilibria in Product Plus Service Solutions with Customer Self Selection and Taste Heterogeneity

Arvind Sainathan, Nanyang Business School, S3-B2a-03, Nanyang Business School, 50 Nanyang Avenue, Ntu, Singapore, 639798, Singapore, Asainathan@ntu.edu.sg

Many firms do not just sell products or services but solutions, integrated combinations of products and services. We analyze the competition between two solution providers (SPs) who sell to taste-heterogeneous customers. Type 1 customers are solution-based and consider the entire solution. Type 2 (Type 3) customers are product-first (service-first) and are primarily concerned about product component(s) (service component(s)). We first model customer self-selection in a novel way through an optimization problem. We then characterize different types of competitive equilibria between the SPs. We find that customer composition plays an integral role in determining the nature of equilibrium.

2 - Component Procurement Contract for an Assembly System with Random Capacity

Xinyan Cao, University of Wisconsin-Milwaukee, 3202 Maryland Ave, Milwaukee, WI, 53202, United States, xinyan@uwm.edu, Xiang Fang

We study a decentralized assembly supply chain under supply uncertainty. In the decentralized assembly supply chain, one assembler assembles a set of components each produced by a different supplier into a final product to meet an uncertain market demand. Each supplier faces an uncertain production capacity. The assembler and the suppliers adopt a so-called Vendor-Managed-Consigned-Inventory contract. We formulate the problem as a two-stage sequential game. We analytically characterize the equilibrium of this game, based on which we obtain several interesting managerial insights.

3 - Dynamic Production and Pricing Decisions in the Presence of Snob Effect

Keita Sogo, Keio University, Yokohama, Japan, k.sogu92@gmail.com, Nobuo Matsubayashi

Snob effect is a phenomenon where the more it is difficult to obtain a product, the higher its utility will be. "Hunger-marketing" is known as a marketing strategy utilizing this effect, in which a firm strategically makes a product shortage. Analyzing a monopoly model to determine price and output levels over multiple periods in the presence of snob effect, we derive the condition under which this type of strategy becomes optimal.

4 - Allocation and Sizing of Fast Charging Station in High-way Network

Yue Wang, Dr., National University of Defence Technology, NVDT, Kaifu Area, Changsha, China, wangyy0115@hotmail.com, Jianmai Shi, Yajie Liu

Adequate charging station distribution is the necessary part to promote Electric Vehicles(EV). Different with refuel stations, the infrastructure is costly with limited service capacity because of the long charging time. Meanwhile, in optimization of location and scale of the charging station, the limited range of EVs and the selection process of drivers must be taken into account. This paper described the behavior of driver and station to illustrate how the demand distribute in road network. Then developed a heuristic algorithm to optimize the location and size of charging stations . A practical case of Hebei highway network in China is also studied to test the efficiency of algorithm.

5 - The Adoption Time of Production Commonality and Consumer Deliberation

Pin Zhou, School of Management,HUST, Wuhan, China, zhoupin@hust.edu.cn, He Xu

We study the impact of commonality strategy and consumer deliberation on the optimal product line design in multiple quality attributes. When the firm adopts the commonality strategy to maximize the profits ,there is a trade off between cost savings and product differentiation(i.e.cost-reduction effect and cannibalization effect).Compared with the quality, profit and consumer surplus in two different scenarios(with and without the commonality strategy),we find that (1)quality dispersion of the customized attribute is always larger with the commonality strategy;(2)the firm prefers the commonality strategy only when the cost reduction effect is strong.

■ TE45

360D

Retail Management

Contributed Session

Chair: Miguel Ruiz, University of Puerto Rico at Mayaguez, Mayaguez, PR, United States, miguel.ruiz6@upr.edu

1 - Extreme Scale Resource Allocation Problem Involving Billion Variables

Kalyanmoy Deb, Porfessor, Michigan State University, Electrical & Computer Engineering, 428 S Shaw Lane, East Lansing, MI, 48824, United States, kdeb@egr.msu.edu

Many resource allocation problems in practice involve extremely large number of variables. Such problems give rise to an integer linear program, for which scalable algorithms are not possible due to the exponential nature of associated branch-and-bound approach. In this presentation, we consider a casting scheduling problem (similar to a cutting stock problem) and propose a metaheuristics based optimization method for finding near-optimal solutions involving as large as Billion variables.

2 - A Column Generation Based Distributed Scheduling Algorithm in Manufacturing Supply Chains

Changchun Liu, Dr., Tsinghua University, Hai Dian, Beijing, Beijing, 100084, China, liucc15@mails.tsinghua.edu.cn

This paper considers a resource constrained scheduling problem with a single shared resource. In this model, there are multiple processors who need to complete jobs with a certain amount of shared resource. The resource is of limited supply and must be shared between processors. We propose a column generation based distributed scheduling algorithm and compare the proposed method with other methods. Computational results prove our proposed method has an advantage both in objective value and CPU time to solve this problem.

3 - Simultaneous Matching Mechanisms for On-Demand Markets with Limited Resources

Seyed Shahab Mofidi, Rensselaer Polytechnic Institute (RPI), 110 8th Street, CII 5107, Troy, NY, 12180, United States, mofids@rpi.edu, Jennifer A.Pazour

In sharing economy applications, a central mechanism (CM) is vital to efficiently facilitate matches between decentralized utilitarian agents and finite available alternatives. The CM makes personalized recommendations, from which myopic independent agents select with full discretion, and CM collects benefit from the matches. However, the alternatives have limited capacity, which creates interdependencies among selections of agents. Thus, personalized recommendations need to be considered holistically and in conjunction with the system's and agents' preferences. A bilevel optimization framework and specialized solution approaches are developed to solve this large scale problem.

4 - Effect of Time Pressure and Individual Learning in the Worker Task Assignment

Yaileen M. Mendez Vazquez, Oregon State University (School of Mechanical, Industrial and Manufacturing Engineering), Corvallis, OR, 97331, United States, mendezvy@oregonstate.edu, David A. Nembhard

This work addresses the worker-task assignment problem when the effect of time pressure and workers learning capacity are considered on the individual worker performance. Previous works related to worker-task assignment does not consider the effect of time pressure and individual learning capacity simultaneously. However, literature states the impact of learning by repeatedly perform a task in the improvement of worker's performance, and as well of time pressure in the individual diligence to perform a specific task. A mathematical model is proposed to incorporate these two factors in the estimation of individual worker performance and investigate its effect for the worker-task assignment.

5 - Optimal Cash Rationing Strategy under Different Product Priority Classes

Youssef Boulaksil, Assistant Professor, United Arab Emirates University, P.O. Box 15551, Building H3, Office 2055, Al Ain, United Arab Emirates, youssef.boulaksil@gmail.com

We consider small, traditional retailers (nanostores) that are widely present in developing countries. They operate under very limited cash availability. Therefore, nanostores categorize their assortment into different (product) priority classes, and consequently, more cash is allocated to replenish a higher priority product. In this paper, we develop a mathematical model and present the optimal cash rationing strategy for the nanostore who faces uncertain demand and uncertain cash position. We also show how this strategy affects the suppliers' distribution process towards the nanostores. An extensive numerical experiment reveals several interesting insights.

6 - Assignment Model Solution for Common Challenges in Complex Service Systems

Miguel A.Ruiz, Student, University of Puerto Rico at Mayaguez, Mayaguez, PR, United States, miguel.ruiz6@upr.edu, Betzabe Rodriguez

Our research tailors the assignment model to account for common challenges faced by service organizations such as detrimental benefit of fulfilling tasks with unfit resources, myriad of tasks and diverse personnel profile. The proposed model uses as a test bed the Puerto Rico Agricultural Extension Service.

■ TE47

360F

Recent Advances in Energy Storage and Others

Invited: Energy Systems Management

Invited Session

Chair: Xiaojie Wang, University of Florida, UFL, Gainesville, FL, 4, United States, xwang828@ufl.edu

1 - Optimal Battery Charging in Smart Grids with Price Forecasts

Sandjai Bhulai, Vrije Universiteit Amsterdam, Department of Mathematics, De Boelelaan 1081a, Amsterdam, 1081 HV, Netherlands, s.bhulai@vu.nl, Sven van der Kooij, Pia Kempker, Hans van den Berg

We consider a residential cluster in which some of the households own home batteries. The battery owners have forecasts of future prices for optimally utilizing the long-term flexibility of the battery. These forecasts become increasingly uncertain the further we look into the future. The home batteries are individually too small to influence prices; collectively however, they have enough capacity to have an influence. We formulate an algorithm based on stochastic dynamic programming to optimize individual/collective/cluster profits. Through simulation, we find that this solution performs well when incentives are put in place to promote the right use of storage in the future grid.

2 - Valuation of Oil Tank in Combustion Turbine under Uncertain Gas Network

Shu Tu, Lehigh University, 200 West Packer Avenue, Bethlehem, PA, 18015, United States, sht213@lehigh.edu

The interdependency of gas and electricity is very high as 83% of electricity produced in 2005 is from gas and that percentage will still be over 70% in 2020. This fact brings a potential threat to the safety of the electricity network. In order to satisfy the electricity network security constraints, fuel flexibility is a good choice. In this paper, we consider the valuation of a combustion turbine which can use both natural gas and oil to produce power under a vulnerable gas network assumption. We solve this problem by developing a finite horizon Markov Decision Process model to determine the optimal policy of generating power with two kinds of fuels and provide reasonable results to support adding oil tank.

3 - Robust Optimal Control of Wind Farm with PHEVS Participating in Energy Market

Xiaojie Wang, University of Florida, Gainesville, FL, 32603, Gainesville, FL, 32603, United States, United States, xwang828@ufl.edu

We consider a wind farm with plug-in hybrid electric vehicles as storage devices participating an energy market by submitting their commitments. This new model gives a robust solution considering price and renewable generation uncertainties. Our numerical results show the advantages of our proposed model.

4 - Strong Formulation for Unit Commitment Considering Storage

Yanan Yu, University of Florida, 321 University Village, Apt 3, Gainesville, FL, 32603, United States, yuyn@ufl.edu, Kai Pan, Yongpei Guan

In this talk, we present a polyhedral structure of integrated minimum-up/-down time and ramping polytope, considering the storage characteristics in the traditional Unit Commitment problems. By exploring its specialized structures, we derive strong valid inequalities and convex hull description. The computational studies show the effectiveness of the proposed strong valid inequalities.

■ TE48

361A

Behavioral Issues in Supply Chains

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Mirko Kremer, Frankfurt School of Finance and Management gGmbh, Frankfurt, 60314, Germany, m.kremer@fs.de

1 - Increasing Retailer Preferences for New Products with Buyback Contracts

Anna Devlin, Assistant Professor, University of Alabama, Huntsville, 301 Sparkman Drive NW, Huntsville, AL, 35801, United States, anna.g.devlin@gmail.com, Wedad Jasmine Elmaghraby, Rebecca Hamilton

We study the ability of buyback contacts to increase retailer preferences for new products in a series of laboratory studies. New products are shrouded with demand uncertainty, decreasing the likelihood they gain market entry. We find that buyback contracts decrease an individual's level of ambiguity aversion and increase preferences for new products in a one time period game. In an extended game, we find that because buyback contracts encourage earlier experimentation with the new product, participants learn faster and converge to selecting the most profitable product faster when offered a buyback back contract rather than a wholesale price contract.

2 - Inventory Decisions in the Presence of Strategic Customers: Theory and Behavioral Evidence

Benny Mantin, University of Luxembourg, 162A, Avenue de la Faïencerie, Luxembourg City, L-1511, Luxembourg, benny.mantin@uni.lu, Yang Zhang, Yaozhong Wu

We study the inventory decisions of a retailer facing a mix of myopic and strategic consumers in a two-period selling horizon with pre-announced markdowns. Testing our theoretical model via lab experiments, we find that while retailer subjects exhibit the pull-to-center bias, as observed in standard newsvendor experiments, their orders may be pulled below the mean demand in the presence of strategic customers (referred to as pull-below-center bias). We develop a behavioral model based on reference dependence and fit it to our data, which explains the pull-below-center phenomenon, as well as the presence and asymmetry of the generalized pull-to-center effect observed in our experiment.

3 - An Experimental Investigation of Transshipment and Local Decision Making

Kay-Yut Chen, University of Texas at Arlington, 511 Pine Island Circle, Mansfield, TX, 76063, United States, kychen@uta.edu, Shan Li

When a retailer has surplus stock and another has a supply shortage, it is desirable to transfer surplus stock from the former to the latter. We experimentally examine how transshipments between two independent retailers affect local decisions of inventory and transfer price. We found that transfer prices and inventory decisions are dependent on whether the prices are set before or after inventory decisions and the realization of the demand. We construct a behavioral model, incorporating bounded rationality, fairness and psychological pain of excess supply to explain the findings.

4 - Trusting the Forecast: the Role of Numeracy

Tobias Stangl, University of Cologne, Cologne, 50923, Germany, tobias.stangl@uni-koeln.de, Gary Bolton, Elena Katok

In a controlled study of decision making in a simple take-the-risk or take-the-cost decision game, we examine compliance rates (trust) for forecast guidance provided as probabilities as well as recommendations. Most strikingly, and contrary to our initial expectation, low numerate subjects exhibit less trust in recommendation forecasts than do high numerates. While we find a positive relationship between subject numeracy and trust in probability forecasts, this relationship is overshadowed by the fact that even high numerate subjects use the probabilities inefficiently.

■ TE49

361B

Practice/Healthcare III

Contributed Session

Chair: Najibe Sadatijafarkalaei, Wayne State University, 4815 Fourth Street, Detroit, MI, 48202, United States, fv0017@wayne.edu

1 - Managing Appointment Scheduling with Walk-ins under Two-agent Perspective

Shenghai Zhou, Shanghai Jiao Tong University, Shanghai, China, zshsjtu2014@sjtu.edu.cn, Guohua Wan

Consider the healthcare appointment system with walk-ins, we develop a two-agent optimization model to determine the optimal template. We demonstrate that, under a mild assumption, the optimal structures are fundamentally different from those existing literature which does not consider two-agent. For the general case, the problem can be formulated as a two stage stochastic optimization model. Numerical analysis is also used to demonstrated the effectiveness of the proposed method.

2 - Managing Operational Efficiency & Health Outcomes at Outpatient OB/GYN Clinics through Effective Scheduling

Samira Fazel Anvaryazdi, PhD Candidate, Wayne State University, Detroit, MI, United States, samira.fazel@wayne.edu, Saravanan Venkatachalam, Ratna Babu Chinnam

We discuss methods for improving flow at outpatient clinics through effective appointment scheduling policies by applying two-stage stochastic programming approach. The aim is to increase throughput per session while providing timely care, continuity of care, and overall patient satisfaction as well as equity of resource utilization.

3 - Fair Allocation of Donor Hearts for Transplantation

Farhad Hasankhani Kohneh Shahri, PhD Student, Clemson University, 278 Freeman Hall, Clemson, SC, 29634, United States, fhasank@clemson.edu, Amin Khademi

The optimal allocation of limited donated hearts to patients on the waiting list is one of the top priorities in heart transplantation management. In order to design an efficient and fair system for allocating donor hearts to patients waiting for transplantation, we model the problem as a constrained stochastic dynamic program to maximize total quality-adjusted life years (QALYs) of the population. Because solving the optimality equation is intractable in our setting, we use fluid approximation, which is an optimal control problem, to produce allocation rules. We assess the quality of any allocation rule by providing an upper bound to the optimal value function.

4 - Optimization of Inventory for Hip and Knee Joint Operations via Multistage Stochastic Programming

Mohammad Pirhooshyaran, Lehigh University, 7 Duh Drive Apt.113, Bethlehem, PA, 18015, United States, mop216@lehigh.edu, Lawrence V. Snyder

Knee and hip joint replacements are among the most common orthopedic operations. Supplying hospitals with prosthetic implants is difficult because the supply is limited, the demand is stochastic. Often the supply logistics fall to the manufacturer or a distributor. We present a multi-stage stochastic optimization model to optimize the distribution of implants from a central depot to hospitals. We find that our model can reduce costs and improve service compared to how our industry partner currently distributes implants.

5 - Interaction between Operational Efficiency and Doctor Incentives in Outpatient Services

Xiaofang Wang, Renmin University of China, Mingshang Building, Room 1023, Beijing, 100872, China, xiaofang.wang@gmail.com, Guoming Lai

This paper studies the interaction between a doctor and a population of patients in a congested health service delivery system. The doctor's prescribing decisions depend on her diagnostic/treatment ability, level of altruism and the institutional framework. Some patients are strategic and decide to see this doctor based on perceived quality, congestion and monetary costs. Within such a setting, we study the socially optimal decisions and provide policy insights.

6 - Perspectives on Real Time Orchestration of Operations in Health Systems

Najibe Sadatijafarkalaei, Wayne State University, 4815 Fourth Street, Detroit, MI, 48202, United States, fv0017@wayne.edu, Ratna Babu Chinnam, Alper E.Murat

Most hospital systems in the U.S. have employed some form of an EHR system in recent years to improve health outcomes. While EHR systems form a critical data backbone for improving operational efficiencies, there is a need for platforms that can promote situational awareness, predictive operational intelligence, and eventually coordinated orchestration. We present findings from the literature and observations derived from major healthcare systems in SE-Michigan.

■ TE50

361C

Autonomous Systems Optimization II

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Jian Wang, Purdue University, 4550, West Lafayette, IN, United States, wang2084@purdue.edu

1 - Stable User Matching for Autonomous Vehicle Co-Ownership Problem

Anpeng Zhang, University at Buffalo, Buffalo, NY, 14228, United States, anpengzh@buffalo.edu

We develop a user matching for autonomous vehicle co-ownership programs based on stable matching and single-vehicle Dial-A-Ride Problem (DARP). The optimization model will determine the optimal schedule of trips in the same car sharing group as well as a fair match for all participants in the program. Our model also utilizes nash bargaining game to consider the utility balance between the members in the same group. A case study based on the travel activity dataset of households in California will be present to show the matching performance.

2 - Commute Ridesharing with Autonomous Vehicles Considering Work End Time Uncertainty

Yan Zhao, University of Michigan, Ann Arbor, MI, 48109, United States, zhaoyann@umich.edu, Xiaolei Guo, Henry Liu

Uncertainty of work end time can prevent ridesharing between two people with identical home and work locations. When two people share a ride from home to work, if the realized work end time results in a long wait between the two, with traditional cars, one has to either bear the long wait or call expensive taxi service. We demonstrate that autonomous vehicles (AV) can increase ridesharing in the context of commute bottleneck congestion with random work end time, where one can share ride from home to work in the morning, and either share ride or call AV to pick her up from work to home in the afternoon, depending on the realized work end time.

3 - Exploring Braess's Paradox for Congested Pedestrian Crowd in Continuous Space

Zhaodong Wang, University of Illinois, Urbana, IL, United States, zwang137@illinois.edu, Yanfeng Ouyang

This paper explains continuous Braess's Paradox under congestion by proposing a continuous user equilibrium model describing the steady state of pedestrian flow. Moreover, the exact overall performance improvement can be quantitatively obtained by our framework, which enables us to develop an optimization-based approach seeking optimal infrastructural design.

4 - Optimal Deployment of Autonomous Vehicle Lanes under Network Equilibrium

Jian Wang, Purdue University, West Lafayette, IL, United States, wang2084@purdue.edu, Srinivas Peeta, Sean X He

This study develops a bi-level program to facilitate the deployment of autonomous vehicle (AV) lanes. The upper-level program seeks to reduce the total travel time, while the lower-level program formulates the network equilibrium with the mixed traffic of AVs and non-AVs. Numerical examples are used to investigate the optimal deployment of AV lanes that provides insights into network design to better accommodate AV-based trips.

■ TE51

361D

Telecommunications

Contributed Session

Chair: Dawoon Jung, Korea University, Seoul, United States, bogsil@korea.ac.kr

1 - Evaluating Antecedents and Consequences of Telemedicine Adoption in Clinics

Xiaojin Liu, University of Virginia, 100 Darden Blvd, Charlottesville, VA, 22903, United States, liux@darden.virginia.edu, Susan Goldstein, Karen Soderberg, Kingshuk K.Sinha

Telemedicine, the technology-enabled remote delivery of clinical care, is one potential means to improve patient access to health care services. We investigate how socioeconomic, geographical, and organizational characteristics determine telemedicine adoption in clinics, and examine how telemedicine interacts with technological characteristics on health care delivery effectiveness.

2 - Technological Discontinuity and Market Competition in the Mobile Service Industry

Xiahua Wei, University of Washington, Bothell School of Business, 18115 Campus Way NE, Box 358584, Bothell, WA, 98011, United States, xhwei@uw.edu

We study how technological discontinuity contributes to market competition in the mobile service industry. Based on a firm-level panel dataset, we examine whether the ability of new entrants to disrupt incumbents depends on the responsiveness of incumbents to new technologies, and whether technological discontinuities by incumbents can delay industry shakeouts.

3 - Cross-culture Collaboration and Research Citation Impact

Xiaopeng Wang, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049, China, Archy714@126.com, Jun Lin, Cui Wentian

This research investigated how national cultural difference among scientific teams affect research citation impact. We classified national culture into 5 culture clusters base on Hofstede's five cultural indicators. The results from the bibliometric analysis showed that articles written by authors from at least two culture clusters has a higher citation impact. Furthermore, we demonstrated a positive moderating effect of focal author's prestige and a negative moderating effect of discipline difference on the relation mentioned above. We also found that increasing the culture diversity (amount of culture clusters involved) of teams has an inverted-U shaped relation with impact.

4 - Optimal Two-period Response Strategy To New Technology

Xiaoxi Liu, Korea University, Seoul, Korea, Republic of, polar1018@korea.ac.kr, Byungcho Kim

Technology develops so rapidly, thus when a new technology appears, innovative firms face a dilemma of whether to keep an old technology along with a new one, or drop it. In reality, many industries show the co-existence of both technologies despite the cost of maintaining two product lines. This paper introduces a two-period decision model that examines a firm's response strategy to the emergence of new technology. In the first period, the firm decides whether to keep the old product line, and in the second period, it chooses whether to improve old version's quality. The equilibrium price and quality levels are investigated and the impact of market share and marginal cost are further discussed.

5 - A Bibliometric Analysis on Human Reliability Analysis

Yangyang Chang, Tsinghua University, ZJ.17#, Tsinghua University, Haidian, Beijing, 100084, China, changyy15@mails.tsinghua.edu.cn, Pingke Li

This study investigates the development and longitudinal trends in human reliability analysis (HRA) during 1986-2015 through the bibliometric analysis on a data set of 4695 publication records retrieved from Web of Science and Ei Compendex. The number of the HRA documents is used as the performance indicator and examined through both the temporal and geographical perspectives. To reveal the conceptual evolutions of HRA research, the three decades are divided into four consecutive periods (1986-1999, 2000-2006, 2007-2011, 2012-2015), and the research fronts in each period are investigated through SciMAT.

6 - Entering Convergent Product Market

Dawoon Jung, PhD Candidate, Korea University, Business School, LG-Posco Hall, # 408, Seoul, 02841, Korea, Republic of, bogsil@korea.ac.kr, Byung Cho Kim, Bosung Kim

Technological convergence is an attempt to integrate disparate technologies across the conventional boundaries and its outcome is convergent product which often exhibits irreplaceable synergetic advantages. This paper examines a firm's strategic choice that confronts the technological convergence with the view of targeting the growing demand and the synergy from convergence.

■ TE52

361E

Robust and Data-Driven Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Phebe Vayanos, University of Southern California, Los Angeles, CA, 90089, United States, phebe.vayanos@usc.edu

1 - Small Data Linear Optimization

Vishal Gupta, University of Southern California, Marshall School of Business, 3670 Trousdale Parkway, Los Angeles, CA, 90026, United States, guptavis@usc.edu, Paat Rusmevichientong

Optimization problems frequently depend on a huge number of uncertain parameters, but the amount of data per parameter is small. We propose a framework for optimization in this small-data/high dimensional regime. We combine ideas from empirical bayes and compound decision problems to 1) pool information across parameters and 2) exploit optimization structure. We prove our approach is never worse than, and often better than, "estimate-then-optimize," sample average approximation, and conventional high-dimensional statistics techniques. As the number of uncertain parameters grows and the amount of data per parameter is fixed, our approach performs comparably to the best-in-class estimator.

2 - Applications of the Wasserstein Metric in Robust Transportation Problem

John Gunnar Carlsson, University of Southern California, 3750 McClintock Avenue, Los Angeles, 90089, United States, jcarlsso@usc.edu

Recent research on the robust and stochastic travelling salesman problem and the vehicle routing problem has seen many different approaches for describing the region of ambiguity, such as taking convex combinations of observed demand vectors or imposing constraints on the moments of the spatial demand distribution. One approach that has been used outside the transportation sector is the use of statistical metrics that describe a distance function between two probability distributions.

3 - Robust Multiclass Queuing Theory for Wait Time Estimation in Resource Allocation Systems

Phebe T. Vayanos, University of Southern California, OHE 310L, University Park, USC, Viterbi School of Engineering, Los Angeles, CA, 90089, United States, phebe.vayanos@usc.edu, Chaithanya Bandi, Nikolaos Trichakis

We present a data-driven optimization approach to estimate wait times for individual patients in the U.S. Kidney Allocation System, based on the very limited system information that they possess in practice. To deal with this information incompleteness, we develop a novel robust optimization analytical framework for wait time estimation in multiclass, multiserver queuing systems. We calibrate our model with highly detailed historical data and illustrate how it can be used to inform medical decision making and improve patient welfare.

■ TE53

361F

Behavioral Operations

Contributed Session

Chair: Abhishek Sharma, Indian Institute of Management-Rohtak, Rohtak, India, aabhishek sharma01@gmail.com

1 - A Cooperative Game with Envy

Ziteng Wang, Assistant Professor, Northern Illinois Universtiy, 590 Garden Road, EB 240, DeKalb, IL, 60115, United States, zwang3@niu.edu

This research proposes an envy-incorporated cooperative game model and investigates the envy effects on players' coalition-forming and payoff-allocating decisions. A player's utility depends on her/his own payoff and the envy toward other players, inside and outside the same coalition, with higher payoffs. Envy core is defined to characterize stable coalition structures and payoff allocations of this new game. Conditions for the envy core to be nonempty are provided. The relative significance of in-coalition envy and out-coalition envy is shown to be a key factor to the form of the envy core. Application to a simple gameshows that envy may significantly change players' decisions.

2 - Anchoring and Demand Chasing in Stockout Avoidance Decision Making

Shivom Aggarwal, IE Business School, IE University, Instututo de Empresa S.L., CIF: B82334319, Calle de Maria de Molina, 12 Bajo, Madrid, 28006, Spain, saggarwal@faculty.ie.edu, Antti Tenhiala

Even though, virtually every major supermarket chain uses an automatic store replenishment (ASR) system to optimize replenishment timing and order quantities; stock-outs (SO) still cost retailers billions of dollars every year in lost sales. In this study we focus on SO avoidance and argue that (i) augmentations of ASR proposals are driven by anchoring and demand chasing, and (ii) deviations triggered by these two biases are generally unsuccessful in avoiding stock-outs, leading to unnecessary inventory inflation. We test our hypotheses with proprietary data from a European high-end supermarket chain. Our study highlights the consideration of biases as critical and distinct from other drivers.

3 - A Summary and Comparison of Common Methods Variance Techniques

Xiaotong Liu, University of North Texas, 2411 S Interstate 35 E, Apt 1218, Denton, TX, 75010, United States, xiaotong.liu@unt.edu, Victor R. Prybutok

In most empirical studies, the existence of common methods variance (CMV) is consideration for which the data should be tested. However, some challenges exist about which technique researchers should use to test CMV for data from a single instrument. This research uses examples to summarize and compare several tests related to CMV.

4 - A Study on Prospect Theory and the Newsvendor Problem
Abhishek Sharma, PhD Scholar, Indian Institute of Management Rohtak, Indian Institute of Management, MDU Campus, Rohtak, Haryana, Rohtak, 124001, India, aabhisheksharma01@gmail.com, Sanjay Jharkharia

It is identified from the experimental studies on newsvendor problem that decision makers do not choose theoretical optimal order quantities, while using some heuristics to take their decisions. Prospect theory, as a theory for decision framing under uncertainty, has been used in literature to explain such preferences of decision makers. The recent literature shows that how these empirical findings can be explained through original prospect theory (OPT), when the reference point differs from the status quo. In this paper, we further study this argument and apply cumulative prospect theory (CPT) that accounts for the better modeling of psychological phenomenon of diminishing sensitivity.

■ TE54

362A

Economics

Contributed Session

Chair: Jing Xu, University of Pennsylvania, Philadelphia, PA, United States, xjing@sas.upenn.edu

1 - Moral Perceptions of Advised Actions
Alexander Gotthard Real, Assistant Professor, Pontificia Universidad Javeriana, Calle 59 # 3A - 24 Apt 504, Bogota, Colombia, agotthard@javeriana.edu.co

Can an organization avoid some blame for an unpopular action by hiring an adviser to advise them to do it? We present experimental evidence suggesting this is the case advice to be selfish substantially decreases punishment of being selfish. Further, this result is true despite advisers conflicts of interest, known to all: Through a relational contract, advisers are motivated to tell the principals what they want to hear. In follow-up treatments, we show advice does not decrease punishment solely by affecting beliefs of how necessary the selfish action was. Finally, when advisers are available, selfish principals act more selfishly.

2 - Surfing or Working? Productivity Responses to Changes in Workload
Erina Ytsma, Post-doctoral Associate, Massachusetts Institute of Technology, MIT IDE, 77 Massachusetts. Avenue, Cambridge, MA, 02139-4301, United States, eytsma@mit.edu, George F. Westerman

We study the effect of workload on productivity, hours worked and internet use while at work using big data on insurance claims examiners. We find that, for every 1% increase in workload, productivity increases by 0.3% to 0.4%, tardiness decreases by 0.06 to 0.13 percentage points, and quality does not falter. Hours worked increase slightly, but extra work time can explain at most 10% of the increase in productivity. Non-productive internet use decreases with workload, while productive uses of internet increase. These findings are consistent with the presence of slack and an increase in efficiency in response to workload surges.

3 - Bargain Network and the Matchmaker
Jing Xu, University of Pennsylvania, 209 S.33rd Street, Math Dept, Philadelphia, PA, 19104, United States, xjing@sas.upenn.edu

I study a dynamic market with an intermediary that matches participants connected in a network to bargain over prices of heterogeneous goods. Players who reach an agreement pay a commission fee to the intermediary and exist from the network without replacement. The intermediary can choose its favorite matching pair each time before participants make the bargain. I establish the existence of Markov perfect equilibria (MPEs) of the infinite horizon game and illustrate the equilibrium matching probabilistic distributions adopted by the middleman. Moreover, when payoffs are homogeneous, any MPE achieves constrained efficiency.

■ TE55

362B

Quantitative Methods in Financial Engineering

Sponsored: Financial Services

Sponsored Session

Chair: Ning Cai, Hong Kong University of Science & Technology, Kowloon, Hong Kong, Hong Kong, ningcai@ust.hk

1 - Recursive Method for Static Options Replication of Complex Structured Products
Kyoung-Kuk Kim, Associate Professor, KAIST, Dept of Industrial & Systems Engineering, 291 Daehak-Ro, Daejeon, 34141, Korea, Republic of, catenoid@kaist.edu, Dong-Young Lim

This study aims to extend static options replication of financial derivatives to complex products with autocallable features and barrier features. The key idea is based on the combination of calendar-spread approach and strike-spread approach in a recursive manner. Such replicating strategies are exact, and we utilize the theory of integral equations. Our numerical examples include complex equity-linked structured products traded in Europe, US, and Korea.

2 - Investment Decisions and Falling Cost of Data Analytics
Jussi Keppo, National University of Singapore, Mochtar Riady Building, BIZ 1 8-69, 15 Kent Ridge Drive, Singapore, 119245, Singapore, keppo@nus.edu.sg, Hong Ming Tan, Chao Zhou

We study how the cost of data analytics and the characteristics of investors and investment opportunities affect investment decisions and their data analytics. We show that the falling cost of the data analytics raises investors' leverage, financially constrained or highly risk-averse investors use less data analytics, the quantity of data analytics is highest with mediocre investment opportunities and it is lowest with a high expected return or a low risk opportunities. Due to the increased leverage, the falling cost of data analytics may lead to more frequent crises or higher losses during the crises.

3 - Susceptibility and Predictability in the NASDAQ Order Book
James Primbs, California State University Fullerton, Fullerton, CA, United States, jprimbs@exchange.fullerton.edu, B. Ross Barmish, Sean Warnick, Scott Condi

In this work, we analyze the structure and predictability of the NASDAQ order book based on ITCH transaction level data. Specifically, we explore the shape of the bid and ask sides of the order book over time, and apply various statistical and machine learning related tools to address questions of predictability and susceptibility to manipulation by adverse agents.

4 - A Structural Model for Liquidity Risk
Ning Cai, Hong Kong University of Science & Technology, Room 5559D, Industrial Engineering, and Logistics Management, Kowloon, Hong Kong, Hong Kong, ningcai@ust.hk

In this paper, we develop a structural model for liquidity risk and credit risk. Empirical studies illustrate that our model captures the features of the market observed credit spreads quite well.

■ TE56

362C

Logistics

Contributed Session

Chair: Satya Malladi, Georgia Institute of Technology, Atlanta, GA, United States, mss@gatech.edu

1 - Tracking Technologies for the Efficient Operations of Distribution Center
Yong-Hong Kuo, Assistant Professor, The University of Hong Kong, Department of Industrial and Manufacturing Systems Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong, yhkuo@hku.hk, Chun Hung Cheng, Matthew Petering

Our work was motivated by a real-world problem in a large air mail centre. We have developed an RFID-based location-positioning platform for the application.The RFID-tag attachments to carts and reader mounts at the top of the building allow the facility operators to locate target carts quickly. We have also conducted an initial analysis of data collected using this technological infrastructure to understand issues on cart movements and operational efficiency.

2 - Analyzing the Benefits of Optimal Dispatching in Shipment Consolidation
Benhur Satir, Assistant Professor, Dr., Çankaya University, Etimesgut, Ankara, 06790, Turkey, benhur@cankaya.edu.tr, F. Safa Erenay, James H. Bookbinder

In practice, most logistics providers dispatch consolidated loads at pre-planned periods, i.e. using a time policy. In this study, we investigate the relative benefit and conditions leading to it when the optimal policy is used instead. The benefit is measured in terms of expected discounted total cost. We model the problem as a Continuous Time Markov Decision Process, and assume compound Poisson arrivals of two customer types, viz. expedited and regular. We prove the existence of quantity-based optimal threshold policies under particular conditions, and develop an efficient solution approach for large problem instances. We provide numerical studies using two industrial cases.

3 - New Insights into Sharing Warehouse Markets in Beijing Metropolitan Area: Scraping and Analyzing Web Rental Listings

Yixuan Ma, Beijing Jiaotong University, Beijing, China, mayixuan@bjtu.edu.cn
Yixuan Ma, University of California-Irvine, Irvine, CA, United States, mayixuan@bjtu.edu.cn, Zhenji Zhang, Baoxiang Pan

Open warehouse marketplace is of fundamental importance for pivoting the accelerating supply chain. Existed warehouse storage trading platforms focus on clients' trading activities, missing the potential to bring the full scope of logistics storage marketplace into light. Given this, we collected, cleaned, analyzed, mapped, and visualized 20,000 real-time web sharing warehouses listings from different platforms for the Beijing Metropolitan Area, one of the most busy logistic districts in the world today. The data revealed fine patterns of warehouse distribution, acreage and price through putting the real-time accumulating database to the urban development background.

4 - A Hybrid Simulation-based Location-allocation Approach of Biofuel Warehouses

Sojung Kim, Assistant Professor, Texas A&M.University-Commerce, P.O. Box 3011, Commerce, TX, 75429-3011, United States, sojung.kim@tamuc.edu, Su Min Kim, James R. Kiniry

The goal of this study is to propose a hybrid simulation-based location-allocation approach of Biofuel Warehouses in order to minimize operational cost of the biofuel supply chain. The proposed approach consists two simulation methodologies: (1) ALMANAC® for estimating production of ethanol based on crop yields and (a) AnyLogic® for finding the best locations of biofuel warehouses with the minimum operational cost regarding supply variability (e.g., seasonality) of crop yields. The proposed approach is demonstrated with real crop yield data in Southern Great Plains, USA.

5 - Transporting Capacity vs. Transshipping Inventory under Nonstationarity

Satya Sarvani Malladi, PhD Candidate, Georgia Institute of Technology, 2209 Briarcliff Rd NE, Apt 17, Atlanta, GA, 30329, United States, mss@gatech.edu, Alan Erera, Chelsea C. White

We study a production-inventory system in which capacity and/or inventory can be moved between locations under nonstationary demands affected by a partially observed underlying state of the world. We seek to determine when moving production capacity is more beneficial than transshipping inventory between locations.

■ TE57

362D

Scheduling

Contributed Session

Chair: Trung Le, International University, Ho Chi Minh, Viet Nam, trung.le@hcmiu.edu.vn

1 - Nonlinear Dynamics Forecasting of Obstructive Sleep Apnea Onsets

Trung Le, International University, Linh Trung Thu Duc, Ho Chi Minh, Viet Nam, trung.le@hcmiu.edu.vn

This paper reports an investigation into heart rate dynamics aiming to predict in real time the onsets of OSA episode before the clinical symptoms appear. A prognosis method based on a nonparametric statistical Dirichlet-Process Mixture-Gaussian-Process (DPMG) model to estimate the transition from normal states to an anomalous (apnea) state is utilized to estimate the remaining time until the onset of an impending OSA episode. Validation tests suggest that the model can be used to track the time until the onset of an OSA episode with the likelihood of correctly predicting apnea onset in 1 min to 5 mins ahead is 83.6 ± 9.3%, 80 ± 8.1%, 76.2 ± 13.3%, 66.9 ± 15.4%, and 61.1 ± 16.7%, respectively.

2 - An ABM Framework to Analyze the Region's Resilience Evolving under Repeated Hazards

Chengwei Zhai, University of Michigan, 1837 McIntyre Drive, Ann Arbor, MI, 48105, United States, cwzhai@umich.edu, Seth Guikema, Allison C. Reilly

Understanding human behavior under repeated hazards is essential in reducing damage from hazards, promoting wise decisions, and providing insights into how community resilience evolves. This talk summarizes an Agent Based Model that can be applied to analyze how decision makers adapt to repeated hazards and different policies and how this influences the evolution of regional vulnerability over time. It introduces modeling different hazard scenarios, agent learning and decision making processes, collective action, and government policies. A case study using open-source data in Maryland is presented to show how this region's vulnerability evolves under repeated hazards.

3 - Risk-based Path Optimization for Unmanned Aerial Systems

Jeffrey W. Herrmann, Professor, University of Maryland-College Park, Department of Mechanical Engineering, College Park, MD, 20742, United States, jwh2@umd.edu, Shapour Azarm

Flying an unmanned aerial system (UAS) over inhabited areas creates a risk to persons on the ground. UAS operators thus need low-risk flight paths, but the lowest-risk flight paths could be excessively long. We present a risk assessment technique and a bi-objective optimization method to find low-risk and time solutions to this problem. We used computational experiments to evaluate the methods' computation time and solution quality. The most promising method constructs a graph for the problem, generates an initial solution using the graph, and improves that solution with a local search.

4 - Innovation and Information Privacy

Gwendolyn K.Lee, Chester C. Holloway Professor, University of Florida, Gainesville, FL, 32611, United States, gwendolyn.lee@warrington.ufl.edu, Ye Xia

Do firms converge or diverge in choosing how much personally identifiable information (PII) to collect when consumers have heterogeneous attitudes about privacy risk and when companies interact competitively in the market? In our model, firms choose their strategies with respect to how much PII they collect from consumers. Based on our game-theoretical analysis, we find that, at the competitive equilibrium, rational firms choose to collect different amounts of PII, thus spreading apart in the space of strategies. Such a finding is by no means obvious. We show exactly how far apart the firms will spread out and explain why firms don't converge to the same strategy, such as collecting the maximum amount.

5 - Developing a Risk Index for Sustainable Freight Transportation

Ravi Shankar, Professor, Indian Institute of Technology Delhi, New Delhi, India, r.s.research@gmail.com, Divya Choudhary

This research introduces an innovative concept of risk index for sustainability (RIS) to evaluate the risk exposure of sustainable freight transportation (SFT). Interval 2-tuple and digraph matrix approaches have been used to model this problem. Different SFT systems are analyzed and managerial implications are drawn.

■ TE58

362E

Layout and Location

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Ardavan Asef-Vaziri, College of Business and Economics, Dept of Systems and Operations MGMT, 18111 Nordhoff Street, Northridge, CA, 91330-8378, United States, aa2035@csun.edu

1 - A Multiple Allocation P-hub Location Problem with Third-party Operated Vehicles

Armin Lüer-Villagra, Universidad Andres Bello, Antonio Varas 880, Providencia, Santiago, 7501085, Chile, armin.luer@unab.cl, Vladimir Marianov, German Paredes-Belmar

Hub and spoke networks are very common in the postal, airline, and parcel delivery industries. Hubs are facilities used to sort, consolidate and transfer flows from multiple origins and destinations. We formulate a multiple allocation p-hub location problem when a third party operate the vehicles and offer volume discount to the operating company. We perform extensive computational experience, noting differences in the solutions obtained.

2 - A Dynamic Data Driven Adaptive Simulation Based Optimization Framework for Layout and Resource Allocation in Horticultural Grafting Nurseries

Sara Masoud, University of Arizona, 1300 E.Fort Lowell Road, # A214, Tucson, AZ, 85719, United States, saramasoud@email.arizona.edu, Bijoy Dripta Barua Chowdhury, Young-Jun Son, Chieri Kubota, Russell Tronstad

Resource allocation and layout design are critical decisions in designing/operating grafting nurseries; yet, their concurrent optimization is challenging due to the dynamics of workers' performance, resource availability, and demands. We propose a dynamic data driven adaptive simulation based optimization framework to optimize layout design and resource allocation by using data gloves to evaluate the workers' performance at a micro level, and radio frequency identification system to study the motion of the workers and material flow at a macro level. The effectiveness of the proposed framework will be demonstrated via a case study in finding the optimal layout design and resource allocation.

3 - The Optimization of a Municipal Solid Waste Management System
Yan Zhang, Associate professor, Dalian Maritime University, No.1 Lingshui Road, Dalian, 116023, China, yan.zhang@dlmu.edu.cn, Hualong Yang

In a waste management system, the location of proper facilities for treating waste is a sensitive issue that has often caused political and social tension. We study the problem of simultaneous design of a distribution network with central treatment facilities, transfer stations and sanitary landfills, and the coordination of waste flows within this network. In order to determine the number, sizes and locations of the solid waste management facilities, we formulate a mathematical model for the problem and propose a heuristic to solve large problems efficiently. Finally, we apply these models and algorithms for the development of a solid waste management system for a specific region in Dalian.

4 - Covering and Connectivity Constraints in the Block Layout Shortest Loop Design Problem
Ardavan Asef-Vaziri, Professor, College of Business and Economics, Dept of Systems and Operations MGMT, 18111 Nordhoff Street, Northridge, CA, 91330-8378, United States, aa2035@csun.edu, Morteza Kazemi

The shortest loop covering at least one edge of each workcenter in a facility layout is an instance of the GTSP. The optimal solution to this problem is a promising design for non-vehicle-based material handling. This formulation is usually embedded within the problem of the concurrent design of the loop and the I/O stations for vehicle-based material handling. The shortest loop provides an effective heuristic scheme to achieve prosperous and robust solutions for the design of the loop and stations. We review and compare covering constraints formulations, provide new insight into connectivity constraints, improve the model formulation and solution procedure, and report computational results.

■ TE59

362F

Health Care, Other

Contributed Session

Chair: Ilgin Acar, Anadolu University, Eskisehir, Turkey, ipoyraz@anadolu.edu.tr

1 - Filling Current Healthcare Gaps: Thoughtful Application of Robust Parameter Design with Conditions-based Selection of Regression Estimators
Kathryn Pegues, Student, Clemson University, 104 Hyde Lane, Clemson, SC, 29631, United States, kpegues@gmail.com

Underlying assumptions for RPD modeling and process conditions should be taken into account when selecting a regression estimator for developing fitted models. If these assumptions are incorrect, then a direct use of estimates obtained has the potential to be problematic, and the results may be potentially catastrophic, particularly when applied to the healthcare field. This paper examines alternative approaches to regression estimation when the process data indicates that asymmetry or a high degree of process variability exists. The performance of select alternative regression methods is compared using Monte Carlo simulation and numerical analysis.

2 - How Does Government's Willingness to Fund Influence the Level of Health Prepayment
Ying Zhang, Southeast University, Nanjing, China, yingzhang@seu.edu.cn

Significant prepayment is a crucial factor to ensure that all individuals have access to effective health care at affordable prices. The research question we address here is, does government's willingness to spend more on health means higher prepayment rates in the health financing system? These questions are addressed in 34 OECD members over the 1995-2013 period. Our findings show that government's willingness to pay on health increases both the level of total prepaid expenditure and public prepayment [social health insurance, tax-financed]. Our research also highlights that government's willingness to fund is not systematically crowding out private prepaid plans.

3 - Developing an HPV Infection Risk Prediction Model and Self-assessment Tool for Young Adult Females
Rachel Holmer, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States, reholmer@uark.edu, Shengfan Zhang

According to the Centers for Disease and Control Prevention (CDC), nearly one in four people are currently infected with Human Papillomavirus (HPV) in the United States. Although most people with HPV never experience symptoms, there is a risk of developing different types of HPV-related cancers after infection. These cancers and other related diseases result in almost $8 billion spent annually for treatment. This research seeks to create a risk prediction model with a focus on young adult females that will assist these individuals to estimate the risk of HPV infection based on demographic, life style, and sexual behavior factors.

4 - Blockchain Application in Healthcare Supply Chain for Effective Recall and Outdates Management
Raja Jayaraman, Khalifa University of Science and Technology, PO Box 127788, Abu Dhabi, United Arab Emirates, raja.jayaraman@kustar.ac.ae, Nelson King

Product Lifecycle Management in healthcare is a complex process due to significant factors such as volume, variety, information inaccuracy on procurement, trends in consumption, poor data quality. In this presentation, we explore the role and use of blockchain technology in integrating critical product information across various processes in healthcare supply chain.

5 - Risk Factors Affecting Work Related Musculoskeletal Disorders in a Manufacturing Company
Ilgin Acar, Anadolu University, Ikieylul Campus, Faculty of Engineering, Eskisehir, 26555, Turkey, ipoyraz@anadolu.edu.tr, Nihal Erginel, Sura Toptanci

Various risk factors including individual factors such as personal and anthropometric variables, physical work and psychosocial factors are used as predictors of Work-related musculoskeletal disorders (WMSDs). The aim of this study is to build fuzzy regression models to understand the relationship between WMSDs and risk factors, to estimate the injuries, and to assess individual's risk levels. A designed survey is used to collect data in a manufacturing company and to measure the influences of risk factors on the musculoskeletal symptoms. As the risk factors can be defined by fuzzy regression models, it may be easy to minimize the effect of risk factors to prevent WMSDs to provide safe environments.

■ TE60

370A

Education and Economic Policy-Making

Sponsored: INFORMEd

Sponsored Session

Chair: Vanitha Virudachalam, Wharton School, OID, 3730 Walnut Street, 500 Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, vanitha@wharton.upenn.edu

1 - The Urban and Rural Income Gap in China Based on the Opportunity Inequality
Xiufan Zhang, Harbin Engineering University, Harbin, China, zhangxiufan@hrbeu.edu.cn

With the continuous improvement of economic, China's income increases fast, but the income gap between urban and rural areas is grim. Gini-coefficient is widely used to measure inequality in the distribution. But the deeper consequences behind inequality are ignored, including policy, institutional and social and cultural opportunities,making the income gap last for long. The paper summarizes various indicators of income inequality,calculates the income gap between urban and rural areas in China and analye the specific influencing factors of opportunity inequality on income inequality.The paper finally put forwards some Countermeasures of Urban - rural Income Gap.

2 - Re-engineering Agricultural Extension Services: Perceptions' Intrinsic Role in the Design Process
Elizabeth Ayala-Medina, Graduate Student, University of Puerto Rico-Mayagüez, Mayagüez, Puerto Rico, elizabeth.ayala@upr.edu, Betzabé Rodriguez

Yearning to uphold a service of quality and excellence that meets the needs of farmers, this study pretends to expand on the intrinsic nature of perceptions throughout the design process. Furthermore, validate the assertiveness of integrating farmers' perception in the development of a tool that aids in their learning process.

3 - Optimizing Performance Pay in K-12 Education
Vanitha Virudachalam, Doctoral Candidate, The Wharton School, 3730 Walnut Street, 500 Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, vanitha@wharton.upenn.edu, Sergei Savin, Matthew Steinberg

We study performance-based contracts in a K-12 educational setting, where a local school district (the principal) contracts with teachers (the agents) to meet student performance goals. Teachers' wages are partly determined by student performance on the end-of-the-year state achievement test. The level of student knowledge is not perfectly known prior to this test; the district may choose to reduce this uncertainty by administering an interim assessment at a cost. We model this setting using a dynamic principal-agent model with partially hidden states. We determine the optimal performance-based contract and testing schedule the school district should offer teachers.

■ TE61

370B

Finance, Portfolio Analysis

Contributed Session

Chair: Aloagbaye Momodu, University of Toronto, Toronto, ON, Canada, aimomodu@mie.utoronto.ca

1 - Portfolio Construction using Gerber Statistics Based Risk Parity Model

Ravi Shankar, Indian Institute of Technology Delhi, New Delhi, India, ravi@dms.iitd.ac.in, Dhanya Jothimani, Surendra S. Yadav

In this research, we use Hierarchical Risk Parity model for portfolio optimization, where covariance of stocks are clustered. Covariance of the stocks is obtained using Gerber statistics. Sample consisted of firms listed on National Stock Exchange during the period 2008-2016. We find that the performance of the proposed model was better than Global Minimum Variance model. The contributions are two-fold: first, the model helps to avoid errors arising from estimation of returns and second, it avoids the need for inversion of covariance matrix.

2 - Identifying Robust Diversified Portfolios with Second Order Stochastic Dominance Constraints

Peng Xu, PhD Candidate, Aalto University School of Business, Runeberginkatu 22-24, Helsinki, FIN-00100, Finland, peng.xu@aalto.fi

Identifying Second-order Stochastic Dominance (SSD)-efficient portfolios is of great interest to finance research where investors are routinely assumed to be rationally risk-averse in making financial decisions. This paper seeks to (i) evaluate some most recent SSD approaches and their out-of-sample performance in portfolio diversification, and (ii) examine if robust optimization improves the out-of-sample performance of these approaches. We report the results from an empirical application analyzing how robust optimization based diversification among industry portfolios increases the likelihood of obtaining out-of-sample SSD over the market portfolio.

3 - Solving Cardinality Constrained Mean – Variance Portfolio Optimization using Message Passing Algorithms

Alexia Yeo, University of Toronto, Toronto, ON, Canada, ayeo@mie.utoronto.ca

The cardinality constrained mean-variance optimization problem has the advantage of reducing transaction costs and the complexity of asset management. It may be see as a special case of the quadratic knapsack problem. We approach this problem by using probabilistic inference in a graphical model to estimate portfolio selections. Message passing is a class of inference algorithms that utilizes the factorization and decomposition properties of the problem's graphical model to efficiently estimate the value of unknown parameters. We evaluate the performance of the message passing algorithms MPLP and TRW against branch-and-cut algorithms. Contributors: Alexia Yeo, Dr. Roy Kwon

4 - Multiasset Game Contingent Claims Valuation using a Projected Successive Over Relaxation Algorithm

Aloagbaye Momodu, University of Toronto, 121, Wolseley Street, Toronto, ON, M6J.1K1, Canada, aimomodu@mie.utoronto.ca, Chi-Guhn Lee

Game contingent claims (Israeli options) are generalizations of American contingent claims in which the writer (seller) has the right to cancel the contract before maturity subject to the payment of a prespecified penalty. This added feature leads to complexities in the valuation with no analytical solution in the literature for finite maturity game contingent claims. In this paper, we value multi-asset game contingent claims in a standard Black-Scholes framework by solving finite difference discretization of the Black-Scholes partial differential equation using a projected successive over relaxation algorithm.

■ TE62

370C

Resource Allocation

Contributed Session

Chair: Young Chun, Louisiana State University, Baton Rouge, LA, United States, prof@drchun.net

1 - Simulation-based Optimization of Prognostics and Health Management Enabled Condition-based Maintenance Policy

Taiwo Joel Omoleye, Mr, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Kowloon, Hong Kong, jtomoleye3-c@my.cityu.edu.hk, Kwok Leung Tsui

The practical implementation of condition-based maintenance (CBM) is trailing behind the widespread theoretical benefits in the literature. This necessitates the growing concern about the effectiveness of CBM policy in industries implementing CBM. To overcome this, research is focusing on the value of Prognostics and Health Management (PHM) information in CBM policy. In this paper, simulation-based optimization is used to assess the benefits of PHM-enabled CBM policy under resource dependence. Also, a framework is developed, numerically illustrated, and compared with classic CBM, and traditional maintenance policies using ARENA-based discrete event simulation model.

2 - Resilience of Core-periphery Networks

Babak Heydari, Assistant Professor, Stevens Institute of Technology, 1 Castle Point, Babbio Center, Hoboken, NJ, 07030, United States, babak.heydari@stevens.edu

We discuss conditions for resilience of core-periphery networks, an important class of complex systems. A successful model that captures resilience needs to model the extent of performance loss due to disruption, the post-recovery performance level, and the relative speed of recovery. We present a network model that incorporate connection costs and direct and indirect benefits of connection, assumes efficiency at both pre-disruption and steady-state post disruption systems, and focuses on core-periphery structures. We investigate conditions under which core-periphery structures increase the overall resilience of the network.

3 - Optimal Selective Maintenance for Networked Infrastructure Systems

Wanshan Li, Tsinghua University, Beijing, 100084, China, liws16@mails.tsinghua.edu.cn, Chi Zhang

Networked infrastructures, such as electricity, telecommunication and transportation, are considered critical for both economic development and social wellbeing of modern societies. To ensure their continued effective performance, cost-effective maintenance without interrupting their operation is necessary. This research proposes a new selective maintenance approach that can help determine optimal maintenance strategies for networked critical infrastructures with general structures. Our approach can also ensure an infrastructure's ability of satisfying the customers' demand continuously, even during the process of maintenance.

4 - Economic Design of Repetitive Inspection Plan with Testing Errors

Young H.Chun, Louisiana State University, 2211 Business Education Complex, Baton Rouge, LA, 70803-6316, United States, prof@drchun.net

Inspection has been widely used as an important tool for quality improvement in manufacturing and service industries. However, inspection errors are inevitable during a screening process of manufactured items such as computer chips; some of the defective items are tested negative and other non-defective items are tested positive erroneously. To improve the outgoing quality, each item is often tested more than once. Based on the test results, we can estimate the defective rate and the inspector's type I and II errors via the method of maximum likelihood. We also propose various types of repetitive inspection plans and compare their performances in a simulation study.

■ TE63

370D

Simulation and Optimization

Contributed Session

Chair: Ashutosh Nayak, Purdue University, West Lafayette, IN, United States, nayak2@purdue.edu

1 - A Decomposition Method for the Two Stage Staffing Problem in Multiskills Call Centers under Arrival Rate Uncertainty

Thuy Anh Ta, University of Montreal, CP 6128 Succursale Centre-Ville, Montreal, QC, H3W1C5, Canada, tathuyanh1989@gmail.com, Wyean Chan, Fabian Bastin, Pierre l'Ecuyer

We consider a stochastic staffing problem with uncertain arrival rates. The objective is to minimize the total cost of agents under some chance constraints, defined over the randomness of the service level in a given time period. In the first stage, an initial staffing must be determined in advance. At a later time, when the forecast becomes more accurate, this staffing can be corrected with recourse actions by adding or removing agents. We propose a decomposition algorithm based on simulation, cut generation and stochastic programming to solve the problem in reasonable computational time.

2 - Selecting Good Enough Designs using Optimal Computing Budget Allocation

Fei Gao, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong, feigao9-c@my.cityu.edu.hk, Siyang Gao

We study the problem of selecting a subset of good designs from a finite set of simulated designs. We develop an approach to select r good enough designs instead of the exact top r designs, where good enough designs are defined as the top g designs ($r \leq g$). Using the optimal computing budget allocation framework, we formulate the problem as that of maximizing the probability of correctly selecting r good enough designs under a simulation budget constraint. Based on the approximate measure of the probability of correct selection, we derive an asymptotically optimal selection procedure for selecting good enough designs. The proposed method shows good performance on some typical selection problems.

3 - Adaptive Secant Tangents Averaged Stochastic Approximation
Marie Chau, Virginia Commonwealth University, 1015 Floyd Avenue, Richmond, VA, 23220, United States, mchau@vcu.edu, Jong J. Lee, Michael C. Fu

We introduce Adaptive Secant Tangents AveRaged SPSA (aSTAR-SPSA) for multivariate stochastic optimization problems. Under the setting, where direct and indirect gradients are available, aSTAR-SPSA employs a hybrid Hessian, which is a weighted combination of gradient-free (GF) and gradient-based (GB) Hessians. GF consists of symmetric finite differences (SFD) of SPSA gradients, and the SFD of the associated direct gradients generate GB. We propose weights to minimize two criteria under the Frobenius norm. We prove convergence, establish asymptotic normality, and investigate the empirical performance of aSTAR-SPSA against second-order SA methods through numerical experiments.

4 - Integrating Lyapunov Optimization with Monte Carlo Simulation for Online Decisions
Ashutosh Nayak, PhD Candidate, Purdue University, 45 N Salisbury Street, Apt 9, West Lafayette, IN, 47906, United States, nayak2@purdue.edu, Seokcheon Lee

With the explosion of real-time information, online decision making is increasingly gaining popularity in different applications. Smart Microgrids receive dynamic load requests from consumers and time-varying electricity from renewables. The stochastic nature of demand and supply makes online load scheduling decisions in Microgrid imperative. Lyapunov optimization is an elegant and simple stochastic dual-gradient method that does not consider estimation of future information. In this work, we integrate Lyapunov optimization with Monte Carlo simulation to construct an online algorithm for dynamic load scheduling decisions based on historical decisions and future estimation.

■ TE64

370E

Data Analytics for System Improvement II

Sponsored: Data Mining

Sponsored Session

Chair: Changyue Song, PhD, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53715, United States, csong39@wisc.edu

Co-Chair: Kaibo Liu, UW-Madison, Madison, WI, 53706, United States, jacoblkb@gmail.com

1 - Manufacturing Functional Data Analysis
Ran Jin, Virginia Tech, 1145 Perry Street, Durham Hall, Room 250 (0118), Blacksburg, VA, 24061, United States, jran5@vt.edu, Hongyue Sun

Modern manufacturing system generates spatially and temporally dense data sets. This talk focuses on manufacturing modeling problems with functional data, where the models will be used in data-driven decision making in smart manufacturing. Examples in functional variable selections, in situ process modeling, and data interpretation from natural language processing perspective will be discussed.

2 - Monitoring for Changes in the Nature of Stochastic Textured Surfaces
Anh Tuan Bui, Northwestern University, Technological Institute 2145 Sheridan Road, Room C210, Evanston, IL, 60208, United States, atbui@u.northwestern.edu, Daniel Apley

This work aims to monitor for global changes in the nature of stochastic textured surfaces, which are fundamentally different than the profiles and images that are the focus of most prior profile monitoring works. We represent normal in-control behavior by using supervised learning models to implicitly characterize the joint distribution of the surface image pixels. Based on this characterization, we develop a monitoring statistic using likelihood-ratio principles to detect changes in the surface nature, relative to the in-control nature. Our approach can detect general surface changes with no prior knowledge of the changes. We demonstrate the approach with a textile example.

3 - Early Detection Vessel Delays using Combined Historical and Real-time Information
Sungil Kim, Assistant Professor, UNIST, Ulsan, Korea, Republic of, sungil.kim@unist.ac.kr

Detecting vessel delays in advance or in real time is important in order to fulfill the expectations of customers and to help customers reduce delay costs. However, the early detection of vessel delays faces the challenges of numerous uncertainties, including weather conditions, port congestion, booking issues, and route selection. This paper proposes a data-driven method for the early detection of vessel delays: in our new framework of refined case-based reasoning, real-time S-AIS vessel tracking data are utilized in combination with historical shipping data. Real data examples from a logistics company demonstrate the effectiveness of the proposed method.

4 - A Generic Multisensor-based Degradation Model
Changyue Song, University of Wisconsin-Madison, Rm 3221, Mechanical Engineering Building, 1513 University Ave, Madison, WI, 53715, United States, csong39@wisc.edu, Kaibo Liu

Nowadays multiple sensors have been widely used to monitor the degradation status of a unit simultaneously, which enables an unprecedented opportunity for condition-based monitoring and maintenance. However, most of the existing studies focus on the modeling and prognosis based on a single signal. Other studies either analyze each signal separately, or fuse multiple signals into a composite index. This paper proposes a generic multisensor degradation model which can capture the correlation among sensors and learn the failure mechanism of units directly from multiple signals. As a result, the proposed method is more flexible and achieves better prognostic performance.

■ TE65

370F

Vehicle Routing

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Justin Goodson, Saint Louis University, St. Louis, MO, 63108, United States, goodson@slu.edu

1 - Generic Branch-and-Bound Schemes for Time Window Assignment Vehicle Routing Problems
Anirudh Subramanyam, Carnegie Mellon University, DH3122, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States, asubramanyam@cmu.edu, Chrysanthos Gounaris

We study the allocation of long term delivery time windows to customers in the context of VRPs. Once a time window has been assigned, the operator must strive to meet it on a daily basis as well as possible. Since operational parameters such as customer demands or travel times vary from day to day, the aim is to assign time windows in a way that minimizes the expected routing cost. In this work, we show that this problem can be reduced to a variant of the Consistent VRP and adapt an algorithm we developed for the latter problem to solve to exact optimality instances of the former. Our approach is highly competitive and can address uncertainty in a wider class of parameters when compared to the previous state of the art.

2 - A Branch-Price-and-Cut Approach for Robust Vehicle Routing
Akang Wang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, akangw@andrew.cmu.edu, Chrysanthos Gounaris

We present a Branch-Price-and-Cut approach for tackling the Vehicle Routing Problem (VRP) under demand uncertainty. We utilize Limited-Memory Subset Row Cuts and robust Rounded Capacity Inequalities to strengthen the linear relaxation at every node. We use a Tabu Search heuristic to generate columns with negative reduced cost, and we resort to exact pricing via Dynamic Programming only if the former fails to identify such columns. Computational studies are performed on VRP benchmark instances stemming from multiple variants.

3 - Travel Time Correlation in Vehicle Routing
Iurii Bakach, Graduate Student, University of Iowa, 2119 Keokuk Street, Apt 9, Iowa City, IA, 52240, United States, iurii-bakach@uiowa.edu, Ann Melissa Campbell, Jan Fabian Ehmke, Timothy Urban

Due to the complexity of the problem, the majority of routing models consider arc costs to be deterministic and independent. However, in reality, arc costs are often correlated, for instance, when they reflect travel times in urban areas. We examine a routing problem with a min-max objective with both stochastic and correlated travel times. We develop a method using extreme-value theory to estimate the expected makespan and embed this within a routing heuristic. We present results that demonstrate the impact of different correlation patterns and levels of correlation on route planning.

4 - Route-Based Markov Decision Processes for Dynamic Vehicle Routing Problems
Justin Goodson, Saint Louis University, John Cook School of Business, Davis-Shaughnessy Hall, St. Louis, MO, 63108, United States, goodson@slu.edu, Marlin Wolf Ulmer, Dirk C. Mattfeld, Barrett Thomas

We propose a model for dynamic routing problems (DRPs) that extends the conventional Markov decision process (MDP) model for dynamic and stochastic optimization problems to more closely align with route-based solution methodologies in the DRP literature. We construct route-based MDPs by redefining the action space to operate on sets of planned routes. We generalize the state to include route plans and redefine the current-period reward/cost to be the marginal change in value associated with an update to a route plan. We show route-based MDPs are equivalent to the conventional MDP model.

■ TE66

371A

Analysis of Shared Mobility Systems

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Mustafa Lokhandwala, Purdue University, 241 Sheetz Street, Apt 14, West Lafayette, IN, 47906, United States, mlokhand@purdue.edu

1 - A Study on the Phenomenon of E-hailing Taxi Order Discard Based on Customer Impatience and Arrival Time Fluctuation Analysis

zhuying Jiang, Sparkzone Research Group, Beijing, China, 2579658790@qq.com, Yu Xin, Yinghao Jia, Yinghao Jia

E-hailing applications are commonly believed to improve the traveling efficiency and service quality by increasing transport supply to meet customers' demand. However, customers may discard the E-hailing taxi and take the cruising taxi instead to minimize the waiting time, depending on fluctuation of arrival time and individual patience. Based on data-driven approaches and human factor analysis, we propose an analytical framework to study the competition of E-hailing and cruising taxis by quantitatively evaluating the extent of reduced efficiency, thus optimizing the balance between system efficiency and service quality.

2 - Modeling Users' Memory in Shared Bike Systems

Dmitry Gimon, Assistant Professor, Fort Hays State University, 600 Park Street, Hays, KS, 67601, United States, dmitrygimon@gmail.com

Shared resources, such as car or bicycle rental systems, have become a norm of life in cities. Since transportation patterns vary during the day, the key problem of these systems is network balance, which affects systems reliability and users satisfaction. We propose to model user satisfaction as a function of relevant concessions that this particular user or other users have made in deciding to use different drop-off/pickup sites. We compare existing and theoretical incentive models and users' strategies to find the one that will result in the most balanced network or the one with the most satisfied users. This study contributes to the area of shared vehicle design and operations.

3 - Ride Sharing a Case Study of Shared Taxis in New York City

Mustafa Lokhandwala, Graduate Student Purdue University, Purdue University, 235 Littleton Street, Apt 15, West Lafayette, IN, 47906, United States, mlokhand@purdue.edu, Hua Cai

This study uses simulation to analyze the benefit of Taxi Sharing using agent-based modeling. The focus of our study is to build an agent-based simulation model using \color{red} real world \color{black}trip data obtained from the New York Taxi and Limousine Commission, model the decision making methodologies of the agents (the taxis and the riders) in a taxi sharing scenario and run this model using the most recent trip data within the GIS setting of New York City. The end result from this experiment is to optimize the number of taxis operating on the streets of New York City and also quantify the economic and environmental benefits of the same.

■ TE67

371B

Quality Technology and Quantitative Management Invited Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Jing Li, Arizona State University, Tempe, AZ, 85287-8809, United States, jing.li.8@asu.edu

1 - Multilinear Principal Component Analysis for Statistical Modeling of Cylindrical Surfaces: A Case Study

Bianca Colosimo, Politecnico di Milano, Milan, Italy, biancamaria.colosimo@polimi.it, Massimo Pacella

The work focuses the problem of modeling manufactured surfaces for statistical process control. The application of Multilinear principal component analysis (MPCA) is discussed. A real case study concerning cylindrical surfaces obtained by a lathe-turning process is taken as reference. The measurements related to a specific surface are stored in a matrix addressed by 2 index variables, while the observed data set related to several surfaces is stored in a 3rd- order tensor addressed by 3 indexes. Any 2.5- dimensional surface (i.e. where scalar measurements are sampled for each item by using a fixed grid of two spatial index variables) can be modeled with the proposed MPCA-based approach.

2 - Monitoring Communications: Aiming to Identify Periods of Unusually Increased Communications between Parties of Interest

Ross Sparks, CSIRO.Computational Informatics, North Ryde, NSW, Australia, Ross.Sparks@data61.csiro.au

Communication monitoring of large networks with aim of detecting unusually increased communications is a challenging task. This talk will cover some of the challenges when firstly the target sub-group of the network with potentially increased communications is known and changes in size over time; and secondly when the sub-group is unknown and needs to be found. The unknown sub-group case will be carried out under two situations. Firstly when the sub-group has a dominant leader and communication sparsity in the sub-group can be exploited. Secondly when sub-group has a collaborative leader and no communication sparsity generally exists in the sub-group.

3 - Two-sided Tolerance Intervals for Members of the (Log)-location-scale Family of Distributions

Yili Hong, Virginia Polytechnic Institute, 213 Hutcheson Hall, Department of Statistics, Blacksburg, VA, 24061, United States, yilihong@vt.edu

In this paper, we propose methods to calculate exact factors for two-sided control-the-centre and control-both-tails tolerance intervals for the (log)-location-scale family of distributions, based on complete or Type II censored data. With Type I censored data, exact factors do not exist. For this case, we developed an algorithm to compute approximate factors. Our approaches are based on Monte Carlo simulations. We also provide algorithms for computing TIs that control the probability in both tails of a distribution.

■ TE69

371D

Sustainable and Responsible Supply Chain Management

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Jose Cruz, jose.m.cruz@uconn.edu

1 - Revenue and Demand Management of Smart Cities

Shivani Shukla, PhD, University of Massachusets, Amherst, MA, United States, sshukla@som.umass.edu

A smart city concept encompasses enhancement of transportation to support growth initiatives, environmental review to sustain modernization, and sustainable travel. Multiple public and private entities cooperate to share information and resources for collective efforts driven to achieve sustainability. This work focuses on measuring the effectiveness of such cooperative enterprises in the realm of demand management through the intended shift from the typical travel practices to more reliable alternatives.

2 - Supply Chain Sustainability through Risk Sharing Contracts

Jose Cruz, University of Connecticut, School of Business, 2100 Hillside Road, Storrs, CT, 06269-1041, United States, jose.m.cruz@uconn.edu

In this paper, we develop a framework that captures sustainability trough d risk-sharing contracts in supply chain networks. Risk-sharing contracts specify who needs to incur the costs when supply chain disruptions occur. We present the behavior of the various decision-makers, derive the governing equilibrium conditions, establish the finite-dimensional variational inequality formulation, and present numerical examples.

3 - Supply Chain Network Competition and Sustainable Environmental Policies

Min Yu, PhD, University of Portland, Portland, OR, United States, yu@up.edu, Jose Cruz, Dong Li

We first develop a competitive supply chain network model consisting of a finite number of firms competing in an oligopolistic manner. We investigate the problem with progressive emission taxes, in which the emission tax function is a piecewise-defined function of the total emission. Second, we extend the single period model to a multiperiod model to study the firm's long-term investment strategy on the sustainable energy-efficient technologies to take advantage of tax incentives while maximizing the net present value (NPV) of the investment.

4 - A Competitive Multiperiod Supply Chain Network Model with Freight Carriers and Green Technology Investment Option

Sara Saberi, Worcester Polytechnic Institute (WPI), Washburn Rm 217, Foisie School of Business, Worcester, MA, 01609, United States, ssaberi@wpi.edu, Jose Cruz, Anna B. Nagurney

This paper presents a multiperiod supply chain with freight carriers model. Manufacturers, retailers, and carriers maximize the net present value of their investments in technology. Future production, inventory, transaction, and transportation costs savings are used to help fund investments. The environmental impact of the costs are all integrated. The tradeoff between the initial technology investment and its ecological footprint effect are considered. We provide variational inequality formulations of the equilibrium conditions and propose the modified projection method. Numerical examples are examined with an analysis of the effects of technology investments on supply chain network.

5 - Polling, Psychology and Propaganda in Forecasting Electoral Outcomes

Dimitris Vayenas, Metapoll, London, United Kingdom, dimitris@metapoll.co.uk

Having predicted the outcomes of recent elections the session addresses the underlying theories that are calling for a re-evaluation of political campaigning. By utilising formal models developed to quantify transparency in many-to-many communications, accurate forecasting is attainable based on the motives of the population as addressed by the campaigns; in the case of Brexit with a 0.1% deviation one month before the elections. The shortcomings of polling methodologies and how analytics can help mitigate the impact of unreliable responses are also addressed. Models of human socialty and motivators are employed in the mapping of quantifiable sentiments and reactions to propaganda.

6 - Optimization of Feedstock Blending for Biochemical Conversion

Mohammad Sadekuzzaman Roni, Idaho National Laboratory, 21 T. Wallace Circle, Starkville, MS, 39759, United States, msr131@gmail.com

Identifying a least cost blend is challenging, especially when decisions about feedstock blending must be based on a number of criteria. This study developed an optimization framework to identify optimal blending of feedstock to meet biochemical conversion specifications. Results reveal the tradeoff among blend components in the least cost blend based on biomass resource availability, quality requirement and logistics cost.

■ TE70

371E

Data Mining

Contributed Session

Chair: Jimi Oke, Massachusetts Institute of Technology, Cambridge, MA, United States, oke@mit.edu

1 - Mathematical Programming Approaches and Data Representations for Multiple Instance Learning

Emel Seyma Kucukasci, Istanbul Commerce University, Kucukyali E5 Kavsagi Inonu Cad No 4, Istanbul, 34840, Turkey, emelseyma@gmail.com
Emel Seyma Kucukasci, Boaziçi University, Istanbul, Turkey, emelseyma@gmail.com, Mustafa Gokce Baydogan, Z. Caner Ta kın

We propose a multiple instance learning framework including new mathematical models of multiple instance classification and enhanced data representations. We efficiently solve MIL problem without imposing strict assumptions on object descriptions. Our approach embeds instance relationships via inputting various data representations and determines class memberships of the objects. We compare our learning procedure with state-of-the-art MIL methods on a wide range of machine learning datasets to highlight the classification success on different application domains.

2 - Forecasting Gathering Events through Continuous Destination Prediction on Big Trajectory Data

Amin Vahedian Khezerlou, University of Iowa, S283 Pappajohn Business Building, Iowa City, IA, 52242, United States, amin-vahediankhezerlou@uiowa.edu, Xun Zhou

Gathering Event Forecasting (GEF) in urban areas is the problem of forecasting unexpectedly high number of arrivals in an urban region. In this work, we propose a trajectory-based approach to forecast the gathering events by predicting the destinations of incomplete trip trajectories at a given time. To the best of our knowledge, this method is the first to adopt this approach to GEF. This method includes a novel destination prediction model, which is superior to the models in the literature in terms of accuracy and computational cost (both running time and memory). We show through experiments that our method successfully forecasts real events.

3 - Discovering Urban Typologies for Future Mobility Scenarios in Prototype Cities

Jimi Oke, Postdoctoral Associate, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Building 1-178, Cambridge, MA, 02139, United States, oke@mit.edu, Yafei Han, Sean Hua, Carlos L. Azevedo, P. Christopher Zegras, Moshe E. Ben-Akiva

Ongoing trends in the development of vehicle fuels and technologies along with potential environmental and policy regulations will produce a complex space of futures of mobility outcomes in urban areas. We gather the most recent land-use, economic, environmental and mobility data from over 331 cities. We extract the key factors and then cluster the cities to find the prevailing urban typologies. Further, we estimate a latent class choice model for mobility responses based on 43000 individual observations from a global sample, thus confirming our typology classes. In a novel effort, we will then generate new representative prototype cities in order to model various urban mobility scenarios.

■ TE71

371F

Modeling and Analysis of Power System Expansion Planning

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Enzo E Sauma, PhD, Pontificia Universidad Catolica de Chile, Pontificia Universidad Catolica de Chile, Santiago, Chile, esauma@ing.puc.cl

1 - Quantifying the Effect of Head-sensitive Hydropower Approximations on Investments and Operations

Francisco Munoz, Universidad Adolfo Ibáñez, Santiago, Chile, fdmunoz@uai.cl, Gonzalo Ramírez

Planning for new generation infrastructure in hydrothermal power systems requires consideration of a series of nonlinearities that are often ignored in capacity-planning models. In this article we use three different capacity-planning models, with different degrees of complexity and accuracy, to quantify the impact of simplifying the head dependency of hydropower generation on investments in thermal units and system operations. We find that simplified investment models can bias the optimal generation portfolios significantly and increase system costs compared to more detailed nonlinear models.

2 - Joint Expansion Planning of Distribution Networks, EV Charging Stations and Wind Power Generation under Uncertainty

Javier Contreras, Univ de Castilla-La Mancha, E.T.S.de Ingenieros Industriales, Campus Universitario s/n, Ciudad Real, 13071, Spain, Javier.Contreras@uclm.es, Pilar Meneses de Quevedo, Gregorio Muñoz-Delgado

This paper describes the consideration of uncertainty in distribution system expansion planning (DSEP) including electric vehicles (EV) and the possibility of joint investment in EV charging stations (EVCS) and wind power generators. The charging demand necessary for EVs transportation is performed using a vehicle decision model based on travel patterns. The problem is defined as a stochastic-programming-based model driven by the minimization of the annualized investment, maintenance, production, losses and non-supplied energy costs. A 24-bus system case study is provided illustrating the results of the proposed approach.

3 - Transmission Expansion Planning: A Distributionally Robust Optimization Approach

David Pozo, Skolkovo Institute of Science and Technology, Mosco, Russian Federation, davidpozocamara@gmail.com, Alexandre Street, Alexandre Velloso

Investment decisions on power systems should be robust among all (infinite) possible future scenarios. This talk addresses the transmission expansion planning (TEP) problem where decisions have to be optimized given that the future is uncertain, there are several scales of uncertain parameters, and there is no knowledge of the true probabilities. A Distributionally Robust Optimization framework is proposed. Numerical test results are reported in comparison with the conventional approaches such as two-stage stochastic optimization and adaptive robust optimization.

4 - Interrelationship Between the Impending Major Energy Transitions and Pollutant Emissions

Daniela Quiroga, Pontificia Universidad Catolica de Chile, Santiago, Chile, diquiroga@uc.cl, Enzo Sauma, David Pozo

Energy sector is facing important transitions motivated by the strong incentives for encouraging renewable energy production and the adoption of energy efficiency measures. We study the interrelationship between the impending energy transitions over the coming decade and local and global pollutant emissions, in the context of the Chilean power system. In particular, we develop and analyze policy-relevant scenarios describing the energy transitions facing Chile over the coming decades and identify the key factors of the power sector contributing to pollutant emissions. We then identify some regulations in the Chilean power sector and study the general and distributional effects on emissions.

■ TE72

372A

Optimization, Large Scale

Contributed Session

Chair: Ahmed Marzouk, Southern Methodist University, Dallas, TX, United States, amarzouk@smu.edu

1 - Solving Uncapacitated Facility Location and Network Design Problems with Disaggregagted Benders Decomposition

Robin Pearce, University of Queensland, School of Mathematics and Physics, Mathematics Department, St Lucia, 4068, Australia, r.pearce2@uq.edu.au

Numerous problems fall under the category of facility location and network design problems, most of which can be effectively solved using Benders decomposition. In this talk we list a number of these problems, present the general problem and show how to apply disaggregated Benders decomposition these problems. In particular, we look at potential improvements that can be applied to improve time to solution, such as Pareto-optimal analytically-derived Benders cuts or tighter feasibility cuts. We will conclude with computational results to demonstrate the effectiveness of this approach.

2 - Robust Optimization to One-way Electric Vehicles Sharing System Considering Uncertain Travel Time

zihao jiao, Beijing Institute of Technology, Beijing, China, zihaobit@163.com

As operators' concern, the main problems of Electric vehicles sharing service such as charging demand and range anxiety, impact operation process and generate several secondary problems. Another unnoticeable aspect of operation is uncertainty, a general issue in engineering systems. We propose a robust model to handle with perturbed data, taking location and layout into consideration as well. Then we use a two-stages algorithm to solve the model. The results of case study show that uncertainty of travel time makes an unstable fleet size each depot, increasing optimal cost and worse cost management ability. Besides, we appraise environment benefits by evaluate the CO2 saving by EVs sharing.

3 - A New Lagrangian Relaxation for Multicommodity Capacitated Network Design Problem

Mohammad Rahim Akhavan Kazemzadeh, Universite de Montreal (DIRO), 5775 ave Wilderton, Montreal, QC, H3S2V7, Canada, akhavanm@iro.umontreal.ca, Teodor Gabriel Crainic, Bernard Gendron

The usual Lagrangian relaxations for multicommodity capacitated network design are the so-called shortest path and knapsack relaxations, which are obtained, respectively, by relaxing linking constraints and flow conservation equations. We present a new reformulation and Lagrangian relaxation for the problem. We show that the Lagrangian dual bound improves upon the so-called strong LP bound (known to be equal to the Lagrangian dual bounds of the shortest path and knapsack relaxations).

4 - The Constrained Covering Tour Problem

Sanaz Goldani, PhD Student, North Carolina State University, 3610 Detrick Drive, Apt 321, Raleigh, NC, 27609, United States, sgoldan@ncsu.edu, Yahya Fathi

The Constrained Covering Tour Problem (CCTP) is an integer programming (IP) problem that arises in the context of solving the Bi-objective Maximal-covering Minimal-tour Problem (BCTP) via the -constraint method. We introduce a family of valid inequalities and propose a branch-and-cut algorithm for solving this IP problem. We also present the results of a computational experiment to assess the effectiveness of this algorithm. We then employ this algorithm to obtain the non-dominated frontier of the corresponding bi-objective optimization problem.

5 - Slim Branch and Price Method for Combinatorial Optimization Problems

Ahmed M. Marzouk, Southern Methodist University, Lyle School of Engineering, Southern Methodist University, Dallas, TX, 75275-0123, United States, ambadr@email.tamu.edu, Erick Moreno-Centeno, Halit Uster

The Slim Branch and Price (SBP) method is a new optimization method that can be described as a framework that borrows ideas from general branch-and-price and cutting plane frameworks. We describe a specific implementation of the SBP algorithm and illustrate its effectiveness in a generalized traveling salesperson problem known as the Hamiltonian p-Median Problem.

■ TE73

372B

4:35 - 5:20 Turner/ 5:20 - 6:05 DiDi Chuxing

Invited: Vendor Tutorial

Invited Session

1 - Analytics and Data Science at Turner

Helena Berube, Turner Broadcasting Systems Inc, Atlanta, GA, United States, Helena.berube@turner.com, J. Antonio Carbajal

Analytics and Data Science plays a critical role at Turner. Our team is uniquely positioned to serve our clients with a focus on innovation, execution and nimble ability. Learn about some of the exciting work we've done that is transforming the media and content business.

2 - Didi Chuxing Technology Session

Wan Zhixi, Didi Chuxing, Beijing, China, wanzhixi@didichuxing.com, Adam Li

(Didi Chuxing is the world's leading mobile transportation platform.) You are warmly invited to learn more about our business and research topics related to platform economics, operations management, transportation science and engineering. You will learn about various opportunities to work together with our internal research teams.

■ TE74

372C

Parallel Algorithms in Optimization

Sponsored: Computing

Sponsored Session

Chair: Oleg Shylo, University of Tennessee, Knoxville, TN, 37996, United States, oshylo@utk.edu

1 - Parallel Branch and Bound Algorithms for Rectangular Maximum Agreement

Jonathan Eckstein, Rutgers University, 100 Rockafeller Road, Room 5145, Piscataway, NJ, 08854, United States, jeckstei@rci.rutgers.edu, Ai Kagawa

Rectangular maximum agreement (RMA) in an NP-hard combinatorial problem arising as a subproblem in various machine learning contexts. We show how the problem arises and discuss its solution using the PEBBL parallel branch-and-bound framework. We discuss various possible branching strategies and the specialized data structures that facilitate them. We give parallel performance results on problem instances derived from real datasets, and may also discuss restricted versions on the problem intended to be easier to solve.

2 - A Flocking-based Approach for Distributed Stochastic Optimization

Shi Pu, University of Florida, Gainesville, FL, United States, sp3dw@virginia.edu, Alfredo Garcia

We consider a distributed asynchronous computing scheme for stochastic optimization with modest communication amongst processors. Specifically, we analyze a scheme with $N > 1$ independent threads implementing each a stochastic gradient algorithm. The threads are coupled via a perturbation of the gradient (with attractive and repulsive forces) in a similar manner to mathematical models of flocking found in nature. We show a flocking-like approach provides a noise reduction effect similar to that of a centralized algorithm. Moreover, when the overhead related to the time needed to gather N samples and synchronization is not negligible, the flocking implementation outperforms a centralized one.

3 - Boosting Performance via Communication in Concurrent Algorithms

Oleg Shylo, University of Tennessee, 523 John D. Tickle Engineering Building, 851 Neyland Drive, Knoxville, TN, 37996, United States, oshylo@utk.edu, Andrii Berdnikov

We discuss a theoretical framework that captures communication in concurrent optimization algorithms, and use the proposed model to streamline parallel communication. In particular, the focus is on communicative algorithm portfolios, where a group of optimization algorithms works in parallel and shares information about the search process to boost performance. Discussion of the structure and content of scalable communication for a class of scheduling algorithms is provided.

4 - Asynchronous Parallel Stochastic Global Optimization using Radial Basis Functions

David Eriksson, Cornell University, 136 Hoy Road, Rhodes Hall 657, Ithaca, NY, 14853, United States, dme65@cornell.edu

We propose an asynchronous parallel surrogate optimization algorithm for global optimization of computationally expensive black-box objective functions. Our algorithm uses a radial basis function surrogate and doesn't require gradient information. We compare our algorithm to a synchronous implementation on several test problems and analyze how the performance depends on the distribution of the objective function evaluation times. Based on our experimental results we propose an empirical method to predict when asynchronous parallel is expected to outperform synchronous parallel.

■ TE75

372D

Recent Advances in First and Second Order Methods

Sponsored: Optimization, Nonlinear Programming

Sponsored Session

Chair: Mingyi Hong, University of Virginia, Ames, IA, 50011, United States, mingyi@iastate.edu

1 - Taming Nonconvexity with Data

Zhaoran Wang, Princeton University, Apt 302, 13 Lawrence Drive, Princeton, NJ, 08540, United States, zhaoran@princeton.edu

In this talk, I will illustrate how statistical thinking enables us to harness the power of nonconvex optimization. In specific, I will present an algorithmic framework for exploiting the latent geometry induced by the randomness of data. By integrating three new global exploration meta-algorithms — namely, homotopy continuation, tightening after relaxation, and noise regularization — with local search heuristics — such as the variants of gradient descent — this unified framework leads to new nonconvex optimization algorithms for a broad variety of challenging learning problems.

2 - SARAH: Stochastic Recursive Gradient Algorithm

Lam Minh Nguyen, Lehigh University, 200 West Packer Avenue, Room 362, Bethlehem, PA, 18015, United States, lmn214@lehigh.edu, Jie Liu, Katya Scheinberg, Martin Takac

We propose a StochAstic Recursive grAdient algoritHm (SARAH), as well as its practical variant SARAH+, as a novel approach to the finite-sum minimization problems. Different from the vanilla SGD and other modern stochastic methods such as SVRG, S2GD, SAG and SAGA, SARAH admits a simple recursive framework for updating stochastic gradient estimates; when comparing to SAG/SAGA, SARAH does not require a storage of past gradients. The linear convergence rate of SARAH is proven under strong convexity assumption. We also prove a linear convergence rate in the strongly convex case for an inner loop of SARAH, the property that SVRG does not possess. Numerical experiments show the efficiency of our algorithm.

3 - Optimal Generalizability in Parametric Learning

Meisam Razaviyayn, University of Southern California, Los Angeles, CA, United States, razaviya@usc.edu, Ahmad Beirami

Cross-validation is the most popular approach for measuring the predictive performance of a statistical model. This procedure requires solving multiple optimization problems which is computationally expensive in practice. In this work, we first propose a computationally efficient surrogate for the cross-validation and provide theoretical guarantees for its performance. Then we use the proposed surrogate to provide an optimization algorithm for finding the optimal regularizer in the empirical risk minimization framework. In our numerical experiments, we illustrate the accuracy and efficiency of of our proposed surrogate as well as our proposed framework for the optimal regularizer.

4 - Iteration-complexity of Linearized Proximal Multiblock ADMMs for Solving Linearly Constrained Nonconvex Optimization Problems

Renato Monteiro, School of ISyE, Georgia Tech, Atlanta, GA, 30332, United States, monteiro@isye.gatech.edu

This talk discusses iteration-complexity of linearized proximal multiblock alternating direction methods of multipliers (ADMM) for solving linearly constrained nonconvex optimization problems. The subproblems are obtained by partially or fully linearizing the augmented Lagrangian with respect to the corresponding minimizing block variables. Complexity bounds are obtained for any choice of a relaxation parameter in the interval (0, 2).

■ TE76

372E

Polynomial Optimization and Integer Programming

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Sercan Yildiz, University of North Carolina at Chapel Hill, Statistical and Applied Mathematical Sciences Institute, 19 T.W. Alexander Drive, Research Triangle Park, NC, 27703, United States, syildiz@email.unc.edu

1 - Stronger Polyhedral Relaxations for Polynomial Optimization Problems

Aida Khajavirad, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15232, Pittsburgh, PA, 15213, United States, aida@cmu.edu, Alberto Del Pia

We consider the Multilinear set defined by a collection of multilinear terms over the unit hypercube. Such sets appear in factorable reformulations of many types of mixed-integer nonlinear programs including polynomial optimization problems. Utilizing an equivalent hypergraph representation for the Multilinear set, we derive various types of facet defining inequalities for its polyhedral convex hull and present a number of tightness results based on the acyclicity degree of the underlying hypergraph. Subsequently, we detail on the implementation of the proposed cutting planes in the branch-and-cut based global solver BARON. Extensive computational results will be presented.

2 - Global Optimization of Power Systems Problems

Burak Kocuk, Sabanci University, Istanbul, Turkey, burakkocuk@sabanciuniv.edu, Santanu Subhas Dey, Andy Sun

In this talk, we consider polynomial optimization problems form power systems. Due to nonlinearity induced by alternating current power flow equations, these two optimization problems are nonconvex and require efficient global optimization methods. We make effective use of several different strategies to handle nonconvexity, including conic relaxations, envelopes, disjunctive extended formulations, cutting planes, variable bound tightening techniques and feasibility heuristics. Our approaches scale well to large power systems problems and provide provably good solutions in time compatible with the needs of the system operators.

3 - Deriving the Convex Hull Form of a Symmetric Multilinear Polynomial

Yibo Xu, Clemson University, 110 Martin Hall, Box 340975, Clemson, SC, 29634, United States, yibox@clemson.edu

We generate all the facets of the convex hull of a symmetric multilinear polynomial (SMP) that is constrained over a symmetric box. Our approach exploits the problem symmetry to: define a "core" family of facets that motivates all remaining facets, develop necessary and sufficient conditions for establishing that a valid inequality is a facet, and use our conditions to derive all "core" facets. We propose algorithms that generate all the facets, and also provide a facet-certification algorithm. Our algorithms run successfully in MATLAB, one of which employs PORTA. The computational results provide insight into the complexity of the convex hull generation of a SMP.

4 - Disjunctive Cuts for Bilinear Programming

Akshay Gupte, Clemson University, Dept. of Mathematical Sciences, O-321 Martin Hall, Clemson, SC, 29634-0975, United States, agupte@clemson.edu, Michael Glen Eldredge

Consider the problem of optimizing a bilinear function x'Qy + cx + dy over the feasible set given by x \in X, y \in Y, where X and Y are two polyhedral sets. This problem is NP-hard in general, and appears either as is in applications or can be extracted as a relaxation of another problem. We borrow the disjunctive programming paradigm from integer programming to derive strong cutting planes for bilinear optimization. We discuss when the proposed valid inequalities generate the underlying convex hull and how many rounds of these cuts are required to achieve this. Computational results on test instances will be presented.

■ TE77

372F

Optimization, Integer Programming

Contributed Session

Chair: Han Liu, UIUC, Champaign, IL, United States, 407049583@qq.com

1 - Alternative Modelings for the Hub Location Problem with Discrete Transportation Cost

Milad Keshvari Fard, ESSEC Business School, 3 Avenue Bernard Hirsch, Cergy, 95021, France, milad.keshvarifard@essec.edu, Laurent Alfandari

In many real world problems, the transportation cost is better approximated as a function of the number of vehicles required, than a linear function of load. In this research we study the Hub Location Problem with discrete costs and show that the location/allocation decisions found under a linear cost function could be significantly different than those found with a discrete cost function. We analyze the resulting optimality gap if a linear cost is used. We show that by choosing a proper linear cost function specific to the problem's data, we can obtain solutions close to those found by a discrete cost function, while avoiding the higher computational complexity.

2 - Relaxations of Discrete Sets with Semicontinuous Variables

Gustavo Angulo, Assistant Professor, Pontificia Universidad Católica de Chile, Avenida Vicuña Mackenna 4860, Macul, Santiago, 7820436, Chile, gangulo@ing.puc.cl

A variable is said semicontinuous if its domain is given by the union of two disjoint nonempty closed intervals. As such, they can be regarded as relaxations of binary or integrality constraints appearing in combinatorial optimization problems. For knapsacks and a class of single-node flow sets, we consider relaxations involving unbounded semicontinuous variables. We analyze the complexity of linear optimization over such relaxations and provide descriptions of their convex hulls in terms of linear inequalities and extended formulations.

3 - Complete Efficient Frontier of Multi-objective Multi-constrained Separable Nonlinear Optimization Problems

Yoshiko.Hanada, Ms., Kansai University, 3-3-35, Yamate-cho, Suita, Osaka, 564-8680, Japan, hanada@kansai-u.ac.jp, Yuji Nakagawa, Chanaka Edirisinghe

Improved Surrogate Constraint (ISC) Method is an enumeration technique to find an exact optimal solution of separable discrete optimization problems with multiple constraints, referred to as a multidimensional nonlinear knapsack (MNK) problem. We introduce a new technique based on the ISC method for finding all efficient solutions for the multi-objective case. Our computational experiments demonstrate the superiority of the proposed method relative to existing algorithms in both speed and accuracy. Also, an application in financial engineering is reported.

4 - First Responder Planning under Hypercube Queuing Equilibrium, Disruption and Cooperation

Han Liu, Ph.D Visiting Student, UIUC, 205 Mathew, Champaign, IL, 61801, United States, 407049583@qq.com, Jian Wang, Yanfeng Ouyang

This talk presents a mixed-integer non-linear program (MINLP) model that integrates hypercube queuing equilibrium, probabilities service disruptions and responder cooperation. Numerical experiments and an empirical case study show applicability of the proposed models. It is shown that cooperative dispatch of responders can potentially reduce expected system-wide costs.

■ TE78

381A

Green Technology Development & Adoption: Environmental Regulation, Competition and Green Consumerism

Sponsored: Energy, Natural Res & the Environment Environment & Sustainability

Sponsored Session

Chair: Arda Yenipazarli, ayenipazarli@georgiasouthern.edu

1 - The Impact of Environmental Regulations on Facilities Decisions: When to Invest in Green Technology and End-of-pipe Abatement

Nazli Turken, Cleveland State University, 1860 East 18th St. BU 544, Cleveland, OH, 44117, United States, n.turken@csuohio.edu, Vedat Verter, Janice E.Carrillo

We analyze the effect of different environmental regulations such as emissions tax, emissions trading, and command-and-control, on the facilities, green technology, and end-of-pipe emissions abatement investment decisions of a company. We find the scenarios when green technologies are preferred over end-of-pipe abatement solutions by firms and vice versa. We identify the regulation parameters that minimize local and global emissions.

2 - Environmental Taxes and Green Technology Choice: The Impact of Competition and Consumer Awareness

Arda Yenipazarli, Assistant Professor of Operations Management, Georgia Southern University, 2224 College Of Business Administration, Statesboro, GA, 30460, United States, ayenipazarli@georgiasouthern.edu

There are many situations where policy makers would like to induce firms to make a major discrete conversion in production technology to reduce emissions intensity of their production processes. We study the impact of emissions tax on the choice of abatement technology in a competitive market, where two profit-maximizing firms facing price- and emissions intensity-dependent demand decide on whether to convert to a pollution-abatement technology and price in response to the tax set by the regulator. On the demand side, customers exhibit horizontal differentiation for product feature and vertical differentiation for emissions intensity reductions achieved by abatement technology adoption.

■ TE80

381C

Use and Enhance Energy Models to Get Insightful Results

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Denis Lavigne, PhD, Royal Military College Saint-Jean, 29, rue Louis-Frechette, St-Jean-sur-Richelieu, QC, J2W 1E9, Canada, denis.lavigne@cmrsj-rmcsj.ca

1 - An Ensemble Approach to Forecast Electricity Day Ahead Auction Prices: Experiences from the Turkish Market

Ezgi Avci-Surucu, Rotterdam School of Management, Technology and Operations, Management Department, Rotterdam, 3062 PA, Netherlands, avcisurucu@rsm.nl, Wolfgang Ketter, Eric Van Heck

Despite the great diversity of electricity price forecasting methods, there are still many forecasting challenges that a bidder has to take into account, such as whether to use individual models on their own, rather than in ensemble, the multi-seasonality problem and how to select appropriate exogenous variables. We address these challenges by using a detailed market-level data from the Turkish electricity day-ahead auctions, which is an interesting research setting in that it presents a number of challenges for forecasters. We examine the key distinguishing features of this market which then allows us to propose individual and ensemble forecasting models that are particularly well suited to it.

2 - Energy Development Pathways to Reach Mexico's Climate Change Goals

Rodrigo Mercado Fernandez, University of Massachusetts Amherst, 65 McClellan Street, Amherst, MA, 01002, United States, rodmerfdez@gmail.com

This paper examines the generation expansion planning (GEP) problem in the Mexican Electrical Grid while considering long term national emissions goals. We will compare results from high level top-down studies, produced by Integrated Assessment Models, with more detailed bottom-up approaches, to inform the feasibility and the requirements for the development of Mexico's electricity portfolio. We will identify the common characteristics for development of the different portfolios, be it generation technologies, critical areas of infrastructure development and investment, or policy measures.

3 - Advances in Modeling Increasingly Integrated North American Natural Gas and Power Markets

Robert Brooks, President, RBAC Inc, 4020 Magnolia, Suite B, Burbank, CA, 91505, United States, robert.brooks@rbac.com

In addition to growth of wind and solar in the generation mix, abundant supplies of low cost natural gas have begun to supplant coal as North American electricity generation's primary fuel source. Yet there are numerous challenges involved in the integration of these disparate technologies and markets. Computer modeling tools have been around for decades to assist understanding the natural gas and power markets. However, these models focus on their own respective markets using simplistic assumptions about the other. My presentation will show techniques my colleagues and I have developed for more realistic combined modeling of increasingly integrated North American natural gas and power markets.

4 - Expanding a Bottom-up Energy Model into a General-equilibrium Model: Rationale, Formulation and Implementation for Saudi Arabia

Hossa Almutairi, Sr. Research Associate, King Abdullah Petroleum Studies & Research Center, Airport Road, Riyadh, 11672, Saudi Arabia, hossa.mutairi@kapsarc.org, Frederic H. Murphy, Axel Pierru, Shreekar Pradhan

We represent the Saudi economy using an applied general equilibrium framework, which combines a bottom-up technology-rich representation of energy-related sectors with a standard top-down CGE representation of the rest of the economy. This work is motivated by the large size of energy and energy-intensive sectors in the Saudi economy and the structural changes that these sectors will experience in the coming years. Our approach can serve as a general template for expanding any bottom-up model into a general equilibrium. To illustrate the capabilities of the model, we applied the energy price reform implemented in 2016 to the static version of the model calibrated to 2013 data.

5 - Osemosys Energy Model: Introducing Elasticity

Denis Lavigne, Professor, Royal Military College Saint-Jean, 29, rue Louis-Frechette, Saint-Jean-sur-Richelieu, QC, J2W. 1E9, Canada, denis.lavigne@cmrsj-rmcsj.ca

The OSeMOSYS project proposes an open-access energy modeling tool for a wide audience. Its relative simplicity makes it appealing for academic researchers and governmental organizations to study the impacts of policy decisions on an energy system in the context of possible severe greenhouse gases emissions limitations. This paper presents how an elasticity of demand capability can be embedded in an OSeMOSYS analysis, allowing leaders to get insightful results on which end-use demands are sensible to such limitations. A detailed description of the approach will be presented.

■ TE81

382A

Multistage Stochastic Programming

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Anthony Downward, University of Auckland, Auckland, 1024, New Zealand, a.downward@auckland.ac.nz

1 - A Deterministic Decomposition Algorithm to Solve Multistage Stochastic Programmes

Regan Baucke, University of Auckland, 70 Symonds Street, Auckland, 1010, New Zealand, rbau155@aucklanduni.ac.nz

Stochastic dual dynamic programmes are an important class of optimisation problems, especially in energy planning and scheduling. Because of the large scenario trees that these problems induce, current solution methods use random sampling of the tree in order to build a policy. Candidate policies are evaluated using Monte Carlo simulation; convergence of a given policy requires a statistical test at a given level of confidence. In this paper, we present a deterministic algorithm to solve these problems. The main feature of this algorithm is a deterministic path sampling scheme during the forward pass phase of the algorithm. This precludes the use of Monte Carlo simulation, increasing performance.

2 - Multi-period Adaptive Fleet Planning Problem

Bruno F. Santos, Assistant Professor, TU. Delft, Kluyverweg 1, Faculty of Aerospace Engineering, Delft, 2629 HS, Netherlands, b.f.santos@tudelft.nl, Laura Requeno Garcia

This works presents a stochastic modelling approach to the multi-period airline fleet planning problem. Approximate Dynamic Programming (ADP) is used to model the impact of demand uncertainty on fleet decisions. The proposed ADP algorithm applies local value function approximations resulting from Gaussian kernel regressions to estimate future airline operating profits. A case study is used to show the effectiveness and practicability of the proposed approach. Optimal solutions are achieved for the deterministic case of the problem, while obtained policies excel the most-likely deterministic solution on stochastic versions.

3 - Investments for Disaster Mitigation Given the Uncertain Effects of Climate Change

Anthony Downward, University of Auckland, Level 3, 70 Symonds Street, Auckland CBD, Auckland, 1024, New Zealand, a.downward@auckland.ac.nz

Climate change is said to be responsible for increases in extreme weather events, however, the exact impact on the frequency or damage of such events is unknown. In this presentation we discuss a multi-criteria multi-stage stochastic programming model for disaster mitigation. In each period, a risk-averse central planner decides on investments that should be made so as to minimize future negative effects on the economy, environment and the society. This is modelled using stochastic dual dynamic programming, with the climate modelled as a Markov chain.

■ TE82

382B

Risk Management in Stochastic Optimization and Machine Learning

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Giorgi Pertaia, gpertaia@ufl.edu

1 - Risky Robust Optimization and Sparsity

Matthew Norton, University of Florida, Gainesville, FL, United States, mdnorton@ufl.edu

Robust Optimization has proven to be an intuitive and fruitful framework for optimization under uncertainty. Typically, Robust Optimization approaches view uncertainty from a pessimistic, or worst-case, viewpoint and thus can be overly restrictive. We diverge from this tradition, and show that an optimistic, or best-case, viewpoint of uncertainty should not be ignored. We show that this viewpoint can help improve the profitability of robust policies without sacrificing significant robustness properties. In addition, we show that this notion provides new insight into the recently popularized non-convex regularization schemes in machine learning that induce sparsity.

2 - Risk Management with POE, VaR, CVaR, and bPOE

Stan Uryasev, University of Florida-Gainesville, AOD, 303 Weilhall, Gainesville, FL, 32611, United States, uryasev@ufl.edu

This paper compares four closely related probabilistic measures: Probability of Exceedance (POE), Value-at-Risk (VaR) which is a quantile, Conditional Value-at-Risk which is a Superquantile, and Buffered Probability of Exceedance (bPOE). We discuss basic properties and relations of these functions. We show equivalence of constraints for POE and VaR and for bPOE and CVaR.

3 - Finite Mixtures with CVaR Constraints

Giorgi Pertaia, 1221 South West 21st Avenue, Gainesville, FL, 32601, United States, gpertaia@ufl.edu

Normal mixtures models are used in financial applications dealing with heavy tail distributions. We have suggested a new CVaR distance between distributions. The CVaR distance is a convex function w.r.t. weights. Weights of normal mixture are found by minimizing CVaR distance between the mixture and the target distribution. We suggested convex constraints on the weights assuring that tail of mixture is as fat as the original distribution. We have conducted a case study demonstrating efficiency of the suggested approach.

■ TE83

382C

Optimization, Stochastic

Contributed Session

Chair: Yanting Wang, Xi'an Jiaotong University, Xi'an, China, wangyt.66@163.com

1 - The Trimmed Lasso: Sparsity and Robustness

Martin S. Copenhaver, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, mcopen@mit.edu, Dimitris Bertsimas, Rahul Mazumder

Nonconvex penalty methods for variable selection in linear regression have been a topic of fervent interest in recent years. In this talk we introduce a continuous family of nonconvex penalty functions that we call the trimmed Lasso. We show that this family of penalties is an exact method for variable selection with direct control over the desired level of sparsity. In analyzing the properties of the trimmed Lasso, we highlight its connection to existing nonconvex approaches as well as its algorithmic implications.

2 - Generalized Affine Decision Rules for Mixed Integer Linear, Quadratic and Nonlinear Adjustable Robust Optimization Problems by Multiparametric Programming

Efstratios N. Pistikopoulos, Texas A&M.Energy Institute, College Station, TX, United States, stratos@tamu.edu, Styliani Avraamidou, Styliani Avraamidou, Chao Ning, Nikolaos A. Diangelakis, Fengqi You

We propose a novel method for the derivation of generalized affine decision rules for linear/quadratic/nonlinear and mixed-integer ARO problems through multi-parametric programming. The problem is treated as a multi-level programming problem that is then solved using M-POP, a novel algorithm for the exact and global solution of multi-level mixed-integer programming problems. The main idea behind the proposed approach is to solve the lower optimization level of the problem parametrically. This will result in a set of affine decision rules optimal for the entire feasible space. A set of illustrative numerical examples are provided to demonstrate the potential of the proposed novel approach.

3 - Integrated Optimization of Proactive and Reactive Project Scheduling to Minimize Uncertain Cost

Yanting Wang, Xi'an Jiaotong University, Xi'an, China, wangyt.66@163.com

In this paper, we present an integrated proactive-reactive model to investigate the optimal fashion of integrating the two scheduling methods under the objective of minimizing the total cost. In proactive phase, resource occupation cost is incurred through inserting buffers to protect potential disruptions and adjustment cost is generated to re-optimize the schedule when disruption occurs. An improved hybrid algorithm that combines a variable neighborhood search and a probabilistic tabu search is developed. Detailed computational experiments are presented to evaluate the improvement strategies and to prove the efficiency of the hybrid algorithm.

Wednesday, 7:30 - 9:00AM

■ WA01

310A

Healthcare Decision Analysis II

Sponsored: Decision Analysis

Sponsored Session

Chair: Mehmet Ayvaci, University of Texas at Dallas, Richardson, TX, mehmet.ayvaci@utdallas.edu

Co-Chair: Yeongin Kim, Yeongin.Kim@utdallas.edu

1 - Determinants of Meaningful Usage of Health Information Technology

Jingyun Li, California State University Stanislaus, Turlock, CA, United States, jli9@csustan.edu, Indranil Bardhan

As Meaningful Use Stage 2 has been rolling out since 2014, a large portion of U.S. hospitals have finished or are undergoing the transition from paper-based medical records to electronic ones and use certified health information technology to improve healthcare quality, safety, and efficiency. Drawing on data from AHA Annual Survey Information Technology Supplement Survey and other databases, we study the characteristics of hospitals that are likely to achieve MU.

2 - Socio-emotional Support in Online Healthcare Q&A Community

Zhe Shan, University of Cincinnati, 2925 Campus Green Dr (Linder Hall) Rm 509, Cincinnati, OH, 45221, United States, zhe.shan@uc.edu, Xin Xu

In online health Q&A platforms, to be selected as best answer is not only about the quality of the response itself, but also affected by other factors such as social-emotional support. In this study, we collected data from "Yahoo! Answers" specifically in the allergies, autism, cancer and diabetes areas, and then used content analysis to encode the questions and their answers respectively. Based on the correlation analysis between different evaluation criteria for information quality, we explored whether socio-emotional support is an important factor in best answer selection.

3 - Accreditation Regime Change: Does "Announcing the Visit" Matter?

Sehwon Kang, University of Minnesota, 321 Nineteenth Avenue South, Suite 3-150, Minneapolis, MN, 55455, United States, kangx584@umn.edu

While accrediting agencies have changed their on-site accreditation survey visits from preannounced to unannounced, little extant literature has empirically examined the impact of this regime change on quality. We examine this impact on the relationship between accreditation and quality performance in US hospitals.

4 - Risk Assessment of Cyber Threats in Healthcare Devices

Arik Sadeh, HIT Holon Institute of Technology, 52 Golomb St., Holon, 58102, Israel, sadeh@hit.ac.il

A treat in a medical device may lead to various damages that can be categorized into two groups: damages to information systems and physical damages to patients. Damages may occur in different level of severity. This research is aimed to explore the importance of 60 cyber threats in healthcare devices. Data about 60 threats was collected from 30 expert respondents. Each threat was analyzed with respect to three information technology dimensions and two healthcare dimensions. The chance for occurrence of that threat was also considered. The concept of winning combinations using the algorithm of Quine-McClusky is used to determine the most important and serious threats.

■ WA03A

Grand Ballroom A

Machine Learning

Sponsored: Applied Probability

Sponsored Session

Chair: David Goldberg, Georgia Institute of Technology, Atlanta, GA, 30332-0205, United States, dgoldberg9@isye.gatech.edu

1 - Weak Convergence Approach to the Multi Arm Bandit Problem

Yilun Chen, Georgia Institute of Technology, 755 Ferst Drive NW, Atlanta, GA, 30332-0205, United States, ylchen@gatech.edu

For the Bayesian multi-arm bandit problem, the optimal policy is known to be the so-called Gittins index policy. However, this policy is essentially a "black box", and it is apriori unclear how such a policy behaves, i.e. what an observer would actually see if a decision-maker implemented this policy. Using the framework of weak convergence, we shed light onto this question and the behavior of several associated stochastic processes. Time permitting, we will also discuss some related results for Thompson sampling.

2 - Optimal Solution to the Multinomial Selection Problem for Two Alternatives

Timur Tankayev, Georgia Institute of Technology, Atlanta, GA, United States, timur.tankayev@gatech.edu, Craig Aaron Tovey

The multinomial selection problem is to find a stopping policy for repeated independent trials, each of which reports a winner among competing alternatives, that has low expected cost and high probability of correct selection (PCS) of the best alternative. In 1959, Bechhofer, Elmaghraby and Morse formulated the problem as minimizing the worst case expected number of trials, subject to a lower bound on PCS and upper bound on the maximum number of trials, over all probability vectors outside an indifference zone. For the case of two alternatives, we prove that if one employs a particular probability vector known as the slippage configuration, then a linear program always finds an optimal stopping policy.

3 - Adaptive Learning with Robust Generalization Guarantees

Rachel Cummings, California Institute of Technology, 1200 E California Boulevard, MC 305-16, Pasadena, CA, 91125, United States, racheladcummings@gmail.com
Rachel Cummings, Georgia Institute of Technology, Atlanta, GA, United States, racheladcummings@gmail.com, Katrina A. Ligett, Kobbi Nissim, Aaron Roth, Steven Zhiwei Wu

The traditional notion of generalization – i.e., learning a hypothesis whose empirical error is close to its true erro – is surprisingly brittle. As has recently been noted, even if several algorithms have this guarantee in isolation, the guarantee need not hold if the algorithms are composed adaptively. In this talk, we study three notions of generalization – increasing in strength – that are robust to postprocessing and amenable to adaptive composition, and examine the relationships between them.

4 - Learning via Distributionally Robust Optimization with Optimal Transport Costs

Karthyek Murthy, Columbia University, New York, NY, United States, karthyek@gmail.com, Jose Blanchet, Yang Kang, Fan Zhang

The idea of distributionally robust optimization (DRO) has been of active research recently in Operations Research to help beat "optimizer's curse" when performing optimization under uncertainty. In this talk, we shall discuss how various machine learning estimators such as generalized Lasso estimator for linear regression, regularized logistic regression, support vector machines, etc. can be viewed under the unifying lens of DRO using optimal transport costs. In addition, for a larger class of useful models, we shall see that these DRO problems can be solved almost as fast, and in some cases even faster than, the respective traditional empirical risk minimization schemes.

■ WA03C

Grand Ballroom C

Empirical Research in New Product Development and Innovation

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Necati Tereyagoglu, Georgia Institute of Technology, Atlanta, GA, 30308, United States, necati.tereyagoglu@scheller.gatech.edu

Co-Chair: Karthik Ramachandran, Georgia Institute of Technology, Atlanta, GA, 30308, United States, karthik.ramachandran@scheller.gatech.edu

1 - Upstream Versus Downstream Experience in Crowdsourcing Platforms with Interdependent Problem Domains: An Empirical Investigation

Anant Mishra, George Mason University, Fairfax, VA, 22030, United States, amishra6@gmu.edu, Nirup M.Menon, Shun Ye

Using detailed archival data from TopCoder, a crowdsourcing platform that hosts contests across software development problem domains (e.g., architecture, design, testing), we use a classification scheme to represent a contestant's experience in related problem domains on the crowdsourcing platform and examine how it impacts her performance in a contest.

2 - Revisiting the Role of Collaboration in Creating Breakthrough Inventions

Tian Chan, Assistant Professor, Emory University's Goizueta Business School, 1300 Clifton Road, Atlanta, GA, 30322, United States, tian.chan@emory.edu, Jurgen Mihm, Manuel Sosa

Using utility and design patents, we compare the effects of working alone (vs. teams) on the probability of creating breakthrough inventions. Working alone lowers performance, consistent with literature. But we also find that this performance disadvantage disappears for design. We find empirical support that the difference is due to the holisticness of design. Finally, we show that lone inventors with a large number of past collaborators significantly improve their propensity to create breakthrough innovations to the point that they outperform teams for holistic inventions.

3 - Employee Mobility and Process Innovation in Manufacturing

Philipp Cornelius, UCL.School of Management, London, United Kingdom, philipp.cornelius.12@ucl.ac.uk, Bilal Gokpinar, Fabian J. Sting

Regular employees can be a good source of innovative ideas to improve operational efficiency. We empirically investigate how mobility affects the innovation value created by the employees. We examine the immediate and long term (static and dynamic) implications as well as the role of direction of employee moves on innovation outcomes.

4 - Help or Hindrance? the Role of Familiarity in Collaborative Product Development

Murat Unal, Georgia Institute of Technology, Scheller College of Business, 800 West Peachtree Street, Atlanta, GA, 30308, United States, Murat.Unal@scheller.gatech.edu, Karthik Ramachandran, Necati Tereyagoglu

We study whether the impact of team familiarity on the outcome of a creative process differs when individuals have design and managerial roles in a video game development setting based on data of the complete careers of 13,230 individuals and 752 different video games. We find that familiarity among individuals who perform design tasks has a detrimental effect on the final performance, while higher familiarity among producers (managers) strengthens the final performance. We also analyze the impact when the source of familiarity is different from or similar to the members' current roles.

■ WA04

320A

Sustainability Issues in Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Xi Chen, University of Michigan-Dearborn, Dearborn, MI, 48128, United States, xichenxi@umich.edu

1 - Green Technology Development and Adoption: Competition, Regulation, and Uncertainty - A Global Game Approach

Xin Wang, Hong Kong University of Science and Technology, Kowloon, Hong Kong, xinwang@ust.hk, Soo-Haeng Cho, Alan Scheller-Wolf

When a government is considering tightening a standard on a pollutant, their decision often is influenced by the number of firms being able to meet the tightened standard, because a higher number indicates a more feasible standard. We study how such regulation may affect a firm's incentive to develop a new technology to reduce a pollutant. To analyze this problem, we use the global game framework recently developed in economics. We find that regulation that considers industry capability, compared with regulation that ignores it, can more effectively motivate development of a new green technology. Surprisingly, uncertainty in the payoff can also help promote development of a new green technology.

2 - Does Supply Chain Visibility Affect Operating Performance? Evidence from Conflict Minerals Disclosures

Caroline Swift, Pennsylvania State University, University Park, PA, United States, cas669@smeal.psu.edu, Suresh Muthulingam, V. Daniel Guide

Firms face the challenge of identifying and monitoring members across their supply chains because they are increasingly held responsible for their supply chain partners' actions. Consequently, supply chain visibility (SCV) is essential to mitigate risks in supply chains. We use data from the U.S. conflict mineral disclosure legislation to assess the extent of firms' visibility across their supply chains. Then, we compare the operating performance of firms with high SCV against those with low SCV. We find that firms with higher SCV benefit from improved profitability, productivity, and sales.

3 - Green Sourcing: the Role of Premium Sharing and Consulting Services

Xi Chen, University of Michigan-Dearborn, 2290 Engineering Complex, 4901 Evergreen Rd, Dearborn, MI, 48128, United States, xichenxi@umich.edu, Niyazi Taneri, Saif Benjaafar

Certified sustainable products often times enjoy a significant green premium in the retail market. In this paper, we study a retailer's use of premium sharing and consulting service offers to incentivize suppliers to exert greening efforts, which improve the chances of receiving certification and in turn capture the green premium. We also examine the case where the retailer has incomplete information about the supplier's cost of greening efforts.

4 - Compete Versus Cooperate? A Strategic Game Behind the EV Standards War

Ni Fang, University of Cologne, Cologne, Germany, fang@wiso.uni-koeln.de, Emmanuel Dechenaux, Marco Ceccagnoli

This paper studies the strategic choice facing two EV manufacturers in light of the standards war currently staged in the EV industry on whether to compete or cooperate in the development and deployment of an extensive EV charging network (a key complementary asset that helps mitigate EV range anxiety). We show that the strategic choice of standardizing EV charging systems has the offsetting effects on EV production volumes and profits. The degree of product differentiation in the EV is the key driver of the private incentives to cooperate in the provision of the complement as well as overall industry diffusion of the EV.

■ WA05

320B

Data-driven Modeling in Healthcare Service

Sponsored: Health Applications

Sponsored Session

Chair: Nan Kong, Purdue University, West Lafayette, IN, 47906-2032, United States, nkong@purdue.edu

Co-Chair: Mingyang Li, Tampa, FL, 33647, United States, mingyangli@usf.edu

Co-Chair: Hambisa Keno, BAE Systems, Burlington, MA, United States, hambisa.keno@gmail.com

1 - Bayesian Fall Risk Assessment for Older Adults in Assisted Living Facilities

Suiyao Chen, University of South Florida, 5017 Patricia Court, Apt 237, Tampa, FL, 33617, United States, suiyaochen@mail.usf.edu, William D. Kearns, James L. Fozard, Mingyang Li

Fall is a devastating critical event with high incidence and mortality rate among older adults in USA. Existing approaches mainly focused on population-level modeling and evaluated average fall frequency in a certain time period. To account for individual heterogeneity of fall occurrences and provide instantaneous assessment of fall risk over time, this paper proposes a personalized fall risk assessment model using Bayesian approaches. Different performance indices are presented to evaluate fall characteristics of individuals. A real case study based on fall records from Florida assisted living facilities is provided to illustrate the proposed work and demonstrate its effectiveness.

2 - Individualized Prediction of Chronic Disease Occurrence
Qingpeng Zhang, City University of Hong Kong, Kowloon, Hong Kong, qingpeng.zhang@cityu.edu.hk, Haolin Wang, Eman Leung, Frank Y. Chen

This research proposes a tensor factorization based model to predict the onset of chronic diseases and the co-occurrence of chronic and acute diseases using patients' EHR record. With 2 year-worth of hospitalization records in a major hospital in Hong Kong, we demonstrate that the proposed model is able to predict the occurrence of new chronic diseases at individual level with superior accuracy.

3 - Two-stage Stochastic Programming Model for Resource Planning in Patient Centered Medical Homes
Mohammad Hessam Olya, Wayne State University, 71 W. Hancock St, Apt 4, Detroit, MI, 48201, United States, mhmdhesam@gmail.com, Kai Yang

One of the biggest challenges in PCMH healthcare delivery system is to find an efficient mechanism to design PCP patient panel where there is a portfolio of healthcare providers. Since the demand is unknown, a framework that incorporates workload prediction model into stochastic allocation is needed. In this study using a novel patient workload prediction model for generating different demand scenarios called multivariate hierarchical structured additive regression, a two-stage stochastic integer programming with integer recourse model for patient allocation is presented for assisting decision makers while minimizing the total cost of patient assignment to care providers at a given time.

4 - Analysis of the Infection Time from a Potential H7N9 Influenza Pandemic Outbreak
Walter A.Silva Sotillo, University of South Florida, 4202 E Fowler Ave, Tampa, FL, 33620, United States, silvasotillo@mail.usf.edu, Mingyang Li, Tapas K. Das

Avian influenza viruses have been affecting human populations for a long time. Since then, other mutations and reassortments of the influenza viruses have emerged causing pandemics. Researchers have developed early estimates of some of the epidemiological parameters to characterize H7N9 virus in China but infected persons appear everyday. In this research we analyzed the distribution that follows the infection time from a potential H7N9 influenza pandemic outbreak using an agent-based (AB) simulation model. We analyzed some continuous probability distributions and conclude that the lognormal distribution provides a better fit estimate to the time to be infected.

5 - A Multi-state Semi-Markov Model of Patient Flow in Long-term Care Network
Hambisa Keno, BAE Systems, Burlington, MA, United States, hambisa.keno@gmail.com, Nan Kong, Steven Landry, Christopher M. Callahan

Long-term care (LTC) represents an expensive segment of the healthcare system. It is essential to carefully characterize patient flow in the LTC network, with implications on model-based policy evaluation. We extend a length of stay based model to characterize patient flow across the network via an multi-state semi-Markov (MSSM) model. We investigate the order of the embedded Markov chain that best characterizes patient transition data. We limit the regression parameters in the model to casual variables through Bayesian network structure learning on care transitions. We diagnose sensitivity of the model parameters and compare goodness-of-fit of the model for different embedded Markov chains.

■ WA07

322A

Recent Advances in Radiation Therapy Planning

Sponsored: Health Applications

Sponsored Session

Chair: Gino J. Lim, University of Houston, Houston, TX, 77204, United States, ginolim@uh.edu

1 - Using Inverse Optimization to Evaluate Knowledge-based Planning Methods for Oropharyngeal Cancer
Aaron Babier, University of Toronto, 153 Robert Street, Unit 2B, Toronto, ON, M5S.2K6, Canada, ababier@mie.utoronto.ca, Justin James Boutilier, Andrea L. McNiven, Timothy Chan

Knowledge based planning (KBP) is often used to predict clinically acceptable dose volume histogram (DVHs), however the predictions may be undeliverable. We develop two KBP methods to predict DVHs for over 200 oropharyngeal cancer patients, and use an inverse optimization model to reverse engineer fluence deliverable maps from the predictions. To illustrate the impact that a prediction has on our pipeline, we compare the plans that were reverse engineered from each KBP method. Each plan is also compared to a clinical plan to validate our fluence maps and demonstrate the role inverse optimization can play in an automated planning pipeline.

2 - Robust Hypoxia-based Radiation Plan Optimization
Arkajyoti Roy, Bowling Green State University, 349 Business Administration Building, Applied Statistics and Operations Research, Bowling Green, OH, 43403, United States, aroy@bgsu.edu, Omid Nohadani

Low oxygen concentration reduces radiosensitivity of tumor cells, adversely affecting radiation treatments. Reoxygenation leads to uncertain temporal changes in cell oxygenation, ranging from short-term fluctuations due to perfusion to gradual changes from angiogenesis. In this work, a time-dependent uncertainty set is employed to model the reoxygenation progression. A robust optimization model incorporating the uncertainty set is solved for a set of clinically realistic reoxygenation scenarios. The proposed method is evaluated in comparison to current clinical practice using a prostate case.

3 - Spatioteporally Integrated Radiotherapy with Treatment Length Update
Ali Ajdari, University of Washington, Seattle, WA, 98199, United States, ajdari@u.washington.edu, Archis Ghate

In a typical formulation of the spatiotemporally integrated radiotherapy, the number of treatment sessions (N) has to be decided prior to the beginning of the actual treatment. However, taking advantage of the new imaging techniques, a more dynamic treatment planning can adapt to the tumor's response thoughout the treatment course and determine N on the fly. In this study, we propose a method to dynamically determine the optimal number of remaining sessions, and reoptimize the treatment plan in each session accordingly. Solutions obtained in this manner have more flexibility to the tumor's evolution and could potentially result in higher biological effective dose.

4 - Optimization of Radiation Therapy Fractionation Dose Considering the Biological Effects
Azin Khabazian, University of Houston, 5465 Braesvalley Dr. Apt 566, Houston, TX, 77096, United States, akhabazian@uh.edu, Gino J. Lim

The goal in fractionation radiation therapy is to maximize tumor-damage while limiting toxic effects of radiation on nearby healthy anatomies. This is achieved through a sequential radiation treatment process in which the treatment plan can be modified using a regular feedback of measurements. In this study, we develop a chance-constrained programming (CCP) framework under a probabilistic description of dose delivery to optimize the fractionation dose by adjusting to tumor response in each fraction of treatment planning. We evaluate the model in the context of tumor coverage and normal tissue sparing and numerically demonstrate its superiority over the traditional treatment planning.

■ WA09

330A

Nonprofit Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Milind Sohoni, Indian School of Business, Hyderabad, 500032, India, milind_sohoni@isb.edu

1 - Improving Societal Outcomes in the Organ Donation Value Chain
Priyank Arora, Georgia Institute of Technology, 800 W. Peachtree Street NW, Atlanta, GA, 30308, United States, priyank.arora@scheller.gatech.edu, Ravi Subramanian

We examine a principal-agent problem in the cadaver organ donation value chain (ODVC) where the principal in our case is a social planner that has an overall quality-adjusted-life-year improvement objective. The agents include a non-profit organ procurement organization (OPO) with a volume-of-care objective and a profit-maximizing hospital (trauma center). While the majority of the healthcare operations management literature focuses on the demand side of the ODVC, we develop an analytical model to study the effects of contextual parameters and operational decisions of the supply-side entities (OPO and hospital) on their respective payoffs and on societal outcomes.

2 - Payment for Results - Funding Non-profit Operations
Sripad K. Devalkar, Indian School of Business, Ac3 L1 Room 3114, Hyderabad, 500032, India, sripad_devalkar@isb.edu, Milind Sohoni, Neha Sharma

Payment for results (PfR), with funding contingent on actual results delivered, has been proposed as a mechanism that allows donors to channel funds to more efficient NPOs. However, many NPOs are financially constrained and need an intermediary to provide the funds required to implement the project upfront. We compare the performance of a PfR mechanism involving a social planner, intermediary and NPO, with that of a traditional upfront funding mechanism involving only the social planner and NPO. For risky projects, we find that the social planner's expected utility under traditional funding can be higher compared to when using PfR.

3 - Supply Constrained Location-distribution Problems in Public and Nonprofit Settings: A Fractional Programming Approach

Chong Hyun Park, Southern New Hampshire University, Manchester, NH, United States, c.park1@snhu.edu, Gemma Berenguer

There is a need to design location-distribution problems in public and nonprofit contexts where limited resources have to be allocated to different demand regions and, thus, a combination of efficiency and equity goals can rightfully be considered. We propose the use of a new inequity measure related to Gini coefficient that is based on the relative utility obtained by each demand region given a certain supply allocation. We suggest a novel bi-objective integer linear fractional programming approach to solve the suggested supply constrained location-distribution models and show the suggested algorithm can solve the problems in polynomial time. A food crisis in Angola is presented as a case study.

■ WA10

330B

Auctions/Mechanism Design

Contributed Session

Chair: Rad Niazadeh, Stanford University, Palo Alto, CA, United States, radniazadeh@gmail.com

1 - Combinatorial Auction Mechanism for Freight Information Platform with Quoted Price Uncertainty

Yuting Zheng, Huazhong University of Science and Technology (HUST), Wuhan, China, ytzheng@hust.edu.cn, Jianbin Li, Peng Hu

We consider a combinatorial auction mechanism for O2O freight information platform with quoted price uncertainty. This research question derived from a O2O freight platform we field investigated for half a year. Meanwhile, a series of numerical examples with real data are enumerated in this paper with the different approaches to cope with the uncertainty of carriers' quoted price which may enlighten the managers in related industry.

2 - Optimal Allocation of Budget for Incentive Structure Design in a Resource Sharing Network

Pu Yang, Cornell university, 292 Rhodes Hall, Ithaca, NY, 14850, United States, py75@cornell.edu, Peter Frazier, Krishnamurthy Iyer

We propose a spatial temporal model for network economic settings with heterogeneous locations, and characterize a mean field equilibrium in this system. We study the problem of how to optimally allocate a budget of incentives to maximize a system level objective, by alternating the equilibrium behavior of agents in the system through subsidies or penalties. We show that the intractable problem of finding the optimal payment structure can be reduced to a problem of finding the optimal equilibrium strategy achievable with the budget, and the latter problem is a standard constrained optimization problem with a low dimension domain that could be solved via mainstream constrained optimization methods.

3 - Preferences and Decision Support in Competitive Bidding

Philippe Gillen, Center for European Economics (ZEW), L7,1, Mannheim, 68161, Germany, gillen@zew.de, Nicolas Fugger, Alexander Rasch, Christopher Zeppenfeld

We examine bidding behavior in first-price sealed-bid and Dutch auctions, which are strategically equivalent under standard preferences. We investigate whether the empirical breakdown of this equivalence is due to non-standard preferences or due to the different complexity of the two formats (i.e. different levels of math./individual sophistication). We elicit measures of individual preferences and then manipulate complexity by offering various levels of decision support. Our results show that the strategic equivalence only breaks down in the absence of decision support. This indicates that the empirical breakdown is caused by differing complexity rather than non-standard preferences.

4 - Bernoulli Factories and Blackbox Reductions in Mechanism Design

Rad Niazadeh, Postdoctoral Researcher, Stanford University, Palo Alto, CA, United States, radniazadeh@gmail.com, Shaddin Dughmi, Jason Hartline, Robert Kleinberg

We provide a polynomial time reduction from Bayesian incentive compatible mechanism design to Bayesian algorithm design for welfare maximization problems. Unlike prior results, our reduction achieves exact incentive compatibility for problems with multi-dimensional and continuous type spaces. The key technical barrier preventing this in prior black-box reductions is that repairing violations of incentive constraints requires understanding the distribution of the mechanism's output. We overcome this barrier by employing and generalizing a computational model in the literature called "Bernoulli Factories", which is about simulating a new coin from old ones by only sampling.

5 - Ants for Auctions – Solving the Winner Determination Problem using Ant Colonies

Abhishek Ray, PhD Scholar, Purdue University, 401 S Grant Street, West Lafayette, IN, 47907, United States, ray52@purdue.edu, Mario Ventresca

At the fundamental level, any combinatorial auction can be treated as an efficient allocation problem widely studied in integer programming. Determining winner in such auctions is demonstrably NP-Complete. Previous work in estimating a winner in combinatorial auctions employs a depth-first branch and bound approach that imposes upper bounds on contribution of unallocated items to the maximum revenue for the auctioneer. Our approach differs drastically since we employ a probabilistic nature-inspired search heuristic that uses the concept of stigmergy to explore and exploit the search landscape.

6 - Online Auctions and Multiscale Learning

Rad Niazadeh, Postdoctoral Researcher, Stanford University, Palo Alto, CA, United States, radniazadeh@gmail.com, Sebastien Bubeck, Nikhil Devanur, Zhiyi Huang

We consider revenue maximization in online auctions and pricing. A seller sells an identical item in each period to a new buyer, or a new set of buyers. For the online posted pricing problem, we show regret bounds that scale with the best fixed price, rather than the range of the values. We also show regret bounds that are scale free, and match the offline sample complexity, when comparing to a benchmark that requires a lower bound on the market share. To obtain this, we generalize the learning from experts and multi-armed bandit problems to their "multi-scale" versions, where the reward of each action is in a different range, and the regret w.r.t. a given action scales with its own range, rather than the maximum.

■ WA11

332A

Incentives in Queueing and Sharing Platforms II

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Rouba Ibrahim, University College London, London, WC1E 6BT, United Kingdom, rouba.ibrahim@ucl.ac.uk

Co-Chair: Amy R Ward, University of Southern California, Los Angeles, CA, 90089-0809, United States, amyward@marshall.usc.edu

1 - Labor Platforms for On-demand Services

Saif Benjaafar, University of Minnesota, 111 Church Street SE, Department of Industrial and Systems Engr, Minneapolis, MN, 55419, United States, saif@umn.edu, Jian-Ya Ding, Guangwen Kong, Terry Taylor

We study consumer and labor welfare in on-demand service platforms that rely on self-scheduled workers. The platform decides on wages and prices knowing that customers are price- and delay- sensitive and agents have reservation wage rates that depend on their availability.

2 - Designing Efficient Budget-constrained Incentive Schemes: To Compete or to Cooperate?

Ragavendran Gopalakrishnan, Research Scientist, Conduent Labs India, Etamin Block, 4th Floor, Wing-A, Prestige Technology Park II, Bangalore, 560103, India, ragavendran.gopalakrishnan@conduent.com, Sabitha Devarajulu, Rahul Ghosh

We study the design of real-world performance-based incentive schemes, which are necessarily budget-constrained, must be simple to understand and implement, and satisfy some fairness criteria. The resulting competition among agents for incentives is modeled as a noncooperative game. We characterize budget-constrained performance maximizing incentive schemes, and find that the maximum performance is a concave function of the available budget. We also study competitive vs. cooperative fairness among high and low performing agents to quantify the efficiency loss in moving from Nash to dominant strategy equilibrium. We conclude with additional insights obtained from numerical experiments.

3 - Pricing in a Two-sided Market with Time-sensitive Customers and Suppliers

Philipp Afeche, University of Toronto, Rotman School of Management, 105 St. George Street, Toronto, ON, M5S.3E6, Canada, afeche@rotman.utoronto.ca, Mustafa Akan

We consider a firm that matches stochastically arriving and time-sensitive customers and suppliers. Agents are rational and choose whether to enter the market upon arrival. Customers and suppliers differ in their arrivals rates, rewards from matching, and waiting costs. The matching is instantaneous and frictionless. We characterize the structure and performance of the profit-maximizing and socially optimal pricing policies.

4 - Independent Contractors or Full-time Employees? On Staffing a Blended Workforce.
Rouba Ibrahim, University College London, MS& I Department, UCL, Gower Street, London, WC1E 6BT, United Kingdom, rouba.ibrahim@ucl.ac.uk, Jing Dong

The rise of the blended workforce is identified as one of the top workplace trends in 2017. A blended workforce melds independent contractors or freelancers with permanent employees. We study optimal sta ng decisions in service systems with a blended workforce, and characterize the pertinent trade-offs.

■ WA12

332B

Simulation and Optimization

Contributed Session

Chair: Keli Feng, South Carolina State University, Orangeburg, SC, United States, kfeng1@scsu.edu

1 - A State Dependent Inventory Policy for Multi Period, Multi Stage Systems
Anna-Lena Sachs, Professor, University of Cologne, Albertus-Magnus-Platz, Cologne, 50923, Germany, anna-lena.sachs@uni-koeln.de, Stewart Liu, Stefan Minner, Philip Kaminsky

Inventory management for perishable products such as fruit and vegetables is a challenging task for retail managers. We investigate a retail chain that owns several stores and keeps inventory both at the stores and at a central warehouse. We determine the optimal inventory policy as a function of external variables such as price, weekday and weather. By integrating forecasting and inventory optimization using robust optimization and a gradient-search algorithm, we are able to solve this complex problem for a large number of stores and variables

2 - Multiperiod Inventory Management with Advance Supply Contracts
Sercan Demir, Teaching/Research Assistant, University of Miami, 1251 Memorial Drive #268, Department of Industrial Engineering, Coral Gables, FL, 33146, United States, s.demir@umiami.edu, Mazhar Arikan, Murat Erkoc

We study a multi-period inventory control problem of a seasonal product where the demand for the product is stochastic and non-stationary across periods. The demand distribution across the planning horizon is shaped by a market signal that is random at the beginning of the planning horizon. The firm has the option of contracting its supplies before the realization of the market signal to benefit from price discounts. It is also possible for the firm to replenish its inventories during the selling season by paying higher spot market prices. Our research is motivated by applications in cruise line industry where contracts are made before the final number of bookings is realized.

3 - A Two-phase Derivative-free Optimization Algorithm for a Process Governed by Non-linear Algebraic Partial Differential Equations
Ishan Bajaj, Texas A&M.University, 503 Cherry St., College Station, TX, 77840, United States, ishan.bajaj@tamu.edu, Shachit S. Iyer, Priyadarshini Balasubramanian, Faruque Hasan

A data-driven two-phase trust-region based optimization algorithm is proposed to solve problems where the constraints and objective function cannot be expressed analytically in terms of decision variables. In the first phase of the algorithm, a feasible point is obtained and in the second phase, the objective function is decreased while maintaining feasibility. The algorithm is applied to optimize the design and operating conditions of an integrated carbon capture and conversion process such that constraints related to product quality and emissions are satisfied and cost is minimized.

4 - Continuous Inspections Assessing Economic Feasibility of Strategies under a Changing Demand Distribution
Anh Ta, University of North Texas, Denton, TX, 76201, United States, Anh.Ta@unt.edu, Robert Pavur

Continuous inspections is an essential part of many processes. Minimizing the long run cost is an important criterion in selecting a strategy. This research assesses proposed continuous auditing methodologies by using a Monte Carlo Simulation approach under conditions that may be changing over time. Estimating the parameters for the rate of occurrences is an important step in using effective continuous inspection techniques. Applications to using this methodology in supply chain inspections are examined.

5 - Bayesian Optimization with Gradients
Matthias Poloczek, Cornell University, 272 Rhodes Hall, 136 Hoy Road, Ithaca, NY, 14853, United States, poloczek@cornell.edu, Jian Wu, Andrew Wilson, Peter Frazier

Bayesian optimization has proven successful for global optimization of expensive-to-evaluate, multimodal functions. However, it typically does not use derivative information. In this talk, we show how Bayesian optimization can exploit derivative information to decrease the number of objective function evaluations required for good performance. In particular, we develop a novel algorithm, the derivative-enabled knowledge-gradient, that provides state-of-the-art performance compared to a wide range of optimization procedures with and without gradients, on benchmarks including logistic regression, kernel learning, and k-nearest neighbors.

6 - Performance Comparison under Two Replenishment Policies in Master Production Scheduling with Demand Uncertainty
Keli Feng, Associate Professor, South Carolina State University, 300 College Street NE, Department of Business Administration, Orangeburg, SC, 29117, United States, kfeng1@scsu.edu

We study a single end-product master production scheduling problem with supply capacity limits and dynamic stochastic demand. Our replenishment options include using an order quantity vector or using order-up-to levels. The performance measures we consider include service levels, average cost, standard deviation of cost, expected upside risk, "cost-at-risk", and probability of exceeding a target cost. Using simulation-based optimization method, we perform a computational experimental design to explore the impact of parameters on performance measures under both replenishment policies.

■ WA13

332C

Decision Support Systems

Contributed Session

Chair: Gizem Erdinç, erciyes university, kayseri, Turkey, gizemerdincc@gmail.com

1 - Using a Moving Reference Approach for Measuring Balance in Resource Allocation Problems
Hale Erkan, Bilkent University, Bilkent University, Engineering Department, Ankara, 06800, Turkey, hale.erkan@bilkent.edu.tr, Ozlem Karsu

We consider a resource allocation settings where there are several categories of projects, each with uncertain cost and benefit values. The decision maker (DM) tries to determine the projects to fund given a limited budget. The two objectives are maximizing efficiency and balance among categories. Balance is measured with respect to a reference distribution (RD), which changes as used budget changes. We propose a biobjective robust optimization model and find Pareto solutions using the E-constraint method. Our results show that considering balance explicitly provides useful insights to the DM.

2 - Context-aware Process and Organization Analytics: Extending Business Analytics Towards More Effective and Flexible Organization
Seunghoon Lee, PhD Candidate, POSTECH, 77, Cheongam-ro Dept. of Industrial and Management Engineering, Pohang, 37673, Korea, Republic of, frhyme@postech.ac.kr, Injun Choi

Recently, as related technologies such as machine learning has been advanced rapidly, interest in business analytics (BA) has been significantly increased in academia and industry. However, existing BA approaches only consider organization from limited perspective thus fail to improve the actual performance of organization from holistic view point. Thus, we propose a new BA paradigm by developing the Context-aware Process and Organization Analytics to flexibly cope with various contextual changes in the complex environment. In particular, we define an ontology that can represent situational knowledge of the organization by identifying the relationships among organizational elements.

3 - Fuzzy Risk Analysis for Construction Projects
Gizem Erdinç, Erciyes University, Kayseri, Turkey, gizemerdincc@gmail.com, Feyza Gurbuz

The construction industry serves humanity in a subjective and risky environment in comparison with other industries. In contrast to automation, almost every processes are done by human. Therefore, project managers should overcome much more uncertainties and probability in solving management problems of construction projects. A risk analysis was presented while adopting some criteria were affect the outcome performance of project such as cost, time quality, performance and safety. The impact levels of criteria and emergence ratings were calculated using Fuzzy Sets and ranked. In this way, decision makers who work in management level in companies can make better and more accurate decisions.

■ WA14

332D

Data-driven Research of Hospital Workflow and Performance

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Jonas Oddur Jonasson, MIT Sloan School of Management, MIT Sloan School of Management, Cambridge, MA, 02142, United States, joj@mit.edu

1 - Staff Planning for Anesthesiologists

Sandeep Rath, University of North Carolina at Chapel Hill, CB #3490, McColl Building, McColl 4705, Chapel Hill, NC, 27599, United States, sandeep@unc.edu, Kumar Rajaram

Staff planning for human resources like anesthesiologists at hospitals takes place sequentially, where planning is done for regular staffing as well as reserve capacity. The staff planners balance the expected overtime, under-utilization costs as well as the cost of keeping staff on reserve. Some of these costs are not explicitly known. We employ a structural estimation model to infer these implicit costs and subsequently find heuristic solution for the medium term staff planning. We apply this approach to staff planning for anesthesiologists.

2 - Proactive Customer Service

Kraig Delana, London Business School, PhD Program Office, London, NW1 4SA, United Kingdom, kdelana@london.edu, Nicos Savva, Tolga Tezcan

We study a service setting where the provider may learn about customers' future service needs and initiate service for these customers proactively if they are flexible with respect to the timing of service delivery. Utilizing both exact and asymptotic analysis, we find that proactive service can generate significant reduction of delays for customers. Despite this, we find that customers are less willing to be flexible compared to social optimum because of a positive externality - flexible customers benefit not only themselves but inflexible customers as well. Hence to achieve the benefits of proactive service, providers may have to incentivize customers to overcome this economic friction.

3 - Hospital Finances and Operations

Christopher J. Chen, London Business School, Regent's Park, London, NW14SA, United Kingdom, cchen@london.edu, Nicos Savva

We analyze how changes in hospital spending affects readmissions and mortality, and lay the foundation for studying the impact of funding cuts on operational decisions such as staffing levels and mix. Combining non-profit tax filings with data from the Centers for Medicare & Medicaid Services (CMS) on hospital characteristics and patient outcomes, and using instrumental variable estimation to address endogeneity in hospital spending, we find that increases in spending per patient in select cost centers have a positive impact on aggregate outcomes. Our findings indicate a potential mechanism through which spending cuts impact patients and sets up further tests on the resource pecking order.

4 - Data Analytics on the Operations of a Radiology Workflow Platform

Gonzalo Romero, University of Toronto, Toronto, ON, Canada, gonzalo.romero@rotman.utoronto.ca, Timothy Chan, Nicholas Howard, Saman Lagzi

Most hospitals in the U.S. follow an unstructured process for assigning images to radiologists, where each doctor has ample freedom to select the next image to work on out of a common pool. This can result in long processing times and sub-optimal use of the specialists' time. A centralized workflow platform can address this problem by routing the right image to the right doctor at the right time. Motivated by our ongoing collaboration, we analyze a large and unique dataset from the operations of a radiology workflow platform, providing interesting and novel clinical findings.

■ WA15

332E

Optimization Modeling in Supply Chains

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Joel Goh, Harvard Business School, Boston, MA, 02163, United States, jgoh@hbs.edu

1 - Retailing with 3D Printing

Yao Cui, Cornell University, Ithaca, NY, United States, yao.cui@cornell.edu, Li Chen, Hau Leung Lee

We consider a firm that produces and sells products in two channels, an online store and a traditional store. The firm may use the traditional production technology or adopt the 3D printing technology in the online channel or in both channels. We study 3D printing's impacts on the firm's product offering and pricing decisions, as well as the firm's supply chain operations.

2 - Inventory Optimization for Fulfillment Integration in Omnichannel Retailing

Aravind Govindarajan, Ross School of Business, University of Michigan, 645 Hidden Valley Club Drive, Apt. 303, Ann Arbor, MI, 48104, United States, arav@umich.edu, Amitabh Sinha, Joline Uichanco

Omnichannel refers to the seamless integration of a retailer's channels such as brick-and-mortar and e-commerce. Using analytical models, we study three basic omnichannel fulfillment systems varying in the level of integration between in-store and online demands, and obtain optimal order quantities for the single period, two-store case. We extend our analyses to a network of stores and fulfillment centers, developing an asymptotically near-optimal heuristic which provides significant cost savings over naive strategies. Finally, we discuss extensions to the multi-period case under lost sales.

3 - Optimal Control and Value of Reverse Logistics in Supply Chains with Multiple Flows of Product

Ozalp Ozer, The University of Texas at Dallas, 800 West Campbell Road, Sm30, Richardson, TX, 75080-3021, United States, oozer@utdallas.edu, Alexandar Angelus

We formulate and solve a finite-horizon, multiechelon inventory model to jointly optimize regular ordering, expedited ordering and reverse-ordering decisions. We identify the structure of the optimal policy that achieves the decomposition of the objective cost function into a sequence of single-dimensional subproblems. We generalize our results to settings when excess inventory can be sold off to secondary markets at each stage. Our results allow us to quantify the value of reverse logistics under a variety of supply chain structures, and establish that reverse logistics and expediting can be either complements or substitutes depending on other elements of the supply chain.

4 - Intermediation in the Supply of Agricultural Products in Developing Economies

Ehsan Valavi, Harvard Business School, 114 Western Avenue 2203C, Boston, MA, 02134, United States, evalavi@hbs.edu, Kris Johnson Ferreira, Joel Goh

The agricultural industry has been growing in developing economies, yet farmers continue to struggle. One reason for this is that farmers bear the risk of mismatched supply and demand, since farmers must make planting and harvesting decisions prior to knowing the price they can get for their crop at an auction. Recently, e-intermediaries have emerged as an alternative channel to the auction for which farmers can sell their crop; e-intermediaries use technology to inform farmers about a fixed crop price prior to harvest. We study the impact that e-intermediaries have on the supply chain.

■ WA16

332F

Operations Management

Contributed Session

Chair: Yuqiao Cheng, University of Houston, Houston, TX, United States, chengyuqiao126@gmail.com

1 - The Operational Implications of Introducing New Products into Consumer Packaged Goods Supply Chains: the Case of a Spanish Manufacturer

Leonardo Laranjeira Gomes, PhD Candidate, MIT-Zaragoza International Logistics Program, Calle Bari 55, Edificio Nayade 5, Zaragoza, 50197, Spain, leogomes@mit.edu, Rafael Diaz

We analyze and measure the operational impact of introducing new products into the supply chain of a consumer packaged goods manufacturer. By conducting an in-depth statistical analysis of a Spanish poultry products company, we identified factors that impact its operational performance and should be considered when analyzing exploration versus exploitation trade-offs.

2 - Selecting Procurement Auction Mechanisms

Andreas Gernert, EBS.University, Burgstr. 5, Oestrich-Winkel, Germany, andreas.gernert@ebs.edu, David Wuttke, H. Sebastian Heese

We compare two procurement auction mechanisms for innovative products. We examine when buyers should first invite multiple suppliers to engage simultaneously in R&D before selecting the winner as opposed to selecting first one supplier who then engages with higher effort in R&D.

3 - Capacity Expansion Strategies in Cloud Computing Environment
Mohammad Ebrahim Arbabian, PhD Student, University of Washington, 4120 Brooklyn Ave NE unit 503, # 4, Seattle, WA, 98105, United States, arbabian@uw.edu, Shi Chen, Kamran MoeinZadeh

We study the problem of deploying new servers in a cloud company. We consider a continuous review system and present the optimal policy which minimizes the total discounted cost rate in finite and infinite horizon settings. Moreover, the optimal server specifications to be ordered each cycle given the current servers are derived.

4 - Managing Innovation Pipeline by Small Firm Researchers
Mengyang Pan, Southwest University of Finance and Economics, 692 Riverview Drive, Apt 128, Columbus, OH, 43202, United States, pan.295@osu.edu, Aravind Chandrasekaran

Small firm researchers may have multiple R&D projects in their pipeline, that are in various development stages and may or may not have substantial external collaborations. This research intends to explore the challenges for them induced by limited time and resources, as well as IP protection risks. Our analyses of longitudinal data suggest the timing and extent of external collaboration in a portfolio of projects can be an important decision for success.

5 - Dynamic Task Allocation with Learning and Forgetting
Thomas Vossen, University of Colorado-Boulder, Leeds School of Business, UCB419, Boulder, CO, 80309, United States, thomas.vossen@colorado.edu, Peter Letmathe

We consider a setting where tasks arrive randomly over time for possible processing. Incoming tasks can be allocated to (human) resources, whose productivity depends on the number of tasks processed by the resource before (learning) and is impacted by changes in the workforce over time (forgetting). We formulate the task allocation problem as a weakly coupled stochastic dynamic programming problem, and use a Lagrangian Relaxation approach to derive heuristic allocation policies. We evaluate the flexibility and resilience that emerge from these policies, and analyze how various environmental factors impact performance.

6 - Linking Operations Characteristics to Operations Strategy in Hospital Merger and Acquisitions
Yuqiao Cheng, University of Houston, 4800 Calhoun Rd, Houston, TX, 77004, United States, chengyuqiao126@gmail.com, Xiaosong David Peng

We present research examining the impact of hospital M&A at the operational level. The impact may stem from similarities in operational characteristics and a more focused operations strategy. We analyze archival data from various sources using Difference in Differences analysis and conduct case studies to present our findings.

■ WA17

340A

Big Data and Queueing Networks

Sponsored: Applied Probability

Sponsored Session

Chair: Cathy Honghui Xia, Ohio State University, Ohio State University, Columbus, OH, 43210, United States, xia.52@osu.edu

1 - Queueing-theoretic Models for Data Center Performance
Mor Harchol-Balter, Carnegie Mellon University, 5000 Forbes Avenue, Computer Science Dept, Pittsburgh, PA, 15213, United States, harchol@cs.cmu.edu

Data Centers are a never-ending source of interesting performance problems for queueing theorists. In this talk we will introduce problems ranging from Job Replication to Hadoop Scheduling to Optimizing Parallelism. For each problem, we will propose queueing-theoretic models (and some solutions), with an emphasis on realistic assumptions. This talk is meant to bridge Computer Systems optimization and OR modeling/analysis.

2 - Queueing Control using Learning Based Semi-online Algorithms
Jin Xu, Texas A&M.University, 3120 Texas A&M.University, College Station, TX, 77840, United States, jinxu@tamu.edu, Natarajan Gautam

Motivated by applications in smart reconfigurable manufacturing, we consider queueing systems where workload is revealed before service with the help of IoT. The objective is to minimize sojourn time for jobs under constraints of order of service and server conditions. We propose a learning-based semi-online algorithm to solve the problem and demonstrate its performance.

3 - Throughput Scalability of Large Parallel and Distributed Processing Systems with Advancing Capabilities
Yun Zeng, The Ohio State University, Columbus, OH, United States, zeng.153@buckeyemail.osu.edu, Cathy Honghui Xia

Parallel and distributed processing systems have expanded in great scale in cloud computing and big data analytics. A critical issue concerns the throughput scalability: whether or not the throughput sustains as the systems scale in size. This issue is highly non-trivial as the systems can have complicated structures and advancing capabilities. We present necessary and sufficient conditions on throughput scalability of parallel and distributed processing systems with arbitrary structure and generally distributed service times. In particular, we present conditions under which scaling storage and scaling processing speed can recover throughput even when the system is not well-structured.

■ WA19

342A

Procurement and Purchasing Management

Contributed Session

Chair: Wei-Shiun Chang, National Cheng Kung University, Tainan City 701, Taiwan, wschang@mail.ncku.edu.tw

1 - Assortment Decisions with Substitutability and Complementarity
Xi Shan, University of Texas at Dallas, Richardson, TX, 75080, United States, xxs130630@utdallas.edu, Dorothee Honhon, Suresh P.Sethi

We consider the assortment plan of a retailer with complementary or substitutable goods/categories. We find that increasing the variety in one category can stimulate more variety in the other complementary category. For a single category retailer, increasing variety for that category will attract more customers but cost more on inventory. Now for a retailer with complementary categories, increasing variety for one category will not only bring more attraction and inventory cost, but also generate more customers having the willingness to visit the other category. And the other category can take this chance to earn more profit.

2 - Dynamic Optimization Models for Sourcing Problems
Nilofar Varzgani, PhD Candidate, Rutgers Business School, 113 Harrison Avenue, Apt 204, Harrison, NJ, 07029, United States, nilofarv@scarletmail.rutgers.edu, Michael N.Katehakis

When manufacturers are sourcing components there always comes the dilemma of deciding between having 1 supplier and using volume leverage to get the best possible cost advantage. On the other hand, this poses a supply disruption risk . Therefore, most manufacturers opt for the multi-supplier model where they have dual or more procurement requirements. The decision problem faced by the manufacturing company is twofold; election problem and volume allocation problem. We solve for this optimal selection and allocation problem as a one step process using a dynamic programming framework in a contract manufacturing framework.

3 - OEM Selling Channels and Supply Chain Performance
Chia-Wei Kuo, National Taiwan University, 85 Sec 4, Roosevelt Rd, Taipei, 106, Taiwan, cwkuo@ntu.edu.tw

This paper studies how an OEM's selling channel can serve as an instrument to enhance its product accessibility in the local market for developing countries. we find that authorizing the OEM selling channel can be a win-win strategy for both the brand (gaining more market share in the international market) and the OEM (earning more profits) because of economy of scales that lowers unit production costs.

4 - Renegotiation in Procurement Auctions with Endogenous Liability
Wei-Shiun Chang, National Cheng Kung University, No.1, University Road, Tainan City 701,, 701, Taiwan, wschang@mail.ncku.edu.tw, Rhea Salonga

The winners in the procurement auctions may find the auction prices unfavorable due to the Winner's Curse phenomenon. Practically buyers offer an opportunity to winning sellers to renegotiate the price in such a case in the hope of preventing sellers from bankrupt. We derive that sellers would be better off to delegate a subsidiary with less liability to bid on behalf of parent companies when renegotiation is allowed at the expense of procurers. We then test the theoretical predictions with experiments. The findings have important implications for procurement policy reform as well as to the procurers' selection of mechanisms (i.e. whether to use renegotiation) to resolve potential bankruptcy issues.

■ WA20

342B

Information Systems

Contributed Session

Chair: Sumate Permwonguswa, University of Colorado-Denver, Denver, CO, United States, sumate.permwonguswa@ucdenver.edu

1 - A Social Network Perspective on user Adaptation Toward its System in Organizations

Yi Wu, Tianjin University, Tianjin, China, yiwu@tju.edu.cn

Social networks are vital mechanisms for users to adapt to changes induced by a new IT system in organizations. However, the effect of social networks on post-adoption IT use is not well understood. Drawing on coping theory and the social network literature, a cognitive-affective-behavioral classification of user adaptation is developed, and seeking-network closure and giving-network closure are identified as key network characteristics pertinent to post-adoption IT use. Thereafter, this paper establishes a theoretical link from network characteristics to post-adoption IT use through the underlying mechanisms of user adaptation.

2 - Doctor's Looking Glass Self: Empowerment and Satisfaction through Telemedicine

Sumate Permwonguswa, University of Colorado Denver, 3 30 E.10th Ave, Apt 506, Denver, CO, 80203, United States, sumate.permwonguswa@ucdenver.edu, Jiban Khuntia

Telemedicine provides higher accessibility for patients to healthcare. Yet, not many doctors adopt telemedicine in their practices. Analogous to patient empowerment, doctor empowerment may be a driver towards telemedicine adoption. We explore the role of empowerment on practice satisfaction of a doctor through the use of telemedicine. Relationships between the three types of empowerment on practice satisfaction have been studied empirically. We also argue that the relationships will be stronger when spatial and power distance orientations in the practice setting are less.

■ WA21

342C

Sustainability

Contributed Session

Chair: Larissa P.G. Petroianu, University of Washington, Seattle, WA, United States, lpetroia@uw.edu

1 - Shipping Peak Demand for Online Sellers: Reserve and Surcharge

Ju Myung Song, Rutgers Business School, PhD Program, 1 Washington Park, Room 430C, Newark, NJ, 07102, United States, jumyungsong@gmail.com

Online retailing is changing the landscape of retail industry in countries as Amazon's market cap has recently doubled that of Wal-Mart in the US. Different from brick and mortar, online sellers rely on 3rd party logistics for the delivery of the goods but the hugely spiked demand during holiday seasons (Christmas in the US, Singles' day in China) poses a substantial challenge for the 3PLs to deliver on time. To better manage demand, 3PLs such as UPS, require the sellers to make reservation and to pay a surcharge for extra work. In this paper, we discuss how these shipping arrangements may affect the online sellers' inventory decisions, how to coordinate the channel for the sellers and shippers to win-win.

2 - The K-shortest Origins Problem

Stefan Poikonen, PhD Candidate, University of Maryland-College Park, 3406 Tulane Dr., Apt 22, Hyattsville, MD, 20783, United States, spoikone@math.umd.edu, Larry Levy, Bruce L. Golden

The k-shortest origins problem will be introduced. As brick-and-mortar retailers increase their online presence, a frequent option presented to online shoppers is to have their orders available for pick-up at a nearby store, because the "last mile" of delivery represents a large portion of the supply chain cost. A customer may be presented with a list of the k nearest pickup locations. Amazon has built over 1700 Amazon Locker locations expressly for this purpose. We present a method to compute the k nearest pickup locations for all customers rapidly. A single call of a modified version of Dijkstra's Algorithm and a phantom "supernode" are used.

3 - Heuristics for Chute and Dock Assignment Problem in a Shipping Area of Cross-docking Center

Takashi Irohara, Professor, Sophia University, 7-1 Kioi-cho, Chiyoda-ku, Tokyo, 102-8554, Japan, irohara@sophia.ac.jp

In this study, genetic algorithm based heuristic with local search is proposed to solve chute and dock assignment problem in a shipping are of cross-dock center. This problem is formulated as mixed integer programming problem to minimize material handling cost from chute to dock and the congestion of the dock in the shipping area. Numerical experiment was conducted to show the effectiveness of the proposed method.

4 - Optimal Middle Mile Transportation with Load Cancelation and Pick-up and Delivery Time Windows

Larissa P.G. Petroianu, PhD Student, University of Washington, University of Washington - 3900 E.Stevens Way NE, Mechanical Engineering Building, Room G6, Seattle, WA, 98195, United States, lpetroia@uw.edu, Mauricio G.C. Resende, Zelda B. Zabinsky

We develop a mixed-integer programming model of a planning and scheduling problem in middle mile transportation. Middle mile transportation consists of moving goods between facilities while satisfying several constraints, including time windows for pickup and delivery. One challenge is that the demand is stochastic, i.e., demand can be cancelled and ad-hoc demand created. We describe a heuristic for this problem and present computational results.

■ WA22

342D

OM and Marketing Interface

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Xiajun Amy Pan, University of Florida, Gainesville, FL, 32611-7169, United States, amy.pan@warrington.ufl.edu

Co-Chair: Quan Ben Zheng, University of Florida, Gainesville, FL, United States, quan.zheng@warrington.ufl.edu

1 - Opaque Selling and Last-minute Selling: Revenue Management in Vertically Differentiated Markets

Hang Ren, University College London, Flat 28, Nansen Village, 21 Woodside Avenue, London, N12 8AQ, United Kingdom, hang.ren.13@ucl.ac.uk, Tingliang Huang

We analyze the performance of opaque selling as a clearance strategy in vertically differentiated markets. Compared to last-minute selling, opaque selling may increase revenue because consumers who wait for the sales cannot choose the preferred product type. Its disadvantage, however, lies in the inflexibility in segmenting different types of consumers. Both the advantage and the disadvantage are radically different from their counterparts in horizontally differentiated markets. This contrast generates opposite policy recommendations across the two settings.

2 - Add-on Pricing under Valuation Uncertainty

Quan Zheng, University of Florida, 302 Diamond Village, Apt 16, Gainesville, FL, 32603, United States, quan.zheng@warrington.ufl.edu, Xiajun Amy Pan

We incorporate a hitherto neglected feature in add-on pricing: the purchase time of base product (e.g., hotel room) is separated with the consumption time of add-on (e.g., Internet service). Consumers can either buy the add-on at a discount with valuation uncertainty or wait until the uncertainty is resolved but at a higher price. We first characterize the optimal selling strategies under various scenarios for a monopoly seller, and then consider duopoly competition with symmetric firms. Interestingly, the results show that there exist asymmetric equilibria in which symmetric firms employ different pricing schemes to alleviate price competition.

3 - Price Restraining Policies and Improving Profits by Increasing Search Frictions

Ozge Sahin, Johns Hopkins University, 524 Manhattan Avenue, Apt 6B, Brooklyn, NY, 11222, United States, ozge.sahin@jhu.edu, Liang Ding, Roman Kapuscinski

While online retail broadens manufacturer's access to consumers through an additional channel, prices are often lower in online stores than in physical stores. Customers experience products in physical store but purchase online for lower prices. As a result, physical store sales decrease and they stop promoting such products. However, for manufacturers, physical stores play a crucial role by showcasing products to customers. We find that deliberately adding search frictions, and using price restraining policies can improve manufacturer's, physical and online retailers' profits by allowing consumers to self-select into low price but high search cost or high price but low search cost retailers.

4 - Crowdfunding under Social Learning and Network Externalities

Fasheng Xu, Washington University in St. Louis, Saint Louis, MO, 63130, United States, fasheng.xu@wustl.edu, Fuqiang Zhang

This paper investigates how the presence of both social learning and network externalities affect the strategic interaction between a crowdfunding campaigner and a forward-looking consumer population. Our analysis yields three main insights. First, we find in the presence of social learning and strategic consumers with strong network externalities can lead to an upward-sloping demand curve. Second, we establish that the presence of network externalities has significant structural implications for optimal crowdfunding reward choice. Third, we characterize the optimal rewarding strategy when facing financial constraints and quantify the impact of the fundraising target.

■ WA23

342E

Revenue Management, Pricing in Airline and Hotel Industry

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Ravi Kumar, rkumar04@pros.com

1 - Pricing Advance Purchase Products

Matthew Maxwell, SAS.Institute, Inc., 500 Sas Campus Drive, Cary, NC, 27513, United States, matt.maxwell@sas.com, Jennie Hu

Advance purchase products are characterized by non-refundable discounted products that are fully paid at the time of booking. Such products give providers increased revenue opportunities and protection against late cancellations; however, if priced incorrectly, these products may reduce overall revenue due to cannibalization of the full fare refundable product. We develop a closed-form model to predict the amount of purchases for each product given prices for both products. We verify that this model satisfies properties of rational behavior from customers and show how model parameters may be estimated and how to calculate optimal prices.

2 - Explicitly Incorporating Competition and Customer Choice in Dynamic Pricing

Siddharth Prakash Singh, Carnegie Mellon University, Tepper School of Business, 5000 Fobes Avenue, Pittsburgh, PA, 15213, United States, sps1@andrew.cmu.edu, Darius Walczak

We analyze a two-competitor dynamic pricing game introduced by Dudey (1992) and subsequently considered by Martinez-de-Albeniz and Talluri (2011). We allow more general distributions of customer valuation and expand the game to include customers who are loyal to each airline, in addition to customers who seek the lowest price in the market. This is particularly relevant in the airline industry where demand may be price-sensitive but dedicated to a particular carrier. We establish the non-existence of subgame-perfect pure strategy Nash equilibria in a market with loyal customers. However, when all customers are flexible, we are able to construct a subgame-perfect pure strategy Nash equilibrium.

3 - Travel Network Optimization Parallelization Techniques under Dependencies Between Daily Itineraries

Evan Davidson, PhD, PROS.Inc, 101 Montgomery St, Suite 400, San Francisco, CA, 94104, United States, edavidson@pros.com

Under many travel network optimization methodologies, often seen in the airline industry, pricing and revenue management problems are solved as separable by day, each day being treated independently. If this daily independence assumption is no longer applicable, here focusing on the passenger bus industry, other techniques must be used to make these large travel network problems tractable. Here we explore a heuristic to parallelize on overlapping sets of days and utilizing the results from only the middle days of each set. We explore the implications on feasibility, optimality, and performance under this parallelization heuristic.

4 - A Dynamic Pricing Model with Capacity Sharing for Airline Revenue Management

Ang Li, PROS, Inc., 3100 Main Street, Suite #900, Houston, TX, 77002, United States, ali@pros.com, Ravi Kumar, Darius Walczak

We consider a Revenue Management setting for airlines where limited capacity from a business compartment can be shared with an economy compartment on each flight. We develop several heuristic dynamic pricing policies for this problem based on a deterministic model and network decomposition related ideas and evaluate their performance via simulation.

■ WA24

342F

Consumer-Driven Innovative Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Mingcheng Wei, University at Buffalo, Buffalo, NY, 14260, United States, mcwei@buffalo.edu

1 - Pricing and Design of Discretionary Service Lines

Laurens G.Debo, Dartmouth College, 100 Tuck Hall, Hanover, NH, 03755, United States, laurens.g.debo@tuck.dartmouth.edu, Cuihong Li

Discretionary services as services whose quality increases in the service duration such as e.g. personal care. In a congested environment, however, longer service time also increases the congestion. We discuss the optimal structure and pricing of a menu of services of different duration— a service line— when customers have heterogeneous quality sensitivity and are delay sensitive. We study both First In First Out (FIFO) and Shortest Processing Time disciplines (SPT). While prices under FIFO always increase, with SPT, they may be non-monotone, or, even decrease in quality (duration).

2 - Choosing to be Strategic: Implications of the Endogenous Adoption of Forward-looking Purchasing Behavior on Multiperiod Pricing

Arian Aflaki, Duke University, Durham, NC, 27708, United States, arian.aflaki@duke.edu, Pnina Feldman, Robert Swinney

We study whether consumers benefit from forward-looking behavior when they purchase from a firm that sets prices over multiple periods. We show that consumers do not necessarily benefit from strategic behavior, and therefore may choose to remain myopic if given the option. We then develop a model in which consumers choose to become strategic by exerting costly effort, and show that it is possible to increase firm profit, consumer, and social welfare simultaneously by increasing this cost. In contrast, strategies such as price commitment can reduce the cost of strategic behavior and harm all parties.

3 - Personalized Advertising and Learning Through High-dimensional Data with Limited Samples

Mingcheng Wei, University at Buffalo, 326C Jacobs Management Center, Buffalo, NY, 14260, United States, mcwei@buffalo.edu, Xue Wang, Tao Yao

In this paper, we propose a Minimax Concave Penalized Multi-Armed Bandit algorithm for a decision-maker facing high-dimensional data with latent sparse structure in an online learning and decision-making process. This algorithm performs favorably compared to other algorithms, especially when there is a high level of data sparsity or when the sample size is not too large.

■ WA25

350A

Innovation/Entrepreneurship

Contributed Session

Chair: Hongzhi Chen, Purdue University, West Lafayette, IN, United States, hzchen@purdue.edu

1 - Entrepreneurial Positive Thinking About the Future Predicts Unethical Behaviors

Jacob Do-Hyung Cha, Seoul National University, Room 313, 58-dong, Seoul National University, Gwanak-gu, 150-742, Korea, Republic of, research.dohyung@gmail.com, Hye-Jin Cho

Psychologists argue that positive thinking about the future predict low performance due to (1) low efforts and (2) favor pro over con information. I propose that entrepreneurs' positive thinking about the future is positively related to his/her earnings manipulation behavior. Low effort may lead to low performance and this poor outcome may increase the pressures to compensate such low performance by manipulation of company earnings. Favoring positive information may lead to (morally) risky decisions, that is, manipulated earnings too. I use content analysis method to measure positive thinking about the future by utilizing corporate documents.

2 - The Strategic use of Opposition for European Patent

Xia Liu, Zhejiang University, Hangzhou, 310000, Hangzhou, 310000, China, liuxia0510@gmail.com

This paper analyses the relationship between technology ownership fragmentation and the opposition filing in the European Patent Office. I develop a two stages game for technology access bargaining. Opposition is more attractive under two conditions: when the ownership to external technologies is concentrated, and profit dissipation is over the licensing revenue for the potential licensee; when the ownership to external technologies is widely fragmented, yet the transaction cost is too high for the entrance. To empirically test this hypothesis, I use a data set that covers patent opposition cases during the period 1985-2005. Regression results confirma U-shape relationship.

3 - Why Innovating Firms Trademark (or Not): Identity Protection and the Maintenance of First Mover Advantage

Xiaoshu Bei, Duke University, 2514 Preston Ave, Durham, NC, 27705, United States, xiaoshu.bei@duke.edu

In this paper I study a special role of trademarks to sustain the innovator's first mover advantage. Even though both innovators and imitators file for trademarks, innovators who anticipate competition have significantly higher propensity to trademark. There is an inverted U relationship between the overall incentive to trademark and the level of competition. When competition is high, imitators decrease in their incentive to trademark, but innovators still have high incentive because trademarks help sustain the first mover advantage. Other factors that condition this role of trademarks include level of information asymmetry and size.

4 - Scope Advantage or Disadvantage? – Cost Spreading and Firm's Innovation Response to Demand Shock

Xiaoshu Bei, Duke University, 2514 Preston Ave, Durham, NC, 27705, United States, xiaoshu.bei@duke.edu

In this paper, I study firms' investment in innovation in response to exogenous shock in demand. I look at firms' patenting activity and how that is correlated with US exportation to China after China joined WTO. I use the cost spreading theory to explain the relationship between firms' structure/diversification strategy and their response to increase in demand. Consistent with early studies, both size and scope confer an advantage in innovation when facing demand pull. Vertically integrated firms have a much higher response in innovation, mostly due to their ability to scale up dynamically and capture the market opportunity. This enables them to attain a larger output to spread the cost of innovation.

5 - Dark Sides of Interpersonal Citizenship Behaviors for Innovation: A Social Network Approach

Hongzhi Chen, PhD Candidate, Purdue University, 146 Arnold Dr Apt 3, West Lafayette, IN, 47906, United States, hzchen@purdue.edu, Lusi Wu, Chunhua Chen

Assuming its desirable outcomes, researchers tend to focus on how to promote interpersonal citizenship behaviors (ICB), leaving its consequences untapped on. Using social network approach, this study examines dark sides of ICB in innovation process. Specifically, how performing and receiving ICB will affect an employee's structural positions within intra-organizational collaboration networks, which in turn unintentionally inhibit innovation through network closure and collaborative overload. Based on time-lagged data from 200 employees in a pharmaceutical R&D center, our findings will provide novel and practical insights on ICB and network dynamics, especially in innovation process.

■ WA26

350B

Simulation and Optimization

Contributed Session

Chair: Melike Meterelliyoz, TOBB University of Economics and Technology, Ankara, Turkey, mkuyzu@etu.edu.tr

1 - Winner Play Structures in Random Knockout Tournaments

Yang Cao, University of Southern California, 909 W. Temple St, Apt 354, Los Angeles, CA, 90012, United States, cao573@usc.edu

We consider a knockout tournament whose contestants are 1,2,...,n. Suppose that each player i has strength v_i, and a game between i and j is won by i with probability v_i/(v_i+v_j). The players are randomly assigned to positions 1,2,...,n. The players in the first two positions play a game in the first round, and then in round r, r = 2,3,...,n-1, the winner of the previous round plays with the player in position r+1. We call this tournament format the winner-play structure. We prove bounds on players' tournament win probabilities, provide efficient simulation algorithms, and propose conjectures with evidence. Moreover, we study a continue play model and give the stationary probabilities.

2 - Compactness Approaches for Importance Sampling

Alexander Shkolnik, Postdoctoral Scholar, University of California-Berkeley, Evans Hall 339, Berkeley, CA, 94720, United States, ads2@berkeley.edu

A standard approach for optimal importance sampling (IS) relies on large deviations (LD) theory. That is, LD techniques are employed to derive upper and lower bounds on the second and first moments of the IS estimator. This requires the development of a LD principle, a program that is frequently too difficult to implement for practical problems. We provide an analysis based on the LD counterpart of Prohorov's (relative compactness) theorem that circumvents many obstacles in this standard program. We demonstrate the effectiveness of the approach on several challenging problems involving Markov chains, affine processes and event timing models.

3 - Governance of Complex Transactions in Project Business Networks

Jaakko Kujala, Professor, University of Oulu, Oulu, Finland, jaakko.kujala@oulu.fi

The purpose of the study is to analyze the effectiveness of network form of governance to coordinate and safeguard complex transactions in inter-organizational project business network. The network form of governance is suggested to arise as a response for demand uncertainty, project uniqueness and project complexity. It is characterized by informal social systems rather than bureaucratic structures and formal contractual relationships. An agent-based simulation model is created to simulate the effectiveness of social mechanisms such as restricted access, macroculture, collective sanctions and reputation, and how structural embeddedness in a network facilitates use of these mechanisms.

4 - Characterization and Prediction of Hyper-jump Diffusion in Consensus Dynamics on Networks

Xin Su, PhD Student, Arizona State University, ASU - CIDSE, PO Box 878809, Room 553, Tempe, AZ, 85287-8809, United States, xinsu3@asu.edu, Theodore P. Pavlic

Network consensus dynamics have been studied for: modeling opinion diffusion, robotic formation-control policies, and development of particle swarm optimization (PSO) metaheuristics. A recent discovery is that stochastic link failures can lead to Levy-like hyper-jump diffusion, which might be used for new PSO strategies or to better understand sharp changes in public opinion. Here, we: (a) quantify the emergence of these jumps; (b) demonstrate the role of parameters in the control of this behavior; and (c) use information-theoretic insights to find real-time predictors for impending jumps.

5 - Multiply Reflected Variance Estimators for Simulation

Melike Meterelliyoz, Assistant Professor, TOBB University of Economics and Technology, Sogutozu Cad. No 43, Sogutozu, Ankara, 06560, Turkey, mkuyzu@etu.edu.tr, Kemal Dingeç, David Goldsman, Christos Alexopoulos

We consider new estimators for the variance parameter of a steady-state simulation output process that are based on the Reflection Principle of Brownian motion. These estimators are computed by invoking multiple reflections of the standardized time series of the underlying process, and thus generalize previous reflected estimators that are each based on only a single reflection point. Our current scheme can be exploited to produce low-bias, low-variance estimators that are superior to their single-reflection-point predecessors. We illustrate the enhanced performance of the multiply reflected estimators via exact calculations and Monte Carlo experiments.

■ WA27

350C

Crowd Wisdom Transformation using Social Media Analytics

Invited: Social Media Analytics

Invited Session

Chair: Wenqi Shen, PhD, Virginia Tech, Blacksburg, VA, 24060, United States, shenw@vt.edu

Co-Chair: Fang Jin, PhD, Texas Tech, Lubbock, TX, 43104, United States, fang.jin@ttu.edu

Co-Chair: Zhilei Qiao, Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061, United States, qzhilei@vt.edu

1 - Sensing Specific Hazards from Online Reviews across Diverse Product Categories

Nohel Zaman, 258 Old Cedarfield Drive, Blacksburg, VA, 24060, United States, znohel@vt.edu, Alan Abrahams, Richard James Gruss

We focus on online reviews that report a physical health and safety concerns of consumers from product-usage in diverse product categories. We distinguish between events that are pathways to injury, and injury outcomes, and between actual injuries and potential injuries. We develop event-specific, injury-specific, and body-part specific "smoke" term lists. These terms can be used for detecting, categorizing, and prioritizing hazards across diverse consumer product categories. We determine which terms are generic and which are hazard-specific. This study facilitates rapid sensing of specific potential hazard events and outcomes, and maps online reviews to standard medical coding schemes.

2 - Aggregating Crowd Opinions using Statistical Learning

Qianzhou Du, Virginia Tech, Pamplin Business School, 100 Otey Street, Room 301, Blacksburg, VA, 24061, United States, qiand12@vt.edu

Recent studies have shown that aggregating crowd opinions has been an effective method to improve the performance of decision making. Most existing crowd opinion aggregation studies employ heuristics to determine a weighting scheme for individual judges based on their expertise or past prediction performance. However, those heuristics based methods often fail to determine the optimal weights and achieve the optimal prediction performance in the aggregated crowd opinion. We propose a new crowd opinion aggregation model, namely aggregating crowd opinions using statistical learning (ASL), which has a fitting procedure for the weighting scheme and a mechanism of estimating the probabilities of event outcomes based on statistical learning. Statistical learning is expected to capture hidden patterns in crowd opinions and assign better weights to individuals than heuristic based weighting methods. We empirically evaluate ASL in comparison to four baseline methods using real data collected from an online stock prediction community, StockTwits. The results show that ASL significantly outperforms all the baseline methods in terms of both a quadratic prediction score and prediction accuracy.

3 - Examining the Effect on Firm Value of Demand-side Supply Chain Disruptions in the Social Media Era

Christopher S. Kwaramba, Virginia Polytechnic Institute and State University, Blacksburg, VA, United States, shingik@vt.edu, Quinton J.Nottingham, Qianzhou Du, Alan Gang Wang

chis paper investigates the long-term stock price effects of social media content following supply chain disruptions based on a sample of 45 disruption announcements made during 2010-2016. We examine the stock price effect for a two-year event time frame beginning with one stock market year before a disruption announcement to one stock market year after. By the end of the year after the disruption announcement, the average return for a stock is about –28% but returns could be as low -47%.

4 - Learn from Context: An Advanced Learning-based Approach for Health Social Media Analytics

Long Xia, Blacksburg, VA, 24060, United States, longxia1@vt.edu

Abstract not available.

■ WA28

350D

Decision Analysis

Contributed Session

Chair: Xuan Wang, Louisiana State University, Baton Rouge, LA, United States, xwang35@lsu.edu

1 - Evaluating Classifiers Based on Cost Range to Minimize Decision Making Cost

Ramy Alsaffar, Graduate Student in LSU, LSU, Edward Gay Apartments, 275 W. Roosevelt Street, Baton Rouge, LA, 70802, United States, ramyalsaffar@yahoo.com

We believe using the hit rate is not enough to evaluate the performance of the classifier and it can be misleading due to overlooking an important element (decision cost). Furthermore, ROC is the most popular graph used to evaluate classifiers. However, one of the biggest ROC shortcomings is assuming equal FP and FN costs. Therefore, our goal is to reduce the total cost of decision making by selecting the classifier that has the least total misclassification cost. Nevertheless, the misclassification cost is unknown. To overcome such hurdle, we can test the data against a range of weight scale. Thus, we use the cost range and operating threshold range to show the performance differences among classifiers.

2 - Two-state Partially Observable Markov Decision Processes with Imperfect Information

Tal Ben-Zvi, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States, tbenzvi@stevens.edu, Tatyana Chernonog, Tal Avinadav

A process can be in either a stable or an unstable state interchangeably. The true state is unobservable and can only be inferred from observations. Several actions are available, including consulting with experts and obtaining (partial) information about the true state of the process for a fixed fee. The objective is to maximize the expected discounted value of the total future profits. We formulate the problem as a discrete-time Partially Observable Markov Decision Process (POMDP). We show that the expected profit function is convex and strictly increasing, and that the optimal policy has control limits. Also, we show that "dominance in expectation" suffices for a control limit structure.

3 - A Kalman Filtering Technique to Reduce Nonactionable Respiratory Rate and Endtidal CO2 Alarm Signals in a Continuously Monitored General Care Floor Patient

John Zaleski, Chief Analytics Officer, Bernoulli, 200 Cascade Blvd, Milford, CT, 06460, United States, jzaleski@bernoullihealth.com

False positive or non-actionable alarm signals along with true alarm signals are produced by Multi-parameter monitors and other bedside medical equipment within emergency departments, intensive care and general care floors. False alarm signals in these settings are a major source of distraction and a major patient safety risk. It is hypothesized that Kalman filtering is a viable means of mitigating these false alarms. An application of the Kalman filter to measured respiratory rate and end-tidal carbon dioxide illustrates its utility as an alarm signal mitigation method on data obtained from a general care floor patient undergoing continuous monitoring for a period of more than 28 hours.

4 - Perspectives on Entropy-based Weightings for Integrating Information

Huguette Tran, Professor, University of North Texas, 1307 West Highland St., Denton, TX, 76201, United States, Huguette.Tran@UNT.edu, Robert Pavur

In Data Fusion applications, data are often weighted according to their source reliability. A proposed weighting technique in the literature uses Shannon's entropy. This research provides a numerical illustration to use an alternative entropy-based method based on Pal and Pal (1991)'s formulation. The alternative formulation has a bounded entropy and may provide a weighting scheme more representative of the sources' reliability. The method is illustrated with an application of the newsvendor problem in which accurate parameter estimation is necessary for optimal profits.

5 - Comparison of Causal Inference Methods

Xuan Wang, PhD Student, Louisiana State University, 2200 Business Education Complex, Nicholson Extension, Baton Rouge, LA, 70803, United States, xwang35@lsu.edu, Helmut Schneider

As "Big Data" motivates an era of transformation, it not only offers many benefits, but also introduces challenges. Therefore, causal inference offers opportunities for maximizing the value of applying Big Data. This study focuses on evaluating various causal inference methods and provides recommendations. Propensity score matching, standardization, IP weighting, Bayesian network and orthogonal arrays will be discussed.

■ WA29

350E

Manufacturing

Contributed Session

Chair: Brett Shields, The University of Tennessee at Knoxville, Tullahoma, TN, United States, bshields@utsi.edu

1 - Concurrent Fused Filament Fabrication with Multiple Extruders

Yu Jin, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States, yujin@uark.edu, Harry Pierson, Haitao Liao

Additive manufacturing (AM) is well-known for its capability in producing complex geometries. However, the fabrication speed of AM technology is considerably slower than traditional manufacturing processes A promising solution is the parallel processing of individual layers. In this research, a concurrent manufacturing strategy is proposed for improving the production speed of the Fused Filament Fabrication (FFF) process.

2 - Project Sustainability Strategies a Case of Textile Production

Rhythm Wadhwa, Prof, NTNU, Teknologiveien 22, Gjoevik, 2821, Norway, rhythmwadhwa@hotmail.com

A systematic literature review has been carried out focusing on cradle-to-grave textile production project sustainability. The literature review covers research published in leading journals in project management and textile production prior to 2017. Distinct perspectives have been proposed in sustianability research from the analysis.The findings of the review are complemented with an illustrative empirical case.

3 - Using Design of Experiments to Study the Significance of Different Control Parameters in Additive Manufacturing

Brett A.Shields, The University of Tennessee at Knoxville, 411 B.H. Goethert Parkway, Tullahoma, TN, United States, bshields@utsi.edu, Andrew Junfang Yu

In this research, the effects of control parameters on the resistivity and temperature gradient uniformity are studied for 3d printed graphene PLA. A thermal camera is used to observe the production process as the printer settings vary. Four factors (printer control parameters) are considered in the experimental design: build plate temperature, extruder temperature, print speed, and layer thickness.

■ WA31

351A

Finance Theory and Empirics

Contributed Session

Chair: Hiroshi Ishijima, Chuo University, Tokyo, Japan, hiroshi.ishijima.jp@gmail.com

1 - Application of the Transmutation Operators to Parabolic Free Boundary Problems: A Numerical Method

Igor Kravchenko, ISCTE-IUL, Edifício II, Av. Prof. Aníbal Bettencourt, Lisbon, 1600-189, Portugal, ivkoh@iscte.pt

The numerical method for solving parabolic free boundary problems will be presented. The method is based on recent results from transmutation operators theory allowing one to construct efficiently a complete system of solutions for the parabolic equation, generalizing the system of heat polynomials. This techniques can be directly applied to path dependent options. The talk is based on the joint works with V. V. Kravchenko, S. Torba and J. C. Dias. "Pricing double barrier options on homogeneous diffusions: a Neumann series of Bessel functions representation" and "Solution of parabolic free boundary problems using transmuted heat polynomials"

2 - Stock Market Spoofing

Jussi Keppo, National University of Singapore, Mochtar Riady Building, BIZ 1 8-69, 15 Kent Ridge Drive, Singapore, 119245, Singapore, keppo@nus.edu.sg, Xianhua Peng

We use a unique trading dataset of one week to analyze the behavior of high-frequency traders. About 8% of institutional traders intentionally or unintentionally first enter and then quickly cancel a buy (or sell) limit order without actually buying (or selling) before the trader actually sells (or buys) a security. We show that the p-value for testing that all this behavior is a random event, and thus unintentional, is extremely small, equal to the probability of observing a 53-standard deviation event. Therefore, most likely at least part of the behavior is intentional and an indication of so-called "spoofing", an attempt to manipulate prices.

3 - Public Information, Investor Trading and Stock Bubble: Evidence from Chinese Stock Market

Kun Chen, Assistant Professor, Southern University of Science and Technology, China, 518055, China, chenk@sustc.edu.cn, Sisi Wu, Leon Zhao, Jian Yin

According to the resale option theory, asset bubble is caused by investor heterogeneous beliefs which are reflected in investor trading behaviors. In this study, we want to explain the formation of heterogeneous beliefs from the information processing perspective, and investigate the circular relations among public information, investor trading, and stock bubble. We focus on the 2015 Chinese stock bubble, and find that different sources of information, such as news, discussion boards, and analyst reports, and different measures of information, i.e. sentiment, coverage, and dispersion, have different impacts on trading behaviors of different investors.

4 - A Generalized Real Estate Pricing Model with Exogenous Affine-form Variables

Hiroshi Ishijima, Professor, Chuo University, 1-18 Ichigaya-tamachi Shinjuku, Tokyo, 1628478, Japan, hiroshi.ishijima.jp@gmail.com, Akira Maeda, Tomohiro Tsuruga

We develop a generalized real estate pricing model that incorporates hedonic attribute variables of real estate as well as exogenous variables in an affine form. We then conduct an empirical analysis to understand Japanese house prices by exogenous variables with hedonic variables controlled. Our analysis reveals that the financial asset prices and conventional hedonic variables serve as the major determinants of Japanese house prices. We also show evidence that low interest rates under the Abenomics monetary policy successfully stimulate Japanese house prices.

■ WA32

351B

Supply Chain, Managing Disruptions

Contributed Session

Chair: Hoda Sabeti, West Virginia University, Morgantown, WV, United States, hoda.sabeti@gmail.com

1 - Flexible Supply Chain Network Design under Uncertainty through Capacity Planning

Nima Salehi Sadghiani, PhD Candidate, University of Michigan, 3735 GreenBrier Boulevard, Apt 223C, Ann Arbor, MI, 48105, United States, nsalehi@umich.edu, Mark Stephen Daskin

Managing uncertainty is one of the challenging issues in supply chains. Deviations from the expected values of key input parameters can make the deterministic formulations infeasible and/or inefficient much of the time. In this study, we address the need for an effective tool to incorporate potential uncertainties associated with the model parameters into sourcing decisions. In particular, we consider the effects of demand, exchange rate, and freight cost uncertainty into sourcing decisions of a manufacturing company. The solutions are compared to those of the current implementations in practice to show the inadequacy of the deterministic formulations in making real-world decisions.

2 - A Quantitative Foundation for Asset-based Design with Application to Supply Chains

RaSheka N. Robinson, Graduate Student, North Carolina A&T State University, 3217 Pleasant Garden Rd, Apt. 1G, Greensboro, NC, 27406, United States, rnrobins@aggies.ncat.edu

Traditionally system performance is measured by common metrics, such as cost, quality and delivery that measure the limitations of the system to 'fix' them. This paper will build upon these metrics by providing a quantitative basis for strength-based design of systems, using supply chains as a primary motivator. This asset-based approach will measure the assets in the system to determine their contributions. Asset-based views the participants in the supply chain as assets. These assets contribute to system function through various modes. The measures are aggregated according to mean and variance and analyzed to offer a greater understanding of supply chain formation and participant development.

3 - The Decision on Stimulating Shared Supplier Innovation under Market Competition

Cong Liu, Huazhong University of Science and Technology, Wuhan, China, cong_liu@hust.edu.cn

This paper construct a cost-sharing game model between the manufacturers and the shared-supplier, discussing the influence of competition degree and innovation cost on the equilibrium solution under different situation. The results show that when the competition degree of market is less, the cost-sharing ratio provided by the manufacturer is higher than that of non-cooperation, and the supplier's innovation level and the manufacturer's profit are higher than the non-cooperative situation. When the market competition degree is high, the cost-sharing ratio provided by the manufacturer is less than that of non-cooperation.

4 - Distributed Subset Reconfiguration Decisions for Fair Demand and Capacity Sharing in Collaborative Network

Ibrahim Yilmaz, State University of New York at Binghamton, Binghamton, NY, 13902, United States, iyilmaz1@binghamton.edu

This research aims a distributed subset reconfiguration decisions to enhance fairness and efficiency among a collaborative network of enterprises (CNEs) by Dynamic-distributed sharing protocol (D2-SP). D2-SP is inspired by the principles of Collaborative Control Theory and Contract Net Protocol. A novel protocol is investigated for control of CNEs. The performance of the proposed D2-SP is evaluated by comparing three sharing protocols (SPs): 1) Static-centralized, 2) Static-distributed, and 3) Dynamic-centralized SP. Experiments are conducted to analyze D2-SP in terms of efficiency, fairness, scalability, utilization of resources, and communication overhead.

5 - Flow Time Variability Estimation using Kriging-based Methods to Integrate Simulation and Real Data

Hoda Sabeti, West Virginia University, 390 Gilmore St., Morgantown, WV, 26505, United States, hoda.sabeti@gmail.com

Quoting a competitive and reliable lead time upon arrival a new order, is a key competitive advantage for manufacturers. Precise lead time quotation requires a good prediction for the mean and variability of the flow time. Due to the uncertainties in manufacturing processes, heteroscedasticity of the variance, and insufficient real time manufacturing data, it is challenging to provide high quality flow time estimation for a new order at its arrival time. This research focuses on predicting the flow time variability. To increase the accuracy, simulation data is integrated with the real data. A stochastic kriging based framework is adopted for infusing the data and predicting the flow time variance.

■ WA33

351C

Operation Research Empowering Airline Crew Scheduling and Crew Planning

Sponsored: Aviation Applications

Sponsored Session

Chair: Abdelouahab Zaghrouti, GERAD Research Center, Université de Montréal Campus, 2920, Chemin de la Tour, Montreal, QC, H3T 1J4, Canada, abdelouahab.zaghrouti@gerad.ca

1 - Constraints Aggregation for Large-scale Airline Crew Pairing Problems

Francois Soumis, Professor, Polytechnique, Polytechnique, C.P. 6079, Montreal, QC, H3C 3A7, Canada, francois.soumis@gerad.ca, Mohammed Saddoune, François Lessard

The crew-pairing problem is modelled as a set-partitioning problem solved by columns generation. However solving a master problem of 50 000 constraints at each of the thousands iterations of the column generation in the branching tree request to much time. In some airlines the Rolling-Horizon heuristic (RH) divides the horizon into 2 days overlapping time slices. However solving 30 problems of 3000 flights requires many days and the quality of solutions in not so good. We introduce the Dynamic Constraints Aggregation to speed-up the master problem and permit to solve a weekly window of 14 000 flights in few hours. The rolling horizon with weekly windows produces solutions improved by up to 5% on salaries.

2 - Considering Crew Preferences in the Airline Crew Pairings to Improve the Crew Rostering

Frederic Quesnel, GERAD, 9382 Joseph-Melancon, Montreal, QC, H2M 2H8, Canada, frederic.quesnel@gerad.ca, Francois Soumis, Guy Desaulniers

The airline crew scheduling problem is usually divided in two steps : the crew pairing problem (CPP) and the crew rostering problems (CRP). While the goal of the CPP is to find feasible pairings at minimum cost, the CRP aims at finding a schedule that satisfy as many employee preferences as possible. The main challenge with this approach is that the pairings generated by the CPP may not be suitable for the objective of the CRP. In order to create pairings that are more compatible with the CRP, we propose a new mathematical formulation for the CPP that takes into account crew preferences. We show how such model can be solved with column generation and we present results showing the effectiveness of our method.

3 - Airline Reserve Planning

Mingzhou Jin, University of Tennessee-Knoxville, 525D John D. Tickle Engineering Building, Industrial and Systems Engineering, Knoxville, TN, 37996, United States, jin@utk.edu, Ying Zhang, Suresh Rangan

Reserve lines are planned in airlines for possible dropping of main crew lines. An approach integrating the demand forecasting, reserve pattern generation, reserve line optimization, and dynamic trip assignment is developed for improving the efficiency of reserve crew scheduling, measured by the utilization and coverage. A column generation algorithm is developed to generate patterns covering the forecasted reserve demands in a stochastic fashion. The approach can avoid the influence of forecasting errors caused by high uncertainty of reserve demands.

4 - An Improved Version of the Integral Simplex using Decomposition Algorithm

Abdelouahab Zaghrouti, Kronos Canadian Systems Inc, 3535 Queen Mary Rd, Montreal, QC, H3V. 1H8, Canada, abdelouahab.zaghrouti@gerad.ca, Issmail El Hallaoui, Francois Soumis

Integral Simplex Using Decomposition (ISUD) is an iterative method that efficiently solves set partitioning problems for the transportation industry. We introduce a new version of ISUD that improves both quality and performance. With its new approach, given a good initial solution, it presents high chances of reaching the best solution without branching. Optimality is reached for large instances five times faster than the previous version. In addition to its performance, an important advantage of the new version is that it opens the possibilities of its extension to arbitrary binary problems.

■ WA35

351E

Supply Chain Optimization

Contributed Session

Chair: Weihang Zhu, Lamar University, Beaumont, TX, United States, weihang.zhu@lamar.edu

1 - The Impact of Adopting 3D Printing Technology on Inventory and Pricing Decisions in a Two-echelon Supply Chain

Sharareh Rajaei Dehkordi, PhD Student, New Jersey Institute of Technology, 10 Hill Street, Apt 2N, Newark, NJ, 07102, United States, sr552@njit.edu, Wenbo (Selina) Cai

As 3D printing technology becomes agiler and better able to react customer demands, one important question for the retailers is whether they should provide 3D printing services in their brick-and-mortar store in addition to the traditional off-the-shelf product? If so, what should be the retailers pricing scheme and optimal inventory level to achieve ahigher profit? In this study, the retailers' optimal joint decisions on inventory management policy and pricing scheme are developed while considering consumer preferences for self-designed, 3D printed products versus off-the-shelf products.

2 - A Supplier Selection and Supply Chain Coordination Model under Price Sensitive Demand and Profit Sharing

Barbara Venegas Quintrileo, Pennsylvania State University, University Park, PA, 16801, United States, bbv105@psu.edu, Jose Antonio Ventura

We study a supplier selection problem in a two stage centralized supply chain under price sensitive demand, formed by a buyer and a set of suppliers. Vendors have fixed production rates and produce a single item with no differences among them. A mixed integer nonlinear programming model under different lot sizing policies is presented, to determine the inventory policies and the final retail price for the customer, using a total supply chain optimization approach. Finally, a profit sharing method is proposed to allocate the benefits obtained through coordination. It restricts the model to pick solutions where each member's rate of return (ROI) is at least a fixed portion of the supply chain's ROI.

3 - Considering Production Planning and Scheduling Decisions in Supply Chain Network Design

Gokhan Memisoglu, Applied Research Scientist, LLamasoft, LLamasoft, Inc., 201 South Division St. Suite 200, Ann Arbor, MI, 48104, United States, gokhan.memisoglu@llamasoft.com, Ali Taghavi, Nejat Karabakal, Jason D. Judd

Production planning and scheduling decisions are important factors in supply chain design problems.. In this talk, we present how Supply Chain Guru (SCG), LLamasoft's network optimization tool, incorporates these decisions into its generic network design formulation.

4 - Buyer and Supplier Strategies for Hedging against Risk in the Ethanol Industry?

Iddrisu Awudu, Quinnipiac University, 12 Kaye Plaza, Apt E-22, Hamden, CT, 06514, United States, iddrisu.awudu@quinnipiac.edu, Anthony Afful-Dadzi e, Vinay Gonela

We model an ethanol supply chain with price uncertainties. We incorporate the concept of copula. We develop a stylized linear optimization problem and solve the resulting problem using Multi-cut decomposition algorithm. We provide insights using a case study in North Dakota.

5 - An Order Acceptance Model for Hybrid Production Strategy

Weihang Zhu, Associate Professor, Lamar University, PO Box 10032, Beaumont, TX, 77710, United States, weihang.zhu@lamar.edu, Arash Abedi

The hybrid production strategy (HPS), a combination of the make-to-order (MTO) and make-to-stock (MTS), has been employed for over a decade. In order for hybrid-production based manufacturing to fully utilize available resources, a compatible order acceptance method is vital. This talk first presents a framework to explain what process the orders undergo until they are satisfied. Within the framework, an order acceptance model (OAM) is proposed. It is able to simultaneously consider production strategy, production capacity, and customer priority, and thus lead to higher profits.

■ WA36

351F

Facilities Planning and Design

Contributed Session

Chair: Li Wei, Huazhong University of Science and Technology, Wuhan, China, liweianthea@gmail.com

1 - Overlap Packing Problem for Layout Design of Task Volumes in Spacecraft

Churlzu Lim, Associate Professor, UNC-Charlotte, 9201 University City Boulevard, Charlotte, NC, 28223-0001, United States, clim2@uncc.edu, Simon M.Hsiang, Claudia Ramirez, Sherry S. Thaxton, Maijinn Chen, Jerry Myers

This study considers a packing problem that searches for a minimum-volume cube container to pack a given number of variously sized cuboids while allowing overlap between cuboids to certain extent. The problem was developed as part of designing arrangements of task volumes performed by astronauts in a spacecraft for a prolonged period of time. Mixed-integer linear programming model is proposed to minimize the volume of the cube container while enforcing additional constraints such as overlap limits, adjacency requirements, and orientation options. Numerical examples will be discussed.

2 - Techniques for Improving Safety on Medium Voltage Electrical Equipment

Raymundo Rivera, PhD Student, UT Health San Antonio, 1814 N Palmetto Ave., San Antonio, TX, 78208, United States, riverar5@uthscsa.edu
Raymundo Rivera, PhD Student, Mississippi State University, MS, United States, riverar5@uthscsa.edu, Linkan Bian

In the United States, the medium voltage electric grid and its complex electrical components which include customer-side automatic transfer switches, transformers, switchgear and breakers receive minimal inspections. When electrical failures develop the most critical issues are often the only ones addressed while the lesser problems are left untouched and fester until the next electrical failure occurs. This paper introduces the classification of datasets based on ultrasound waveforms, age, and type of equipment in order to minimize arc flash hazards to electrical personnel, minimize power outages, minimize lost revenue and reduce the risk of lost customer data.

3 - The Adoption Strategy of Electric Vehicle
Li Wei, Student, Huazhong University of Science and Technology, Wuhan, 430074, China, liweianthea@gmail.com

This paper applies game theory to study how EV manufacturer makes location and pricing decision when facing the competition of the gasoline car. We characterize a two-stage game model describing EV manufacturers' operation decisions and consumers' consumption decision, after solving the model we derive the optimal number of charging stations and the optimal charging price, and then analyze how city structure, customers' traveling demand and EV range affect the results.

■ WA37

352B

Models of Co-production and Co-creation

Sponsored: Service Science

Sponsored Session

Chair: Paul R. Messinger, University of Alberta, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca

1 - Competing with Co-created Products
Amit Pazgal, Rice University, Jones Graduate School of Management, 6100 Main Street (MS.- 531), Houston, TX, 77005, United States, pazgal@rice.edu, Dinah Vernik-Cohen, Niladri Syam

We analyze the strategic choices of two competing downstream firms who simultaneously decide whether or not to co-create with an upstream supplier. Within this framework we incorporate, endogenous pricing and effort choice by both the supplier and the competing firms. Firms contemplating co-creation with a supplier are faced with a trade-off. They can benefit from the supplier's innovation efforts and therefore obtain a better product than they themselves can produce. However, they may face the adverse effect of their own innovation efforts spilling over to their rivals via the supplier who would sell the co-created products to all firms. Our model captures this tension and offers several insights.

2 - Strategic Role of Self-service Co-production
Paul R.Messinger, University of Alberta, Faculty of Business, 3-20e Faculty Of Business Bldg, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca, Kursad Asdemir, Bora Kolfal

This paper examines the strategic implications for duopoly firms offering a self-service option in a stylized game-theoretic model. Queuing behavior is modelled to equilibrate so that customers sort themselves into groups that choose the self-service or full service options according to what is best for them. The model also endogenously determines the boundary of the firm (which activities are conducted by the firm and which are done by customers outside the firm). By focusing on the offering of self-service as a strategic variable, this paper differs from much of past managerial research on self-service that focuses on the productivity gains to market participants.

3 - Co-creation: the Consumer Side with Bandwagon Effects
James D. Hess, Bauer Professor of Marketing Science, University of Houston, University of Houston, Houston, TX, 77204-6021, United States, jhess@uh.edu, Niladri Syam, Rambod Dargahi

We study the behavior of consumers who co-produce goods and services with a firm and ask how bandwagon effects (social preferences) on the consumers affect their co-production choices. Consumers have to make three related decisions: (1) buy the standard or customized product? (2) What is the optimal design of the customized product and how to split the design task between themselves and the firm ? (3) How should they take into account the preferences of other customers? Our main result finds that an increase in the bandwagon intensity can either increase or decrease the mass of co-producers. We have experimentally tested this main result.

■ WA39

352D

Networks and Graphs

Contributed Session

Chair: Nima Safaei, Bank of Nova Scotia, North York, ON, Canada, nima.safaei@scotiabank.com

1 - Interactive Community in Temporal Networks
Jongeun Kim, University of Florida, 2901 SW. 13th St, Apt 212, Gainesville, FL, 32608, United States, kje0510@ufl.edu, Vladimir Boginski

One of the important research area in network analysis is detecting a significant cluster. Most proposed works have been done in static networks. However, many real-world networks including person-to-person communication networks, brain signal networks, dynamic sensor networks and infrastructural networks have a potential to gain better knowledge by applying temporal network frame which considers changing the connections through time. We will define the condition of an interactive community in a temporal network and design both exact approaches and rapid heuristics to find it.

2 - Derisking in Crossborder Payment Banking Networks
Nima Safaei, Associate Director, Network Analytics, Bank of Nova Scotia, Unit 1205, 72 Esther Shiner Blvd, North York, ON, M2K.0C4, Canada, nima.safaei@scotiabank.com, Ivan Sergienko

De-risking is defined as "the phenomenon of financial institutions terminating or restricting business relationships with clients to avoid, rather than manage, risk in line with the risk-based approach". This phenomenon raises profitability pressure due to increased competition and more regulations to mitigate the risk of money-laundry, terrorist financing, credit loss, etc. We propose a methodology to classify the banks in a cross-border network in terms of risks and benefits. Our analysis is supported by SWIFT customer payments data from an international bank.

■ WA40

352E

Advances in Transportation Planning and Operations

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Xia Yang, SUNY Polytechnic Institute, 100 Seymour Road, Troy, NY, 13502, United States, yangx2@sunyit.edu

1 - Bus Schedule Optimization for Multimodal Emergency Evacuation
Xia Yang, SUNY Polytechnic Institute, Utica, NY, 3502, United States, yangx2@sunyit.edu, Sean He

This study proposes a mixed integer linear programming model that optimizes the schedule of buses in a multimodal transportation system to minimize the total evacuation time for heavily populated urban areas. The proposed model factors evacuation traffic dynamics, evacuation priority, the cooperative behavior of evacuees, and the capacities of facilities in the multimodal transportation system. Numerical experiments are conducted to investigate the proposed model and its solution algorithm.

2 - Real-time Estimation of Value of Time Distribution using Measurements on Managed Lane Networks
Venktesh Pandey, University of Texas, Austin, TX, United States, venktesh@utexas.edu, Stephen Boyles

The value of time (VOT) distribution among drivers is critical for understanding the lane choice behavior of drivers and setting optimal tolls for travelers in a managed lane network. We propose a formulation for simultaneous estimation of traffic state and percentage of travelers in each VOT class in the population by measuring the flows before and after each diverge-point on managed lane networks. The performance of the estimation algorithm is tested on managed lane networks with multiple entrances and exits. The issues of non-observability of the states are also highlighted.

3 - Arterial Signal Coordination with Uneven Double Cycling and Secondary Bandwidth
Hongmin Tracy Zhou, Texas A&M Transportation Institute, 701 North Post Oak Rd, Suite 430, Houston, TX, 77024, United States, h-zhou@tti.tamu.edu, Gene Hawkins, Luca Quadrifoglio

Arterial signal coordination between large intersections often requires a long cycle length which may causes excessive delay at intersections of low volume cross streets. This paper describes two optimization models developed to enable uneven double cycling (UDC) at minor intersections where a background cycle has two sub-cycles of different lengths to address this issue. The first model maximizes variable bandwidths and minimizes through delay on cross streets at UDC intersections. The second model also maximizes secondary bandwidths for arterials with two or more consecutive UDC intersections. Simulation results show great potentials of the UDC control scheme.

4 - Credit Risk of Real Option in Private-Public-Partnership Based Road Infrastructure Project Evaluation under Market Realism
Choungryeol Lee, Purdue University, West Lafayette, IN, United States, lee1210@purdue.edu, Srinivas Peeta, Yong Hoon Kim

We propose an extended real option valuation (ROV) framework to price real options for PPP-based road projects subject to credit risk concerning the private firm's bankruptcy. This framework integrates the existing ROV frameworks and measurement of credit risk in terms of the expected loss from a public perspective. Results of numerical experiments show that impacts of credit risk on option value are significant and suggest that public access to proprietary information of the private firm is needed to accurately evaluate PPP-based road projects leveraged with real options.

■ WA41

352F

Decision Analysis

Contributed Session

Chair: Seyede Yasaman Amirkiaee, University of North Texas, Denton, TX, United States, SeyedeYasaman.Amirkiaee@unt.edu

1 - Inferential Modelling and Decision Making under Uncertainty
Jian-Bo Yang, Professor, University of Manchester, F36 MBSE, Booth Street West, Manchester, United Kingdom, jian-bo.yang@manchester.ac.uk, Dong-Ling Xu, Chao Fu, Xiaobin Xu

This paper is aimed to investigate issues related to how to make the best use of imperfect data collected from different sources routinely for scientific inference & robust decision making. A data-driven method is introduced & numerical examples are examined to show how evidential reasoning (ER) can be conducted to implement and generalise Bayesian inference in situations where data can be incomplete, ambiguous or inaccurate with different degrees of reliability & weight. A real life case study on the diagnosis of irregularity faults of railway track is conducted to demonstrate a practical procedure for developing an ER-based diagnosis method.

2 - Utilization of Statistical Approaches for Comparing Association Rule Mining Algorithms
Sanam Azadiamin, Ohio University, 35 N Mckinley Ave. Apt 112, Athens, OH, 45701, United States, sa349416@ohio.edu, Gulser Koksal

Finding the most appropriate association rule mining algorithm according to its application area is studied using statistical approaches. For this purpose, test data is developed based on a statistical experimental design and logistic regression. Interesting rules are found considering pre-specified support level. Finally, the comparison is done compromising over several measures and using the interesting rules. Illustrative examples are provided.

3 - An Adaptive Heuristic for Feature Subset Selection Based on Feature Complementarity
Sumanta Singha, Doctoral Student, University of Kansas, 1654 Naismith Drive, Capitol Federal Hall, Lawrence, KS, 66045, United States, sumanta.singha@ku.edu, Prakash P. Shenoy

The paper presents a novel approach to feature subset selection, which optimizes relevance, redundancy, and complementarity using an adaptive framework, and determines the trade-off rule endogenously based on these factors. The heuristics explicitly characterizes complementarity, and allows the redundancy-complementarity ratio to guide the search process. Using benchmark datasets, the proposed heuristic outperforms many existing methods of feature subset selection.

4 - Networked Pattern Recognition Framework for Classification
Safak Yakti, Research Assistant, Binghamton University, Johnson City, NY, 13790, United States, syakti1@binghamton.edu, Salih Tutun, Mohammad Khasawneh

This research aims to propose a comprehensive new framework, namely Networked Pattern Recognition (NEPAR) Framework for different applications. The NEPAR and five different classification methods (SVM, NB, LR, DT, and kNN) are improved by adding information from the proposed network metrics. Information from observations is extracted by building the network, and feature properties for each observation are used to classify the output. Six different datasets (Australian credit approval, diabetes, breast cancer, abalone, SturPlus fMRI, German credit) are used to show the framework outperforms other traditional classification.

5 - Enhancing Lasso's Sparsity via Mixed Integer Quadratic Programming
Ahmed M. Marzouk, Southern Methodist University, Lyle School of Engineering, Dallas, TX, 75275-0123, United States, Marzouk Halit Uster

We present a Mixed Integer Quadratic program (MIQP) to find a sparse solution for linear regression (LR) models. We show that the proposed MIQP provides sparser solutions than that provided by LASSO without any degradation in the LR prediction power. Specifically, the average improvement in sparsity when using MIQP was 32.3% and the average computational time was less than one minute.

6 - Public Opinion on Self-driving Vehicles: A Comment Mining Approach
Seyede Yasaman Amirkiaee, PhD Student, University of North Texas, 1307 West Highland Street, BLB 375D, Denton, TX, 76201, United States, SeyedeYasaman.Amirkiaee@unt.edu, Nicholas Evangelopoulos

Automated driving vehicles are disrupting the transportation industry. As many top motor vehicle and high-tech companies are entering this market, it is important to look at public attitude towards this latest technology. While traditional research has relied on structured surveys, in this research, we are reviewing public opinion by mining posted comments on published news stories, promotional videos, and micro-blogging web sites (Twitter).

■ WA42

360A

Planning

Contributed Session

Chair: Anparasan Mahalingam, Purdue University, West Lafayette, IN, United States, anparasan@purdue.edu

1 - Silence in Identity Salience : the Perks and Downsides of Spanning Multiple Categories on Forming Collaboration Ties
Pyung Nahm, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul, 08826, Korea, Republic of, joeynahm@gmail.com

We explore the effects having an organizational identity that span multiple categories on the actor's formation of collaboration ties. We posit that actors without salient identities, spanning multiple categories, are likely to face 'multiple-category discount' when selecting potential partners. These actors are more likely to form ties with unexperienced alters because experienced alters question the competence of actors spanning diverse areas. Reputation, a stronger social judgment for competence, will eventually moderate the discounting effect. We utilized co-author network in the management field, analyzing all researches published in the top journals from 2000 to 2016.

2 - When Does Paying More Pay Off?
Hazhir Rahmandad, Associate Professor, MIT, 100 Main Steet, E62-442, Cambridge, MA, 02142, United States, hazhir@mit.edu, Zeynep Ton

Can well-paying and satisfying jobs accompany, or lead to, profitability in low-cost service sector? Building on qualitative data from a few case studies we map out the systemic feedback mechanisms that could enable good jobs in services. Using a simulation model we show that on a strategy space defined by two dimensions of task richness and compensation, two distinct local profitability peaks emerge: one with low compensation and task richness, representing employee cost minimization, and the good jobs peak with high compensation and task richness. Simulations establish the conditions under which each peak dominates, and the challenges of moving to the good jobs peak due to temporal tradeoffs.

3 - Untangle Interorganizational Collaboration from Value Cocreation Perspective
Marian Dan-Wei Wen, National Cheng Kung University, No. 1, University Rd., East Dist.,, Tainan, 70101, Taiwan, marian.wen@gmail.com, Shih-Chieh Fang, Ching-Ying Huang

Received literature on inter-organizational collaborations emphasizes value capture more than how value is jointly created. This research adopts value co-creation approach from service science to address (1) the variety of value that can be created, and (2) key factors making multiple organizations co-create value, then present a tentative research framework. Theoretically, this paper extends inter-organizational value creation by going into the multi-partner settings and promoting multiple organization collaborations. Practically, this paper reflects collaborations with other organizations can be viewed from a collaboration-oriented manner to make pies bigger.

4 - Forming Balance in Status Between Female Directors and Male CEOs: Through Adjusting Male CEO's Economic Status
Junghyun Mah, Seoul National University, KangnamGu, Irwonbondong Mokryun Town 107-601, Seoul, 06355, Korea, Republic of, junghyunmah@gmail.com

Little has been explored on how the subdivision of status for female directors and male CEOs invoke social comparison when determining male CEOs' compensation. Female directors enjoy the high economic status, whereas they occupy low social status compared to male CEOs. In contrast, male CEOs occupy high economic and social status. Status inconsistent female directors aim to balance their overall status with status consistent male CEOs through targeting male CEOs' economic status. It is observed by decreased growth rate of male CEOs' compensation, narrowed pay disparity, increased shareholder's wealth, and the number of board appointments by female directors moderates the influence.

5 - Information Systems Integration in Mergers and Acquisitions
Aditya N.Saharia, Associate Professor, Fordham University, Gabelli School of Business, 140 West 62nd Street, New York, NY, 10023, United States, saharia@fordham.edu

Often corporate mergers fail because (or create negative values) because of the difficulty in integrating IT systems and the operational and management processes they support. In this work we use a knowledge based view of the firm to identify critical success factors for post-merger IT integration.

6 - Evolution of Hierarchical and Modular Patterns in Strategic Networks

Anparasan Mahalingam, PhD Candidate, Purdue University, 403 W State Street, Krannert Building, West Lafayette, IN, 47906, United States, anparasan@purdue.edu, David Richard Johnson, Umit Ozmel

We have applied network analysis tools to a database of biopharmaceutical alliances, developing methods to identify emergent hierarchical and modular network structures, find sub-communities, and trace temporal dynamics. Findings suggest that smaller sub-communities organize hierarchically into larger networks with local clustering. Patterns and structures are consistent with features found in many other types of networks. These methods lead to greater understanding of the strategic implications of network structure and organization when fused with econometric analysis.

■ WA43

360B

Public Sector OR Utilizing GIS

Sponsored: Public Sector OR

Sponsored Session

Chair: Ronald McGarvey, University of Missouri, Columbia, MO, 65211, United States, mcgarveyr@missouri.edu

1 - Addressing Health Disparities at U.S. Community Health Centers: A Focus on Pregnancy-related Health Outcomes

Andreas Thorsen, Montana State University, Bozeman, MT, United States, andreas.thorsen@montana.edu, Maggie Thorsen, Rohith Mahdi Reddy, Ronald G.McGarvey

Federally qualified health centers (FQHCs) provide comprehensive health care services to under-served populations. We aim to identify whether there exist different typologies for FQHCs and to better understand the differences between and within these typologies in terms of efficiency, quality of care, and pregnancy-related health outcomes. We identify FQHC typologies by performing a latent class analysis incorporating information such as demographics and services provided. Then we apply data envelopment analysis to measure the efficiency of health centers within latent classes. The purpose of this analysis is to determine systematic issues that may hinder successful FQHC operations.

2 - A Demand Response Model for Biopower Generation to Identify Optimal Multi-state Collaborations

Ronald McGarvey, University of Missouri, IMSE and TSPA, E3437D Lafferre Hall, Columbia, MO, 65211, United States, mcgarveyr@missouri.edu, Bayram Dundar, Francisco X. Aguilar

In this study, we investigate the impact of energy policy-related regulations on biomass demand and procurement cost using econometric models. We develop a robust optimization model to identify min-cost approaches for reducing carbon emissions via biomass co-firing subject to spatially-explicit biomass availability constraints. We utilize a simulated annealing heuristic approach to solve the resultant robust mixed integer nonlinear programming model. We apply this model to a set of 18 states in the northern US to identify optimal sets of multi-state collaborations.

3 - Coupled Natural and Human System Model to Support Climate-adapted Water Management Policies in the Great Plains

Jessica Heier Stamm, Assistant Professor, Kansas State University, Manhattan, KS, United States, jlhs@k-state.edu, Gabriel Granco

Policy makers face challenges developing and enacting policies to help communities mitigate or adapt to climate change impacts. We study a coupled natural and human system in the U.S. Great Plains that is vulnerable to water supply challenges. In this talk, we describe a geographically explicit agent-based simulation model that integrates the decision making perspectives of community members, landowners, and policy makers with biophysical system models. We aim to identify water management policies that balance economic and environmental sustainability.

4 - Inventory Management of Blood Platelets at Hospitals

Suchithra Rajendran, The Pennsylvania State University, 265 Blue Course Drive, Apt 3E, State College, PA, 16803, United States, sur205@psu.edu, Arunachalam Ravindran

This research proposes stochastic mathematical models for blood platelet inventory management at the hospitals. On one side, there is a 20% wastage of platelets due to outdating and on the other side, there is severe blood shortage due to which surgeries are postponed by nearly 120 days. Therefore, it is necessary to minimize wastage and shortage of platelets. In this research, inventory models are developed to achieve this objective incorporating several real-life constraints. The result act as a decision support system to the hospital administrator.

■ WA44

360C

Operations Management/Marketing Interface

Contributed Session

Chair: Yang Zhan, Shanghai Jiao Tong University, Shanghai, China, zhanyangjy@sjtu.edu.cn

1 - Cheating or Delighting Customers on Product Quality?

Fouad El Ouardighi, ESSEC Business School, Avenue B. Hirsch BP.105, Cergy Pontoise, 95021, France, elouardighi@essec.fr, Konstantin Kogan

In this paper, we claim that, though based on different tradeoffs, cheating and delighting policies are the two faces of the same coin. Cheating allows for inflated goodwill and provides a cheating rent as long as the cheating is not disclosed, while delighting allows for enhanced goodwill and yields a delighting rent as soon as the delighting is awarded. The conditions that allow for rent equalization between the two policy options are identified. We also characterize the conditions under which either cheating or delighting customers on quality is beneficial.

2 - Joint Optimization of Capacitated Assortment and Pricing Problem under the Tree Logit Model

Yanqiao Wang, UC Berkeley, 1945 Milvia St, Apt 101, Berkeley, CA, 94704, United States, yanqiao@berkeley.edu, Zuo-Jun Max Shen

Assortment and pricing decisions are of significant importance to firms and have huge influences on profit. How to jointly optimize over both assortment and prices draws increasing attention recently. In this paper, we study the joint capacitated assortment and price optimization problem where the consumer choosing behavior is governed under the multistage tree logit model. Under the cardinality constraints, we develop an efficient algorithm that runs in polynomial time to find the optimal assortment with optimal prices. Under the space constraints, we can obtain a 2-approximate solution within the same time scale compared to the cardinality constraints.

3 - Competition in Food Quality Standards when Consumer Confusion Exists

Yang Song, East China University of Science Technology, Meilong Road No.130, Shanghai, China, skye_y.song@qq.com

As food quality is a kind of credence attribute, Certification can reduce the problem of information asymmetry. This paper assumes that duopoly firms produce product with vertical differences and two different standards. We focus on the analysis on the equilibrium and our results show that the existence of two quality standards can increase the producer's benefits as well as social welfare. Especially, I takes into account the existence of consumer confusions. It shows that a second standard led to an increase in prices and a reduction in qualities. At last, comparison between the social effects of markets consisted of different consumers were made.

4 - Coordinating Customers' Choices for Cost-effective Healthcare Service Delivery

Harihara Natarajan, Associate Professor, University of Miami, Coral Gables, FL, United States, hari@miami.edu, Fang Fang

Service providers vary greatly in their costs to the insurance company, but may have little difference to the consumers in terms of coinsurance payment and other out-of-pocket expenses. As a result, without alignment, consumers may choose more expensive treatment that increases the cost to the insurance company. Facing this problems, we exam how an insurance company could provide incentives to consumers to gain alignment without compromising the quality of care or customer service.

5 - Profiting from Refund: the Value of No-shows

Yang Zhan, Shanghai Jiao Tong University, 1954 Huashan Road, Shanghai, 200030, China, zhanyangjy@sjtu.edu.cn

To migrate the negative effects of no-shows, a pre-charge strategy, which charges a deposit when a patient requests an appointment, is observed in an increasing number of clinics. We consider two policies including to refund or not to refund the deposit, respectively. Under the refund policy, the patient can get partial or full refunds, is assumed to report the cancellation for sure. While under the no-refund policy, the patient cannot get any refund, not reporting the cancellation, and no-shows may incur. We show that the refund policy can be more profitable (1) without charging a higher deposit compared to the no-refund policy (2) even when overbooking is allowed in the no-refund policy.

■ WA45

360D

Retail Management

Contributed Session

Chair: Shin Woong Sung, KAIST, Daejeon, United States, sw.sung@kaist.ac.kr

1 - Sustainability Trends in Retail Sector : A Text Mining Approach
Youqin Pan, Salem State University, Bertolon School of Business, 352 Lafayette Street, Salem, MA, 01970, United States, ypan@salemstate.edu

This paper applies a text mining approach to discover sustainability trends in the retail sector. The findings demonstrate that green store operations, green transportation, consumer education, and employee engagement are considered as important sustainability issues or concerns in retail industry. Insights based on this study will help retail companies identify improvement opportunities by comparing its own sustainability efforts with the overall trends in the retail sector.

2 - Service Dependency and the Role of Labor in Retailing
Chien-Ming Chen, Associate Professor, Nanyang Technological University-Singapore, 50 Nanyang Avenue, Singapore, 639798, Singapore, cmchen@ntu.edu.sg, Howard Hao Chun Chuang

We empirically examine how service dependency of the shopper population may affect labor's effect on retail store performance. The results show that labor's marginal contribution to conversion and average sales are highly contingent on service dependency. Our study is based on multi-year panel data from a major retail chain in North America.

3 - Ship-from-store Operations in Omni-channel Retailing
Armagan Bayram, Assistant Professor, University of Michigan Dearborn, 31035 Morlock Street, Apt 716, Livonia, MI, 48152, United States, armagan@umich.edu, Bahriye Cesaret

We consider an omni-channel retailer having both online and store operations and implementing ship-from-store fulfillment model. In this model, store orders are fulfilled from store inventories, but for an online order the retailer can ship it either from the online distribution center or from any store location that maximizes its overall profit. We investigate dynamic fulfillment decisions: from which location to fulfill an online order when it arrives. We incorporate the uncertainty both in demand and in the cost of shipment to individual customers. We develop a stochastic dynamic framework and present some results on optimal fulfillment strategies.

4 - A Customer Choice Model for Estimating the Halo Effect
Reza Yousefi Maragheh, University of Illinois, Urbana-Champaign, Urbana, IL, United States, ysfmrgh2@illinois.edu, Alexandra Chronopoulou, James Mario Davis

According to Halo effect, customers value the same product differently if the offered assortment varies. A customer choice model is developed that captures the pairwise effect of products on each other's intrinsic values, i.e. the latter is a function of the offer set. This allows the model to violate the Independence of Irrelevant Alternatives property. A procedure is proposed for parameter estimation and sufficient identifiability conditions are derived. For special cases, closed form expressions are obtained. Simulation results confirm the theoretical findings. When testing the proposed model on synthetic data, it outperforms the MNL model in terms of AIC and in most cases in terms of BIC score.

5 - Environment Analysis for Global Operations Strategy in Retailing Industry
Yeming Gong, Em Lyon Business School, Building B, Office 1018, 23 Avenue Guy De Collongue, Ecully, 69134, France, gong@em-lyon.com, Jiawen Liu

Considering an operational decision in distribution centralization , we examine relationships between discretionary inputs of supply chain, non-discretionary inputs of environment, and organizational performance in retailing. We develop a non-discretionary DEA model to assess the corporate performance in retailing industry. Our main contribution is: (1) to provide a new method using non-discretionary DEA integrated with econometric analysis in environment analysis for GOS, and (2) to establish a new framework to understand the role of centralized distribution and its competitive environment in retailing supply chain strategy.

6 - Image-based Inventory Distribution System for Fashion Products using Convolutional Neural Network
Shin Woong Sung, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon, Korea, Republic of, sw.sung@kaist.ac.kr, Hyeonjun Sim, Hyunsuk Baek, Young Jae Jang

We present the image-based inventory distribution optimization method for fashion products. Due to the product variety and short product life cycles, the distribution of the fashion product to stores is challenging. Particularly for the product lines with limited quantity, the product mix is critical in the distribution decision. The proposed distribution method first identifies the visual similarity between products using convolutional neural network. Then mathematical optimization method determines the product mix and the distribution based on the visual similarity. This work is done with an academic-industry collaboration and the method has been tested and validated with actual data.

■ WA46

360E

Project Management

Contributed Session

Chair: Sinan Obaidat, University of Arkansas, Fayetteville, AR, United States, sfobaida@uark.edu

1 - Efficient Reproduction Scheduling Against Defectives under Uncertainty
Atsushi Kurimoto, Osaka University, Osaka, Japan, atsushi.kurimoto@ist.osaka-u.ac.jp, Hiroshi Morita

There are many uncertain factors such as defectives and machine failure in production process. We have to deal with them by rescheduling or adaptive scheduling, which may cause the delivery delay and excess inventory. Robust schedule for uncertainty brings us the reduction of delivery delay and inventory. We consider to provide the appropriate production plan by taking into account of the uncertainty.

2 - Production Planning and Quality Testing under Random Yield
Candace Arai Yano, University of California-Berkeley, IEOR.Department, 4141 Etcheverry Hall, Berkeley, CA, 94720-1777, United States, yano@ieor.berkeley.edu, Sandra Transchel

We study a co-production system in which there is a two-stage testing process with limited capacity. Finished products are differentiated according to their quality levels in two dimensions, and the firm sells these products at different prices. Demand can be fulfilled using a substitute product of equal or higher quality but at the price of the requested quality. We develop a stochastic dynamic programming model with three types of decisions: (i) ordering decisions, (ii) testing policy, and (iii) allocation of the post-final-test inventory to the quality-differentiated demands.

3 - Performance Analysis of Multi-product Manufacturing Systems with Dedicated Finite Buffers
Kyungsu Park, University of Wisconsin-Madison, Madison, WI, United States, kyungsu@kaist.ac.kr, Jingshan Li

Many flexible manufacturing systems process multiple products with dedicated buffers. In such systems, scheduling and control polices play a critical role. Priority, cyclic, and WIP-based policies are among the most typical ones. In this talk, we study the performance of two-machine lines with multiple product types, unreliable Bernoulli machines, and finite dedicated buffers, under these three policies. Exact solutions for small scale systems are derived and iteration procedures are introduced for larger ones through decomposition. It is shown that the proposed method results in high accuracy in throughput estimation.

4 - A MILP Model for Job and Labor Scheduling to Minimize Weighted Tardiness and Labor Costs for Parallel Machines
Weihang Zhu, Associate Professor, Lamar University, PO Box 10032, Beaumont, TX, 77710, United States, weihang.zhu@lamar.edu, Sujay Mahale, Ezra Wari, Alberto Marquez

Scheduling problems often requires optimization of multiple resources. In this paper, a two stage mixed integer linear programming (MILP) model is formulated to optimize two resources sequentially based on their priorities: machines (first level resource) and labor (second level resource). Minimizing tardiness (continuous time model) for machines and the cost of temporary employees (discrete time model) for labor are set as objectives. With the resulting schedule for machine run and individual labor assignments, the proposed model enables organization to improve their production and labor planning and assist in efficient capacity utilization.

5 - Solution Approaches for an Integrated Process Configuration, Lot Sizing and Scheduling Problem in the Packaging Industry
Karim Perez Martinez, Federal University of São Carlos, Rua José Duarte de Souza, 36, São Carlos, 13564030, Brazil, karim@dep.ufscar.br, Yossiri Adulyasak, Raf Jans, Reinaldo Morabito, Eli Vitor Toso

We study an integrated process configuration, lot sizing and scheduling problem in a real environment of the packaging industry. Main decisions include determining which process configurations are used, how long they are used, and in what sequence. Non-linear mathematical models are presented and symmetry-breaking constraints are applied to the formulations. A Branch-and-cut algorithm and a MIP-based heuristic are proposed to solve the problem. Results show that the exact algorithm outperforms the linearized models solved by a commercial solver for all the instances tested and the heuristic finds good quality solutions for large instances in shorter computational times.

6 - Quality Control Sampling in Continuous Production
Sinan Obaidat, PhD Student, University of Arkansas, 1690 Live Oak Dr, Apt 12, Fayetteville, AR, 72704, United States, sfobaida@uark.edu, Haitao Liao

In this study, a quality control sampling for continuous production is proposed. Items are sampled during the production process at specified intervals such that one item is inspected at each interval. The production process is stopped for maintenance if the number of nonconforming items found in sampling exceeds a certain acceptance limit. The production time is divided into sampling cycles of fixed sizes, but it is not necessary to complete a sampling cycle if the number of nonconforming items exceeds the acceptance limit. The objective of this paper is to find the parameters of the sampling plan: sampling interval, sampling size, and the acceptance limit to minimize the total cost of quality.

■ WA47

360F

Practice/Healthcare IV

Contributed Session

Chair: Leon Cui, Binghamton University, 62 Decatur St, Binghamton, NY, 13903, United States, cui@binghamton.edu

1 - Improving Inventory Management of Perishable Substitutable Goods
Gina Dumkrieger, ASU, Tempe, AZ, 85281, United States, gina.dumkrieger@asu.edu

For families of perishable good where substitution is possible (such as blood products or antibiotics) outdating can be reduced through proactive use of substitution in the inventory allocation process.

2 - Managing Access To Care At Primary Care Facilities
Sina Faridimehr, Wayne State University, 4815 Fourth Street, Manufacturing Engineering Building, Detroit, MI, 48202, United States, sina.faridimehr@wayne.edu, Saravanan Venkatachalam, Ratna Babu Chinnam

One of the most important challenges confronting healthcare facilities is the effective management of access for patients to primary care. In this study, we develop appointment scheduling models using two-stage stochastic programming to improve access to care while maintaining high levels of provider capacity utilization and improving patient flow in clinic.

3 - Effectiveness of a Rapid Response Team in a Large Hospital: An Empirical Study.
Valery Pavlov, Senior Lecturer, University of Auckland Business School, University of Auckland, Private Bag 92019, Auckland, 1142, New Zealand, v.pavlov@auckland.ac.nz, Ali Vahabzadeh

In order to identify critically ill patients in the wards and timely transfer them to an ICU, and to prevent unnecessary ICU admissions, hospitals around the world have implemented Rapid Response Teams (also known as CCOT, MET or PAR teams). To date, the evidence on their effectiveness, coming exclusively from the medical literatures, has been scarce and controversial. One possible explanation is that these studies did not fully account for operational factors. Using a 12-month data from an 800-bed hospital in New Zealand, we investigate the impact of the hospital's rapid response team on patient outcomes treating operational factors as instrumental variables.

4 - Systematic Layout Planning of A Radiology Reporting Area To Optimize Radiologists' Performance
Flavio S. Fogliatto, Associate Professor, Federal Univ of Rio Grande do Sul, Av. Osvaldo Aranha, 99/5o andar, Porto Alegre, RS, 90040020, Brazil, ffogliatto@producao.ufrgs.br, Carla Schwengber Ten Caten, Ricardo A. Cassel

Optimizing radiologists' performance is a major priority for managers of health services/systems, since the radiologists' reporting activity imposes a severe constraint on radiology productivity. Despite that, methods to optimize radiologists' reporting workplace layout are scarce in the literature. This study was performed in the Radiology Division (RD) of an 850-bed University-based general hospital. The analysis of the reporting workplace layout was carried out using the Systematic Layout Planning (SLP) method, in association with cluster analysis as a complementary tool in early stages of SLP.

5 - Improving Quality of Care At A Hypertension Clinic using A Mobile Health Application
Leon Cui, Assistant Professor, Binghamton University, 62 Decatur St, Binghamton, NY, 13903, United States, cui@binghamton.edu, Saligrama Agnihothri, Anu Banerjee, Ramanujapuram Ramanujan

Chronic conditions place a high cost burden on the healthcare system and deplete the quality of life for millions of Americans. To monitor their health, some hypertension patients now use mobile devices to measure blood pressure outside of the doctor's office. These mobile health apps benefit patients by (i) yielding more accurate readings compared to in-office measurements, and (ii) offering timely information to the physician. However, the magnitude of this benefit is unclear. We collect data from a local clinic that has adopted this technology, and use it to evaluate the impact of continuous monitoring of blood pressure via smartphone app on the quality of patient care.

■ WA48

361A

Topics in Behavioral Operations Management

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Ruth Beer, Indiana University, Kelley School of Business, Bloomington, IN, 47404, United States, ruthbeer@indiana.edu

1 - Risk in Channels
Paola Mallucci, University of Wisconsin, 4261 Grainger Hall, 975 University Avenue, Madson, WI, 53706, United States, mallucci@wisc.edu

In a set of incentivized experiments we explore the role of risk in pricing decisions in a dyadic channel. We systematically vary who holds the risk while holding expected payoff constants across treatments. We find that subjects' behavior is inconsistent with classical economic theories, risk aversion as well as theories of fairness.

2 - Auctions, Efficient Coordination, and Strategic Complementarities
Anthony M. Kwasnica, Pennsylvania State University, 332 Business Bldg, University Park, PA, 16802, United States, kwasnica@psu.edu, James Fan

The likelihood of auctions to lead to efficient outcomes in order statistic coordination games as originally studied by Van Huyck et al. (1993) is re-examined under varying conditions. Specifically, we examine whether minimum order statistic games results in similarly positive results to those originally found in median order statistic games. We find that coordination on the efficient outcome as a result of a pre-play auction is sensitive to the degree of strategic complementarity. Our results are examined in relation to the behavioral learning model proposed by Crawford and Broseta (1998).

3 - Wage Transparency in Sales Agents Compensation Schemes
Javad Nasiry, Hong Kong University of Science and Technology-HKUST, Hong Kong, Hong Kong, nasiry@ust.hk, Xiaoyang Long

Sales agents with social preferences evaluate their pay in comparison with their peers and experience a positive or negative utility. We characterize the optimal salesforce compensation schemes in this context and characterize the conditions under which wage transparency benefits the firm.

4 - Monitoring or Disclosure? the Role of Observability in Buyer-supplier Collaborative Projects
Ruth Beer, Indiana University, Kelley School of Business, 314 W. 4th Street #404, Bloomington, IN, 47404, United States, ruthbeer@indiana.edu, Anyan Qi

Many manufacturers' projects (such as innovation and new product development) often involve tight collaboration with a key supplier. The success of such initiatives depends on both firms committing resources and generating high quality outputs. We study two ways in which a manufacturer can increase output observability (at a cost) in this setting: monitoring the supplier's progress and disclosing her own progress to the supplier.

■ WA49

361B

Behavioral Operations

Contributed Session

Chair: Sina Zare, University of Texas-Arlington, Arlington, TX, United States, sina.zare@uta.edu

1 - Suppliers Learning in Supply Chain Competition
Mohsen Ahmadian, University of Massachusetts-Boston, Boston, MA, United States, mohsen.ahmadian001@umb.edu, Ehsan Elahi, Roger H. Blake

Our research uses the results of laboratory experiments in which subjects playing the role of suppliers compete for the business of a buyer outsourcing the manufacture of a commodity product. These results show significant differences with predictions from theory, and our research uses the Quantal Response Equilibrium (QRE) to consider whether bounded rationality and learning effects can offer some explanation for these variances. By developing this model from the QRE framework, we will be able to evaluate learning effects and whether they vary under different scenarios of competition.

2 - CEO Scapegoating and Consumer Product Recalls
Kevin Mayo, Indiana University, 1309 E 10th Street, Bloomington, IN, 47405, United States, mayok@indiana.edu, George Ball, Alex Mills

Product recalls have significant impact to a firm's financial and legal standing as well as on consumer health and safety. In this study, we explore the relationship between CEO turnovers and product recalls. Do recalls lead to CEOs being fired or quitting? Do new CEOs scapegoat and blame problems on their predecessors by recalling soon after taking over? Using a recurrent hazard model with 40 years of consumer product recalls and CEO turnover data, we examine the hazard of a CEO turnover after a recall and a recall after a CEO turnover. Results support a recall scapegoating effect.

3 - Leadership, Social Preferences and Productivity: Evidence from Truck Drivers
Francisco Brahm, PhD Student, University of Cambridge, Trumpington 10, Cambridge, CB2 1AG, United Kingdom, fb435@cam.ac.uk

We explore how the traits of leaders affects team productivity in the context of 53 customer-delivery trucks where the driver leads a team of two/three helpers. We collect social preferences from lab-in-the-field behavioral games and personality traits from a big-five survey. We show that "generalized trust" and "altruism" improves daily performance across several measures of productivity and quality. In contrast, "trusting helpers" is detrimental, with Big five traits having negligible impact. We also show that going from employee-driver to owner-driver, and thus directly employing its helpers, increases performance, particularly if the driver is "altruistic" and "open to experience".

4 - Asymmetry and Sharing of Sales Information under Revenue Sharing Contract
Ummuhan Akbay, Visiting Instructor, Sabanci University, Istanbul, Turkey, ummuhana@sabanciuniv.edu

We study revenue sharing contract on a one manufacturer-one retailer supply chain under sales information asymmetry. The sales quantity to be disclosed to the manufacturer is determined by the retailer who has an opportunity to underreport. We investigate how the truth-telling behavior and ordering decisions of the retailer are affected by the contract parameters and the demand realization; how the manufacturer's contract parameters are affected by the possible distortion in the shared sales information; and how both firms' profits and the contract efficiency is affected in this scenario.

5 - Does Advance Warning Help Mitigate the Impact of Supply Chain Disruptions? An Experimental Investigation
Sourish Sarkar, Assistant Professor, Penn State-Erie, The Behrend College, 5500 Copper Dr, Apt 301, Erie, PA, 16509, United States, sourishs@gmail.com, Sanjay Kumar

We explored the impact of an advance warning of a disruption on supply chain performance. Using controlled laboratory settings, we considered disruptions at both upstream and downstream echelons. For each of these disruptions, scenarios with and without advance warning were compared. We also investigated the impact of communicating such warning to other echelons of the supply chain. We found a behavioral bias that results in worse performance in advance warning scenario for downstream disruptions.

6 - Gamified Newsvendor Experiment: the Impact of Leaderboards on Learning and Behavioral Biases
Sina Zare, University of Texas-Arlington, 1020 W. Abram, Apt 289, #103, Arlington, TX, 76013, United States, sina.zare@uta.edu

We present research examining how a gamified traditional Newsvendor experiment impacts individual's decision making performance. We hypothesized that a gamified Newsvendor experiment with leaderboards positively influence newsvendor's performance through improving learning process and mitigating the influence of behavioral biases.

■ WA50

361C

Shared Mobility Systems

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Neda Masoud, University of Michigan, Ann, MI, 48109, United States, nmasoud@umich.edu

1 - Stochastic Control of Traffic Flow to Manage Ride-Sharing Platform
Qi Luo, University of Michigan, 2465 Lancashire Drive, Apt 2A, Ann Arbor, MI, 48109, United States, luoqi@umich.edu, Romesh Saigal

We investigate the Ride-Sharing Platform management using a continuous-time continuous-space approach. A monopolistic principal matches two sides of the market, i.e. supply (vacant vehicles) and demand (customers' trip requests) dynamically. The supply model prevents the exponential growth of state space by adopting multi-population traffic flow theory. The demand side employs a queuing model. We further formulate the platform's problem as an optimal stochastic control to maximize the revenue by redistributing initial conditions. This simple formulation enables to incorporate myopic agents' local optimum decisions without treating combinatorial explosion.

2 - Ride-Matching in Large-Scale Transportation Networks
Neda Masoud, University of Michigan, 2350 Hayward St., 2124 GG Brow, Ann Arbor, MI, 48109, United States, nmasoud@umich.edu, Yuexi Tu

This study presents a divide-and-conquer algorithm for solving the ride-matching problem in a large-scale peer-to-peer ridesharing system. The complexity of the ride-matching problem grows with the number of riders, drivers, and the rider-driver pairs that are eligible to be matched. The divide and conquer algorithm divides the ride-matching problem into multiple smaller sub-problems of the same structure, and combines the solutions to these sub-problems to propose an approximation for the original problem.

3 - A Hub and Shuttle Transit System for Ann Arbor
Pascal Van Hentenryck, University of Michigan, 1813 IOE Building, 1205 Beal Avenue, Ann Arbor, MI, 48108-2117, United States, pvanhent@umich.edu, Antoine Legrain, Connor Riley

This talk describes a novel Hub and Shuttle Transit System for the Ann Arbor Campus of the University of Michigan (about 7.5 million passengers a year). The system addresses both congestion and the infamous first/last mile problem. The talk describes the design and implementation of the new transit system, simulation results, and early feedback from deployment.

4 - Matching Assignment Game for Mobility as a Service Transportation Assignment
Saeid Rasulkhani, New York University, 328 91st Street, Apt 2R, Brooklyn, NY, 11209, United States, sr4262@nyu.edu, Joseph Y.J. Chow

The emergence of more transportation options in smart cities requires more generalized transportation assignment models. We develop a transportation assignment model based on a route-based bipartite matching assignment game. For any mobility as a service operating design, we can determine not just the flow of travelers, but also the route service provision decisions of the operator(s) and cost allocations for all parties. Stability conditions under congestion are explored.

5 - Semi-door-to-door On-demand Transit System: Analytics and Practice
Hao Zhou, Ford Motor Company, 2101 Village Road, Dearborn, MI, 48124, United States, hzhou35@ford.com

We will discuss Ford's various ongoing efforts in shared mobility, in particular, semi-door-to-door on demand ride sharing service. In contrast to traditional on-demand transit system that provides customers' door-to-door rides, semi-door-to-door ride-sharing service dynamically clusters customers and thus have higher ride-sharing potential.

We will discuss various analytics aspects of such ride-sharing system, efficiency evaluation, demand forecasting, dynamic pricing, etc.

■ WA51

361D

Design and Planning of Ports

Sponsored: Transportation Science & Logistics

Sponsored Session

1 - A Framework for Building a Smart Port and Smart Port Index
Anahita Molavi, University of Houston, 4722 Calhoun Rd, E224, Engineering Bldg 2, Houston, TX, 77204-4007, United States, anahita.molavi@gmail.com, Gino J. Lim, Bruce Race

Globally, ports and harbors are facing stiffer competition for market share and delivering more effective and secure flow of goods. High performing ports are implementing smart technologies to better manage operations. We present a comprehensive literature review of the studies regarding Smart Port as a basis for a holistic definition for a Smart Port Index. The Smart Port Index in this paper is based on Key Performance Indicators and organized around four key elements: operations, environment, energy, and safety and security. Case studies and data analysis are used to test the KPIs to understand their characterization of the Smart Port performance of some busiest ports.

2 - Assessment of Container Port Efficiency using Data Envelopment Analysis

Sonal Jain, University of Houston, Houston, TX, 77204, United States, jsonal@gmail.com, Qianmei Feng

Maritime ports have become a major source of trade, with $900+ billion worth of goods moving in and out of United States by containers. Growing shipping capacity and severe congestion in American ports raises a concern on their state of efficiency. An assessment of relative efficiency of container ports can provide insight into a port's productivity and performance. This study applies the appropriate Data Envelopment Analysis (DEA) models to study changes in efficiency for 15 U.S. container ports. The relationships between inputs and outputs are examined using the available records since 2000.

3 - Modelling the Service Availability and Resource Allocation for Quay Crane Double Cycling via Closed Queuing Networks

Qingcheng Zeng, Dalian Maritime University, School of Transportation Management, Dalian, 116026, China, qzeng@dlmu.edu.cn, Xiaoju Zhang, Ping Wang

This paper addresses the resource allocation problem with quay crane double cycling in container terminals. The operation processes is formulated by closed queuing networks. A cost-minimizing optimization model is developed to obtain an optimal resource allocation schedule, and the objective function proves to have convex behaviour with one or two optimal solutions. The asymptotic results offer insight into the types of equipment that should be added to increase efficiency. The imbalances of service ability in each operation have a critical effect on equipment utilization and handling efficiency.

■ WA52

361E

Energy

Contributed Session

Chair: Stefan Feuerriegel, University of Freiburg, Freiburg, Germany, stefan.feuerriegel@is.uni-freiburg.de

1 - Design of Flexibility Portfolio to Facilitate Integration of High Shares of Renewable Energy in Europe

Violette Berge, Energy Analyst and Optimization Consultant, Artelys, Montreal, QC, Canada, violette.berge@artelys.com

By 2030, the share of fluctuating renewable power generation could attain 30%, following EU targets. This raises the need for additional flexibility to balance demand and supply at all times. Although system flexibility can be provided by various technologies, there is no "one-size-fits-all" solution at a national level and the optimal flexibility portfolio depends on the peculiarities of each country. In this context and using its powerful tool Artelys Crystal Super Grid, Artelys carried out a study for the EC that aimed at evaluating the national flexibility needs and the optimal flexibility portfolio of flexibility solutions at the Member State level to ensure a cost-effective RES integration.

2 - Two Level Distribution Network Planning Problem with Distance Limited Intermediate Facilities

Ayse Selin Kocaman, Assistant Professor, Bilkent University, Endustri Muhendisligi, Ankara, 06800, Turkey, selin.kocaman@bilkent.edu.tr, Kagan Gokbayrak

We introduce a new two-level network planning problem which might have wide applications in the planning of centralized energy and water distribution networks for greenfield development. The network connects demand points to a source point via intermediate facilities in the continuous space. The intermediate facilities reside a primary network that has a tree topology rooted at the source. The demand points are connected to the intermediate facilities with a secondary network in star topology rooted at each intermediate facility. The coverage distance limit on the intermediate facilities can be associated with physical loss constraints in energy or water distribution networks.

3 - A New Approach to the Operation of Micro Grids in Rural Areas

Jose-Ignacio Munoz-Hernandez, University of Castilla-La Mancha, Edifico Politecnico - UCLM, Avda Camilo Jose Cela, S/N, Ciudad Real, 13071, Spain, joseignacio.munoz@uclm.es, Luis Serrano-Gomez

Distribution networks in rural areas are characterized by high seasonal consumption and alterations in the quality of the supply, which affect both the availability of the service and the electrical components connected to it. Moreover, extinction of the feed-in-tariff for renewable energy is generating uncertainty that is leading towards new solutions for maximizing the operating account. This work analyzes the possibility of establishing a new operating model for isolated micro grids, in rural areas, powered by renewable energy sources.

4 - Applying a Game Theory Approach for a Dynamic Energy Bilateral Contract Scheduling

Reinaldo Crispiniano Garcia, Associate Professor, University of Brasilia - UnB, SQS.403, BLOCO.R, APT. 106, Brasilia, 70237-180, Brazil, rcgar@yahoo.com, Javier Contreras, Janiele Custodio, Felipe Toledo, Paulo Vinicius Da Cunha, Matheus Barbosa

In deregulated electricity markets, contract parties (buyers and sellers) aim to deliver electricity in time intervals during the contract period to obtain the highest possible profits. The parties can operate in spot and retail energy markets. Since this problem includes different parties trying to maximize their own profit, a game theory approach is implemented for the contract settlement. A numerical example shows the properties of this optimization problem for contract scheduling. Moreover, the contract value and the contract volumes are determined to maximize the returns of the involved parties.

5 - Minimization of Investment Costs for Designing Electricity Distribution Networks

Stefan Feuerriegel, University of Freiburg, Platz der alten Synagoge, Freiburg, 79098, Germany, stefan.feuerriegel@is.uni-freiburg.de, Alexander Schlüter, Gunther Gust, Dirk G. Neumann

We minimize the investment costs for constructing or extending electricity distribution networks, that supply electricity to neighborhoods, while complying with physical constraints. This problem encompasses the optimization of both locations and capacities of conductor lines and is, thus, an extension of the NP-hard capacitated shortest spanning arborescence problem. For this reason, we propose a heuristic that decomposes the problem: it first identifies the network layout and then decides upon capacities, followed by a variable neighborhood search. Its performance is detailed in a real-world case study.

■ WA53

361F

Dynamic and Stochastic Routing and Scheduling

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Debdatta Sinha Roy, University of Maryland, 7699 Mowatt Lane, 3330 Van Munching Hall, College Park, MD, 20742, United States, debsroy@rhsmith.umd.edu

1 - An Exact Approach for the Vehicle Routing Problem with Time Windows and Flexible Delivery Locations

Alexander Döge, Technical University of Munich, Munich, Germany, alexander.doege@tum.de, Markus Frey, Rainer Kolisch, Guy Desaulniers

We present an extension of the vehicle routing problem (VRP): the VRP with time windows and flexible delivery locations (VRPTW-FL). In the VRPTW-FL, a customer is no longer automatically assigned to a service location. Instead, one of a set of potential service locations has to be chosen, each of which has a specific capacity. In order to solve the VRPTW-FL, we develop a branch-and-price-and-cut algorithm. In our economic analysis, we assess the benefit of location flexibility on a variety of performance metrics.

2 - Multiple Plan Approach for the Dynamic Team Orienteering Problem

Emre Kirac, Assistant Professor, University of Houston-Clear Lake, 2700 Bay Area Blvd., MC41, Houston, TX, 77058, United States, kirac@uhcl.edu, Ashlea Milburn

In this study, we introduce a new dynamic routing problem, namely the Dynamic Team Orienteering Problem (DTOP) in which some customers are known a priori while others are dynamic, each associated with a profit. The goal is to maximize the sum of collected profits by visiting a set of customer locations within a time limit. This problem arises in several practical applications such as disaster relief, technician, tourist and school bus routing problems. We adapt a Multiple Plan Approach (MPA) to solve the proposed problem. A total of 1161 new DTOP benchmark instances are introduced and solved.

3 - Simulation-based Learning for Dynamic Time Window Allocation in Attended Home Deliveries

Magdalena A.K. Lang, Research Assistant, RWTH Aachen University, Kackertstraße 7, Aachen, 52072, Germany, magdalena.lang@ada.rwth-aachen.de, Catherine Cleophas, Jan Fabian Ehmke

Allocating time slots to attended home delivery requests affects providers' delivery costs and future acceptable orders. As the travel time per order depends on the complete routing, revenue management controls face the challenge of undetermined capacity consumption on request arrival. Vehicle routing can approximate travel time but does not anticipate customer choice and future controls. Our simulation-based learning approach approximates the opportunity costs of delivery time slot allocation. It informs dynamic allocation decisions when requests arrive. We present results of a computational study.

4 - Models and Algorithms for the Traveling Salesman Problem with Time-dependent Service Times

Paolo Toth, Professor, University of Bologna, DEI, Viale Risorgimento 2, Bologna, I-40136, Italy, paolo.toth@unibo.it, Valentina Cacchiani, Carlos Contreras Bolton

We consider the "Traveling Salesman Problem with time-dependent Service Times" (TSPST), a variant of the classical Asymmetric TSP. In the TSPST, each customer requires a service time whose duration depends on the time at which the customer is visited. The TSPST calls for finding a Hamiltonian circuit minimizing the total duration of the circuit (i.e. the sum of the travel times and of the service times). A branch-and-cut algorithm and a metaheuristic are proposed. Computational experiments on benchmark TSPST instances are reported, showing the effectiveness of the proposed algorithms.

5 - Addressing Uncertainty in Meter Reading for Utility Companies using RFID Technology

Debdatta Sinha Roy, PhD Candidate, Robert H. Smith School of Business, University of Maryland, 7699 Mowatt Lane, 3330 Van Munching Hall, College Park, MD, 20742, United States, debsroy@rhsmith.umd.edu, Bruce L. Golden, Edward Andrew Wasil

Utility companies collect usage data from meters on a regular basis. It is done automatically using radio-frequency identification (RFID) technology. Each meter has a signal transmitter that is read by a receiver within a specified distance. It is a Close Enough Vehicle Routing Problem (CEVRP) on a street network. In practice, there is uncertainty while reading meters. The signal transmitted by an RFID tag is discontinuous and each meter differs with respect to the specified distance. These factors can lead to missed reads. We address this uncertainty using Bayesian statistics and data analytics and perform simulation experiments to show that we design improved routes for the vehicles.

■ WA54

362A

Simulation

Contributed Session

Chair: Xianyong Wang, Clemson University, Clemson, SC, United States, xianyon@clemson.edu

1 - Models for Merging Fire and Emergency Medical Units

Cheng Hua, Yale School of Management, Yale School of Management, P.O. Box 208200, New Haven, CT, 06520-8200, United States, cheng.hua@yale.edu, Arthur J.Swersey, Fernando Y. Chiyoshi, Ana Paula Iannoni, Arthur J. Swersey

We consider an innovative emergency service spatial queuing system in which there are crossed trained personnel assigned to fire-medic units that respond to fire alarms or emergency medical calls. A fire-medic unit may be in one of three states: available, busy at a fire incident, or busy at an emergency medical call. To make the problem computationally tractable for typical real-world systems, we devise an approximation that solves two 2-states systems to determine steady state probabilities and performance measures and discuss its application in St. Paul, Minn. The model includes both fire-medic units and separate fire and emergency medical units.

2 - Antecedents of Service Provision by Manufacturing Firms

Sina Golara, Doctoral Candidate, Arizona State University, 1249 East Spence Avenue, Apt 336, Tempe, AZ, 85281, United States, sgolara@asu.edu, Nasim Mousavi, Kevin Dooley

This paper empirically investigates the drivers of servitization by manufacturing firms. We suggest that the extant diversification theory does not completely explain servitization. We study a sample of 2450 public manufacturing firms for the period of 1976 to 2006. We find that firms in industries characterized with high technology or firms in their earlier life cycle stage offer a higher level of service. We also demonstrate that a larger market share and larger stock of proprietary knowledge encourage manufacturers to introduce more services.

3 - Service Failure Recovery Strategies from the Consumer Perspective

Ahasan Harun, PhD Student, University of North Texas, 316 Fry Str,eet Apt 203, Denton, TX, 76201, United States, MdAhasanUddin.Harun@unt.edu, Md Rokonuzzaman, Victor R. Prybutok

This research develops and tests a model about consumer positive word of mouth intention after service failure. Antecedents such as service recovery strategies, recovery evaluation, and justice perception are evaluated in the context of the proposed theoretical framework. In addition to identifying the factors, we develop a survey to measure effective means to overcome service failure in a real situation. This approach overcomes the shortcomings of the currently predominant scenario-based survey research.

4 - Sharing Economy: A Literature Review and Directions for Future Research

Xianyong Wang, Student, Clemson University, 100 Sirrine Hall, Clemson, SC, 29634, United States, xianyon@clemson.edu

This paper aims to examine both empirical and theoretical studies published in leading business journals regarding sharing economy and hopes to provide a better understanding of its scope, business models, operations strategies, and its impacts on well-established industries. This paper also presents a theoretical framework to explore the potential directions for future research.

■ WA55

362B

Economics

Contributed Session

Chair: Jing Xu, University of Pennsylvania, Philadelphia, PA, United States, xjing@sas.upenn.edu

1 - Multidimensional Bayesian Persuasion

Youzong Xu, Xi'an Jiaotong-Liverpool University, 111 Ren'ai Road, Business Building 423B, Suzhou, 215123, China, xu.youzong@wustl.edu

This paper studies a Bayesian persuasion game on a multidimensional state and action space. We characterize Sender's optimal persuasion strategies and show that, when the conflict between Sender and Decision Maker is not very large, Sender benefits more from using a signaling system that provides correlated information for different dimensions of the state. When the conflict between Sender and Decision Maker is large, Sender benefits more from using a signaling system that provides independent information for different dimensions of the state. Regardless what signaling system that Sender uses, Decision Maker's welfare is not affected by Sender's persuasion.

2 - Dynamic Duopolistic Competition with Sticky Prices under Uncertainty

Luca Colombo, Deakin University, Melbourne Burwood Campus, 221 Burwood Hwy, Melbourne, VIC 3125, Australia, luca.colombo@deakin.edu.au, Paola Labrecciosa

We extend Fershtman and Kamien (Econometrica, 1987) to a stochastic environment. We study a differential game where two quantity-setting firms compete over an infinite time horizon under the assumption that the market price does not adjust instantaneously to the level specified by its demand function and is subject to stochastic fluctuations (governed by a Wiener process). We derive analytically the closed-loop (feedback) equilibrium strategies and the evolution path of the expected price. We show that demand uncertainty is pro (anti) competitive if market size is relatively small (large).

3 - Stackelberg Leadership in a Productive Asset Oligopoly

Paola Labrecciosa, Monash University, Department of Economics, Clayton Campus, Wellington Road, Melbourne, VIC 3800, Australia, paola.labrecciosa@monash.edu, Luca Colombo

We study a differential oligopoly game where m Stackelberg leaders and n-m Stackelberg followers are engaged in the exploitation of a common-pool renewable resource over an infinite time horizon. At each point in time, firms sell their harvest in the marketplace at a price that depends on total harvest. We derive a multiple-leader feedback Stackelberg equilibrium and proceed with a comparative dynamics analysis w.r.t. various parameters of interest. We also compare and contrast the multiple-leader feedback Stackelberg equilibrium with the Cournot equilibrium and obtain a number of novel results on the relative efficiency of the two equilibria.

4 - Network Externalities in a Buyer-seller Search Platform

Jing Xu, University of Pennsylvania, 209 S 33rd Street, Math Dept, Philadelphia, PA, 19104, United States, xjing@sas.upenn.edu

I model a setting where buyers search for sellers directly or through a platform with lower search costs, and the platform charges both sides for the transactions it facilitates. Equilibrium strategies are determined by two coexisting positive and negative cross-group externalities: (i) while buyers appreciate more choices of available sellers on the platform, (ii) increasing the number of available sellers makes the search for low-priced and high-value sellers harder due to an unfavorable price dispersion. A platform optimally adopts a threshold strategy of targeting sellers with lower prices to balance the competing externalities.

■ WA56

362C

Logistics

Contributed Session

Chair: Yujiao Sun, Dalian University of Technology, Dalian, China, sunyujiao@126.com

1 - Quintessence of Third Party (3PL) Logistics

Tuhin Sengupta, Indian Institute of Management-Indore, Rau-Pithampur Road, Indore, 453331, India, f13tuhins@iimidr.ac.in, Sudipendra Nath Roy

In this article, we provide a systematic literature review and contribute to academic understanding and practitioner needs of third party logistics (3PL) which had been developed over the last decade. Practical relevance of our study stems from mapping managerial perspectives to the academic body of knowledge. We made a sincere attempt to link our review with previous literature reviews for keeping the knowledge continuum intact from the genesis of 3PL. The paper also identifies different research gaps; conceptual, contextual and methodological, which will facilitate understanding and aid to identify opportunities for future research in 3PL context.

2 - Studying the Tradeoff Between Police Presence and Response Time

Fatemeh Mousapour, University at Buffalo, 338 Bell Hall, Buffalo, NY, 14260, United States, fmousapo@buffalo.edu, Jose Luis Walteros, Rajan Batta

Rapid response time and adequate coverage are two key factors in police patrol problems respectively to stop, deter and prevent a crime. Our approach is to integrate the hypercube queueing model with a coverage objective to examine the tradeoff between police presence and response time in the context of server cooperation. Computational results are presented based on case study used by other researchers from Northern Israel.

3 - Optimization of NGL Rail Car Distribution

Robert A.Russell, Professor of Operations Management, University of Tulsa, Finance & Operations Mgmt Dept, 800 South Tucker Drive, Tulsa, OK, 74104, United States, rrussell@utulsa.edu

A goal programming network model is developed to optimize the allocation and distribution of NGL rail cars from production plants to supply terminals over a one year planning horizon. Key factors include contracted purchase amounts, distributions costs, tiered terminal storage capacities, and NGL future prices.

4 - A Two-stage Close-loop Queueing Network with Different Sizes of Workload and Service Rates

Yujiao Sun, Dalian University of Technology, Ganjingzi District, 2 Linggong Road, Dalian, China, sunyujiao@126.com, Ping Wang, Qingcheng Zeng, Xiangpei Hu

We model an intermodal logistics hub as a two-stage close-loop network with one server at one stage, and two servers at the other with different sizes of workload and service rates. We argue the existence of an optimal number of customers regarding the system utilization rate. Case-based numerical results justify the relationships between the number of customers and utilization rate.

■ WA57

362D

Scheduling

Contributed Session

Chair: Yuping Lin, Tsinghua-Berkeley Shenzhen Institute, Tsinghua University, Shenzhen, China, linyuping@berkeley.edu

1 - A Branch-and-price Algorithm for Solving Bi-criteria Batch Scheduling Problems in Hybrid Flow Shops

Rasaratnam Logendran, Professor, Oregon State University, School of Mech Industrial & Mfgr. Engr., Rogers Hall Rm 204, Corvallis, OR, 97331-6001, United States, logen.logendran@oregonstate.edu, Omid Shahvari

We address a batching and scheduling problem consisting of several jobs belonging to pre-determined groups as inconsistent batches with respect to desired lower bounds on batch sizes in hybrid flow shops. The objective is to simultaneously minimize the total weighted completion time and total weighted tardiness of jobs. By implementing an efficient MILP model, the optimal solution or good quality lower bound of medium- and large-size problems is established with a Branch-and-Price algorithm based on Dantzig-Wolfe-Decomposition.

2 - Research on New Techniques for Multi-project Scheduling

David Poza, INSISOC - University of Valladolid, Paseo del Cauce, 59, Valladolid, 47011, Spain, poza@insisoc.org, Felix Villafañez, Javier Pajares, Adolfo López-Paredes

Very few software tools for project scheduling support multi-project resource leveling, which is an essential feature in order to obtain a feasible schedule when resources are shared between several projects. We compare the results yielded by well-known commercial scheduling software with those of the newest algorithms proposed by the latest research on this topic. We claim that these achievements in the field of Operations Research should be incorporated in commercial software in the interest of small and medium enterprises.

3 - Integrated Staff Scheduling at a Medical Emergency Service: An Optimization Approach

Hendrik Vermuyten, PhD Student, KU. Leuven, Warmoesberg 26, Brussel, 2800, Belgium, hendrik.vermuyten@kuleuven.be Hendrik Vermuyten, PhD Student, Universidade de Lisboa, Av. Rovisco Pais 1, Lisbon, 1049-001, Portugal, hendrik.vermuyten@kuleuven.be, Joana Namorado Rosa, Ines Marques, Ana Barbosa-Póvoa

In this article, we study a real-life personnel scheduling problem at the Portuguese National Institute for Medical Emergencies (INEM). We develop a column generation-based diving heuristic to solve our problem. Two column generation schemes and two branching methods are compared. While a commercial IP solver does not succeed in finding a reasonably good solution within an acceptable time, our method succeeds in finding a much better solution in a relatively short amount of time.

4 - Dynamic Airline Scheduling with Multiple Runways while Considering Separation Time Between Sequential Actions

Sheida Gohari, Research Graduate Assistant, SUNY at Binghampton, 4400 Vestal Parkway East,, Binghamton, NY, 13902, United States, gohari.sheyda@gmail.com, Sarah S. Lam

Increasing demand of aircraft travels has encouraged the airline industries to focus more on the optimization of airline scheduling. This research addresses airline scheduling while avoiding aircraft collusions and considering the separation time between two sequential actions. The objective is to minimize the earliness and tardiness costs dynamically in a multiple-runways system. Mathematical programming and agent-based models are developed for this research problem. The results will be compared with existing approaches in the literature.

5 - Comparison of Various Workforce Policies for Retail Store Workforce Scheduling Problem

Peeyush Pandey, Assitant Professor, Indian Institute of Management-Rohtak, Rohtak, 124001, India, f12peeyushp@iimidr.ac.in, Hasmukh Gajjar, Bhavin J. Shah

We generate different workforce demand patterns for a retail store traffic to compare various workforce policies. In particular, we analyse full time workforce, working time account, overtime, and hybrid (mix of full time and part time workers) workforce policies from retailer's perspective.

6 - Electric Bus Scheduling Problem with the Sizing of Bus Charging Station

Yuping Lin, Tsinghua-Berkeley Shenzhen Institute, Tsinghua University, Shenzhen, China, linyuping@berkeley.edu Yuping Lin, Industrial Engineering and Operations Research Department, UC Berkeley, Berkeley, CA, United States, linyuping@berkeley.edu, Max Shen, Max Shen, Max Shen, Kai Zhang, Lixin Miao

Besides operation timetable, electric bus scheduling problem needs to take charging time and limited driving range into consideration to schedule operation trips and charging for each bus. On the other hand, supporting charging infrastructure is required in the electric bus system. The original bus scheduling optimization without considering charging facility utilization will result in high charging facility cost. Combining bus scheduling problem with the sizing of charging station, the objective is to balance the number of electric buses and charging piles needed to minimize their total cost and a mixed integer programming is formulated.

■ WA58

362E

Facility Location I

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Trevor S Hale, University of Houston-Downtown, One Main Street, Houston, TX, 77002, United States, halet@uhd.edu

1 - Dynamic Ambulance Location with Time-dependent Parameters: A Two-stage Stochastic Programming

Chun Peng, PhD Candidate, Beijing Institute of Technology, Haidian District, 5 South Street, Beijing, 100081, China, pengchun12.18@163.com
Chun Peng, PhD Candidate, HEC Montreal, Montreal, QC, H3T.2A7, Canada, pengchun12.18@163.com

In this paper, we highlight a novel two-stage stochastic programming framework that accounts for stochastic nature of emergency demand and time-dependent parameters for multi-period ambulance location. Besides minimizing total cost, we embed chance constraint in the recourse to guarantee a reliable coverage level. Furthermore, we present another stochastic model with generalized chance constraint that forcing violated probability over all possible level, to make a trade-off between coverage and cost management. An enhanced decomposition scheme is developed for the large-scale MIPs. Finally, a real-life case study is conducted and some managerial insights are drawn for EMS managers.

2 - Mathematical Programming Approaches for Facility Location Problems with Neighborhoods

Victor Blanco, University of Granada, Dpt. Quant. Meth. Economics & Business, Fac. Ciencias Economicas y Empresariales, Granada, 18011, Spain, vblanco@ugr.es

We introduce a new version of the classical p-median facility location problem in which it is assumed that the exact position of the potential facilities is unknown. Instead, assuming that the facilities are embedded in $\mathbb{R}^d$, the open facilities are required to belong to a region around their initial estimated positions: the neighborhoods. Two decisions have to be made: (1) determinate the open facilities; and (2) compute of the positions of them into their neighborhoods, at global minimum cost. We present several MINLP formulations for ordered median location problems and describe two math-heuristic approaches that allow us to solve larger instances at smaller CPU times.

3 - Population-based Metaheuristics for Fairer Facility Location

Christopher M. Rump, Applied Statistics and Operations Research, Bowling Green State University, 344 Business Administration Building, Bowling Green, OH, 43403-0267, United States, cmrump@bgsu.edu, Cameron R.King, Robert Green

We study complements to classic facility location problems on a discrete network. These complementary problems provide fairer solutions for decision makers seeking to consider the impact beyond extremal focus on either one (center) or all (median) customers. However, solving these problems is more computationally demanding than their well-known counterparts as they lose the incentive that customers should travel to the closest open facility. We employ two meta-heuristics, particle swarm optimization and adaptive large neighborhood search, to find good solutions to these intractable problems.

4 - A Graph Theoretic Approach to the Location Allocation Problem on a Network

Trevor S.Hale, Professor, University of Houston - Downtown, One Main Street, Houston, TX, 77002, United States, halet@uhd.edu, Ryan Pepper, Michelle Hutnik, Faizul Huq

Building upon previous research that developed graph-theoretic solutions for the location-allocation problem on a path, this research constructs graph-theoretic solutions for the location-allocation problem on cycles, stars, and complete graphs. This knowledge is then leveraged to help predict solutions for more general graphs. Some avenues of future research are also delineated.

■ WA59

362F

Aviation Applications

Contributed Session

Chair: Daniel Felipe Otero, Universidad de los Andes, Bogotá, Cundinamarca, Colombia, otero.df@uniandes.edu.co

1 - Airline Cargo Business Efficiency Measurement using DEA_PCA

Hossein Najmi, University of North Texas, Denton, TX, 76203-5017, United States, hossein.najmi@unt.edu, Seock-Jin Hong

In this study, we show that air cargo growth rate is declining. In addition, a negative relationship exists between the cargo business ratio and airline's efficiency in airlines, which serve passengers and cargo (combination carriers) using exclusive freighter from 2008 to 2015. The authors suggest that combination carriers should assist their customers in positioning air cargo capability as part of their integrated supply chain strategies. Such effort will help air cargo avoid commoditization.

2 - An Airport Task Assignment Problem with Travel Time and Purity Consideration

Fan Xiao, Ms, Tongji University, Zhangwu Rd 1, Tongji Building A, 1913, Shanghai, 200092, China, 892225786@qq.com, Zhe Liang

We study an airport task assignment problem with travel time and purity consideration, which is to assign a list of airport tasks to a set of shifts designed for airport personnel, so that the total operation cost is minimized. There are two major differences between the problem studied in this paper and the traditional assignment problem. First, we consider the travel time between different tasks, so it is not only to determine the assignment of the tasks, but also the routing between different tasks. The second is to consider shift purity in this problem, i.e., to limit the number of task types/qualifications in each shift. We propose a column generation algorithm to solve the problem efficiently.

3 - Flight Outsourcing to Regional Airlines

Soheil Sibdari, Associate Professor, University of Massachusetts Dartmouth, 1933 Commonwealth Avenue, Unit 408, Boston, MA, 02135, United States, ssibdari@umassd.edu, Farbod Farhadi

In this paper we address the reasons behind outsourcing flights to regional airlines. We show how outsourcing improves airline operations by adjusting their capacity. We also study the competitive effects of flight outsourcing on the U.S. domestic airline market.

4 - Sustainable Hub Location Model under Uncertainty in Aviation Industry

Suresh Kumar Jakhar, Assistant Professor, Indian Institute of Management Lucknow, Lucknow, 226013, India, skj@iiml.ac.in, Himanshu Rathore, Devendra Singh

Literature on Sustainable Hub Location models (SHLP) is limited because of their computational complexity and multidimensional nature (Mohammadi et al. 2014). We propose a realistic SHLP model in aviation industry by using chance constraint programming nested in queuing theory (M/D/s) to incorporate noise pollution and GHG emissions during the entire landing and take-off cycle of the aircraft. It determines a sustainable network strategy. To solve the NP hard formulation, we propose a methodology based on Fireworks metaheuristic algorithm embedded in Benders decomposition approach.

5 - A Stochastic Optimization Model for Fleet Assignment under Uncertainty Conditions

Daniel Felipe Otero, Instructor, Universidad de los Andes, Cr 1 este #19 A.40, Bogotá, Cundinamarca, Colombia, otero.df@uniandes.edu.co, Edwin Camilo Quiroga Gomez, Andres Medaglia

The variability in operational times has a great impact on aircraft scheduling. This work analyzes fleet assignment, considering the stochastic behavior of operational times. To solve the Fleet Assignment Problem (FAP), we propose a stabilized column generation problem, applying a set of specialized auxiliary shortest path models, based on lineal and dynamic programming (k-Shortest Path Problem with Resource Constraint - SPPRC). Finally, employing a Monte Carlo simulation, the On - Time Performance (OTP) of the fleet assignment is evaluated in specific scenarios.

■ WA60

370A

Approaches to Teaching Operations Management

Sponsored: INFORMEd

Sponsored Session

Chair: Dorothy Klotz, Fordham Univeristy, 140 West 62nd Street, New York City, NY, 10023, United States, klotz@fordham.edu

1 - Building the Complete Operations Management Course Around a Web-based Simulation Game

Ardavan Asef-Vaziri, Professor, College of Business and Economics, Dept of Systems and Operations MGMT, 18111 Nordhoff Street, Northridge, CA, 91330-8378, United States, aa2035@csun.edu

We describe how a simulation game can be implemented as a bridge interfacing the concepts, techniques, and procedures thought in an OM course and real-world applications. Students examine their theoretical take-away in a pseudo-real-life environment. Our experience shows that after playing these games, the students realize that understanding the course material plays a significant role in their performance in real-life applications.

2 - Case Study: Challenges in Assembly Line Design
Balaraman Rajan, Assistant Professor, California State University East Bay, 25800 Carlos Bee Blvd, Hayward, CA, 94542, United States, balaraman.rajan@csueastbay.edu, Ravichandran Narasimhan

In this case study we discuss the production plan of two different assembly lines and how the activities can be reorganized to meet an increase in demand. The case can be used for teaching topics in operations and supply chain management at both undergraduate and graduate level. The first part of the case focuses on topics including capacity and bottleneck analysis, line balancing, and capacity requirement analysis. The second part of the case involves Just In Time manufacturing and developing a production plan. The case also demonstrates the usefulness of process flow and precedence diagrams.

3 - A Simulation Companion for 'the Goal" Match/Dice Game
Tom Brady, Purdue University, 1401 S US.Hwy 421, Westville, IN, 46391, United States, tbradyjr@pnw.edu

Since its release in 1986, The GOAL has become the seminal book in Operations Management. One of the most oft-cited passages of the book is the Boy Scout camping trip where the main concept of the book, statistical fluctuations and dependent events are introduced through a simple match/dice game. While simple in concept, most people who read the book do not get the full understanding of the concepts. I have used a physical and computer-based simulation of this game at the undergraduate, graduate, and executive levels and have seen the level of understanding greatly improved. The simulation has allowed many embellishments to be added to the simple game that extend the learning concepts in many directions.

4 - A Best Practice Approach for a Hybrid Delivery of an Undergraduate Operations Management Course
Dorothy Klotz, Professor of Management Systems, Fordham Univeristy, 140 West 62nd Street, New York City, NY, 10023, United States, klotz@fordham.edu

The modular design of both the course and the learning materials facilitated the successful transition of quantitative content online while reserving classroom time for active learning exercises. Online technologies were used to pace student learning and maintain student accountability. This approach not only resulted in a dramatic reduction in student seat time, but also resulted in improved learning outcomes.

■ WA61

370B

Finance, Portfolio Analysis

Contributed Session

Chair: Xiaoling Mei, Xiamen University, Xiamen, Fujian, China, meilingluck@gmail.com

1 - Bayesian Dynamic Linear Models for Strategic Asset Allocation
Jared D.Fisher, University of Texas, 2110 Speedway Stop B6500, Austin, TX, 78712, United States, jared.fisher@phd.mccombs.utexas.edu, Carlos Carvalho, Davide Pettenuzzo

We find statistical and economic evidence of the predictability of risk premia for multiple risky assets. We present a unifying model that accounts for parameter uncertainty, stochastic volatility, and time-varying parameters through a Bayesian dynamic linear model framework with variance discounting. To account for model uncertainty, we average over many potential models of different combinations of predictors and discount factors. For an investor allocating his wealth between a risk-free asset, stocks, and bonds with maturities from 2 to 10 years, we demonstrate an ensemble of features that is preferable to others, including the models assumed by the efficient markets hypothesis.

2 - The Curious Case of Negative Volatility
Christoph Merkle, Associate Professor, Kuehne Logistics University, Grosser Grasbrook 17, Hamburg, 20457, Germany, christoph.merkle@the-klu.org

Investors mostly perceive their own portfolio as no more volatile than the market portfolio. Taking into account observed portfolio betas, this implies a belief in very low idiosyncratic portfolio volatility, which is even negative for a considerable fraction of the population. Possible explanations are extreme overconfidence in combination with a misunderstanding how market and portfolio volatility are related. The identified bias strongly contributes to underdiversification, as a belief in negative idiosyncratic volatility conceals the benefit of diversification.

3 - Optimal Pairs Trading with Dynamic Mean-variance
Dongmei Zhu, Southeast University, Nanjing, China, dongmeizhu2013@126.com

Pairs trading strategy has been popularly adopted by hedge funds.In this paper, we investigate optimal pairs trading strategies for dynamic trading problems.The price difference of a pair of securities is modeled by an Ornstein-Uhlenbeck (OU) process.We study and formulate the mean-variance (MV) portfolio problem and the optimization problem is solved dynamically by utilizing the purely-buy-and-sell-securities strategy.We extend the results to optimally allocate money in pairs of securities and riskless asset and transform the primal optimization problem into a quadratic optimization problem with a closed-form solution.

4 - Using Social Media Sentiment in Automatic Portfolio Rebalancing
Jing-Rung Yu, National Chi-Nan University, Nantou, Taiwan, jingrungyu@gmail.com, Wan-Jiun Paul Chiou, Cing-Hung Hung, Wen-Kuei Dong, Yi-Hsuan Chang

Studies have documented the impact of the social media on stock pricing. We analyze sentiments by applying the Stock Market Lexicon to quantify the posted opinions in the Twitter combining with various portfolio models to construct optimal asset allocation. Using the daily returns and the tweets of the component stocks in S&P 500 Index during July 1, 2016 to January 31, 2017, we rebalance portfolio by identifying the 10 most tweeted stocks in previous three days. The empirical results show the dynamic rebalancing portfolios incorporating social media opinions outperform the fixed rebalancing portfolios in various measures.

■ WA62

370C

Reliability

Contributed Session

Chair: Hung Do, University of Vermont, Burlington, VT, United States, hdo@uvm.edu

1 - Performance Analysis of Finite Production Run-based Manufacturing
Liang Zhang, University of Connecticut, 371 Fairfield Way, Unit 4157, Storrs, CT, 06269, United States, liang@engr.uconn.edu, Zhiyang Jia

Many manufacturing systems operate under finite production runs. In such systems, a certain number of products (e.g., a customer order) are entered into the system. The in-process buffers are typically empty when a production run starts. This leads to transient period to build up the throughput and inventory during the process. One of the key problems for such systems is to calculate the performance of the system while completing such a production run. In this abstract, we discuss analytical and approximate methods to accomplish this.

2 - Management of a Shared Spectrum Network in Wireless Communications – A Queueing Approach
Shining Wu, Assistant Professor, The Hong Kong Polytechnic University, LMS.Dept, Hong Kong, 999077, Hong Kong, sn.wu@polyu.edu.hk, Jiheng Zhang, Rachel Q. Zhang

We consider a band of the electromagnetic spectrum with a finite number of identical channels shared by both licensed and unlicensed users. Such a network differs from most many-server, two-class queues in service systems including call centers due to the restrictions imposed on the unlicensed users in order to limit interference to the licensed users. We first approximate the key performance indicators under the asymptotic regime and then study the optimal sharing decisions of the system to maximize the system throughput rate while maintaining the delay probability of the licensed users below a certain level. Our analysis reveals a number of distinctive properties of the system.

3 - Online Priority Service Pricing with Heterogeneous Customers
Ping Cao, University of Science and Technology of China, University of Science and Technology of China, Hefei, 230026, China, pcao@ustc.edu.cn, Jingui Xie, Yaolei Wang

Consider a service system with a single server and two queues (i.e., the VIP queue and the ordinary queue), in which the server gives priority to the VIP queue. Customers are heterogeneous in their waiting cost rate, the distribution of which is unknown. If the arriving customer joins the VIP queue, he will be charged a fee K. The service system's objective is to maximize his long-run average profit by setting the additional fee. We find that there might be multiple equilibria of customers' chosen behavior under a fixed fee and the system can always reach the largest equilibrium by setting a proper initial delay announcement. Later, we use an online optimization method to find the optimal charged fee.

4 - New Perspective on Performance Measurement in Multi-server Queuing Systems
Hung Tuan Do, University of Vermont, 55 Colchester Avenue, 207 Kalkin Hall, Burlington, VT, 05405, United States, hdo@uvm.edu, Masha Shunko, Alan Scheller-Wolf

In some service systems, performance in the right tail of the queue size and/or waiting time distribution is the main source of managerial concern. We propose a new perspective on analyzing performance of such systems by defining new stochastic orders to compare the tail of distributions and performance measures based on these orders. We also propose a class of control policies that guarantee Pareto improvement based on the newly dened measures.

■ WA63

370D

Inventory Management in Vehicle Routing

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Ingrid Marcela Monroy Licht, McMaster University, 2685 Kent Avenue, Apt 201, Montreal, QC, H3S 1M8, Canada, marcela.monroy@polymtl.ca

1 - Predictive Analytics and Routing Optimization for an Urban Food Delivery Service

Alexander Hess, Research Assistant, WHU. - Otto Beisheim School of Management, Burgplatz 2, Vallendar, 56179, Germany, alexander.hess@whu.edu

This talk illustrates the application of predictive analytics in conjunction with vehicle routing for an urban food delivery service. In particular, we show how an improved routing decreases the waiting time for the customers. Further, the ETAs for each delivery can be given with greater accuracy.

2 - Dynamic Inventory Routing Problem with Traffic Congestions

Gitae Kim, Hanbat National University, Dept. of Industrial Management Engineering, School of Engineering, Daejeon, 34158, Korea, Republic of, gitaekimemail@gmail.com

Vehicle routing problem (VRP) is a complex problem in operations research. When VRP combines with inventory problem, the complexity increases. The combined problem, so called inventory routing problem (IRP), has been studied in recent decades. Like other problems, there are uncertainties in IRP. To cope with uncertain or dynamic situations, dynamic or stochastic IRP has to be considered. However, most studies for stochastic IRP assume that the demand is stochastic. In dynamic VRP, traffic congestion plays an important role for dynamic conditions. Thus, we suggest a stochastic and dynamic IRP model with traffic congestions. We also provide a solution method and numerical results for the problem.

3 - Inventory Routing Problem with Returnable Containers

Ingrid Marcela Monroy Licht, Postdoctoral Fellow, McMaster University, Michael G. DeGroote School of Business, Hamilton, ON, ONL8S, Canada, lichti@mcmaster.ca, Kai Huang

We present a problem inspired by the gas supply industry where a company provides customers with filled containers in a finite period. Over the days, the customers release the containers; therefore empty containers are accumulated on customer sites depending on the rate consumption. The containers belong to the company; consequently the empty containers should be collected at customers to re-use. This case is modeled as an inventory routing problem with additional considerations. The supplier carries routing and inventory cost, while satisfies the periodic demands of his customers. A branch and price algorithm is proposed to solve the problem. Some computational experiments are analyzed.

■ WA65

370F

Routing Problems

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Ali Ekici, Ozyegin University, Endustri Muhendisligi Bolumu, Nisantepe Mahallesi Ormak Sokak No:13, Istanbul, na, Turkey, aliekici@gmail.com

1 - Dynamic Vehicle Routing Problem with Roaming Delivery Locations

Gizem Ozbaygin, PhD Candidate, Bilkent University, Dept. of Industrial Engineering, Ankara, Turkey, ozbaygin@bilkent.edu.tr, Martin W. P.Savelsbergh

Motivated by the increasing interest in trunk delivery applications, we study the vehicle routing problem with roaming delivery locations (VRPRDL) in a dynamic setting where there may be deviations from original customer itineraries. We propose a rolling-horizon based solution framework that uses the branch-and-price algorithm developed for the VRPRDL to re-optimize the vehicle routes every time an itinerary update is realized and test its efficiency.

2 - Arc Tour Problems with Complex Objectives

Mehmet Basdere, Northwestern University, Technological Institute, 2145 Sheridan Road, Evanston, IL, 60208, United States, MehmetBasdere2016@u.northwestern.edu, Karen Smilowitz, Sanjay Mehrotra

In this talk, we present a visit order-based approach and corresponding reformulations for time- and sequence-dependent arc tour problems. Our application comes from marathon course design where the aim is to find a valid simple cycle which visits a predetermined subset of landmark streets without preventing the public access to critical facilities in the network. Time-dependent objective functions are used to measure metrics that change over different stages of the race while sequence-dependent ones are used to measure total turn angle and incline change throughout the course.

3 - Comparison of Several Clustering Algorithms for an Inventory Routing Problem

Okan Orsan Ozener, Ozyegin University, Nisantepe Mh. Orman Sk. No 13 Cekmekoy, Istanbul, 34794, Turkey, orsan.ozener@ozyegin.edu.tr, Ali Ekici

We propose several clustering algorithms as a subroutine of an integrated solution approach for a variant of inventory routing problem. In the clustering phase, we generate several (possibly overlapping) clusters and choose a subset of these generated clusters by solving a set partitioning problem. We determine the cost of serving each cluster by a new tour generation-based algorithm. We compare both the clustering algorithms against each other and the new tour generation-based algorithm against a benchmark algorithm in the literature. The proposed algorithm not only finds results with lower optimality gaps but also finds feasible solutions for difficult instances.

4 - An Application of Inventory Routing Problem in Humanitarian Relief Supplies Distribution

Ali Ekici, Ozyegin University, Endustri Muhendisligi Bolumu, Nisantepe Mahallesi Ormak Sokak No:13, Istanbul, Turkey, aliekici@gmail.com, Okan Orsan Ozener, Emre Cankaya

Motivated by the practices in humanitarian relief chain, we study an application of inventory routing problem in distribution of humanitarian relief supplies. Different from the classical route cost/length minimization objective in routing problems, our objective is to make a fair distribution to the affected areas. In order to address this distribution problem, we propose a three-phase (clustering, routing and improvement) solution approach. In the proposed solution approach, we take the interaction between routing and allocation decisions into account by first solving the routing problem based on an approximate allocation and then improving the allocation based on the routing decision.

■ WA66

371A

Transportation Infrastructure Planning

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Seyedbehzad Aghdashi, North Carolina State University, 112 Gwinnett Pl, Cary, NC, 27518, United States, saghdas@ncsu.edu

1 - Robust Optimal Management of Highway Pavement a Utilitarian Approach to User vs. Agency Costs

Umit Deniz Tursun, University of Illinois, 205 N Mathews Ave., Urbana, IL, 61801, United States, umitdeniz.tursun@gmail.com

Management of highway pavement requires considering a very extensive set of structural performance and environmental impacts simultaneously from both agency and user perspectives. Framework for employing mathematical decision modelling to address analytic approach need for addressing life cycle impacts. A constrained optimization formulation with multi-attribute utility function that reflects the users' and agencys' incentives serving as the objective function under feasibility constraints is presented. A case study on Illinois Tollway authority network is presented.

2 - Demand Monotonicity of a Pavement Cost Function Used to Determine Aumann-shapley Values in Highway Cost Allocation

Saurav Kumar Dubey, PhD Student, University of Tennessee at Knoxville, 1615 Laurel Avenue, Box 203, Knoxville, TN, 37916, United States, skumardu@utk.edu, Alberto Garcia-Diaz

Pavement Thickness and Traffic Lanes are two fundamental requirements of a highway design project. Viewing lanes and 18-kip Equivalent Single-Axle Load (ESAL) as two types of players, a pavement cost function is used to determine the average marginal cost for players also known as the Aumann-Shapley values to allocate cost among vehicle classes. This approach results in large number of players for which an efficient form of computing A-S value is needed. This article will derive a compact form for discrete A-S value whose pavement cost function will be proven to have monotonically increasing cost when demand (ESALs) is increased.

3 - Multiple Change-point Modeling and Exact Bayesian Inference of Degradation Signal for Prognostics Improvement

Yuxin Wen, PhD Student, University of Texas-El Paso, El Paso, TX, 79968, United States, ywen@miners.utep.edu

We propose a Bayesian multiple change-point modeling framework to better capture the degradation path for prognostics improvement. At the offline modeling stage, a novel stochastic process is proposed to model the joint prior of change-points and positions. At the online monitoring and RUL prediction stage, a recursive updating algorithm is developed to exactly calculate the posterior distribution and RUL prediction sequentially. To control the computational cost, a fixed-support-size strategy at the online stage and a partial Monte Carlo strategy in the RUL prediction are proposed. The effectiveness and advantages of the proposed method are demonstrated simulation and real case studies.

4 - Economic Impact of Raised Medians on Businesses in South Carolina

Samaneh Shiri, University of South Carolina, 1076 Pavilion Tower Circle, Columbia, SC, 29201-2361, United States, shiri@email.sc.edu, Mohammad Torkjazi, Nathan Huynh

Access management techniques affect economic activities along highway corridors. Raised medians that restrict left turns at mid-block are often considered as an effective access management technique which has been shown to improve traffic operations and safety. However, such restrictions also limit access to driveways. In this study, the economic impact of raised medians on businesses in South Carolina is examined using two methods: (1) surveys to study the perception of businesses and customers about raised medians, and (2) an assessment of the actual impact of a raised median on sales volume of adjacent businesses.

■ WA67

371B

Data Analytics for System Improvement III

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Xi Zhang, Peking University, Beijing, China, xi.zhang@pku.edu.cn

Co-Chair: Kaibo Liu, UW-Madison, Madison, WI, 53706, United States, jacoblkb@gmail.com

1 - Stochastic Modeling and Diagnosis of Leak Areas for Surface Assembly

Jie Ren, Graduate Research Assistant, Florida State Unigersity, Tallahassee, FL, 32310, United States, jr14r@my.fsu.edu, Hui Wang, Chiwoo Park

Assembly through mating a pair of machined surfaces plays a crucial role in automotive powertrain production, and the mating errors during the assembly can cause internal leakage and functional problems. The surface mating errors are difficult to diagnose because they are not measurable. To address these limitations, this talk presents a novel diagnostic method to predict potential leak areas given the measurements on the profiles of mating surfaces. The effectiveness of the proposed method is verified by case studies. The approach provides practical guidance for the subsequent assembly process as well as troubleshooting in surface machining processes.

2 - Causation-based Monitoring and Diagnosis for Multivariate Categorical Processes with Ordinal Information

Xiaochen Xian, UW-Madison, Madison, WI, United States, xxian@wisc.edu, Jian Li, Kaibo Liu

The monitoring and diagnosis of multivariate categorical processes (MCPs) have drawn increasing attention lately. In these applications, there usually exists natural order among the attribute levels of some categorical variables, such as good, neutral, and bad for measuring the product quality. In this paper, we leverage Bayesian networks to characterize MCPs with a causal structure, where the categorical variables can be either nominal, ordinal, or a combination of both. We develop one general control chart and one directional control chart, both of which fully exploit the causal relationships and the ordinal information for better process monitoring and diagnosis.

3 - System Redesign under Unknown Demand Rates

Qianru Ge, TU/e, Paviljoen N.5, IE&IS, Den Dolech 2, Postbus 5, Eindhoven, 5612 AZ, Netherlands, q.ge@tue.nl, Willem van Jaarsveld, Zumbul Atan

We consider a newly developed system sold under a PBC. The system is subject to failures with a random failure rate. The OEM is responsible for the availability of the system and makes a redesign decision at each decision period. The trade-off is that low failure rates require high redesign costs while high failure rates result in high repair and penalty costs. We use a MDP model to support the decision. As more information become available over time, we use Bayesian model to update the failure rate distribution. We show that the optimal redesign policy has a nondecreasing control limit structure. We benchmark the optimal policy against the policy only optimizing the initial design but with no redesigns.

4 - Estimation of Spatiotemporally-varying Parameters in Partial Differential Equation Models

Xi Zhang, Peking University, 298 Chengfu Road, Founder Building 512, Beijing, China, xi.zhang@pku.edu.cn, Di Wang

Estimation of temperature field provides a prerequisite opportunity to understand the dynamics of complex systems in many areas. By combining the data collected from sensor networks, the accuracy of the estimation could be greatly improved. This article presents an estimation method to model the spatiotemporal dynamics of a temperature field by integrating a physical dynamics model and a spatiotemporal Gaussian process. Results of the studies give some insight into the spatiotemporal dynamics of a temperature field and provide guidance to the optimum design of engineering structures to conserve energy and reduce production cost.

■ WA68

371C

Quality, Statistics and Reliability

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Anahita Khojandi, Assistant Professor, University of Tennessee, Knoxville, TN, 37996, United States, anahitakhojandi@gmail.com

1 - Optimizing Condition based Maintenance for Systems with Degrading Sensors

Anahita Khojandi, University of Tennessee, 521 Tickle Building, Knoxville, TN, 37996, United States, khojandi@utk.edu, Mahboubeh Madadi

We consider a degrading system with non-silent failures. System failure is costly and it requires an immediate system replacement. The system status may be partially observed using a set of heterogeneous sensors at a given cost. The sensors are noisy and their noise level is a function of the sensor status. Our goal is to develop a POMDP model to determine the optimal condition based maintenance scheme to minimize the total expected discounted cost.

2 - A Decomposition Algorithm to Measure Redundancy in Structured Linear Systems

Vishnu Vijayaraghavan, Texas A&M.University, 400 Nagle Street, College Station, TX, 77840, United States, vishnunitr@tamu.edu, Kiavash Kianfar, Yu Ding, Hamid R. Parsaei

The degree of redundancy of linear sensor systems is a measure of robustness of the system against sensor failures. Finding the degree of redundancy for structured linear systems is proven to be NP-hard. Bound and decompose, mixed integer programming, l1-minimization methods have all been studied and compared in the literature. We propose a mixed integer programming based decomposition technique that utilizes the bordered block diagonal structure inherent in most practical linear sensor systems to decompose the problem into much smaller sub-problems on which the computations are performed, thereby leading to significant reductions in run time.

3 - Hierarchical Spatially Varying Coefficient Process Model

Heeyoung Kim, Assistant Professor, Industrial and Systems Engineering, Daejon, Korea, Republic of, heeyoungkim@kaist.ac.kr

The spatially varying coefficient process model is a non-stationary approach to explaining spatial heterogeneity by allowing coefficients to vary across space. In this study, we develop a methodology for generalizing this model to accommodate geographically hierarchical data. We consider two-level hierarchical structures and allow for the coefficients of both low-level and high-level units to vary over space.

4 - Optimizing Periodic Inspection Frequencies for a Class of Stochastically Degrading Systems

Mahboubeh Madadi, Louisiana Tech University, College of Engineering and Science, P.O. Box 10348, Ruston, LA, 71272, United States, madadi@latech.edu, David Kaufman, Murat Kurt

We consider existing models that optimize repair-replacement decisions for systems the degradation status of which follow a discrete time Markov chain over a set of finite states and can be revealed only by costly inspections. Given worse conditions imply higher operation costs, we utilize first-order stochastic dominance relationship among the powers of IFR-structured degradation matrices to propose approximately-optimal periodic inspection decisions that minimize the total expected discounted cost due to the operation, repair, and inspection. We illustrate our approach through numerical examples.

■ WA70

371E

Data Mining

Contributed Session

Chair: Tejas Huddar, Texas A&M University-Kingsville, San Antonio, TX, United States, tejashuddar@gmail.com

1 - A Novel MILP Based Approach to Multi-class Data Classification Problem

Fatih Rahim, Koç University, Koç Üniversitesi, Rumelifeneri Yolu, Sariyer, Istanbul, 34450, Turkey, frahim@ku.edu.tr, Metin Turkay

Multi-class data classification is a supervised machine learning problem that involves assigning data to multiple groups. We present a novel MILP-based approach that splits each class's data set into subsets such that the subsets of different classes are separable by a hyperplane. The hyperplanes form a polyhedral region for each subset and the regions of different classes are disjoint. A MILP model is used to find the optimal separation by minimizing the total number of regions and misclassified samples. A preprocessing step is proposed to simplify the problem considering pairwise separation of classes. We evaluated the convex hulls of subsets and the polyhedral regions for the testing phase.

2 - What Factors Influence Consumer's Online Purchase Decision? the Driving Effect of Customer Perceived Value

Peng Zhu, Nanjing University of Science and Technology, 200 Xiaolingwei Street, Nanjing, 210094, China, p.zhu@outlook.com, Yuefen Wang, Mingsheng Zhao

What factors influence consumers' online purchase decisions? This paper points out that in the online shopping mode, customer perceived value includes three dimensions: Product perceived value, Service perceived value and Social perceived value. Based on this three dimensions, the paper constructs online purchase decision impact model and collects Taobao's massive consumer purchase behavior data. Through large sample analysis, the research found that the length of online reviews, the volume of goods sold, the sellers' credit rating, the sellers' DSR service score and the time length of the online shop have positive impact on the consumer's online purchase decision.

3 - Decision Making Process for Selecting Efficient and Cost Effective Motors for Humanoid Robot Arm

Tejas Huddar, Mechanical Engineer, Texas A&M.University-Kingsville, 4510 Eisenhauer Rd, San Antonio, TX, 78218, United States, tejashuddar@gmail.com, Joon-Yeoul Oh

Selecting an option from numerous available choices in market has always been a vague task, especially, in a component selection of robot systems. The objective of this research is to develop a decision-making process for the best set selection of motors from various options considering three criteria: weight, cost and lifting capacity. The suggested decision-making process uses profile model, checklist model, AHP and lastly presents LP and NLP models using the correlations of the criteria. The results show that the suggested method is effective yet efficient not only in this problem but also in cases that need to select the best candidate from large available options.

■ WA71

371F

Optimization, Large Scale

Contributed Session

Chair: Ezgi Karabulut, Georgia Institute of Technology, Atlanta, GA, United States, ezgi.karabulut@gatech.edu

1 - Team Formation in Social Networks

Nihal Berktas, Bilkent University, Ankara, Turkey, nihal.berktas@bilkent.edu.tr, Hande Yaman

People work in teams to complete a job or project that requires a number of skills and that needs to be finished by a deadline that cannot be met by one individual. The success of a team depends on the technical capabilities of people as well as the quality of the communication among them. We study the team formation problem in which communication is taken into consideration by assuming the potential members constitute a social network. We develop integer programs for different versions of the problem and present computational results using different data sets.

2 - An Overview of Recent Advances in Pyomo

William E. Hart, Sandia National Laboratories, 8625 Napa Valley Road NE, Albuquerque, NM, 87122, United States, wehart@sandia.gov, John Siirola

Pyomo is a Python-based, open-source optimization modeling language with a diverse set of optimization capabilities. This presentation will review significant advances in recent Pyomo releases, including advanced modeling of subproblems with blocks, automatic differentiation, modeling with units, and a new kernel software layer for advanced scripting applications.

3 - Cyclic Best First Search: using Contours to Guide Branch-and-bound Algorithms

Wenda Zhang, University of Illinois at Urbana-Champaign, 1618 Melrose Park Court, Apt 1722, Urbana, IL, 61801, United States, wzhang95@illinois.edu, David R.Morrison, Jason Sauppe, Sheldon H. Jacobson, Edward C. Sewell

The cyclic best-first search (CBFS) strategy is a modification of BFS that groups search tree subproblems into contours, and repeatedly cycles through all non-empty contours to select subproblems to explore. In this paper, the theoretical properties of CBFS are analyzed. CBFS is proved to be a generalization of all other search strategies. Further, a bound is proved between the number of subproblems explored by BFS and the number of children generated by CBFS, given a fixed branching strategy and set of pruning rules. Finally, a discussion of heuristic contour-labeling functions is provided, and proof-of-concept computational results for mixed-integer programming problems are shown.

4 - Decentralized Online Integer Programming

Ezgi Karabulut, Georgia Institute of Technology, Atlanta, GA, United States, ezgi.karabulut@gatech.edu, Shabbir Ahmed, George L. Nemhauser

We consider a set of agents that need to coordinate their actions to optimize the sum of their objectives while satisfying a common resource constraint. The objective functions of the players are unknown to them a priori and are revealed in an online manner. The resulting problem is an online optimization problem to optimally allocate the resource among the players prior to observing the item values. We show that for any deterministic online algorithm for this problem, there exists a lower bound of $\Omega(T)$ on regret. Furthermore, when the players' integer programs satisfy a special concavity condition, we propose a randomized online algorithm that guarantees an upper bound of $O(\sqrt{T})$ on the expected regret.

■ WA72

372A

Optimization, Network

Contributed Session

Chair: Onur Tavaslioglu, University of Pittsburgh, Houston, TX, United States, ont1@pitt.edu

1 - Advancements of the Double Pivot Simplex Method

Fabio T.Vitor, Kansas State University, 2061 Rathbone Hall, 1701B Platt St., Manhattan, KS, 66506, United States, fabioftv@k-state.edu, Todd W. Easton

Recently, Vitor and Easton introduced the Double Pivot Simplex Method (DPSM). Each iteration of the Simplex Method (SM) pivots on exactly one variable. In contrast, DPSM can pivot on two variables at a time. The talk will briefly present DPSM and focus on the computational comparison of DPSM and SM. Both methods are implemented using several CPLEX routines. Computational experiments demonstrate that DPSM requires approximately 40% fewer pivots than SM when tested on some benchmark instances. Additional comments will be provided on DPSM's impact to degenerate linear programs.

2 - Diet Problem with Ingredient Preferences

Fariborz Y. Partovi, Professor, Drexel University, 3141 Chestnut St, Philadelphia, PA, 19104, United States, partovi@drexel.edu

It has been close to seventy years since the Diet problem was introduced by Stigler (Stigler 1945). However the problem with the classical Diet models is based on lack of proper presentation of food preferences. For many people, especially when they are eating outside their home, the content of the food as far as nutrition is concern, maybe not, as important as the taste of the food or other consumptions. In this article we modify Diet problem using extensions of Data Envelopment analysis to satisfy customer's preferences.

3 - Finding Enclosures of the Optimal Set of Interval Linear Programming Problems: An Empirical Analysis

Mohsen Mohammadi Dehcheshmeh, University of Louisville, Louisville, KY, United States, m0moha15@louisville.edu, Monica Gentili

Determining the set of optimal solutions for an interval linear programming problem is challenging due to the possibility of non-convex and/or disconnected optimal sets. Several approximation methods have been developed to compute enclosures of the optimal set, that is a super set that includes it. In this study, we present an experimental analysis to compare the quality of the enclosures obtained by different existing methods in the literature.

4 - On the Structure of the Inverse-feasible Region of a Linear Program

Onur Tavaslioglu, University of Pittsburgh, 7171 Buffalo Speedway, Apt 1934, Houston, TX, 77025, United States, ont1@pitt.edu, Taewoo Lee, Andrew J.Schaefer

Given a feasible solution, inverse linear programming considers perturbing the objective vector of a linear program such that the solution is optimal and the perturbation is minimum under an Lp norm. We study the polyhedral characterization of the feasible region of an inverse linear programming problem. We characterize the inverse-feasible region to show the relationship between the dimensions of the minimum faces and inverse-feasible regions, which gives necessary and sufficient conditions of the extreme, boundary, and inner points of a linear program. We characterize the set of objective vectors that generate a selected unique optimal solution for a considered linear program.

■ WA73

372B

Power System Reliability

Invited: Energy Systems Management

Invited Session

Chair: Mohammad Najarian, University of Houston, 4722 Calhoun Road, Engineering Building 2, Houston, TX, 77204-4008, United States, mohammad.najarian@gmail.com

1 - Designing Resilient Electric Networks under Natural Hazards

Tomas Ignacio Lagos, University of Chile, Beauchef 851, Santiago, 7640031, Chile, tomas.lagos.gonzalez@gmail.com

We propose an optimization framework for designing a resilient electric power grid under high impact low probability events such as earthquakes. An Optimization via Simulation approach is used to solve this discrete decision problem, where the measure of resilience is the expected energy not supplied, assessed through an existing simulator that contains historical earthquake data, fragility curves of the network components, and a unit commitment model. We use this framework to discuss various approximation methods applied to select subsets of scenarios and take optimal decisions on network investment.

2 - Modeling Dependent Outages of Electricity Power Plants

Vishwakant Malladi, University of Texas-Austin, McCombs School of Business, CBA 5.202, IROM, Austin, TX, 78712, United States, vishwakant@gmail.com, Stathis Tompaidis, Rafael Mendoza

We propose a new framework to model dependence of outages of electricity power plants. Our framework accounts for commonality in outages, such as weather events and fuel shortages using a unique data set of actual outages. We calibrate our model for the Electricity Reliability Council of Texas (ERCOT) and the Western Electricity Coordinating Council (WECC) regions. We find strong evidence of dependence in outages both in the input fuel and the geographic location of the power plants and discuss the consequences of this dependence on the reliability of electricity supply.

3 - Resilience Assessment of Interdependent Gas Network and Electrical Power System Infrastructures: A Quantitative Approach

Mohammad Najarian, PhD Student, University of Houston, E206, Engineering Bldg 2, 4722 Calhoun Rd, Houston, TX, 77204-4008, United States, mohammad.najarian@gmail.com, Masoud Barati, Gino J. Lim

To reduce the consequences of hazards resilience must be incorporated into the design of the electrical power systems(EPS) and it must be quantified.The interdependence between EPS and other critical infrastructures, such as natural gas systems (NGS), compounds the complexity of resilience measurement. In this paper, we provide a method to measure and analyze the impact of NGS resilience on the EPS resilience. This method is also used to assign limited resources to both EPS and NGS aiming at increasing the resilience of the EPS. For this, a combination of security-constrained unit commitment with gas dependency constraint and Monte Carlo simulation is used.

■ WA74

372C

Joint session ICS/ Practice: PMU based Data Analytics and Machine Learning in Power Grids

Sponsored: Computing

Sponsored Session

Chair: Deepjyoti Deka, Los Alamos National Lab, Los Alamos, NM, 87544, United States, deepjyotideka@gmail.com

Co-Chair: Andrey Lokhov, Los Alamos National Laboratory, CNLS, MS B258, Los Alamos, NM, 87545, United States, lokhov@lanl.gov

1 - Real-time Data-driven Detection of Low-quality Synchrophasor Measurements

Meng Wu, PhD Student, Texas A&M.University, College Station, TX, 77840, United States, mariewumeng@gmail.com, Le Xie

An online data-driven approach is proposed for the detection of low-quality synchrophasor measurements. The proposed method leverages the spatio-temporal similarities among multiple-time-instant synchrophasor data, and formulates the low-quality synchrophasor data as spatio-temporal outliers. A density-based local outlier detection technique is proposed to detect the spatio-temporal outliers. This data-driven approach involves no system modeling information. The algorithm can operate under both normal and fault-on system conditions, with fast computation speed suitable for online applications. The effectiveness of the proposed approach is verified via case studies.

2 - Smart Grid Security through Synchrophasor Data: Real-time Detection of Attacks on AC State Estimation

Biplab Sikdar, PhD, National University of Singapore, bsikdar@nus.edu.sg

One of the most important functions in the control and monitoring of a power grid is AC state estimation whose output is used by Energy Management System (EMS) applications such as economic dispatch, contingency analysis, and optimal power flow. Protecting the state estimator against cyber-attacks that bias its outputs is thus of critical importance. This paper proposes a simple non-iterative technique for detecting false data injection attacks on AC state estimators, by using synchrophasor data. As the proposed method is independent of the state estimator outputs and does not depend on any EMS functionality, it can be used to test the data even before the execution of the state estimation algorithm.

3 - Reconstructing the Power Grid Dynamic Model from Sparse Measurements

Andrey Y. Lokhov, Los Alamos National Laboratory, CNLS, MS.B258, Los Alamos, NM, 87545, United States, lokhov@lanl.gov, Deepjyoti Deka, Marc Vuffray, Michael Chertkov

We describe the problem of parameter reconstruction in the power grid dynamics from sparsely located phasor measurement units (PMUs) observations. We assume that the dynamics is described by a system of coupled linearized second-order differential swing equations. In the ambient regime, fluctuations on individual nodes are assumed to be independent and Gaussian distributed. The goal is to reconstruct the inertia and damping coefficients of generators, as well as line susceptances. We discuss how this learning task can be efficiently combined with the problem of state estimation of consumption in the grid, and solved using regularized maximum likelihood and least-squares estimators.

4 - High-dimensional Data Analytics of PMU Measurements by Exploiting Low-dimensional Models

Meng Wang, Rensselaer Polytechnic Institute, Troy, NY, United States, wangm7@rpi.edu

The increasingly denser coverage of phasor measurement units (PMUs) enables dynamic visibility into power systems. The large amounts of data obtained by PMUs impose significant challenges to data management and information extraction. Interestingly, the spatial-temporal blocks of PMU data exhibit low-dimensional structures despite the high ambient dimensions. Such low-dimensionality can be exploited to enable and simplify multiple PMU data analysis tasks under the same framework.

■ WA76

372E

Rounding: Methods and Applications

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Arash Asadpour, New York University, New York University, New York, NY, 10012, United States, aasadpou@stern.nyu.edu

1 - Assignment Mechanismsunder Distributional Constraints

Shameli Ali, Stanford University, Stanford, CA, 94305, United States, shameli@stanford.edu, Itai Ashlagi, Amin Saberi

We study the allocation of heterogeneous positions to agents under distributional constraints. Each agent has a public type, and a private ranking over positions. The goal is to find a Pareto efficient assignment that maximizes the number of assigned agents. A natural benchmark is the solution of a linear programming relaxation that allows agents to be assigned to positions fractionally. We introduce a mechanism that achieves this goal while violating each constraint by a small number. This mechanism is strategyproof if agents' acceptable positions are public. We also propose a weakly strategyproof mechanism that improves upon the first mechanism by finding an ordinally efficient assignment.

2 - Stable Matching with Proportionality Constraints

Rakesh Vinay Vohra, University of Pennsylvania, Economics Department, 3718 Locust Walk, Philadelphia, PA, 19104, United States, rvohra@sas.upenn.edu, Nguyen Thanh

The problem of finding stable matches that meet distributional concerns is usually formulated by imposing various side constraints. Prior work has focused on constraints whose "right hand sides" are absolute numbers specified before the preferences or number of agents on the "proposing" side are known. In many cases it is more natural to express the relevant constraints as proportions. We treat such constraints as soft, but provide ex-post guarantees on how well the constraints are satisfied while preserving stability. Our technique requires an extension of Scarf's lemma, which is of independent interest.

3 - Approximate Random Allocation Mechanisms

Akbarpour Mohammad, Stanford University, Stanford, CA, United States, mohamwad@stanford.edu

We extend the scope of random allocation mechanisms, in which the mechanism first identifies a feasible "expected allocation" and then implements it by randomizing over nearby feasible integer allocations. Previous literature had shown that the cases in which this is possible are sharply limited. By constructing a new rounding algorithm, we show that if some of the feasibility constraints can be treated as "goals" rather than hard constraints then, subject to weak conditions that we identify, any expected allocation that satisfies all the constraints and goals can be implemented by randomizing among nearby integer allocations that satisfy all the hard constraints exactly and the goals approximately. By defining ex post utilities as goals, we are able to improve the ex post properties of several classic assignment mechanisms, such as the random serial dictatorship.

4 - A Primal-dual Framework for Decomposition and Rounding Methods in Assemble-to-order Systems

Levi DeValve, Duke University, 716 Turmeric Lane, Durham, NC, 27713, United States, levi.devalve@duke.edu, Sasa Pekec, Yehua Wei

We develop a primal-dual framework that allows a systematic approach to assessing heuristic performance in hard integer programs, and apply it to the assemble to order (ATO) problem. Our high level approach is to: (i) solve a relaxation to obtain a dual solution, (ii) construct a primal solution from the relaxation, and (iii) use our primal-dual framework to provide approximation guarantees. We demonstrate the versatility of our approach by analyzing various ATO heuristics within a unified primal-dual framework. In particular, for ATO, we provide performance bounds for LP rounding schemes and newsvendor decompositions, as well as insights into issues driving performance.

■ WA77

372F

Optimization, Integer Programming

Contributed Session

Chair: Marco Luebbecke, RWTH Aachen University, Aachen, Germany, marco.luebbecke@rwth-aachen.de

1 - Mixed-integer Quadratic Optimization Formulations for Eliminating Multicollinearity based on Variance Inflation Factor

Yuichi Takano, Senshu University, Kawasaki, Japan, ytakano@isc.senshu-u.ac.jp, Ryuta Tamura, Ken Kobayashi, Ryuhei Miyashiro, Kazuhide Nakata, Tomomi Matsui

The variance inflation factor, VIF, is the most frequently used indicator for detecting multicollinearity in multiple linear regression models. This talk presents mixed-integer quadratic optimization formulations for selecting the best subset of explanatory variables under upper-bound constraints on VIF of selected variables. Computational results illustrate the effectiveness of our optimization formulations based on comparisons with conventional local search algorithms.

2 - Modeling Road Vulnerability to Snow using Mixed Integer Optimization

Tony Rodriguez, University of Tennessee, Knoxville, TN, 37996, United States, trodrig5@vols.utk.edu, Olufemi Omitaomu, Jim Ostrowski

As the number and severity of snowfall events continue to grow, the need to intelligently direct road maintenance during these snowfall events will also grow. In several locations, local governments lack the resources to completely treat all roadways during snow events. As a result, many schools, businesses, and government offices must be unnecessarily closed, which directly impacts the social, educational, and economic well-being of citizens and institutions. In this work, we propose a mixed integer programming formulation to optimally allocate resources to manage snowfall on roads using meteorological, geographical, and environmental parameters.

3 - Mathematical Programming for Regression Subset Selection with Diagnostic Constraints

Seokhyun Chung, Korea University, Korea Univ. New Engineering Building, 214, Seongbuk-gu, Seoul, Korea, Republic of, csh98016@gmail.com, Young Woong Park, Taesu Cheong

Many existing algorithms for regression subset selection focus on minimizing objective function such as sum of squared errors (SSE). However, it is also important to satisfy all underlying assumptions and diagnostics of linear regression. In this paper, we propose a mixed integer quadratic programming model to minimize SSE and satisfy regression assumptions and diagnostics. A procedure is also proposed to obtain near-feasible solutions when a solution satisfying all constraints cannot be easily found. A computational study is provided with real-world data.

4 - Sparse Classication: A Discrete Optimization Perspective

Jean Pauphilet, PhD Candidate, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Building E40-103, Cambridge, MA, 02139, United States, jpauph@mit.edu, Dimitris Bertsimas, Bart Paul Gerard Van Parys

In this paper, we formulate the sparse classification problem as a mixed-integer convex optimization problem and propose a cutting-plane algorithm to solve it exactly. For sparse logistic regression and sparse SVM our algorithm finds optimal solutions for n and p in the 10,000s within minutes. If there is enough data, the algorithm is fast, accurately detects all the true features and returns no false features. In contrast, Lasso persistently returns incorrect ones, even as the number of observations increases. Finally, we apply our method in genomics. Sparse classification returns a classifier based on 32 genes only, while Lasso selects 172 with a similar predictive accuracy.

5 - Learning When to Use a Decomposition

Marco Luebbecke, Professor, RWTH Aachen University, Operations Research, Kackertstr. 7, Aachen, D-52072, Germany, marco.luebbecke@rwth-aachen.de, Markus Kruber, Axel Parmentier

Applying a Dantzig-Wolfe decomposition to a mixed-integer program (MIP) aims at exploiting an embedded model structure. Recently, automating the process and embedding it in standard MIP solvers have been proposed, with the detection of a decomposable model structure as key element. If the detected structure reflects the (usually unknown) actual structure of the MIP well, the solver may be much faster on the reformulated model than on the original. We propose a supervised learning approach to decide whether or not a reformulation should be applied. First numerical experiments show a significant performance improvement on structured instances, with little deterioration on others.

■ WA80

381C

Joint session PSOR/ENRE: Models for Energy Policy 1

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Erin Baker, Univ of Massachusetts-Amherst, University of Massachusetts-Amherst, Amherst, MA, 01003, United States, edbaker@ecs.umass.edu

Co-Chair: Zana Cranmer, Bentley University, Waltham, MA, United States, zanacranmer@gmail.com

1 - Potential for Widespread Electrification of Vehicle Travel

Jessika Trancik, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-241, Cambridge, MA, 02139, United States, trancik@mit.edu

Electric vehicles can contribute to climate change mitigation but only if vehicle range matches travelers' needs. Evaluating electric vehicle range against a population's needs is challenging because detailed driving behavior must be accounted for. Here we develop a model to combine information from expansive travel surveys with high-resolution GPS data to estimate the energy requirements of personal vehicle trips across the U.S. We find that the energy requirements of most driving days could be met by today's affordable electric vehicles. For the highest-energy days, other vehicle technologies are likely needed, and predictive models combined with car sharing could play an important role.

2 - Identifying Portfolios of Energy Technologies that are Robust to Multiple Models

Franklyn Kanyako, Research Assistant, University of Massachusetts, Amherst, Amherst, MA, 01003, United States, fkanyako@umass.edu, Erin Baker

This project investigates the problem of allocating R&D funds across low-carbon energy technologies in the context of climate change. Multiple expert elicitation on the future cost of low energy technologies are used as input into three Integrated Assessment Models(IAMs), GCAM, WITCH, and MESSAGE. IAMs are designed with a different representation of processes and assumptions about the economy, energy, and policy, which create an uncertainty known as model uncertainty. Outputs from these models are used to conduct robust portfolio decision analysis to identify the non-dominated portfolio of alternatives that are robust to all models.

3 - Improving Land Use Efficiency of Utility-scale Solar Photovoltaics

Jeremiah Johnson, University of Michigan, 440 Church Street, Dana Building, Ann Arbor, MI, 48109, United States, jxjohns@umich.edu, Noah Mitchell-Ward

This study explores the ability and limitations to increase the land use efficiency of solar photovoltaic generation through decisions available to solar project developers. To achieve this, we developed a physics-based model to determine solar angles and shading impacts as a function of time, location, collector orientation, and collector tilt. Using Typical Meteorological Year data, we determine the maximum solar generation per unit of land area for various locations and module efficiencies. These findings show the potential reductions in land use for utility-scale solar, as well as the tradeoff between generation per module and generation per land area, as driven by shading losses.

4 - Valuing Offshore Wind Energy

Zana Cranmer, Bentley University, Waltham, MA, United States, zanacranmer@gmail.com, Erin Baker

Much attention has been paid to the environmental costs of offshore wind energy in terms of the impacts on ecosystems and species such as birds, bats, and marine wildlife. For comparison, we need to understand the value of permitting offshore wind farms in terms of mitigating global climate change. We develop a model for estimating the value of permitting offshore wind projects globally over the rest of the century and estimate that the value ranges between $25 billion to $48.8 trillion dollars in a business as usual case. The corresponding value of technological change ranges from about $474 billion to $45.2 trillion dollars in this case.

■ WA81

382A

Enhancements of Stochastic Approximation

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Uday Shanbhag, Pennsylvania State University, University Park, 310 Leonhard Bldg, University Park, PA, 16802, United States, udaybag@psu.edu

1 - On the Analysis of Accelerated Variable Sample-size Stochastic Approximation (VSSA)

Uday Shanbhag, Pennsylvania State University, University Park, 310 Leonhard Bldg, University Park, PA, 16802, United States, udaybag@psu.edu

Traditional stochastic approximation (SA) schemes employ a single gradient or a fixed batch of noisy gradients in computing a new iterate. To mitigate computational complexity, we consider increasing sample size when the total simulation budget is finite. We present amongst the first stochastic generalizations of Nesterov's accelerated gradient scheme where we first show that when the objective is strongly convex, the expected sub-optimality error diminishes at a geometric rate while upon termination. Also, for convex case we can recover optimal convergence rate as well.

2 - A Unifying Selftuned Stepsize Rule for Stochastic Mirror Descent Methods

Nahidsadat Majlesinasab, Oklahoma state university, nahid.majlesinasab@okstate.edu, Farzad Yousefian, Arash Pourhabib

Motivated by big data applications, we consider stochastic mirror descent methods for solving stochastic convex optimization problems. The performance of this class of methods is very sensitive to the choice of the stepsize sequence. We present a unifying self-tuned stepsize for smooth and nonsmooth problems such that: (i) it is characterized in terms of problem parameters and algorithm's settings; and (ii) under this update rule, a suitably defined error metric is minimized. We present the performance of this update rule for the soft margin linear SVM problem over different large datasets.

3 - On Variable Sample-size Stochastic Mirror-descent and Fista-like Schemes for Nonsmooth Stochastic Optimization

Afrooz Jalilzadeh, 424 Waupelani Drive, Apt Q34, State College, PA, 16801, United States, Azj5286@psu.edu, Uday Shanbhag

Traditional stochastic approximation (SA) schemes with convex constraints employ a single gradient and a projection on a convex set in computing an update. To reduce computational complexity, we consider two schemes; nonsmooth Variable Sample-Size Stochastic Mirror-Descent (VS-SSMD) and Variable sample-size FISTA (VS-FISTA), in which N_k samples are utilized at step k and the total simulation budget is M. Under a strong convexity assumption, we prove linear convergence of iterates. Additionally, we show that the proposed VS-FISTA scheme for merely convex case displays the deterministic O(1/k^2) convergence rate.

4 - Sampling-based Schemes for the Solution for Two-stage Risk-limiting Economic Dispatch Problems

Wendian Wan, Pennsylvania State University, University Park, PA, United States, wzw121@psu.edu

Risk Limiting Dispatch (RLD) is a new operating paradigm that uses real-time information about supply and demand, integrating complex stochastic nature of power system. Tradeoff between computational complexity and accuracy need to be considered by system operator. In this talk, two-stage risk-limiting economic dispatch problem is formulated and a sampling-based schemes has been utilized in order to meet the scalability requirement of power system.

■ WA82

382B

Risk-Averse Stochastic Optimization

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Alexander Vinel, Auburn University, Auburn University, Auburn, AL, 36832, United States, alexander.vinel@auburn.edu

1 - Risk-averse Stochastic Optimization Model for Hazardous Material Transportation using Risk Parity and Modern Risk Measures

Nasrin Mohabbati Kalejahi, PhD Candidate, Auburn University, Auburn, AL, United States, nasrin@auburn.edu, Alexander Vinel

Hazardous material (hazmat) transportation problem aims to ship hazmats from an origin to one or several destinations through a road network. Using a single optimal path repeatedly over time increases the risk of accidents for the population in surrounding area. One of the biggest challenges in hazmat transportation is to reach risk equity over the network. In this research, risk parity concept is combined with modern risk measures and a risk-reward-diversification framework is developed. The objective of the optimization model is to find multiple routes and fairly distribute the exposure to risk in the transportation network to guarantee the equal risk contribution of each route to the total risk.

2 - An Alternate Way of Real Options Valuation with Loss Function
Kyongsun Kim, Auburn University, Auburn, AL, United States, kimkyon@auburn.edu, Chan Park

Adopting the financial option pricing method for real options implicitly assumes the project value follows a geometric Brownian motion. Because of many practical difficulties of formulating real option strategies based on financial option framework, we propose an alternative method for valuing non-financial assets with the standardized loss function that provides practically identical results with the well-known Black-Scholes formula.

3 - Obtaining Lower Bounds for Multi-stage Risk-averse Stochastic Mixed-integer Programs
Ge Guo, Iowa State University, 3004 Black Engineering Building, Iowa State University, Ames, IA, 50011-2164, United States, geguo@iastate.edu, Sarah M.Ryan

Traditional stochastic programming is risk-neutral in the sense that it is concerned with the optimization of an expectation criterion. In many applications, however, the decision makers are more concerned about large losses. Thus, risk-averse optimization has attracted attention in stochastic programming. We present a method to obtain convergent and tight lower bounds from the Progressive Hedging algorithm (PHA) for multi-stage risk-averse stochastic mixed-integer programs focusing on time-consistent risk measures. This method can assess solution quality for PHA and also integrate with exact algorithms that rely on lower bounds. We report computational results on lot sizing instances.

4 - Identifying Error- and Attack-resilient Clusters in Networks under Decision-dependent Uncertainties
Hossein Dashti, hdashti@email.arizona.edu, Pavlo A. Krokhmal

Network robustness is crucial in many areas such as energy and defense. Possible disruptions may affect network's functionality. One of the key robustness requirements is every pair of nodes are connected through number of short intermediate links. Moreover, having multiple paths makes such a cluster more robust. The cluster represents a R-robust 2-club, which is a subgraph with at least R disjoint paths of length at most 2 connecting each pair of nodes. Uncertainty manifested as stochastic errors/attacks in different nodes. If one can reinforce the network components against future threats, the goal is to determine optimal reinforcements that would yield a cluster with minimum risk of disruptions.

■ WA83

382C

Optimization, Stochastic

Contributed Session

Chair: Mehdi Behroozi, Northeastern University, Boston, MA, United States, m.behroozi@neu.edu

1 - Applications of Wasserstein Distance in Distributionally Robust Optimization
Ye Wang, University of Southern California, 3767 Clarington Avenue, Apt 206, Los Angeles, CA, 90034, United States, wang141@usc.edu

Wasserstein distance is a statistical metric that describes a distance function between two probability distributions. In our research, we consider the entropy maximization problem and the highest density region optimization problem in which we will search through all distributions whose Wasserstein distance to the empirical distribution of a given set of data points is sufficiently small.

2 - Robust Binary Linear Programming under Implementation Uncertainty
Jose E. Ramirez, PhD Student, Texas A&M.University, 3131 TAMU, College Station, TX, 77843, United States, ramirez.jose@tamu.edu, Victor J. Leon

This paper studies robust binary linear programming in the presence of uncertainties that may prevent the implementation of solutions exactly as prescribed. A formal model of this type of uncertainty, termed implementation uncertainty, is presented and used to develop a robust binary linear programming formulation under implementation uncertainty. The solution approach involves a mixed-binary linear program reformulation used in conjunction with identified structural properties, allowing the generation of a set of optimal solutions. Three methods to control the level of conservatism are developed including a cardinality-constrained reformulation of the original problem.

3 - A Robust Optimisation Approach to the Manpower Planning Problem
Gar Goei Loke, Public Service Division, 9 Jalan Grisek, Singapore, 419440, Singapore, e0012863@u.nus.edu, Melvyn Sim

A Robust Optimisation approach is applied to the manpower planning problem of optimal recruitment and progression through a hierarchy, under constraints of budget, productivity, headcount and managerial span of control. The model also incorporates employees' time-in-grade as a determinant, and is endogenic in this sense. A Satisficing approach was adopted, which guarantees that the probability of violation of constraints is controlled up to T time periods. The effectiveness and robustness of the model is tested against existing methods in the literature and compared.

4 - A Robust Optimization Approach to Transshipment Problem under Demand Uncertainty
Nafiseh Ghorbani Renani, Graduate Research Assistant, The University of Oklahoma, 519 South University Blvd, Apt 21, Norman, OK, 73069, United States, Nafiseh.ghorbani.renani-1@ou.edu

In each country, there are a number of food supply companies which are in charge of distributing food properly throughout cities. In fact, the main duty of these organizations is preventing of the food shortage. In such a company, the role of network flow management has become bold. Since demand is uncertain in this situation, two different probabilistic linear programming models have been suggested by using stochastic method and robust optimization method to find the optimum solution. This study is mainly focusing on a multi-period robust optimization model for transshipment of N products among N cities for a food supply company.

5 - Data Driven Robust Optimization for Logistics and Transportation Problems
Mehdi Behroozi, Assistant Professor, Northeastern University, Boston, MA, 02115, United States, m.behroozi@neu.edu, John Gunnar Carlsson

Using Wasserstein metric in defining the ambiguity set in robust optimization allows us to circumvent common overestimation that arises when other procedures are used. In this paper, we consider a distributionally robust version of the Euclidean travelling salesman problem in which we compute the worst-case spatial distribution of demand against all distributions whose Wasserstein distance to an observed demand distribution is bounded from above. We compare the advantages of this method with other approaches for describing the region of uncertainty, such as taking convex combinations of observed demand vectors or imposing constraints on the moments of the spatial demand distribution.

Wednesday, 9:40 - 10:30AM

■ Keynote

GBCC- General Assembly B, Level 3

Keynote: A Probabilistic Theory of Deep Learning

Invited Session

1 - A Probabilistic Theory of Deep Learning
Rich Baraniuk, Rice University

A grand challenge in machine learning is the development of computational algorithms that match or outperform humans in perceptual inference tasks that are complicated by nuisance variation. For instance, visual object recognition involves the unknown object position, orientation, and scale in object recognition while speech recognition involves the unknown voice pronunciation, pitch, and speed. Recently, a new breed of deep learning algorithms have emerged for high-nuisance inference tasks that routinely yield pattern recognition systems with near- or super-human capabilities. But a fundamental question remains: Why do they work? Intuitions abound, but a coherent framework for understanding, analyzing, and synthesizing deep learning architectures has remained elusive. We answer this question by developing a new probabilistic framework for deep learning based on the Deep Rendering Model: a generative probabilistic model that explicitly captures latent nuisance variation. By relaxing the generative model to a discriminative one, we can recover two of the current leading deep learning systems, deep convolutional neural networks and random decision forests, providing insights into their successes and shortcomings, a principled route to their improvement, and new avenues for exploration.

■ Keynote

GBCC- Grand Ballroom A, Level 3

Keynote: Smarter Tools for (Citi)Bike Sharing: Cornell Rides Tandem with Motivate

Invited Session

1 - Smarter Tools for (Citi)Bike Sharing: Cornell Rides Tandem with Motivate
David Shmoys & Shane Henderson

Cornell's School of Operations Research and Information Engineering (ORIE) has been working with the bike-sharing company Motivate with an emphasis on its New York system Citi Bike since it began operations in 2013. Cornell ORIE provides data analysis and advice about strategy and operations to Motivate, which operates most of the leading bike-sharing programs in the United States. We will describe a suite of models and algorithms that provide data-driven decision-making tools not just for operations but also for strategic system planning.

Wednesday, 10:30AM - 12:00PM

■ WB01

310A

Statistics and Decision Analysis

Sponsored: Decision Analysis

Sponsored Session

Chair: Huaiyang Zhong, Stanford University, 119 Quillen Ct, Stanford, CA, 94305, United States, hzhong34@stanford.edu

1 - Forecast Combining for Multivariate Probability Distributions

Xiaochun Meng, PhD Student, Saïd Business School, University of Oxford, Park End St, Oxford, OX1 1HP, United Kingdom, xiaochun.meng@sbs.ox.ac.uk, James W. Taylor

When faced with several competing forecasts, accuracy is very often improved by forming a combination of the individual forecasts. In addition to theoretical and empirical results regarding the combination of point forecasts, recent research supports the use of combining for probabilistic forecasting. For marginal distributions, it has been shown that combining quantiles is preferable to combining probabilities. We investigate whether this is also the case for joint distributions. Our empirical results concern forecasts of the joint distribution of the daily maximum and minimum temperature, which relates to the probabilistic forecasting of extreme weather events, such as heat waves.

2 - Sample Size Determination for Split Testing Based on Expected Cumulative Regret

Daniel Frey, Professor, Massachusetts Institute of Technology, 77 Massachusettes Avenue, Room 3-449D, Cambridge, MA, 02139, United States, danfrey@mit.edu, Nandan Sudarsanam, Balaji Pitchai Kannu, Ravindran Balaraman

Our work presents theoretical results for determining optimal sample size for A/B tests in the online setting. Unlike traditional criteria of Type 1 and 2 errors used in sample size determination, the online setting imposes the additional cost of poor performance incurred during the testing phase. We model the theoretical means of the tested alternatives, as well as the noise in the system across a range of probability distributions. In the case which explores Gaussian distributions (for both the means as well as noise), our solution for the sample size simplifies to a function of the trial horizon and a ratio of the standard deviations of the distributions.

3 - Quantile Markov Decision Processes

Huaiyang Zhong, Stanford University, 119 Quillen Ct, Apt 217A, Stanford, CA, 94305, United States, hzhong34@stanford.edu, Xiaocheng Li, Margaret L. Brandeau

Sequential decision making is an important task widely appeared in the fields of operations research, management science, artificial intelligence and stochastic control. In this work, we novelly introduce the framework of Quantile Markov Decision Process (QMDP) which enables us to maximize quantiles of the cumulative reward in the Markov decision process. We provide an efficient dynamic programming algorithm to solve QMDP with analysis from both theoretical and algorithmic perspectives.

■ WB02

310B

Preferences and Risk Modeling

Sponsored: Decision Analysis

Sponsored Session

Chair: Adolfo R. Escobedo, Arizono State University, ASU, Tempe, AZ, 77802, United States, adres@asu.edu

1 - Downside Risk Aversion and Cumulative Prospect Theory

Qiulin Yang, Lancaster University, Lancaster, United Kingdom, q.yang5@lancaster.ac.uk, Zhan Pang, James Huang

The increasingly popular Cumulative Prospect Theory (CPT) has challenged the Expected Utility Theory (EUT) in describing individuals' choices of risky prospects. Our paper attempts to bridge CPT and EUT by providing a choice-theoretic characterization of the tradeoff between overall risk (variance) and downside risk for downside risk averse decision makers in the CPT paradigm. We also discuss the intrinsic relationships between the defined downside risk change and the familiar skewness measures. Moreover, we show that our analysis for S-shaped value functions can be readily extended to reverse S-shaped value functions.

2 - Stochastic Dominance and Value of Information

N. Onur Bakir, Associate Professor, Istanbul Kemerburgaz University, Istanbul Kemerburgaz Üniversitesi, Mahmutbey Dilmenler Caddesi, No:26,, Istanbul, 34217, Turkey, onur.bakir@kemerburgaz.edu.tr

In this study we analyze the information acquisition problem in a multi-action setting where a decision maker chooses among multiple lotteries. In particular, we comparatively evaluate information on two lotteries that are related to each other in the sense of restricted stochastic dominance. We show in general that drawing conclusions on ranking of information for a risk averse decision maker is possible for specifically structured information alternatives.

3 - A Framework for Dealing with Baseline Uncertainty: An Analysis of China's Carbon Intensity Target

Anastasis Giannousakis, Potsdam Institute for Climate Impact Research, Telegraphenberg A.31, Potsdam, 14473, Germany, giannou@pik-potsdam.de, Elmar Kriegler, Lavinia Baumstark

Intensity targets are being used as alternatives to quantity targets in the presence of baseline uncertainty. Currently, nearly one third of global emissions are under indexed control. We propose a framework to assess to what extent this is a meaningful alternative. Analyzing the Chinese intensity target with respect to situations were in multi-stage policy design either choice of target can be implemented we highlight the importance of explicitly accounting for uncertainty in economic growth, as it can lead to substantial amounts of hot-air or unexpected costs. We also identify what type of structural transformations could be more economic and how target updating creates risk of stranded assets.

4 - A New Correlation Coefficient for Aggregating Incomplete Rankings Equitably

Adolfo R. Escobedo, Arizono State University, Tempe, AZ, 77802, United States, adres@asu.edu

The consensus ranking problem is central to group decision-making. It involves finding an ordinal evaluation which minimizes the collective disagreement relative to a set of individual preferences over a set of competing objects; two common examples are corporate project selection and academic paper competitions. Although different measures for quantifying agreement between rankings can be employed, those founded on axiomatic distances are regarded as the most suitable due to their intuitive appeal and social choice-related axiomatic properties. This work introduces a ranking correlation coefficient founded on the Kendall tau distance metric, and it establishes its equivalence to an axiomatic ranking distance designed to handle a realistic variety of ranking formats including those containing non-strict (i.e., with-ties) and incomplete (i.e., null) preferences. Moreover, it demonstrates that alternative ranking correlation coefficients inadvertently introduce systemic biases when considering the same variety of preferences, thus rendering them inadequate for aggregating rankings in the general case. The efficacy of the presented ranking correlation coefficient to solve the consensus ranking problem and to provide alternative optimal solutions is illustrated via computational results of a new combinatorial branch-and-bound algorithm.

■ WB03A

Grand Ballroom A

Machine Learning & Causality

Sponsored: Applied Probability

Sponsored Session

Chair: Nathan Kallus,Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, kallus@mit.edu

1 - Balanced Policy Evaluation and Learning

Nathan Kallus, Cornell University, New York, NY, 02139, United States, kallus@cornell.edu

Policy learning from observational data aims to transform electronic health records to personalized treatment regimes, transactional records to personalized pricing strategies, and click-streams to personalized advertising campaigns. However, existing inverse propensity weighting and doubly robust methods rely on a problematic plug-in approaches that leads to dealing with division by near zeros, data waste, and awkward two-stage procedures. I present a new approach based on optimal balance and demonstrate how it outperforms existing approaches and explain why, as supported by theory characterizing the method and regret bounds.

2 - Off-policy Evaluation and Optimization with Continuous Treatments

Angela Zhou, Cornell University, Ithaca, NY, United States, az434@cornell.edu, Nathan Kallus

We develop new methods for off-policy evaluation and learning with continuous treatments, going beyond previous work on discrete treatments. Using observational data such as electronic health and transactional records, our method is able to learn effective policies in such contexts as medical dosing and personalized discounts. Our estimator uses a kernel to smoothly reweight data by the proximity of proposed treatments and performs well in a case study on personalized warfarin dosing. We analyze the bias and error of our method and prove favorable regret bounds that support this empirical success.

3 - Efficient Policy Learning

Stefan Wager, Stanford GSB, Stanford, CA, 94305, United States, swager@stanford.edu

There is considerable interest in methods that reduce the problem of learning good treatment assignment policies to the problem of accurate policy evaluation. Given a class of candidate policies, these methods first effectively evaluate each policy individually, and then learn a policy by optimizing the estimated value function. Despite the wealth of proposed methods, the literature remains largely silent on questions of statistical optimality, and there are only limited results characterizing which policy evaluation strategies lead to better learned policies than others. Here, we consider efficiency bounds for policy learning, and propose new methods motivated by this optimality theory.

4 - Sensitivity Analysis for the Sample Average Treatment Effect under Effect Heterogeneity

Colin Fogarty, Massachusetts Institute of Technology, Cambridge, MA, 02114, United States, cfogarty@mit.edu

In observational studies, a sensitivity analysis assesses how strong unmeasured confounding needs to be to alter the study's findings. Methods for sensitivity analysis have been established under the assumption that the treatment effect is constant for all individuals. While innocuous for the analysis of randomized experiments, it has been argued in observational studies that certain patterns of unobserved effect heterogeneity may render the performed sensitivity analysis inadequate. We present a method for conducting a sensitivity analysis in the presence of effect heterogeneity. In so doing, we illustrate that concerns about the constant treatment effect model are largely unwarranted.

■ WB03B

Grand Ballroom B

Empirical/Data Driven Revenue Management and Pricing

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Serguei Netessine, University of Pennsylvania, Wharton School, Philadelphia, PA, 138676, United States, netessin@wharton.upenn.edu

Co-Chair: Jun Li, Ross School of Business, University of Michigan, Ann Arbor, MI, 48109, United States, junwli@umich.edu

1 - How to Operationalize Modern Personalization Algorithms

Vivek Farias, MIT, 100 Main Street, Cambridge, MA, 02142, United States, vivekf@mit.edu, Andrew A.Li, Deeksha Sinha

Modern recommender systems rely on encoding preferences via a mapping of users and items to a latent space, and while there exist sophisticated methods to estimate such mappings, the problem of efficiently operationalizing these embeddings is not well-understood. Thus motivated, we propose a sublinear time algorithm for this problem, and show that it achieves a constant-factor approximation under general random utility choice models. Our algorithm relies on a new sublinear time sampling scheme, which we develop to solve a class of problems that subsumes the classic nearest neighbor problem. We demonstrate the efficacy of our approach on a massive content discovery dataset from Outbrain.

2 - A Conditional Gradient Approach for Nonparametric Estimation of Mixtures of Choice Models

Ashwin Venkataraman, New York University, 719 Broadway, 7th Floor, New York, NY, 10003, United States, ashwin@cs.nyu.edu, Srikanth Jagabathula, Lakshminarayanan Subramanian

We propose a new method to nonparametrically estimate the mixture of logit models from aggregated sales transactions and product availability data. We formulate the estimation problem as an infinite-dimensional constrained convex program and use the conditional gradient (aka Frank-Wolfe) algorithm to solve it. We characterize the structure of the estimated mixing distribution. In two real-world case studies, we outperform the EM benchmark on speed (16x faster), in-sample fit (up to 24% gains in the log-likelihood loss), and predictive (28% gains on the RMSE metric in predicting market shares) and decision accuracies (extracts 1.4x more revenue).

3 - Discrimination with Incomplete Information in the Sharing Economy: Field Evidence from Airbnb

Dennis Zhang, 8342 Delcrest Drive, Apt 328, University City, MO, 63124, United States, denniszhang@wustl.edu, Ruomeng Cui, Jun Li

Recent research has found widespread discrimination by hosts against guests of certain races in online marketplaces, which endangers the very basis of a sharing economy — building trust in the communities. In this paper, we explore the root cause of discrimination and how to eliminate discrimination by conducting two randomized field experiments among 1,256 hosts on Airbnb.

4 - Multi-dimensional Decision Making in Operations: An Experimental Investigation of Joint Pricing and Quantity Decisions

Necati Tereyagoglu, Assistant Professor, Georgia Institute of Technology, 800 W Peachtree St NW, Atlanta, GA, 30308, United States, necati.tereyagoglu@scheller.gatech.edu, Karthik Ramachandran, Yusen Xia

Firms in several industries like medicine, retail and publishing must jointly determine the price and production quantity of their products well in advance of the selling season. In this study, we experimentally examine subjects' performance when they jointly determine price and quantities. We find that subjects systematically deviate from the theoretically optimal price and quantity levels. In a series of follow-up experiments, we isolate several factors that influence decision-making in this context. We show that decisions improve by making subjects more aware of interdependence and by reducing the uncertainty.

■ WB03C

Grand Ballroom C

Customer Choice in Retail Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Adam J. Mersereau, University of North Carolina, Chapel Hill, NC, 27599-3490, United States, ajm@unc.edu

1 - Online Assortment Optimization when Customers Refine Their Search

Zhichao Feng, University of Texas at Dallas, 2200 Waterview Pkwy, Apt 1828, Richardson, TX, 75080, United States, zxf140830@utdallas.edu, Shengqi Ye, Dorothee Honhon

When shopping online, a consumer often searches a keyword and checks the products displayed by the retailer. In many cases, the retailer has numerous products matching the keyword, with different features and functionalities, but is only able to show a subset of them due to limited displaying space. The assortment shown by the retailer influences the consumer's decision to buy or not. In addition, when the consumer is not familiar with the product category, the assortment may trigger interest in a specific product feature, leading the consumer to refine her search, and focus only on products with this feature. Taking this into consideration, we study the online retailer's optimal assortment decision.

2 - On Consumption and Composition of N-packs

John H. Semple, SMU, 6212 Bishop Blvd, Dallas, TX, 75205, United States, jsemple@mail.cox.smu.edu, Aydin Alptekinoglu

We consider the optimal consumption of a pack of n substitutable products within a general random utility framework. Using dynamic programming, we demonstrate that many basic properties of this problem are independent of the error distribution.

3 - Learning Choice Model Trees: Recursively Segmenting Individuals to Better Understand Their Choices

Michael Young, Doctoral Candidate, Harvard Business School, Boston, MA, United States, miyoung@hbs.edu, Kris Johnson Ferreira, Mohammed Ali Aouad

Choice modeling is a technique used by many retailers to better understand the impact of operational levers, e.g. price, on the customer's product choice. Similarly, customer segmentation is a common practice used to personalize the customer's shopping experience, e.g. targeted ads/offers. In this work, we combine a popular machine learning technique with a choice model in order to jointly achieve both choice modeling and customer segmentation objectives.

4 - Management and Effects of In-Store Promotional Displays
Oguz Cetin, Kenan Flagler Business School, 213 Ivy Meadow Lane, Durham, NC, 27707, United States, oguz_cetin@kenan-flagler.unc.edu, Adam J.Mersereau, Ali Kemal Parlakturk

We examine a brick-and-mortar retailer's choice of product to include in a promotional display. The display provides a visibility advantage to both the featured product and its category, but it also has consequences on customer traffic and substitution. Retailers need to understand the promotional display problem because it is a powerful demand-shaping lever and as an input to its negotiations with manufacturers. We develop analytical insights using a problem formulation based on a nested multinomial logit model of customer choice. Our work provides guidance for how retailers can use and value promotional displays effectively.

■ WB04

320A

Models in Sustainable Operations Management

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Foad Iravani, University of Washington, Seattle, WA, 98195-3226, United States, firavani@uw.edu

1 - Peak Load Energy Management by Direct Load Control Contracts
Ali Fattahi, ali.fattahi.1@anderson.ucla.edu, Sriram Dasu, Reza Ahmadi

Energy firms use direct load control contracts (DLCCs) to curtail customers' electricity consumption during peak load periods via remote control devices. The question is: when and which groups of customers should reduce their energy consumption, and for how long? Implementing DLCCs require solving a stochastic dynamic optimization problem each day. We develop a near-optimum heuristic procedure with two simplifications in our approximation scheme: aggregating the customer groups into a single group, and ignoring the detailed structure of the uncertainty. We show that the asymptotic relative error of our heuristic approach is zero.

2 - Optimal Allocation Rules with Waste Considerations
Sara Rezaee Vessal, HEC Paris, Paris, France, sara.rezaee-vessal@hec.edu, Sam Aflaki

We study capacity allocation of a scarce and perishable product among stockout-averse retailers that face stochastic demand. We focus on two commonly practiced allocation mechanisms and using a dynamic model characterize the conditions under which each allocation mechanism performs superior from a waste and profit point of view.

3 - Wind Generation Strategic Bidding in a Competitive Electricity Market
Ali Shantia, HEC, Paris, France, ali.shantia@hec.edu, Owen Wu, Roman Kapuscinski

We empirically study how strategic behaviour of renewable generators translates to their higher profitability. Using the day-ahead and real-time market data, provided by Midcontinent Independent System Operator (MISO), we study what differentiates the bidding behaviour of wind generators. We also analyze whether such strategic behaviours practically increase wind generation profitability.

4 - That's Not Fair: Tariff Structures for Electricity Markets with Rooftop Solar
Siddharth Prakash Singh, Carnegie Mellon University, Pittsburgh, PA, United States, sps1@andrew.cmu.edu, Alan Scheller-Wolf

Increased penetration of rooftop solar has led to decreased utility company profitability and undesirable cross-subsidization among customers. Regulatory responses have been controversial: changes in Nevada induced SolarCity, the market leader in solar systems, to suspend local operations. We demonstrate that choosing the right tariff structure is crucial to fair regulation: the sort proposed in Nevada have limited ability to allocate the financial losses (or gains) from solar adoption among different parties. We then present a contract, featuring full retail price repurchasing solar customers that does offers full flexibility. We illustrate our findings numerically.

■ WB05

320B

Decision Making for Hospitals and Health Systems

Sponsored: Health Applications

Sponsored Session

Chair: Jens Brunner, University of Augsburg, Universitÿtsstraße 16, Faculty Business Administration/Economics, Augsburg, 86159, Germany, jens.brunner@unikat.uni-augsburg.de

1 - Dynamic Capacity Allocation for Elective Surgeries
Steven Shechter, University of British Columbia, Vancouver, BC, V6T.1Z2, Canada, steven.shechter@sauder.ubc.ca

We model a longer-term, dynamic capacity planning problem, in which a children's hospital semiannually apportions available operating room time to di erent surgical specialties. We consider an objective of minimizing urgency-weighted wait time, and use approximation methods to identify good solutions. We also discuss the use a probabilistic model of the queueing discipline to represent noisy patient selection patterns observed in practice.

2 - Market-Based Risk Adjustment in Capitated Healthcare Systems
Zhaowei She, Georgia Institute of Technology, Atlanta, GA, United States, zshe3@gatech.edu, Turgay Ayer

Risk adjustment is essential component of all capitated healthcare systems, such as Medicare Advantage and Medicaid Managed Care. However, it is hard for payers to perfectly predict their customers' cost patterns based on pure statistical methods. To complement the existing statistical risk adjustment models, this study presents a market based risk adjustment model where perfect risk adjustment can be endogenously generated by proper market segmentation. Specifically, we explicitly characterize the competitive bidding outcomes in Medicare Advantage in a queueing framework, and show that the proposed mechanism can help CMS to achieve the targeted service levels more cost efficiently.

3 - Task-related Resident Scheduling under Uncertainty using Column Generation
Jens Brunner, University of Augsburg, Universitÿtsstraße 16, Faculty Business Administration/Economics, Augsburg, 86159, Germany, jens.brunner@unikat.uni-augsburg.de, Sebastian Kraul

Residents have to perform different tasks while passing several departments in a specific time period. Hospitals have to make efforts to get the best candidates for their programs but need to stay cost-efficient. We present a cyclic optimization model to generate robust training schedules determining the optimal number of residents. The model allows hospital management to derive employment policies. Solving the problem efficiently, we present a new pattern generation approach for the Dantzig-Wolfe decomposition. We present preliminary results using real-world data.

■ WB06

320C

Machine Learning in Medicine

Sponsored: Health Applications

Sponsored Session

Chair: Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, dbertsim@mit.edu

Co-Chair: Ying Zhuo, Massachusetts Institute of Technology, 70 Lincoln Street, Unit L612, Boston, MA, 02111-2670, United States, zhuo@mit.edu

1 - Predicting Response and Adverse Events in Immunotherapy-treated Patients
Ying Zhuo, Massachusetts Institute of Technology, 70 Lincoln Street, Unit L612, Boston, MA, 02111-2670, United States, zhuo@mit.edu, Dimitris Bertsimas

Recent development in immunotherapies has shown remarkable efficacy in treating melanoma and lung cancer patients, yet the response and adverse events associated with use of immunotherapy are highly variable across patients. We aim to build highly individualized predictive models. We obtained 11 years of electronic health records (EHR) from a large cancer center with hundreds of features: demographics, genomics, vitals, lab tests, etc. We fitted state-of-the-art machine learning models to predict 60-, 90- and 180-day mortality and adverse events such as rash, colitis, and hepatitis.

2 - Estimating Risk of Morbity and Mortality After Emergency Surgery with Machine Learning

Jack W. Dunn, Massachusetts Institute of Technology, 24 Hardwick St, Unit 1, Cambridge, MA, 02141, United States, jackdunn@mit.edu, Lauren E.Berk, Dimitris Bertsimas, Haytham Kaafarani, Thomas Peponis, George Velmahos

Emergency surgery comprises an ever-increasing proportion of hospitalizations, and carries a higher risk of morbidity and mortality compared to non-emergent or elective procedures. We apply novel machine learning methods to develop models that predict the risk of mortality and associated co-morbidities following emergency surgery. Our approach delivers best-in-class accuracy whilst remaining intuitive and interpretable. We demonstrate the power of these models for patient counselling prior to surgery, as well as for benchmarking and improving the quality of emergency surgery care.

3 - Predicting Mortality to Prevent Deaths on the Liver Transplant Waitlist

Yuchen Wang, Massachusetts Institute of Technology, Cambridge, MA, United States, yuchenw@mit.edu, Dimitris Bertsimas, Jerry L. Kung, Nikolaos Trichakis, Parsia Vagefi

Current organ allocation process uses the Model for End-Stage Liver Disease (MELD) score to rank disease severity. We propose a new data-driven analytics-based method to predict the mortality rate within three months for patients on the liver transplantation waitlist. Our model not only outperforms the MELD score in accurately predicting mortality, but also addresses several of its shortcomings with respect to its inability to generalize to cancer patients.

4 - Identifying Exceptional Responders in Randomized Trials via Mixed-integer Optimization

Alexander Weinstein, Massachusetts Institute of Technology, Cambridge, MA, United States, amw22@mit.edu, Dimitris Bertsimas, Nikita Korolko

In randomized clinical trials, there may be a benefit to identifying subgroups of the study population for which a treatment was exceptionally effective or ineffective. In this chapter, we present an efficient mixed-integer optimization formulation that can directly find an interpretable subset with maximum (or minimum) average treatment effect. Using both simulated and real data from randomized trials, we demonstrate the effectiveness and stability of the optimization approach in identifying subsets with exceptional response and verifying their statistical significance.

■ WB07

322A

Remote Patient Monitoring and mHealth Applications

Sponsored: Health Applications

Sponsored Session

Chair: Julie Lynn Hammett, Texas A&M University, College Station, TX, 77840, United States, jhammett@tamu.edu

1 - Quantifiable Fatigue Risk Assessment through Activity Recognition

Karla Ivette Gonzalez Coronado, Texas A&M.University, 23908 Killerbee Lane, New Caney, TX, 77357, United States, kalleyranch08@tamu.edu

The development of a modern fatigue risk assessment is necessary. An algorithm to classify activities and a person's heart rate variability through the day to track fatigue throughout the day is a solution for this. To develop this, 30 participants took part in a 90-minute study to identify and objectively define attributes of accelerometer readings, heart rate, breathing rate, and skin temperature and their role in understanding common daily activities. The activities included sitting, walking, picking up boxes, going up/down stairs, pulling ropes, and working on a computer. An application in mHealth is possible through the integration of this algorithm into smartwatches and smartphones.

2 - Remote Patient Monitoring System Model

Julie Lynn Hammett, Texas A&M.University, 301 Holleman Dr E, Apt 728, College Station, TX, 77840, United States, jhammett@tamu.edu

Healthcare providers are facing an increasing number of patients requiring long-term care, introducing new challenges to providing fast and affordable care. We present ongoing research to create a framework for the design, development, and implementation of remote patient monitoring (RPM) for chronic care. Using System Dynamics modeling, we demonstrate the potential impact of a remote health system on resource utilization in the healthcare continuum. The model shows the change in burden on existing resources when the flow of patients through a primary care facility changes.

3 - Activity Estimation using Ambient Sensor Network Data

Yan Wang, University of South Florida, 4202 E Fowler Ave, ENB118, Tampa, FL, 33620, United States, yanwang2@mail.usf.edu

Data from ambient sensor networks deployed in residential environments is used in daily activity recognition, behavior pattern discovery, abnormal behavior detection and physical and mental health assessment. In this work, we describe a spatio-temporal status tracking algorithm based Pyroelectric Infrared (PIR) motion sensor data to estimate resident's location, time outside of home and sleep behaviors. The significance of this information is discussed as it relates to monitoring chronic health conditions and enabling older adults to age-in-place safely and independently.

4 - Occupant Activity Profiles from Smart Home Sensor Event Streams

Garrick Aden-Buie, University of South Florida, 4202 E Fowler Ave, ENB118, Tamp, FL, 33620, United States, gadenbuie@mail.usf.edu

Faced with a growing elderly population, learning and characterizing activity profiles of smart home occupants will support senior health care management for older adults living in homes augmented by ambient intelligence solutions that combine ubiquitous computing and artificial intelligence. In this work, we explore a bag of n-grams approach for creating occupant-specific activity profiles from event streams collected from passive, embedded sensors in real-world sensor networks in the homes of several older adults.

■ WB08

322B

Learning

Contributed Session

Chair: Joseph Kapena Agor, North Carolina State University, 141 Hunt Club Lane, Apt C, Raleigh, NC, 27606, United States, jkagor@ncsu.edu

1 - Learning from Operational Experience and Benchmark Failure Experience in Telecom Sector in India

Shaili Singh, Research Scholar, Indian Institute of Management, IIM Rohtak, Rohtak, 124001, India, singhshaili631@gmail.com, Mahua Guha

Organizations learn from their own experiences and from experiences of peer organizations. Focus of this study is on learning from success and failure experiences. We identify success as enhanced operating experience and failure as benchmark failure experience which is measured based on the key performance indices set by Telecom Regulatory Authority of India and analyse the influence of aspiration performance discrepancy on organizational learning. Our findings suggest that in case of operating experience for performance above aspiration, firms fail to learn but for benchmark failure experience, firms learn from themselves. For performance below aspiration, we found no significant results.

2 - Learning Manufacturing Networks

Dimitrios Katselis, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, United States, katselis@illinois.edu, Seo Taek Kong, Carolyn Beck, R. Srikant

Manufacturing networks are described by task precedence relationships, which indicate the flow of work in the network. The precedence relationships are designed by systems engineers, but they are often implemented quite differently than the intended design. The goal is to infer the precedence relationships in the implemented network using data about the observed start and end times of various tasks in the network. We will present an algorithm for performing the network inference and obtain bounds on the sample complexity by exploiting a relationship with the coupon collector problem.

3 - Arterial Probabilistic Traffic Modeling with Vehicle Probe Data using Machine Learning

Bahar Zarin, PhD Candidate, University of Maryland, College Park, College Park, MD, 20742, United States, bzarin@umd.edu, Ali Haghani

This study proposes a probabilistic modeling framework for the prediction of arterial travel time distribution using Probe Data. We modeled spatiotemporal correlations of the network, including the intersections, using machine learning. We also investigated the effects of other factors such as driver behavior on the travel time. The data used in this study are INRIX vehicle trajectory and Open Street Map.

4 - Predicting Stock Market Short-term Price Based on Machine Learning

Xing Wang, Auburn Univeristy, 371 W Glenn Avenue, Apt 14, Auburn, AL, 36830, United States, xzw0005@auburn.edu, Bin Weng, Lin Lu, Fadel Mounir Megahed, Alexander Vinel

New forms of collective intelligent have emerged with the rise of the Internet. The changes on these platforms will significantly affect the stock market. In this study, we combined disparate online data sources with the traditional time series signal. Several machine learning techniques are applied to train a short-term price prediction model, including decision tree, support vector machine, boosting, as well as different neural network architectures in deep learning. The internal nature and applicability of these models would be analyzed, and their performances would be compared.

5 - Conducting Confirmatory Factory Analysis on an Instrument to Measure Systems Thinking Capacity

Morteza Nagahi, PhD Student, Graduate Research Assistant, Mississippi State University, 450 Campus Trails, Apt 229B, Starkville, MS, 39759, United States, mn852@msstate.edu

The Instrument to Assess Capacity for Systems Thinking was developed to measure individual systems thinking capacity, providing a useful baseline to facilitate agent-assignments, training, and education for effective complex systems problems. The research-based instrument generates systems thinking profiles by capturing the state of individual inclination toward systemic thinking as well as a preference for engaging and solving complex system problems. Researchers perform confirmatory factor analysis (CFA)to verify the factor structure of the construct and evaluate construct validity.

6 - Bilevel Programs for Cross Validation in Classification Models

Joseph Kapena Agor, PhD Student, North Carolina State University, 2500 Stinson Drive, Apt C, Raleigh, NC, 27695, United States, jkagor@ncsu.edu

Statistical methods that utilize cross validation for model selection are shown to be effective in the classification process while identifying the most important features that influence the classification. In this work, we propose a bilevel framework to be used in the cross validation procedure and develop a novel genetic algorithm as a solution approach. We implement the proposed framework and solution procedure in an influenza classification case study where we classify the antigenic variation between influenza virus strains. Our results demonstrate that bilevel programming can improve the strength of classification models when implemented in the cross validation process.

■ WB09

330A

Supply Chain Economics

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: C Gizem Korpeoglu, University College London, London, WC1E 6BT, United Kingdom, c.korpeoglu@ucl.ac.uk

1 - Supplier Diversification under Random Yield: the Impact of Price Postponement

Nan Yang, University of Miami, Coral Gables, FL, United States, nyang@bus.miami.edu, Lingxiu Dong, Guang Xiao

We characterize a firm's pricing and sourcing decisions under supply yield uncertainty, and study the interplay between supply diversification and pricing. We compare the optimal sourcing decisions under two pricing schemes: ex ante pricing and responsive pricing. Although the firm is better off with responsive pricing, the effect of price postponement on the optimal sourcing decision and the firm's need for supply diversification varies and is influenced by factors such as unit procurement cost, supply portfolio, and supply reliability.

2 - Inventory Strategy of Omni-channel

Xiaolin Xu, Nanjing University, School of Business, 23 Hankou Road, Nanjing, 210093, China, xuxl@nju.edu.cn, Ming Hu, Weili Xue, Yi Yang

The future of retailing seems to be omnichannel as the mix of online vs. offline selling. Online retailers such as Amazon move offline by setting up local stores, whereas brick-and-mortar retailers such as Walmart and Target have long set up online stores. We show that buy-online, pick-up-in-store strategy has a drastically different impact on retailers of different natures.

3 - Consumer Taste Uncertainty in the Context of Store Brand and National Brand Competition

Arcan Nalca, Smith School of Business, Queen's University, Goodes Hall Queen's University, Kingston, ON, K7L.3N6, Canada, arcan.nalca@queensu.ca, Tamer Boyaci, Saibal Ray

We study how a retailer can benefit from acquiring information about uncertain consumer tastes in the presence of competition between the retailer's store brand and a manufacturer's national brand. We identify retailer's optimal information sharing strategy with the manufacturer as well as the equilibrium product positioning and pricing of the brands. We find that, when the store brand introduction is not very costly, the retailer voluntarily shares information with the manufacturer so that the both product are better positioned even though this increases the competition between the brands.

4 - Supply Chain Expansion and Integration

C. Gizem Korpeoglu, University College London, Gower Street, London, WC1E 6BT, United Kingdom, c.korpeoglu@ucl.ac.uk, Ersin Korpeoglu, Soo-Haeng Cho

We study expansion and integration of supply chains where multiple suppliers sell to multiple retailers. Though retailers influence wholesale price in practice, prior literature fails to capture this influence. To overcome this limitation, we develop a novel model that considers retailers' buyer power. We show that more retailers raise wholesale price and can improve retailer profits, and that supply chain expansion is more beneficial than prior literature finds. We then show that integration of two supply chains may reduce total profits in a retailer-oriented supply chain. This result suggests that as UK disintegrates from EU via Brexit, supply chain profits may increase in UK and decrease in EU.

■ WB10

330B

Auctions/Mechanism Design

Contributed Session

Chair: Wenwei Wang, Hong Kong University of Science & Technology, Kowloon, Hong Kong, wwangaw@connect.ust.hk

1 - Creating a Transition Schedule for Broadcast Television

Karla L.Hoffman, George Mason University, System Eng. and Operations Research Dept, 4400 University Drive Mailstop 4a6, Fairfax, VA, 22030, United States, khoffman@gmu.edu

Due to the successful Broadcast Incentive Auction, many television stations in the United States and Canada will be required to move to new channels. In many cases, one station will not be able to move to its new channel until another station vacates its old channel. This difficulty led the FCC to create a phased transition plan to ensure that television stations maintain coverage during the transition while completing the entire transition in 39 months. In this talk, we will present the problems presented by the transition and the methodology that the FCC used to resolve these issues.

2 - Sequential Effects and Bidder Heterogeneity in B2B Auctions

Alex Scott, Assistant Professor, Northeastern University, 216 Hayden Hall, Boston, MA, 02038, United States, f.scott@northeastern.edu

We study a longitudinal dataset of truckload spot auctions in which we observe exogenously-imposed business constraints on the bidding firms - some firms can perform work only using assets that they own and operate, while others must outsource work - i.e., brokers. These business constraints manifest themselves in strikingly different behavior by the bidding firms in single and sequential auctions. Brokers adjust their prices in subsequent auctions based on whether they won or lost the previous auction, while firms who operate assets decide whether or not to place a bid. We examine other sources of heterogeneity and discuss implications for our focal industry.

3 - Deterministic Truthful Mechanisms for Interval Scheduling with Applications to Cloud Computing

Peter McGlaughlin, Graduate Student, University of Illinois at Urbana-Champaign, 117 Transportation Building, 104 S. Mathews Ave, Urbana, IL, 61801, United States, mcglghl2@illinois.edu, Jugal Garg

Motivated by cloud computing, we study a market-based approach for scheduling where jobs have hard deadlines and prefer earlier completion times. In our model, completing a job earns its present value. Users submit job requirements to the cloud provider who non-preemptively schedules jobs to maximize social welfare, i.e. the present value of completed jobs. Using a greedy algorithm, we obtain a $1/(1-b)$ approximation to the optimal schedule, where $b < 1$ is the discount factor shared by all jobs. For sufficiently small b, this beats the best known approximation algorithms applicable to the problem. Finally, we construct a pricing rule to incentivize users to truthfully report all job requirements.

4 - Mechanism Design with Efficiency and Equality

Wenwei Wang, Hong Kong University of Science & Technology, Room 5569, Academic Building, HKUST, Kowloon, Hong Kong, wwangaw@connect.ust.hk, Zhou Chen, Qi Qi, Changjun Wang

In this work, we consider the problem of allocating a set of homogeneous goods among multiple strategic players to balance the efficiency and equality from a game-theoretic perspective. We develop a general truthful mechanism framework which optimally maximizes the resource holder's efficiency while guaranteeing some equality constraints. We use the Generalized Gini index as the equality measure, and fully characterize the optimal allocations. Based on the characteristics, we propose a polynomial-time algorithm that computes the optimal allocation and corresponding truthful payments for any bids profile. We also show how the optimal efficiency varies under varying equality constraints.

■ WB11

332A

Information and On-Demand Services

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Luyi Yang, University of Chicago, Chicago, IL, 60615, United States, lyang6@chicagobooth.edu

1 - The Impact of Bilateral Rating System on Online to Offline Platforms

Chen Jin, University of Pennsylvania, 3730 Walnut Street, 500 Jon M. Huntsman Hall, Philadelphia, PA, 19104, United States, jinchen1@wharton.upenn.edu, Kartik Hosanagar, Senthil Veeraraghavan

Platforms like Uber and Lyft adopt a bilateral rating system (BRS) that allows service providers to rate customers and to make accepting/rejecting decisions based on the customers' rating much the same way as the privilege enjoyed by customers exclusively in the traditional on-line platforms, e.g., eBay and Amazon that implement a unilateral rating system (URS). This novel feature of the rating system changes fundamentally the service providers' effort structure and also affects the pricing strategy of the platform. With a stylized model, we compare URS and BRS in the context of ride-sharing service to study their impact on the decisions as well as revenue/welfare of all stakeholders.

2 - Efficient Inaccuracy: Information Sharing in a Queue

Jianfu Wang, Nanyang Business School, Nanyang Technological University, Block S3-B2C-85, 50 Nanyang Avenue, Singapore, 639798, Singapore, wangjf@ntu.edu.sg, Ming Hu

Shared congestion information takes the form of a snapshot of the service system with a time stamp. Future customers can access the information shared by previous customers. We focus on the equilibrium behavior of customers with shared, lagged queue length information to address the following research question: How does this shared information structure affect the throughput and social welfare compared with the full and no information structures?

3 - Queues with Redundancy: Is Waiting in Multiple Lines Fair?

Leela Aarthy Nageswaran, Tepper School of Business, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, lnageswa@andrew.cmu.edu, Alan Scheller-Wolf

In a service system, a redundant customer is one who may join multiple queues simultaneously and is "served" when any one of her copies completes service; systems with redundant customers range from supermarkets with multiple checkout lines to multiple listing for organ transplants. We study the performance of two queues serving two classes of customers, one of which is redundant. We show that non-redundant customers forming independent Poisson streams to each queue prefer that the other class be redundant as opposed to non-redundantly joining the shortest queue if the queues are symmetric (i.e., in this case redundancy is fair); however, this may not hold if the queues have different loads.

4 - "Your Order has Been Picked Up and Will Arrive Shortly": Innovation in Service Delivery

Andrew E. Frazelle, Duke University-Fuqua School of Business, 540 South LaSalle Street, #4340, Durham, NC, 27705, United States, andrew.frazelle@duke.edu, Pnina Feldman, Robert Swinney

On demand delivery has been one of the hottest VC sectors in recent years. However, while service providers benefit from gaining access to uncharted demand for delivery, without the ability to increase capacity, their revenue from walk-in customers may be harmed. We examine conditions under which on demand delivery platforms benefits consumers and the firm.

■ WB12

332B

Sports and Entertainment

Contributed Session

Chair: Mikhail Gordon, University of Pittsburgh, Pittsburgh, PA, United States, m.gordon@pitt.edu

1 - Human Machine Interface using Axiomatic Design Industrial Case of Drone Tracker

Rhythm Wadhwa, NTNU, Teknologiveien 22, Gjoevik, 2821, Norway, rhythmwadhwa@hotmail.com

The paper presents a novel application of axiomatic design in combination with AHP process used in early product development of a drone human machine interface for sports applications. The product is intended and was field tested for professional downhill skiiers and skateboarders. Axiomatic design was used for decoupling the design parameters associated with the functional requirements.

2 - Resilience Assessment in Sports

Marcela Gomez, USF, Tampa, FL, United States, marcelag1@mail.usf.edu, Daniel Hernando Romero

In sports, operational resilience is defined as the ability of a team or player to overcome difficulties and comeback from a adverse result to be able to draw or win a game. Resilience metrics are proposed and evaluated in soccer and other sports. Our model will enable to decision makers to make online decisions while the team or player is in disadvantage.

3 - Analysis of College Football Wins and Their Effect on School Athletics Revenue

Mikhail Gordon, University of Pittsburgh, 241 Mervis Hall, Pittsburgh, PA, 15260, United States, m.gordon@pitt.edu

The use of hierarchical linear regression leads to information linking the revenue of an NCAA school to the number of wins of that school's football team. This analysis includes differences between divisions and conferences in which the schools lie.

■ WB13

332C

Decision Support Systems

Contributed Session

Chair: Lin Guo, University of Oklahoma, Norman, OK, United States, lin.guo@ou.edu

1 - Developing Robust Strategic Partnership Portfolios in the Retail Industry using a Multi-stage Knapsack Model

Stanislaus Solomon, Assistant Professor of Supply Chain Management, Sam Houston State University, 1821 Avenue I, 236S.Smith Hutson Building, Huntsville, TX, 77341, United States, solomon@shsu.edu, Esha Christie, Jason Riley

The selection and development of suppliers in the retail industry is critical to supply chain robustness and profitability. This research focuses on the implementation of a multi-stage knapsack model that considers conflicting objectives and provides decision support on the appropriate strategic partnership portfolios to develop, based on the decision maker's criteria. Experimental results from a case study will be presented.

2 - Stochastic Modeling for Biofuel Supply Chains

Edgar Gutierrez-Franco, University of Central Florida, 12104 Napiers Circle, Orlando, FL, 32826, United States, edgargutierrezfranco@gmail.com, Qipeng Phil Zheng, Alfonso Sarmiento, Luis Rabelo

This research is proposing a formal methodology for decision-making for a renewable supply chain, based on deterministic and stochastic optimization models. This methodology takes into account the forecast of available technology for vehicles using probabilistic scenarios to represent the biofuel regulations. The decision support system allows the planner to determine which and where the bio-refineries have to be opened, the amount and period of time of raw material to be sown depending on their life cycle, production plans, optimal flows of products and inventory. The methodology became a decision tool for strategic and tactical levels in a supply chain.

3 - A Systems Thinking Approach for Waste Management in University Campuses

Misagh Faezipour, Assistant Professor, Middle Tennessee State University, 1500 Greenland Drive, Engineering Technology, Box 19, Murfreesboro, TN, 37132, United States, Misagh.Faezipour@mtsu.edu

United States is among the top leading trash generators in the world and accounts for more than 30% of the waste worldwide. The threat of waste will cause enormous social, economic, environmental, health, and safety consequences. Universities produce large amounts of trash each year. This paper explores the application of system dynamics modeling in universities to better manage waste.

4 - Exploration of the Solution Space of Compromise Decision Support Problems with a Large Number of Goals

Lin Guo, University of Oklahoma, Norman, OK, United States, lin.guo@ou.edu, Warren Smith, Janet Katherine Allen, Farrokh Mistree

In this paper, we propose an approach for exploration of the solution space of a compromise Decision Support Problems model with ten goals. Since the complexity of exploration of the solution space grows steadily with the increasing of the number of goals, we approximate the problem by using Principal Components Analysis to identify the main goals that represent more than eighty percent of the design preferences; and then we convert the other goals into constraints. In this way, we can reduce the dimension of the problem and save the exploration time while maintain our design space in a satisficing level. An example of supply chain design is used to show the advantage of this approach.

■ WB14

332D

Applications in Healthcare

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Sandeep Rath, Sandeep_Rath@kenan-flagler.unc.edu

1 - IMPT Treatment Planning Optimization Considering RBE and LET

Gino J.Lim, University of Houston, Houston, TX, United States, ginolim@uh.edu, Guven Kaya, Jiming Peng

We present optimization models and algorithms to obtain optimal beamlet intensities considering relative biological effectiveness (RBE) in intensity modulated radiation therapy. Based on three RBE biophysical models, quadratic programming optimization models (RBEMs) are developed with the use of linear energy transfer (LET) values. We implement a functional parallelism approach to achieve substantial speed gains. We also compare results of RBEMs with the traditional dose-based fluence map optimization model. Two cancer cases; prostate and head-and-neck (including LET data) are tested.

2 - Learning from Many: Partner Exposure and Team Familiarity in Fluid Teams

Jonas Oddur Jonasson, MIT.Sloan School of Management, 30 Memorial Drive, E62-588, Cambridge, MA, 02142, United States, joj@mit.edu, Zeynep O.Aksin Karaesmen, Sarang Deo, Kamalini Ramdas

We use data from London Ambulance Service to study the impact of partner exposure of new paramedics on their operational performance. We find that the greater diversity in prior partners directly improves performance for an unstandardized process. For a more standardized process, this effect is moderated by a new recruit's total experience. We explore the implications of our results for team formation strategies by balancing the benefits of partner diversity with those of team familiarity.

3 - Modeling Emotional Health and Quality of Therapeutic Alliance using Data from Chat Conversations

Shishir Dash, Ginger.io, SanFrancisco, CA, United States, shishir.dash@gmail.com, Sai Moturu

Each year, one in five people suffer from stress, anxiety or depression. Apps providing chat-based talk therapy, video sessions with professionals and self-care tools are crucial to addressing the huge access and cost hurdles in this space. They also enable the continuous modeling of the therapeutic alliance and patient progress. We present initial analysis of a large trove of anonymized conversation data collected via the Ginger.io app to (a) identify indicators of depression and anxiety, (b) triage users to the right level of care, and (c) identify successful talk-therapeutic strategies. We aim to show how these technologies can help build a more scalable and efficient mental health care system.

4 - Kidney Transplant Wait List Management: Patient Assessment and Prioritization

Joseph Milner, University of Toronto, Toronto, ON, Canada, milner@rotman.utoronto.ca, Adam Diamant

We consider the admission control problem for the kidney transplant wait list for a major research and teaching hospital located in Toronto, Ont. With increasing demand and limited diagnostic capacity, the transplant program seeks to ensure sufficient patients of each type are maintained on the list. Uncertain supply leads to significant delays in obtaining an organ. Because patient states are dynamic, there are significant costs to being maintained on the list. We develop an evidence-based policy to lower patient costs while maintaining hospital service levels.

■ WB15

332E

Forecasting within a Supply Chain

Sponsored: Manufacturing & Service Oper Mgmt, Supply Chain

Sponsored Session

Chair: Gary R Waissi, PhD, Arizona State University, 6049 S Backus Mall, Sutton Hall #340J, 6049 S Backus Mall, Sutton Hall #340J, Mesa, AZ, 85212, United States, gary.waissi@asu.edu

1 - Tactical Demand Forecasting from an Industry Perspective – Opportunities and Challenges

Divya Prakash, Intel, 5000 W. Chandler Blvd, Chandler, AZ, 85226, United States, divya.prakash@intel.com, Nital S. Patel

Changing business landscape is driving changes in supply chain design resulting in the need to be more responsive to market needs. Given the manufacturing lead times along with the changing demand landscape it is crucial to closely examine the horizon and fidelity of tactical forecasting for purposes of optimizing supply chain efficiency. The presentation will focus on technologies to help manage forecasting inaccuracies, to improve responsiveness, and also find opportunities to improve the forecast itself. The presentation will also cover some of the opportunities and challenges for further improvements and hopefully encourage a dialog on research directions.

2 - Automation of Strategy with Respect to Supply Chain using Neural Networks

Kumail Selani, Arizona State University, Mesa, AZ, United States, kselani@asu.edu

We will discuss and demonstrate a working model that exemplifies how automation of strategy with respect to supply chain can capitalize on the available data. The proposed technique makes use of neural networks embedded in an IDEF0 environment. It is founded on the IDEF0 strategy model as presented in the paper "Automation of strategy using IDEF0 — A proof of concept" (Operations Research Perspectives (ORP) Dec. 2015 by Waissi et.al.). We will look at the unique advantage of neural networks in their ability to map variable data points to show trends and relationships, their high flexibility, adaptability and explore how supply chain strategy can be automated using this novel machine learning approach.

3 - A Three-dimensional Modelling Approach for Short-term Demand Forecasting

Jay Patel, Arizona State University, Tempe, AZ, United States, jdpatel2@asu.edu

Forecasting methods are either quantitative or qualitative, or combination of both. Any practical forecasting model is a combination of both. A novel approach is being introduced in this paper. We will construct a three-dimensional model for short-term demand forecasting by treating the supply chain as a "hybrid three-dimensional ecosystem". The first two dimension include quantitative and qualitative techniques, and the third dimension is a weighting matrix to combine the two dimensions into one model. We will first analyze supply chain forecasting models using the first two dimensions, and then develop the weighting matrix. We will then combine the dimensions into an integrated model.

4 - Facility Location Problem with Joint Disruptions using Subordinated Markov Chains

Vishwakant Malladi, Doctoral Student, University of Texas-Austin, McCombs School of Business, CBA 5.202, IROM, Austin, TX, 78712, United States, vishwakant@gmail.com

Classical facility location problems do not incorporate the possibility of correlated disruptions amongst facilities and often result in optimal solutions that are too conservative. We propose using subordinated Markov chains to model the probability of the correlated risk of disruptions which offers a more realistic disruptions scenarios. We also present a new methodology to solve the facility location problem with correlated disruptions. Optimal solutions considering correlated disruptions show improved performance over traditional disruption models

■ WB16

332F

Operations Management

Contributed Session

Chair: Jie Yang, Tianjin University, Tianjin, China, nemoyj1989@126.com

1 - New Experience Good Introduction Decisions

Eylem Koca, Assistant Professor, Ozyegin University, Nisantasi Mah. Orman Sk. 34-36, Cekmekoy Campus, Istanbul, 34794, Turkey, eylem.koca@ozyegin.edu.tr

We investigate the two crucial decisions when introducing new experience goods: 1) preannouncements, and 2) availability of return policies. In our model, the main role of preannouncements is that of making product information available in order to reduce the product fit uncertainty for the consumers; the preannouncement timing decides on the available information. Coupled with this, we study the possibility of the firm selling the products in two forms simultaneously - with and without a return policy - and we characterize the conditions for which doing so is optimal.

2 - When to Offer Free Extended Warranty? Customer Segmentation, Repairing Cost, and Product Reliability

Wen-Hsing Ting, National Taiwan University, Taipei, Taiwan, d04724017@ntu.edu.tw, Ling-Chieh Kung

We study a firm's optimal design of base and extended warranty plans when product reliability is exogenous or endogenous. We consider customers with different needs of repairing a damaged product and find that the firm's decision depends two critical factors, the number of frequent users and customers' repairing cost without warranty production. When the reliability is exogenous and the number of frequent users is large, the firm should sell extended warranty when customer's repairing cost is either high or low but should not if moderate. With endogenous reliability, free extended warranty should be offered if customers' repairing cost is low. The warranty should be life-long under some conditions.

3 - Pricing and Availability Strategies with Strategic Customer Behavior and Scarcity Effects

Hanqing Liu, City University of Hong Kong, Hong Kong, work.lhq@gmail.com, Peng Hu, Stephen Shum

We study the dynamic pricing and availability decisions of a firm that repeatedly introduces new generations of a product over time. Customers are strategic and are affected by two types of scarcity effects: direct scarcity effect and relative scarcity effect. Firm-induced scarcity is never optimal in the absence of scarcity effects but it can be optimal when customers are affected by scarcity effects. We study the long-run optimal policy of the firm and characterize when firm-induced scarcity is optimal. Our results show that the firm's long-run optimal policy may be a constant availability policy or a varying availability policy, depending on certain parameters.

4 - To Buy or Not to Buy? Purchasing Decision and Spillover Effect of the Sharing Economy for the Manufacturing Industry

Jie Yang, Phd Candidate, Tianjin University, Nankai District, 92 Weijin Road, Tianjin, 300072, China, nemoyj1989@126.com, Daozhi Zhao

We first study how the presence of sharing economy affects the consumer's purchasing decision. We focus on this question, and identify the conditions for consumers to purchase products. In the presence of the conspicuous consumption, we develop a model in which consumers make purchase decisions and then have the option to participate in a sharing economy contingent on a realized usage level. We compare the consumers' purchase decisions to a situation where ex-post sharing is impossible. Second, we investigate the spillover effect of the sharing economy on the manufacturing industry.

■ WB17

340A

Stochastic Models for Shared Transportation

Sponsored: Applied Probability

Sponsored Session

Chair: Siddhartha Banerjee, Cornell University, Ithaca, NY, 14853, United States, sbanerjee@cornell.edu

1 - The Value of State Dependent Control in Ride-sharing Systems

Pengyu Qian, Columbia Business School, Columbia Business School, c/o PhD Office, New York, NY, 10027, United States, PQian20@gsb.columbia.edu, Yash Kanoria, Siddhartha Banerjee

We consider the design of state-dependent control policies for a closed queueing network model of ride-sharing systems, where the platform can choose which car to match to any incoming passenger. We propose a gradient-based control policy associated with a novel Lyapunov function, and show that this is rate-function optimal, i.e., under mild conditions, it minimizes the asymptotic rate of demand-dropping as the number of vehicles scales to infinity. We further show how this large-deviations approach can be used to study the trade-off between estimation, computation and performance.

2 - Minimizing Multimodular Functions and Allocating Capacity in Bike-sharing Systems

Daniel Freund, 1, 109 Lake St, Ithaca, NY, 14850, United States, danielrfreund1990@gmail.com, Shane Henderson, David B. Shmoys

Bike-share systems (BSS) allow users to rent and return a bike at any station within the system. Whereas the question of how to mitigate the effects of resulting imbalances using rebalancing has received much attention, our work considers the more strategic question of how to allocate dock capacity within such systems. Extending known models from the rebalancing literature and connecting it to the literature on discrete convexity, we present a provably polynomial algorithm that finds the optimal allocation of docks within such systems. Our work has yielded improvements for the BSS in major American cities like Boston, Chicago, and NYC, where strategically reallocating docks has improved service.

3 - Online Matching in a Ride Sharing Platform

Chinmoy Dutta, Lyft, San Francisco, CA, United States, cdutta@lyft.com, Adam Greenhall, Keshav Puranmalka, Chris Sholley

We study the online problem of matching passengers with each other for sharing rides. Our setting is motivated by real-world ride-sharing platforms like Lyft. In this setting, a passenger can request a ride at any time, and the task of the matching algorithm is to find another ride to match with it. A ride can get matched only to another ride that arrived close in time, and there is a bounded time interval to match a ride since its arrival. The efficiency of a match between two given rides defines the weight of the match. The goal of the matching algorithm is to maximize the total weight of the matching constructed over a given time interval. We present algorithms and bounds for this problem.

■ WB18

340B

Applied Probability

Contributed Session

Chair: Suneel Babu Chatla, National Tsing Hua University, Hsinchu, Taiwan, suneel.chatla@iss.nthu.edu.tw

1 - Revisiting the Two-sample Z-test from the Perspective of Almost Stochastic Dominance

Chin Hon Tan, National University of Singapore, 1 Engineering Drive 2, Department of Industrial and Systems Engineer, Singapore, 117576, Singapore, isetch@nus.edu.sg

The two-sample z-test is often used to compare the mean of two populations. However, such tests are not sufficient for studying preferences between two uncertain prospects. In particular, the z-test only accounts for sampling errors and neglects the risk preferences of the decision maker. In practice, the preferences of the decision maker is unclear. Here, we revisit the two-sample z-test in light of recent advances in the almost stochastic dominance literature which expound on the relationship between preferences and distribution moments.

2 - Video Streaming in Distributed Erasure-coded Storage Systems

Vaneet Aggarwal, Purdue University, 315 N. Grant St., West Lafayette, IN, 47906, United States, vaneet@purdue.edu, Abubakr Al-Abassi

This work considers video streaming over distributed systems where the video segments are encoded using an erasure code for better reliability thus being the first work to our best knowledge that considers video streaming over erasure-coded distributed cloud systems. The download time of each coded chunk of each video segment is characterized and ordered statistics over the choice of the erasure-coded chunks is used to obtain the playback time of different video segments. Using the playback times, bounds on the moment generating function of the stall duration is used to bound the mean stall duration. This metric represents an important quality of experience (QoE) measure for the end users.

3 - Additive Model for Unbalanced Longitudinal Data via Smooth Backfitting

Suneel Babu Chatla, PhD Candidate, National Tsing Hua University, Hsinchu, 30013, Taiwan, suneel.chatla@iss.nthu.edu.tw, Li-Shan Huang

We propose a new method for estimating an additive model for the unbalanced longitudinal data using smooth backfitting. Our method uses the concept of global smoothing matrix and it enables estimating the regression function at the data points in addition to the grid points. We use profile least square technique to estimate the correlation structure over repeated measurements. We prove that the proposed estimator is asymptotically efficient compared to the estimator obtained using working independence assumption. A Monte Carlo simulation study was conducted in order to evaluate the finite sample performance of the estimators. A real data application is also provided.

4 - Predictive Control and Fault Detection of Natural Gas Networks

Kevin Melendez, PhD Student, University of South Florida, 4411 Shady Terrace Lane, Apt 303, Tampa, FL, 33613, United States, kmelendez7@mail.usf.edu, Tapas K. Das, Changhyun Kwon

The objective of this study is to generate a comprehensive methodology to optimally design and operate a natural gas network. A Mixed Integer Nonlinear Programming model is proposed to locate the pipelines and compression stations while minimizing the total cost over a planning horizon. A Bayesian approach is used for demand forecasting and a model predictive control strategy is introduced for maintaining the network on the optimal operation point. Finally, multivariate statistics methods are used for early fault detection. The proposed methodology aims to help the engineers of a natural gas company with the decision-making and the online control and atypical operating condition identification.

5 - Confidence Sets for Split Points in Model Based Regression Trees

Suneel Babu Chatla, National Tsing Hua University, Hsinchu, 30013, Taiwan, suneel.chatla@iss.nthu.edu.tw, Galit Shmueli

Model-based (MOB) trees are popular for their ability to incorporate parametric models into classification and regression trees. The existing MOB uses an exhaustive search to identify the split points and it is computationally very intensive. In addition, there is no way to assess the variability of the identified split points, which is crucial for the statistical generalizability of the results. To solve this problem, we propose a new split point estimation method which uses the change point framework. We consider two popular bootstrap methods to estimate the confidence sets: conditional and smooth. From a simulation study, we find that the smooth bootstrap provides much narrower confidence sets.

■ WB19

342A

Production and Scheduling

Contributed Session

Chair: Zhengyang Hu, Iowa State University, Ames, IA, United States, zhengya@iastate.edu

1 - Optimal Integration of Solar Power to Minimize Operational Costs and Carbon Dioxide Footprint in a Production System

Samuel Trevino, PhD Graduate Research Assistant, University of Tennessee, 525 John D. Tickle Engineering Building, 851 Neyland Dr., Knoxville, TN, 37996, United States, strevin1@vols.utk.edu

Production scheduling problems have generally been studied from a lean manufacturing perspective, however, energy consumption and environmental footprint have not been completely considered. To fill this gap, an optimal production planning framework for a production system is presented utilizing on-site solar power generation to minimize its energy consumption costs and CO2 footprint. Integrating uncertainty in both equipment reliability and customer demand, the multi-objective optimization model presents insights into the economically feasible solar power capacity to be installed and how production inventory planning can offset solar source uncertainty.

2 - A Client Server Framework for a Job Shop Scheduling System to Minimize Tardiness and Labor Overtime Costs under Labor and Machine Constraints

Weihang Zhu, Associate Professor, Lamar University, PO Box 10032, Beaumont, TX, 77710, United States, weihang.zhu@lamar.edu, Sujay Mahale, Alberto Marquez

Simultaneous scheduling of machine and labor in a job shop is a NP hard problem. In this study, we developed a system for minimizing tardiness and overtime labor costs in a job shop style service manufacturing facility, while incorporating client server framework for schedule visibility. The core of the optimization engine is a double sequenced simulated annealing algorithm. The model includes various machine and labor constraints including sequence dependent setups, labor availability and overtime regulations, and dispatching rules for the different parallel machine centers.

3 - Integrated Ordering and Scheduling Optimization for Make-to-order Supply Chains under Uncertainty: A Stochastic Programming Approach

Yue Sha, Tsinghua University, Tsinghua University, Beijing, Beijing, 10084, China, shay15@mails.tsinghua.edu.cn, Hui Cao

Customer driven supply chain management is recognized as a viable approach to the rapid changing market demand. Yet the coordination strategies have been little studied to align supply chain operations on a make-to-order basis. This work tries to integrate the material ordering and job scheduling decisions considering uncertain processing times and resource consumptions. The problem is formulated as a stochastic integer program incorporating decision dependent uncertainties. With the proposed approximation algorithm, numerical experiments show that the integrated policy significantly reduces the total cost.

4 - Robust Project Scheduling Integrated with Materials Ordering under Uncertain Environment

Yan Zhang, Doctoral Candidate, Huazhong University of Science and Technology, Hongshan District, 1037 Luoyu Road, Wuhan, China, zhangyan0621@hust.edu.cn, Nanfang Cui

Project Scheduling and Materials Ordering Problem (PSMOP) generates not only the project schedule but also the corresponding martials ordering plan. In our study, we consider the uncertainty of activity durations and propose a robust project schedule. We first get a baseline schedule with deterministic activity durations via genetic algorithm, basing on which a creative robust schedule is obtained by an iteration algorithm under uncertain circumstances. Finally, under different project uncertainties, computational experiments are conducted to compare the two schedules and we show that the robust schedule performs better.

5 - Hybrid Lot-sizing and Scheduling Production under Uncertainties

Zhengyang Hu, Iowa State University, 3020 Regency Ct, Unit 68, Ames, IA, 50010-2701, United States, zhengya@iastate.edu, Guiping Hu

Lot-sizing and scheduling, one of the medium-term production problems in assembly manufactories, is universally challenged with the need to reduce cost and improve customer satisfaction. A hybrid decision making model is proposed to address the combination of uncertainties on the shop floor considering real time information. Stochastic programming is adopted for random machine failure time and robust optimization is utilized to address the uncertain demand. Sample average approximation is introduced to generate discrete scenarios. The model is able to minimize the overall production cost as well as adjust satisfaction of customers based on the market environment.

■ WB20

342B

Information Systems

Contributed Session

Chair: Lifei Sheng, University of British Columbia, Vancouver, BC, Canada, fay.sheng@sauder.ubc.ca

1 - Cloud Deployment Model and Impact on Provider's and Users' Incentives to Invest in Security

Mingwen Yang, University of Texas-Dallas, Richardson, TX, United States, mxy131030@utdallas.edu, Varghese S. Jacob, Srinivasan Raghunathan

Cloud computing has emerged as a key strategy to meet the IT needs of firms. Despite its benefits, cloud computing's adoption and growth is hindered by information security concerns. The security of a cloud is the joint responsibility of the cloud provider and cloud users, but the extent to which the provider and users can affect the cloud security through their efforts depends on the cloud deployment model. In this study, we focus on how the cloud deployment model affects the incentives of the cloud provider and users to invest in security, which, in turn, affects the price charged by the cloud provider, the demand, and the provider's profit.

2 - Understanding Determinants of Idea Quality in On-line Communities

Orcun Temizkan, Assistant Proffesor, Ozyegin University, Cekmekoy Campus, Nisantepe Mah. Orman Sok., Istanbul, 34794, Turkey, orcun.temizkan@ozyegin.edu.tr, Ram Kumar

This research proposes a model to understand determinants of Idea Quality in on-line communities. The proposed model integrates multiple types of variables including creator (idea generator) characteristics, contributor (idea developer) characteristics and idea characteristics. Theories from the organization and innovation literature are used to develop the model. Empirical results using data from Stack Overflow will be presented.

3 - Once Bitten, Twice Shy? Examining Customer Responses to Stolen Customer Data

John N. Angelis, Assistant Professor, Elizabethtown College, 1 Alpha Drive, Elizabethtown, PA, United States, angelisj@etown.edu, Joseph C.Miller

Data breaches represent an increasing nuisance for companies. Nonetheless, the impact on future business remains underinvestigated. We surveyed 400 individuals with four unique real-world data breaches. The nuances of each case differed in two dimensions: 1) localization of the breach and 2) individualization of affected customers. We use critical components of both the Theory of Reasoned Action (TRA) and Technology Acceptance Model (TAM) in our model of business revisits. Localization has a significant effect on company opinions, while individualization has a significant effect on attitudes about the crime. We find that mainly opinions about the company have a significant effect on revisits.

4 - Innovation vs. Security: Customer Demand Reaction to Adverse Events and Industry Innovation

Melanie Lisa Yeo, Assistant Professor, University of California-Merced, Merced, CA, 95340, United States, melanie.yeo@gmail.com, Raymond Patterson, Jacquelyn Rees Ulmer, Erik Rolland

We examine the tradeoff between product innovation and the risk of security breaches in digitally-enabled products. The demand for a product, such as a mobile phone, is often influenced by innovations in features. We explore the trade-off between investing in product features and security. Using a continuous-time markov chain model, we explore the impact of differing customer demand reactions to security breaches on feature investment.

5 - Designing Services in the Presence of Customer Churn

Lifei Sheng, University of British Columbia, Sauder School of Business, 2053 Main Mall, Vancouver, BC, V6T.1Z2, Canada, fay.sheng@sauder.ubc.ca, Christopher Ryan

We explore how to design experiential services, in particular determine the quality and sequence of activities, to maximize customer satisfaction. We assume that customers are subject to memory decay and are free to quit the service at any time. This model fits experiential goods that must first be experienced by users before their value is understood. Examples include freemium software where the goal is maximize customer utility by the end of some initial phase subject to the possibility of early quitting. We show that the quality of the experience should be scheduled in a U-shape. The quitting option and memory decay lead to high service quality at the beginning and at the end of the trial period.

■ WB21

342C

Supply Chain, Shipping and Transportation

Contributed Session

Chair: Sangpil Ko, Michigan Technological University, Houghton, MI, United States, sangpilk@mtu.edu

1 - Impact of Free-flow Operation on Drayage Productivity

Samaneh Shiri, University of South Carolina, 1076 Pavilion Tower Circle, Columbia, SC, 29201-2361, United States, shiri@email.sc.edu, Nathan Huynh

In the last decades, due to increase in international trade volume, the world container terminal throughput has increased enormously. As a result, terminals are under pressure to develop strategies to accommodate demands and increase the efficiency of their operation. The Port of Los Angeles has launched a container free-flow operation to reduce truck turn time, free up terminal space and optimize container moves. This study assesses the impact of free-flow operation on drayage productivity using the previously developed drayage scheduling model by the authors. To efficiently solve the model a reactive tabu search algorithm combined with an insertion heuristic is used.

2 - Improving Supply Chain Production Reliability through Risk-averse Interdiction

Mehdi Zolghadrasli, Stevens Institute of Technology, Hoboken, NJ, United States, mzolghad@stevens.edu, Ricardo A.Collado

We consider the problem of quality assurance on industrial assembly lines where checking all productions is impossible due to sampling cost and physical limitations. Given the total sampling budget, we determine the optimum sampling rate on each production line by solving a risk-averse multi-stage stochastic optimization problem on the production network. By leveraging the theory of dynamic coherent risk measures, we obtain a method that minimizes the probability of defective items reaching the consumers. We show that our method performs well even under erroneous beliefs/data about the reliability of each machine and process.

3 - A Multi-product Production/distribution System Design Problem with Direct Shipments and Lateral Transshipments

Jianing Zhi, Penn State-Erie, The Behrend College, Black School of Business, Burke Center 228, 5101 Jordan Road, Erie, PA, 16563, United States, jzz5296@psu.edu, Burcu B.Keskin

We investigate a multi-product, three-stage production/distribution system design problem with the direct shipment and lateral transshipment capabilities. Our goal is to find the most efficient network design to minimize the total fixed facility and transportation costs. Specifically, we locate p capacitated distribution centers in the second stage from a set of candidate locations. We propose two solution algorithms based on simulated annealing and GRASP heuristics. Both long-term and short-term memory lists are applied to maintain an efficient local search, combined with a custom greedy solver that can effectively evaluate the quality of a solution candidate.

4 - Optimal Supply Network for Biomass Co-firing Power Plant Considering Advanced Woody Biomass Feedstock Logistics

Sangpil Ko, Michigan Technological University, 1400 Townsend Dr., Houghton, MI, 49931, United States, sangpilk@mtu.edu, Pasi T. Lautala

One of the most implementable technologies to generate electricity with less environmental emissions is co-firing biomass in existing coal-fired power plant. One of the challenges for co-firing is procurement cost for biomass feedstock and as part of it, the cost of biomass transportation. Our study considers the advanced woody biomass feedstock logistics that allows for a local biomass processing depot where the biomass is torrefied and densified prior to transport to the plant. One research finding revealed large capacity power plants with a small inventory of forest residue nearby gain more benefits from such arrangements under the advanced biomass feedstock logistics scenario.

■ WB22

342D

Online Business Models

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Simone Marinesi, Wharton, Philadelphia, PA, 75003, United States, marinesi@wharton.upenn.edu

1 - Social Pricing in Sharing Economy: Theory and Empirical Evidence from Airbnb

Yao Cui, Cornell University, Ithaca, NY, United States, yao.cui@cornell.edu, Ming Hu

An important difference between the lodging sharing economy platforms (e.g., Airbnb) and the traditional hotels is that in sharing economy, the guest may have social interactions with the host. In this paper, we study the effects of social interactions on rental pricing in sharing economy. To investigate the effects, we analyze a theory model and also test our theory with an empirical study using a dataset of Airbnb transactions and listing attributes.

2 - Designing Rewards-based Crowdfunding Campaigns for Strategic Contributors

Soudipta Chakraborty, Duke University, 100 Fuqua Drive, Durham, NC, 27708, United States, sc390@duke.edu, Robert Swinney

We study a model of rewards crowdfunding with the all or nothing funding mechanism. The creator of a crowdfunding campaign sets a target funding level and the campaign is successful only if the funding it receives meets this target. The contributors incur a transaction cost while pledging to a campaign. As a result, they behave strategically and decide whether to pledge before the target is met or to incur a waiting cost and delay their pledge until the campaign succeeds. We study how a creator who encounters such strategic behavior should design her crowdfunding campaign.

3 - Reward-based Crowdfunding Campaigns: Informational Value and Access to Venture Capital

Rachel Rong Chen, University of California-Davis, 3208 Gallagher Hall, One Shields Avenue, Davis, CA, 95616, United States, rachen@ucdavis.edu, Esther Gal-Or, Paolo Roma

Consider an entrepreneur who designs a reward-based crowdfunding campaign when the campaign provides a demand signal for the product and subsequent Venture Capital (VC) is needed. Her design entails choosing both the campaign goal, and the pledge level that entitles backers to the product if it becomes available. While failure to reach the goal sends a negative signal likely to eliminate the entrepreneur's access to VC funding, succeeding does not guarantee subsequent VC funding either. We examine how the informativeness of the campaign and considerations related to gaining access to VC funding affect the choice of campaign instruments, as well as the decision of whether to run a campaign.

4 - The Dark Side of Crowdfunding

Simone Marinesi, Wharton, 201 S.25th Street, Apt 621, Philadelphia, PA, 75003, United States, marinesi@wharton.upenn.edu, Elena Belavina, Gerry Tsoukalas

We explore the pros and cons of reward-based crowdfunding by comparing it with traditional bank funding, accounting for two characteristics of crowdfunding: the unobservability of products' true performance (performance opacity) and risk of entrepreneurs' misbehavior (moral hazard). We find that both features hampers crowdfunding profits, and characterize how their interaction and its implications for profit and welfare. We then propose an improved crowdfunding design that remedies the negative consequences of such features.

■ WB23

342E

Revenue Optimization in Online Markets

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Vahideh Manshadi, Yale University, New Haven, CT, 06511, United States, vahideh.manshadi@yale.edu

1 - Promotion Planning of Network Goods

Saed Alizamir, Yale University, 339 Willow St., New Haven, CT, 06511, United States, saed.alizamir@yale.edu, Ningyuan Chen, Sang Kim, Vahideh Manshadi

Many products/services exhibit network externality: a customer who consumes the good increases the utility of consumption for her neighbors. To promote diffusion of the good in the network, the firm can initially charge a lower price. The price is raised to a higher level when enough consumers join the pool of adopters. We find that it is optimal for the firm to stop the promotion when the total externality of the existing users reaches a threshold, which depends on the adjacency matrix. We investigate how the structure of the network affects the firm's optimal strategy and profit, and show that more heterogeneity among customers increases the firm's revenue; a balanced network yields the lowest revenue.

2 - Online Bipartite Matching in Two-sided Markets

Van-Anh Truong, Columbia University, 500 West 120th Street, 338 Mudd Hall, New York, NY, 10027, United States, vt2196@columbia.edu, Xinshang Wang

We study a class of bipartite matching problems in which demand and supply units of various types arrive randomly and sequentially over time. Supply units can wait for a fixed amount of time, but demand units must be matched irrevocably upon arrival to existing supply units if any, or rejected. The above problem is motivated by two-sided crowdsourcing markets in which demand and supply are matched by an intermediary firm, which earns a revenue on each transaction. We provide the first efficient algorithms with worst-case performance guarantees for this class of problems.

3 - Online Resource Allocation under Partially Learnable Demand
Vahideh Manshadi, Yale University, 165 Whitney Ave, Rm 3473, New Haven, CT, 06511, United States, vahideh.manshadi@yale.edu

We study a basic online resource allocation problem where stochastic information about demand is unknown a priori, and it can only be partially learned. We design online algorithms that significantly outperform those that do not utilize the partial information, highlighting the value of (even partial) learning in online resource allocation.

4 - Dynamic Recommendation at Checkout under Inventory Constraintconstraint
Xi Chen, New York University, 44 W. 4th St, NYU. KMC Room 8-50, New York, NY, 10012, United States, xchen3@stern.nyu.edu, Will Ma, David Simchi-Levi, Linwei Xin

This talk is motivated by a new checkout recommendation system at Walmart's online grocery, which offers a customer an assortment of up to 8 items that can be added to an existing order, at potentially discounted prices. We formalize this as an online assortment planning problem under limited inventory. Multiple item prices, combined with customer withdrawal when their initially selected items stock out, pose additional challenges for the development of an effective online policy. We overcome these challenges by introducing the notion of an inventory protection level in expectation, and present an online algorithm with bounded competitive ratio for arbitrary arrival sequences.

■ WB24

342F

Innovative Practices in Hotel and Sports Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Pelin Pekgun, University of South Carolina, Columbia, SC, 29205, United States, Pelin.Pekgun@moore.sc.edu

Co-Chair: Ovunc Yilmaz, University of Notre Dame, Mendoza College of Business, Columbia, SC, 29201, United States, oyilmaz@email.sc.edu

1 - Dynamic Availability and Pricing of Time-limited Upgrade Offers
Xiao Zhang, The University of Texas at Dallas, 800 West Campbell Rd, Richardson, TX, 75080, United States, xiao.zhang@utdallas.edu, Metin Cakanyildirim, Ozalp Ozer

Upgrade, a strategy used in the travel industry to balance supply-demand mismatches among products of different quality levels, is usually implemented either at the booking time or at the check-in time. We study a revenue management problem of a firm that sells two products at fixed prices and offers upgrades dynamically. The optimal policy specifies the timing, the pricing, and the quantity of the dynamic upgrades.

2 - The Effects of Peer Reviews and Manager Responses on the Hotel Ratings
Saram Han, 110 Joanne Dr., Ithaca, NY, 14850, United States, sh2322@cornell.edu

This study examines how the interaction between the members of the TripAdvisor community affects the ratings of future review writers. Specifically, using the peer-effect model, we aim to examine both peer reviews and manager responses' influence on a future reviewer's rating. The effect of the reviews are captured at two different points: 1) before booking the hotel, and 2) during the review-writing process. We examine how the information received at the expectation stage affects the evaluation about the hotel. The effect of the peer reviews is also analyzed by different contributor levels. Lastly, we discuss the effect of manager responses regarding their response style.

3 - An Empirical Look at the Team-specific Ticket Options Market?
Guangzhi Shang, Florida State University, Department of Marketing, College of Business, Tallahassee, FL, 32306, United States, gshang@fsu.edu, Ovunc Yilmaz, Mark Ferguson, Pelin Pekgun

Team-specific ticket options, where fans can make a team-specific reservation for the right and obligation to purchase a face value ticket if their team qualifies for the final game, has recently gained popularity in the sports industry. Over the past two years, a significant portion of the College Football National Championship game tickets was allocated to Teamtix, a company offering these options. In this study, we investigate the drivers of prices and transaction volumes in Teamtix's marketplace using their Twitter feed and detailed game/ranking information.

■ WB25

350A

Innovation/Entrepreneurship

Contributed Session

Chair: Xiaojin Liu, University of Virginia, Charlottesville, VA, United States, liux@darden.virginia.edu

1 - How Does the Entrepreneur with Shortages Evaluate the Hidden Market?
Sinan Erzurumlu, Associate Professor, Babson College, 231 Forest St, Babson Park, MA, 02457, United States, serzurumlu@babson.edu, Ethem Canakoglu, Yaman Erzurumlu

When entrepreneurs evaluate a business opportunity, they assess its value, and the value of the business based on internal factors, including their risk preference and shortages of resources, routines, reputation and regulations along with external factors including market-related uncertainties. These internal and external factors may impede the entrepreneur's ability to directly evaluate the true state of the market for a business opportunity; hence the market is considered 'hidden'. We present a Markov decision process model to evaluate the hidden market for the business opportunity. We provide an algorithm that explains how entrepreneurs can implement a market-evaluation procedure.

2 - CEO Duality Leadership, Security Analysts Feedback and Corporate Research and Development Investments
Jacob Do-Hyung Cha, Seoul National University, Room 313, 58-dong, Seoul National University, Gwanak-gu, 150-742, Korea, Republic of, research.dohyung@gmail.com, Hye-Jin Cho

A commonly held view is that a hazardous short-termism has taken hold across the publicly held firms. Critics say that top managers have become myopic due to capital market pressures. This study examines whether CEO duality leadership can mitigate this myopic behavior in the context of corporate R&D investments under the pressures from the capital market intermediaries - securities analysts. I propose that CEO duality tend to cut R&D investments when the CEO faces the pressures from the capital market which is consistent with the agency theorists. I test this hypothesis by a large-scale, cross-industry data from a sample of U.S. manufacturing firms during the period of 1992 to 2014.

3 - Innovation in a Dynamic Technology Landscape
Kibae Kim, Research Assistant Professor, KAIST, Daehakro 291, Yuseong, Daejeon, 34191, Korea, Republic of, kibaejjang@kaist.ac.kr, Jorn Altmann

Although previous studies suggest innovation strategies on the ground of technology recombination in a technology landscape, they do not discuss two restricting assumptions that exist in their analysis: the technology space is (1) compact and (2) invariant. In this research we replace these assumptions with realistic ones by redefining the technology space at a meta level and admitting the evolution of technology landscape. Based on these assumptions we analyze innovation strategies using patent data, and show the effect of innovation strategies varies according to how the technology landscape evolves.

4 - Technology Convergence and its Market Performance
Kibae Kim, Research Assistant Professor, KAIST, Daehakro 291, Yuseong, Daejeon, 34191, Korea, Republic of, kibaejjang@kaist.ac.kr, Wonjoon Kim

Although technological convergence is a paradigm of innovation dominating technology advances across a variety of industry sectors, innovation studies have not yet explored the economic impact of convergence patterns. In this research, we examine whether the market performance causes from the combination of pre-existing technologies or the re-use of converged technologies. To do so, we design a knowledge flow network, which consists of technologies and citation relations, to analyze the combination in backward flowings and the reuse in forward ones. Our findings emphasizes both reuse and combination of technologies and the impact of industry sectors.

5 - How does Social Orientation Influence Firm Innovation
Xiaojin Liu, University of Virginia, Charlottesville, VA, 22903, United States, liux@darden.virginia.edu, Raul Chao, Jared D. Harris

Corporate social responsibility (CSR) has gained momentum as a driver of long term competitiveness. Appling portfolio and resource allocation theory to understand how firms manage funding for CSR projects, this research addresses the questions of whether and how firm social orientation relates to firm innovation. We empirically find that in the long term, both proactive and reactive social orientation can strengthen firm innovation. However, such benefits are moderated by the firm's technological and business contexts.

■ WB26

350B

Simulation and Optimization

Contributed Session

Chair: Si Zhang, Shanghai University, Shanghai, China, zhangsi817@sina.com

1 - Resilience Based Network Design under Uncertainty

Xiaoge Zhang, Vanderbilt University, 6501 Harding Pike, Apt. P-25, Nashville, TN, 37205, United States, zxgcqupt@gmail.com, Sankaran Mahadevan, Shankar Sankararaman, Kai Goebel

A nonlinear function is introduced to characterize the component restoration behavior in the presence of a disruptive event. The introduction of such a function facilitates the modeling of absorptive ability, restoration capability and recovery speed related with each system component. A system resilience constraint is formulated to impose that the system resilience at a given time meet a desired target. We use the maximum flow through the network as an indicator of system performance. Our objective is to design an optimal network that incurs the least cost, but meets a system resilience constraint. Two numerical examples are used to illustrate the effectiveness of the proposed method.

2 - A New Reinforcement Learning Algorithm for Average Reward with Numerical Results on Total Productive Maintenance

Angelo Encapera, Missouir University of Science and Technology, 15512 Tamarac Ct, Wichita, KS, 67230, United States, amet3b@mst.edu, Abhijit Gosavi

We present a new Reinforcement Learning (RL) algorithm for average reward Markov decision processes (MDPs) and semi-Markov decision processes (SMDPs). The existing RL algorithm for SMDPs, namely R-SMART, requires exploration decay. Our new algorithm, named iSMART, is fully exploratory and hence eliminates the need for turning the exploration decay. iSMART is designed using principles of deep learning for RL. We present numerical results on small cases, as well as with a larger case study on Total Preventive Maintenance. The new algorithm is more robust than its precursor R-SMART and generates near-optimal solutions on all test cases studied.

3 - Actor-critics Revisited: A New Bounded Algorithm and Numerical Results with Revenue Management

Ryan J. Lawhead, Missouri University of Science and Technology, 113 West 16th St, Rolla, MO, 65401, United States, rjlm97@mst.edu, Abhijit Gosavi

Actor-Critics are Reinforcement Learning algorithms that can solve large-scale Markov Decision Processes (MDPs) and semi-MDPs. The classical actor-critic has a critical drawback in that the actor's values get unbounded. The artificial bounding required as a result limits the exploration of the state-action space, which can cause sub-optimal behavior even on small-scale problems. We propose a new version that keeps the actor's values bounded, allowing the algorithm to search the state-action space more thoroughly and generate optimal solutions. We also present results on a large-scale problems from airline revenue management where our algorithm outperforms a standard industrial heuristic.

4 - Heuristic Algorithm for Initial Sample Size in Ranking and Selection Problem

Ruijing Wu, Phd Student, Shanghai Jiao Tong University, 2334 Willowbrook Drive, Apt 258, Shanghai, 200030, China, wu_ruijing@yeah.net

Ranking and selection problem is to choose the best system from a set of systems. When variance are unknown, it is necessary to take some initial samples to estimate it. In most procedures, initial sample size (ISS) is predetermined and fixed. In this paper, we present a heuristic algorithm to calculate ISS, which is a generalization of the idea in Hartmann (1991). To check the validity and effectiveness of our algorithm, we implement it on KN procedure and compare it with KN procedure and Hartmann's method. The numerical experiments show that our procedure can (1) guarantee the probability of correct selection; (2) reduce the total sample size by 20%-80%.

5 - Path Planning of Multiple Unmanned Surface Vehicle under Communication Constraint

Md Saiful Islam, Texas Tech University, 2500 Broadway, Lubbock, TX, 79409, United States, md-saiful.islam@ttu.edu, Timothy I. Matis

Unmanned Surface Vehicles (USV) in current application has limited payload and endurance. Multiple USV's are often used to overcome these limitations but, path planning of multiple USV's mostly uses either leader - follower approach or formation fleet which leads to a myopic optimization problem. Only the leader vehicle have the ability to make an independent decision. To avoid this problem, USV's in this study will be considered as mobile agents where each USV can make a decision independently and will maintain communication with other members of the team.

6 - Efficient Computing Budget Allocation for Optimal Subset Selection with Correlated Sampling

Si Zhang, Shanghai University, Shang-Da Road No. 599, Shanghai, China, zhangsi817@sina.com, Loo Hay Lee, Ek Peng Chew, Chun-Hung Chen

This study mainly considers the problem selecting the top-m alternatives under the environment with correlation. Correlation demonstrates the relationship between alternatives and can provide more information when comparing two alternatives. Hence, it is sometimes intentionally introduced into simulation to reduce the variance of the difference between two alternatives. We model the optimal subset selection problem with correlated sampling based on the optimal computing budget allocation framework and derive the respective optimal allocation rules.

■ WB28

350D

Supply Chain, Decision Analysis

Contributed Session

Chair: Shuxiao Sun, Peking University, Beijing, China, sunshuxiao@pku.edu.cn

1 - Game Theoretic Modeling of a Biofuel Supply Chain with Existence of Incentives to Promote Cellulosic Based Biofuel Production

Amirsaman Hamzeh Bajgiran, PhD Candidate, University of Wisconsin-Milwaukee, 1320 E Capitol Drive, Apt 205, Milwaukee, WI, 53211, United States, hamzehb2@uwm.edu, Jaejin Jang, Xiang Fang

We consider a biofuel supply chain (BSC) problem in which a farmer supplies two downstream refineries with non-identical crops (corn and energy crop) to study the feasibility of reaching the goal of RFS. The problem has been modeled as a multi-leaders one follower game to capture the farmer's decisions on land use as well as refineries' proposed prices to the farmer. We have considered subsidizing the farmer and the refinery which uses energy crop to study whether it is capable of enhancing advanced biofuel production. This work can provide insights for governments and help them to make effective policy-making decisions to achieve their goals.

2 - Optimal Advertising and Pricing in a Dynamic Omnichannel Supply Chain

Yang Bai, Ajou University, Suwon, Korea, Republic of, b198716y@hotmail.com, Byeong-Yun Chang

Channel coordination and advertising promotion strategy play an important role in modern lives. In this research, we examine an effective and efficient coo-petition model and consider advertising decisions for a retailer directing omni-channel. We derived the N-A model in dynamic analysis of coo-petition in an omni-channel. Using the optimal omni-channel model, we obtain the optimal dynamic pricing and advertising decisions.

3 - Leadership and Information Flow in a Supply Chain with Coopetition

Maosen Zhou, Shenzhen University, No.3688, Nanhai Road, Shenzhen, China, moussin@gmail.com, Qingyu Zhang

We study the issue of coopetition in a two-echelon supply chain where competing manufacturers purchase through a common GPO to achieve economies of scale. Our game-theoretical modeling generalizes information structures about uncertain demand with horizontal and vertical information flows, and quantifies horizontal coopetition under different vertical leadership. By analyzing the effects of coopetition, leadership, information flow, and their interplay, managerial insights into exploiting the relationship and information structures for coopetitive supply chains will be provided.

4 - Entry Deterrence and Price Competition under Asymmetric Information

Jooyol Maeng, Assistant Professor, Pacific Lutheran University, School of Business, 12180 Park Avenue S, Tacoma, WA, 98447-0003, United States, maengjy@plu.edu, Sungyong Choi

An incumbent has an incentive to deter entry of a potential entrant by lowering pre-entry price. We study limit pricing in a price-based duopoly market under asymmetric demand information. We present a separating perfect Bayesian equilibrium, which indicates the incumbent with private information can successfully deter entry.

5 - Horizontal vs. Vertical Cooperation in Supply Chains under Competition

Shuxiao Sun, Doctoral Candidate, Peking University, No.5 Yiheyuan Road Haidian District, Beijing, Beijing, 100871, China, sunshuxiao@pku.edu.cn, Xiaona Zheng

We study the impact of horizontal and vertical cooperation with different degree on firms' profits in two-tier supply chains. The cooperating firm maximizes its own profit and a proportion of its partner's. We find that, when retailers are asymmetric in variable cost or market base, under horizontal cooperation, the "strong" retailer is always better off while the "weak" one is likely to get worse; under vertical cooperation, the manufacturer prefers cooperation with the "weak" player whereas the supply chain favors "an alliance between giants." Finally, we extent our model to one manufacturer and multiple retailers.

■ WB29

350E

Manufacturing

Contributed Session

Chair: Sanam Azadiamin, Ohio University, Athens, OH, United States, sa349416@ohio.edu

1 - A MILP Formulation for Combined Planning and Scheduling of Multistage Multipurpose Batch Plants

Zhaohui Li, Shanghai Jiao Tong University, 1954 Huashan Road, Shanghai, 20030, China, lzh_cathy@sjtu.edu.cn, Yongpei Guan, Guohua Wan

A mixed formulation is presented for a real world planning and scheduling instance with multistage, multipurpose batch plants in rolling horizon. Besides, the input of storage between mixing and filling is discrete while the output is continuous. Sequence dependent setup and storage expiration are also taken into consideration. Lot sizing is achieved from an aggregation planning model for management's sake, based on which a schedule model is formulated to get the optimal scheduling. Simulation is conducted to find the bottleneck of this procedure.

2 - Optimization of Automated Guided Vehicle Dispatching in Shop Floors

Shiyang Huang, Iowa State University, 0076 Black Engineering, Ames, IA, 50011, United States, shuang@iastate.edu, Guiping Hu

Automated guided vehicle (AGV) have been widely adopted for material handling on shop floors. We proposed a series of strategies to guide the dispatching of AGV based on heuristic rules and optimization models of material handling on shop floors. The optimization models were formulated and specially solved with designed algorithms that were proved to be more efficient than common solution techniques. The strategies were demonstrated in a case study based on a shop floor in literature, and the simulation results showed that the proposed methods outperformed classic strategy in optimizing different criteria on the shop floor.

3 - A New Hybrid Supply Chain Strategy with Expected Demand in Regional Facilities and a Common Service Plant

Sanam Azadiamin, Ohio University, 35 N. Mckinley Ave. Apt 112, Athens, OH, 45701, United States, sa349416@ohio.edu, Gursel Suer

A hybrid global supply chain strategy is proposed where regional plants are designed to meet expected demand whereas one service plant covers the remaining demand in all regions. This strategy requires transportation lead times and safety stocks to be considered to achieve a certain service level at a minimum cost. The relation between service levels and safety stocks is explored.

■ WB31

351A

Production and Scheduling

Contributed Session

Chair: Feifan Wang, Arizona State University, Tempe, AZ, United States, feifan.wang@asu.edu

1 - Assembly Line Balancing: the Difficulty of Solving Certain Instances

Jorge Pereira Gude, Universidad Adolfo Ibanez, 750 Avda Padre Hurtado, Office 216-C, Vina del Mar, 2530852, Chile, jorge.pereira@uai.cl

The simple assembly line balancing problem is a classical optimization problem, which has been widely studied in the literature. While recent effort has been geared towards the identification of difficult instances, the question of what makes them difficult is still open. In this work, several new exact solutions procedures are put forward and their behavior under different instance characteristics is considered. An extensive computational experiment with these methods allows us to close several open instances and to give some insight into the difficulty of solving certain instances.

2 - Multi-job Production Systems: Theory and Application

Pooya Alavian, PhD Candidate, University of michigan, Ann Arbor, MI, 48109, United States, alavian@umich.edu, Semyon M. Meerkov

Multi-job production (MJP) is a class of flexible manufacturing systems intended to produce different job types based on a product-mix or build-schedule.In MJP, jobs are processed by the same sequence of operations, but with different processing times for each job type.We introduce the Work-based model, use it to characterize MJP systems, analyze the performance of MJP systems as functions of the product-mix, and report an application in automotive industry.

3 - Flexible Maintenance Schedules for Multistage Degradation Systems

Yunyi Kang, Arizona State University, 1850 E Hayden Lane, Apt 207, Tempe, AZ, 85281, United States, ykang37@asu.edu, Feng Ju

We present a flexible preventative maintenance problem on two-machine-and-one-buffer manufacturing systems, in which machines are subject to multi-stage degradation. Condition-based maintenance decisions are made on both machines, considering machine degradation stages and the buffer level. Moreover, flexible policies are included such that a machine can be recovered to any better operating state, comparing to which to only the best operating state is possible in many previous work. A Markov decision model is formulated to find the optimal maintenance policy in finite production runs and computational experiments are designed to show the improvements comparing to other policies.

4 - Hierarchy Machine Setup for Lot Scheduling at Assembly and Test Facilities

Youngbum Hur, PhD Candidate, University of Texas at Austin, 11500 Jollyville Road, #1917, Austin, TX, 78759, United States, Youngbum.hur@utexas.edu, Jonathan F.Bard

The importance of machine setups has been neglected in scheduling assembly and test (AT) operations in semiconductor back-end facilities. We examine the full dimensions of the problem in a multi-machine, multi-tooling environment with minimize the number of demand shortages and maximize weighted throughput. Our model determines machine setups, lot assignments and lot sequences using a greedy randomized adaptive search procedure (GRASP). In this paper, we consider a hierarchical approach to scheduling lots and to investigate the impact of different setup times and hierarchy rule. The performance of methodology is evaluated using data provided by a semiconductor company.

5 - An Integrated Approach to Production Planning and Scheduling for Automotive Wiring Harness Cut and Crimping Lines

Jeongin Koo, Korea Institute of Industrial Technology, 89, Yangdaegiro-gil, Ipjang-myeon, Seobuk-gu, Researcher Bldg, Cheonan, 31056, Korea, Republic of, jikoo@kitech.re.kr, Minjae Ko, Hwanju Ryu, Sangsik Ha, Hyunchul Tae

This study considers a production scheduling problem of automotive wiring harness cut and crimping lines where all the harnesses should be processed manually or automatically by different types of machines. To produce wiring harnesses, every order of wiring harness production should be handled by the process allocation processes, the equipment allocation processes, and equipment scheduling in the cut and crimping lines. Given allocated processes for each wire to produce, we formulate an mixed integer linear programming model of the equipment allocation and scheduling to solve the case study of the wiring harness production line.

6 - Real Time Control of Geometric Serial Lines with Residence Time Constraints

Feifan Wang, Arizona State University, 669 S.Mill Ave, Tempe, AZ, 85281, United States, feifan.wang@asu.edu, Feng Ju

Scrap due to residence time constraints are commonly seen in manufacturing systems. In such systems, minimum and maximum waiting times for each part are enforced in the buffer. To optimize the trade-off between production rate and scrap rate, an on-off control policy for a two-machine geometric production system is derived using Markov decision processes with state approximation. An iteration method is further provided to improve the control policy.

■ WB32

351B

Supply Chain, Risk Management

Contributed Session

Chair: John Kros, East Carolina University, Greenville, NC, United States, krosj@ecu.edu

1 - Mitigating Supply Chain Risk through Supply Chain Responsiveness a Prioritization Approach

Seyed Vahid Reza Nooraie, NC A&T.State University, 2205 Newgarden Road, Greensboro, NC, 27410-1718, United States, snooraie@aggies.ncat.edu, Paul M.Stanfield, Mahour Parast, Masoud Narenji, Saeed Zamiri Marvizadeh

The global market is characterized by decreasing product life cycles, rapid change in customer demands, and shortened lead time to respond to environmental uncertainty. In such situations, the capability of a firm to quickly respond to changes in its external environment is an initial determinant of the firm's performance. This can only be possible when the supply chain is responsive. The purpose of this paper is to identify different factors for responsive supply chains. Based on a review of the literature, we propose a conceptual model for supply chain responsiveness that encompasses practices such as flexibility, agility, internal integration, and visibility.

2 - Optimization-based High Performance Packaging for Moldable Items

Roshanak Akram, Graduate Research Assistant, University of Tennessee, Knoxville, 851 Neyland Drive, 525 John D. Tickle Building, Knoxville, TN, 37996, United States, roshanak@utk.edu, Rupy Sawhney

A food supplying company, constantly strives to improve the delivery of items, which reach their intended recipient in form of meal bags. Defects in packaging the meal bags into the boxes or transporting them improperly along the supply chain cause quality defects. These defects are not acceptable within company's high quality standards. A three-pronged approach is proposed:Improve packaging by developing a high-performance optimization algorithm for moldable food bagsImprove inspection by developing an automated machine-learning based inspection system, andImprove accountability and identify training opportunities in the supply chain by connecting an observed defect to its root cause.

3 - Does Traceability Help Product Quality?

Chao Liang, Cheung Kong Graduate School of Business, Main Campus, Oriental Plaza 2/F,, Tower E2, 1 East Chang An Ave.,, Beijing, 100738, China, cliang@ckgsb.edu.cn, Xianjun Geng

In a supply chain with one manufacturer and one supplier, we study how traceability impacts the manufacturer and the supplier's incentive to improve product quality. Interestingly, we find that traceability may reduce the final product's quality.

4 - The Impact of Counterfeiting on Cost and Service Delivery in the Supply Chain

John F. Kros, Vincent K. McMahon Distinguished Professor, East Carolina University, College of Business Dept of M&SCM, 3205 Harold Bate Building, Greenville, NC, 27858-4353, United States, krosj@ecu.edu, Scott Dellana, W. Jason Rowe

Counterfeiting of goods is an emerging stream of research. Firms are increasingly facing a multitude of challenges in preventing inferior products from reaching end-users. The emphasis has largely focused on counterfeiting risks in relation to the deleterious effects on brand image and customer perceptions of unethical behavior by final-tier channel members. Research is lacking which considers the implications of counterfeiting as a disruptive force in the supply chain. Our study aims to research the extent to which firms seek to detect the presence of counterfeiting and the subsequent effects the detection and occurrence of counterfeiting has on costs and service delivery in the supply chain.

■ WB33

351C

Reducing Air Transport Disruptions through Improved Operations

Sponsored: Aviation Applications

Sponsored Session

Chair: Bruno F Santos, TU Delft, Delft, 2629 HS, Netherlands, b.f.santos@tudelft.nl

1 - An Integrated Airline Recovery Approach Capturing Passenger Compensation Impacts

Luis Cadarso, Rey Juan Carlos University, Camino del Molino s/n, Fuenlabrada, 28943, Spain, luis.cadarso@urjc.es, Vikrant Vaze

The European flight delay compensation regulation (EC) No 261/2004 establishes common rules on compensation to passengers in the event of disruptions. We develop an integrated approach that recovers airline timetable, fleet assignment, aircraft routings, and passenger itineraries capturing the impacts of airlines' decisions on passenger compensation. We evaluate scenarios involving disruptions, and optimize recovery decisions to maximize profits by modeling passenger no-shows after disruptions.

2 - Optimal Control of Flight Parameters for Re-scheduling Airline Operations

Ángel Marín, Technical University of Madrid, Madrid, Spain, angel.marin@upm.es, Jesús Gabriel Galindo, Luis Cadarso

Flight planning determines the route, speed, and fuel burn of a flight. In case of disruptions, it has been usually either poorly addressed or obviated. We present a novel approach addressing airline recovery, which integrates flight planning and passenger re-scheduling and develop an integrated non-linear model that recovers airline timetable and passenger itineraries capturing the impacts of airlines' decisions on passenger compensation and loss of goodwill. We evaluate scenarios involving disruptions, and optimize recovery decisions to maximize profits.

3 - Sequential Approach for Solving the Dynamic Aircraft Recovery Problem

Bruno F. Santos, Assistant Professor, Delft University of Technology, Delft, Netherlands, b.f.santos@tudelft.nl, Jeroen Vink, Wim J.C. Verhagen, Ivo Medeiros, Ricardo Filho

This paper presents a new approach for solving the recovery of aircraft routing, using a heuristic that iteratively solves selections of the airline's fleet. An initial solution is always presented in seconds, after which potential reductions of disruption cost are investigated. The model is solved dynamically, re-solving the airline's schedule based on new disruption information starting from the last found solution. Aircraft specific requirements such as maintenance schedules are taken into consideration. The selection heuristic can find an optimal solution in 90% of the disruption instances tested, while on average only requiring 4% of the time needed to find the global optimum.

4 - Stochastic Dynamic Airline Disruption Management using Airport Stochastic Delay Data

Lavanya Marla, University of Illinois at Urbana-Champaign, Urbana, IL, United States, lavanyam@illinois.edu, Jane Lee, Alexandre Jacquillat

We present and evaluate an approach which integrates advanced disruption management (incorporating flight planning) with a stochastic and dynamic decision framework, to create a more robust handling of the disruptions caused by congestion at the airport. We develop an online algorithm that utilizes a rolling horizon approach for solving the recovery model with flight planning, where the future expected cost of stochastic disruptions are used as input for look-ahead period. We show empirically that having a look-ahead period with stochastic airport information reduces recovery costs compared to a naïve model.

■ WB35

351E

Supply Chain, Competition

Contributed Session

Chair: Lisha Duan, The Pennsylvania State University, University Park, PA, United States, lud149@psu.edu

1 - Supply Chain Network Equilibrium Model under Carbon Cap and Trade

Yiping Jiang, Associate Professor, Nanjing Agricultural University, 40 Dian Jiang Tai Road, Pukou, Nanjing, 210031, China, ypjiang@njau.edu.cn, Xiaoling FU

This paper investigates the network equilibrium problem in a supply chain network considering carbon allowance trading and demand uncertainty. We first link carbon cap-and-trade with transaction decisions in a supply chain network, and identify its unique characteristics. Then we formulate this problem as a network equilibrium optimization model, and further convert it into a monotone variational inequality. Next, we propose a projection-based prediction correction algorithm to solve the developed model. Finally, we report the numerical results and give some management insights.

2 - An Integrated Model for a Two-attribute Warranty Policy Involving the Manufacturer, Suppliers, and Distributors

Amitava Mitra, Professor, Auburn University, College of Business, Lowder Building Suite 419, Auburn, AL, 36849-5266, United States, mitraam@auburn.edu

A two-attribute warranty policy, consisting of warranty period and usage limit, is considered. A portion of the warranty costs, incurred by a manufacturer, is usually assigned to the suppliers associated with the particular part/component failure through a "burden ratio". Additionally, the manufacturer may pay a commission to the distributor/retailer of products based on the achieved market share. An integrated model is developed from the manufacturer's perspective involving the decision variables of unit product price, warranty period, usage limit, commission paid, and burden ratio.

3 - Effectiveness of Coordination Mechanisms Based on the Exchange Prices

Ali Hassanzadeh Kalshani, Graduate Student, University of California-Irvine, 1723 Verona Place, Irvine, CA, 92617, United States, ahassan2@uci.edu, John G.Turner, Luyi Gui

In many real-world settings where resources are shared, decentralized agents (e.g., individual competing firms) maximize their profits, and in so doing, choose to use an amount of resources. Motivated by a desire to understand the theoretical and structural underpinnings of what makes coordinating decentralized agents hard or easy, we study what is known as the Price of Anarchy, defined as the ratio of the combined profit achieved by all decentralized agents to the profit achievable by a monopolist which owns all of the resources herself.

4 - System of Systems Approach to Develop an Energy Water Nexus Model under Uncertainty

Afshin Ghassemi, University of Illinois at Chicago, 1200 W. Harrison St, Chicago, IL, 60607, United States, Aghass2@uic.edu, Michael J. Scott

A water-energy nexus model is an interdependent systems approach to study two infrastructure subsystems, energy and water, simultaneously. A robust, linear, mixed-integer, multi-period model is proposed to study the water-energy nexus as an integrated system. The proposed model leads to decreased total system cost and limits total system pollution (e.g., waste water pollution). Moreover, the robust model is immune to a reasonable amount of uncertainty (e.g., water demand uncertainty). The model solutions include detailed decisions for all existing sub-systems in the water-energy nexus.

5 - A Mixed- Integer Quadratic Consolidation Model for a Two-echelon Supply Chain

Sepideh Alavi, PhD Candidate, University of Wisconsin Milwaukee, 3202 N Maryland Ave, Milwaukee, WI, 53202, United States, alavi@uwm.edu, Matthew Petering, Anthony Ross

This paper proposes a shipment consolidation model addressing production and consolidation decisions by a manufacturer which provides inventory replenishments to multiple distribution centers (DCs). The model is not restricted to specific rules such as aggregation of shipments at regular times or consolidating when a predetermined quantity is accumulated. We develop a mixed-integer quadratic optimization model to simultaneously determine the optimal inventory replenishment and consolidation times. Numerical results, obtained via MIQP and a genetic algorithm are discussed.

6 - A Dynamic Supplier Selection and Inventory Management Model in a Serial Supply Chain with a Novel Price Break Scheme and Flexible Time Periods

Lisha Duan, PhD Student, The Pennsylvania State University, University Park, PA, United States, lud149@psu.edu, José Ventura

A new supplier price break scheme is introduced and incorporated into an integrated inventory planning model for a serial supply chain that minimizes the overall incurred cost including procurement, inventory holding, production, and transportation. A mixed-integer linear programming(MILP)formulation is presented addressing this multi-period, multi-supplier, and multi-stage problem with time-varying demand. Then, the length of the time period is considered as a variable. A new MILP formulation is derived. Sufficient evidence demonstrates that the length of the time period has a significant influence on supplier selection, lot sizing allocation, and inventory planning decisions.

■ WB36

351F

Service Science

Contributed Session

Chair: Arpan Rijal, Erasmus University, Rotterdam, Netherlands, rijal@rsm.nl

1 - Single-machine Common Due Date Earliness/tardiness Scheduling with Machine Unavailability

Kerem Bulbul, Associate Professor, Sabanci University, Faculty of Engineering & Natural Sciences, Orhanli, Tuzla, Istanbul, 34956, Turkey, bulbul@sabanciuniv.edu, Safia Kedad-Sidhoum, Halil Sen

We study the problem of scheduling a single machine as to minimize the total deviation of the job completion times from an unrestrictive common due date when one or several fixed intervals of unavailability are present in the planning horizon. Several interesting cases are identified and explored, depending on the resumability scheme (resumable, non-resumable, semi-resumable) and the location of the interval of machine unavailability with respect to the common due date. The focus of analysis is on structural properties and drawing the boundary between polynomially solvable and NP-complete cases. Pseudo-polynomial DP algorithms are devised for NP-complete variants in the ordinary sense.

2 - No Wait Open Shop Scheduling Problem with Sequence Dependent Setups and Release Dates

Rahman Khorramfar, PhD Student at North Carolina State University, North Carolina State University, Raleigh, NC, United States, rahman.khorramfar@gmail.com

This paper deals with no-wait open shop scheduling with sequence dependent setup times and release dates, minimizing total completion times. We present three formulation of the problem based on different decision variable paradigms and investigate some computational aspects of the models. For large size problems, we first propose a novel encoding and decoding scheme, and present four particle Swarm Optimization (PSO)-based algorithms and four Tabu Search (TS)-base algorithms. To evaluate the performance of the algorithms we carry out two cpmputational experiments.The evaluation of algorithms indicate that one of the TS-based algorithms slightly outperforms the others.

3 - Performance of Various Formulations for Machine Scheduling Problems with and with out Setups

Ekin Koker, University of Massachusetts, Mechanical and Industrial Engineering, 160 Governors Drive, Amherst, MA, 01003, United States, ekoker@umass.edu, Ana Muriel

Machine scheduling problems are one of the most widely studied problem families in operations research. Yet, due to their challenging nature, most of the literature has focused on developing heuristics, testing meta-heuristics or exploring the effectiveness of dispatching rules. Comparison of different modeling techniques in exact approaches such as mixed integer programming has received surprisingly little attention. In this paper, we computationally compare the effectiveness of formulations based on direct positional variables against relative positional variables in a variety of machine scheduling problems, including parallel machine and flow shop settings with and without setups.

4 - Minimizing Labor Costs in Picker-to-parts Warehouses with Delivery Due Time Windows

Arpan Rijal, PhD Candidate, Erasmus University, Postbus 1738, Rotterdam, 3000 DR, Netherlands, rijal@rsm.nl

Many picker-to-parts face temporal and spatial limitations in the staging process. To address these limitations, orders have to be brought to staging lanes within a predefined due time window before they are loaded onto trucks and shipped. We study the scheduling of order-pickers in picker-to-parts warehouses with hard pick delivery due time windows. We formulate the problem and evaluate its complexity. Additionally, we present an efficient heuristics to tackle real-sized instances.

■ WB37

352B

Research on Service Operations

Sponsored: Service Science

Sponsored Session

Chair: Aly Megahed, IBM Research-Almaden, San Jose, CA, 95123, United States, aly@gatech.edu

Co-Chair: Vahid Nourbakhsh, University of California- Irvine, The Paul Merage School of Business, Irvine, CA, 9, United States, vahidn@uci.edu

1 - Managing Service Design in Decentralized Supply Chains

Huaqing Wang, Emporia State University, 1 Kellogg Circle, Cremer Hall, Emporia, KS, 66801, United States, hwang4@emporia.edu, Haresh B. Gurnani, Yu Tang

Customers buying certain products may lack functional knowledge and need help after purchase. The retailer (or manufacturer) can invest in pre-sales effort to educate customers; We study the service channel design problem with different structures and show that the retailer would even be worse off in a cost-sharing contract.

2 - Optimal Practice of Bundling in a Duopoly

Araz Khodabakhshian, UCLA, 501 Gayley Avenue, Apt 11, Los Angeles, CA, 90024, United States, arazkhodabakhshian@gmail.com, Uday S.Karmarkar, Guillaume Roels

Service bundles are common in many industries, but there are also several examples of firms that choose not to bundle. We study bundling in the presence of competition to examine its implications for bundling strategy. We model the bundling strategy of two firms offering two products to heterogeneous customer populations as a two-stage non-cooperative game. Firms can practice mixed bundling. In the first stage, firms choose their product offering combinations. In the second, they simultaneously choose prices for their offerings. We modeled this game as a price competition and show that in equilibrium, at most one firm bundles. We also study the quantity competition dual of this game.

3 - Surge Capacity: From Individual Hospitals to Communities
Yu Wang, Indiana University Bloomington, 1309 E Tenth Street, Bloomington, IN, 47405, United States, yw39@indiana.edu, Kurt M.Bretthauer, Alex Mills

We study how hospitals and communities create surge capacity to respond to sudden increases in demand, such as mass-casualty incidents. We discuss our earlier work, where we modeled the effectiveness of response and mitigation strategies for individual hospitals. Now, we consider how decisions of individual hospitals contribute to community capacity when their joint effort is required to address an incident.

4 - Routing Heterogeneous Jobs to Heterogeneous Servers: A Global Optimization-based Approach
Vahid Nourbakhsh, University of California-Irvine, The Paul Merage School of Business, Irvine, CA, 92617, United States, vahidn@uci.edu, John G.Turner

We study the problem of routing heterogeneous jobs to heterogeneous servers, where the service rate is job-server dependent. We employ a math programming approach which is desirable since it can easily be embedded within larger planning problems. For nonconcave objective function of maximizing the service level, i.e., the probability that a job is served within an acceptable waiting time, we develop an optimization algorithm called fixed-ratio shifting envelopes to find near-optimal solutions to our math program, and design online routing policies, which make use of these solutions. To showcase our model, we apply our model and method to the problem of assigning Irvine districts to fire stations.

■ WB39

352D

Operations Management

Contributed Session

Chair: Benjamin Lawrence, Cornell University, Ithaca, NY, United States, benlawrence@cornell.edu

1 - Metrics to Characterize Temporal Patterns in Lifespans of Artifacts
Soumyo D. Moitra, Senior Member of Technical Staff, Software Engineering Institute, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, smoitra@sei.cmu.edu

This paper discusses some metrics that are useful to model the lifespans of artifacts observed over time that do not follow a traditional lifecycle. Some examples these stochastic point processes are presented and some metrics are developed that help to characterize their patterns and allow the lifespans to be clustered. Results from simulated data are presented and the paper discusses how the metrics can be applied and interpreted.

2 - The Application of Machine Learning in Management Science – Compared with China and the International
Xuan Wei, PHD Student, Harbin Engineering University, Harbin, 150001, China, weixuangood@qq.com, Wei Chen

Based on bibliometrics theory and the data from the database of Web of Science, the Chinese Social Sciences Citation Index and the Chinese Science Citation Database, this paper draws maps include the map of co-occurring keywords, co-cited authors and co-cited references from 1998 to 2015 by the use of a visual analysis tool——Cite Space. From this, research hot points, knowledge foundation and evolution of the theory of machine learning in management science in both China and other countries or areas are analyzed and contrasted.Acknowledgment: This paper is funded by the International Exchange Program of Harbin Engineering University for Innovation-oriented Talents Cultivation.

3 - Relatedness in Diversification and Performance of Public Firms
Muhammad Zubair, Beaconhouse National University, Lahore, Pakistan, zubair.m@outlook.com

This study empirically examines the link between relatedness in the diversification of a firm and its inventory performance. The study is based on firms' annual financial and segment sales data in addition to US industry input-output data.

4 - Multiple Methods Analyses of the Relationship Between the Quality Management Practices and Operation Performance
Heng Xie, University of North Texas, 1307 West Highland Street, Denton, TX, 76201, United States, Heng.Xie@unt.edu, Xianghui (Richard) Peng, Victor R. Prybutok

This study employs latent semantic analysis and meta-analysis to investigate the impact of the quality management (QM) on an organization's operation performance. The correlation and gaps between QM practices and industry performance are examined. Multiple methods of data analyses are used to analyzed the results from empirical based Baldridge Award studies.

5 - Super Size Me? the Effect of Franchise Size and Geographic Location on Compliance with Corporate Brand-building Initiatives
Benjamin Lawrence, Cornell University, 565B Statler Hall, Ithaca, NY, 14853, United States, benlawrence@cornell.edu, Brett Massimino

We examine the effects of a retail outlet's governance structure and distance from headquarters on compliance with corporate-driven initiatives. We obtain proprietary data from a large, national restaurant chain - capturing performance for ~1,000 outlets over a 3-year period - and supplement these with data with several other secondary sources. We address potential endogeneity by incorporating several instrumental variables into our analyses. Surprisingly, we find compliance tends to increase with an outlet's distance from headquarters. We further find an interaction with franchise size, indicating contextual dependencies novel to extant literature on distributed operations.

■ WB40

352E

Electric Vehicle Charging Problems and Freight Transportation

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Trilce Encarnacion, Rensselaer Polytechnic Institute, 110 8th Street, Jonsson Engineering Center # 4049, Troy, NY, 12180, United States, encart@rpi.edu

1 - Integrated Modelling of Dynamic and Static Charging Facilities for Electric Vehicles
Xiaotong Sun, University of Michigan, Ann Arbor, MI, 48109, United States, xtsun@umich.edu

This paper investigates the optimal deployment of both charging stations and charging lanes considering the interaction between transportation and power networks. A network equilibrium model is firstly developed to capture the interdependency among route choice, recharging plan of electric vehicles and price of electricity. A mixed-integer bi-level program is then formulated to deploy charging facilities to minimize the social cost in the coupled networks. Several state-of-art solution algorithms are applied to solve this model, and their performances are compared in different numerical experiments.

2 - Robust Planning of Dynamic Wireless Charging Infrastructure for Battery Electric Buses
Ziqi Song, Utah State University, 4110 Old Main Hill, Logan, UT, 84322-4110, United States, ziqi.song@usu.edu, Zhaocai Liu, Ye Song

Battery electric buses with zero tailpipe emissions have great potential in improving environmental sustainability and livability of urban areas. However, the problems of high cost and limited range associated with on-board batteries have substantially limited the popularity of battery electric buses. The technology of dynamic wireless power transfer (DWPT), which provides bus operators with the ability to charge buses while in motion, can effectively alleviate the drawbacks of electric buses. In this paper, we address the problem of simultaneously selecting the optimal location of the DWPT facilities and designing the optimal battery sizes of electric buses for a DWPT electric bus system.

3 - Impact of Congestion Pricing Schemes on Routing Costs and Emissions
Shu Zhang, Chongqing University, Chongqing, China, zhangshu@cqu.edu.cn, Ann Melissa Campbell, Jan Fabian Ehmke

Many city governments have introduced toll charges to discourage vehicles from entering the inner city to reduce congestion. However, little research has been done to examine the impact of congestion charges on commercial fleets, especially on resulting costs and emissions. In this study, we consider a vehicle routing problem considering different pricing schemes for several city types. We find that higher congestion charges may not necessarily lead to less emissions, and some congestion pricing schemes may even increase the emissions in the city center.

4 - Impacts of Congestion on Supply Chains
Trilce Encarnacion, Rensselaer Polytechnic Institute, 110 8th Street, Jonsson Engineering Center # 4049, Troy, NY, 12180, United States, encart@rpi.edu, Jose Holguin-Veras,

Congestion in urban areas heavily impact supply chains, we present a methodology to assess the economic impacts of congestion on logistic costs and estimate the direct environmental impacts of urban freight activity. In designing the methodology, the following objectives guided the process: (1) Applicability; (2) Comparability; (3) Practicality; and (4) Robustness. In order to test the principles developed, pre-pilot studies were conducted in three Latin American Cities: Barranquilla, Colombia; Santiago, Chile and Sao Paulo, Brazil. Results from these pilot tests will also be discussed

5 - Last-Mile Distribution and Horizontal Cooperation in Urban Logistics

Javier Faulin, Public University of Navarre, Pamplona, Spain, javier.faulin@unavarra.es, Adrian Serrano-Hernandez, Christian Fikar, Patrick Hirsch, Alejandro Garcia del Valle

This talk introduces the topics of Last-Mile Distribution and Horizontal Cooperation in an integrated way showing the key role of Horizontal Cooperation as a new strategy for goods distribution optimization in urban logistics. This approximation is particularly interesting knowing the importance of smart distribution as a new paradigm of e-commerce. We have used an agent-based simulation to measure savings in lead times in an assorted group of Horizontal Cooperation agreements among some distribution companies. Moreover, the impact of store-wholesaler structure is investigated to improve the final urban delivery. Finally, we have provided some computational results to enhance the role of Horizontal Cooperation in urban distribution

■ WB41

352F

Decision Analysis

Contributed Session

Chair: Jie Zhang, Virginia Institute of Technology, Blacksburg, VA, United States, jiezhang@vt.edu

1 - Coalition with out Trust: the Intra-brain Connectivity and Inter-brain Synchronization of Herd Behaviors in an Economic Bubble Game

Jonathan Tong, Phd. program Student, National Taiwan University, 7F., No. 28, Ln. 325, Zhungjing Rd.,, Taipei, 110, Taiwan, d03323003@ntu.edu.tw

Economic bubbles form and burst because of human beings' higher-order reasoning, believing in earning pure capital gains due to other people's similar beliefs. We design a two-person investment game that simulates the natural situation of the form and the burst of economic bubbles. Using hyper-scanning fMRI to look into the correlation and the interaction of subjects' brain activities, we are able to gain insights about the coupling phenomenon of the two minds in the context of strategic interaction.

2 - Phases of Physical 3D Networks

Soodabeh Milanlouei, Northeastern University, Boston, MA, 02130, United States, milanlouei.s@husky.neu.edu, Nima Dehmamy, Albert-Laszlo Barabasi

In many real networks, from neural cells forming a brain to bundles of cables, the nodes and links have physical reality, unable to cross each other. Therefore, their physical layouts are jointly determined by these non-crossing conditions and their tight-packed nature, limiting how they can evolve. By ignoring the physical reality and dimensions of the links and nodes, current network layout algorithms are inherently unable to capture the properties of such real networks. Hence, we develop and study a series of 3D layout models that observe the physical constraints we encounter, allowing us to systematically explore how these limitations affect the network layout.

3 - From Mind Reading to Mind Sharing: A Study on Neural Correlates of Cognitive and Affective Tom and their Applications to Salesforce Enhancement

Jonathan Tong, PhD Program Student, National Taiwan University, 7F., No. 28, Ln.325, Zhungjing Rd.,, Taipei, 110, Taiwan, d03323003@ntu.edu.tw

Adopting the approaches of neuromarketing and social cognitive neuroscience, our purpose is to study the neural dynamics of sales' mind reading capabilities via a Chinese Drinking Game experiment with hyper-scanning of fMRI and how mind reading predicts their real performance.

4- Determinants of Alcohol Consumption Among College Students

Lu Xu, Ph.D candidate, University of North Texas, 1155 Union Circle #305249, Denton, TX, 76203-5017, United States, lu.xu@unt.edu, Gayle Prybutok, Victor R.Prybutok, Alexandra Ruuska

This research examines factors influencing the amount of alcohol consumed by college students. Predictor variables include demographics, academic factors, social factors, and alcohol-related factors. Data from 431 college students was collected using a Qualtrics survey that incorporates the Student Alcohol questionnaire. Linear regression was employed to analyze the data. The findings emphasize when effective intervention is needed.

5 - Budget Constraint Newsvendor Model in Reverse Supply Chain with Customer Driven Substitution

Jie Zhang, Virginia Institute of Technology, 820 Newport Terrace, Blacksburg, VA, 24060, United States, jiezhang@vt.edu, Subhash C.Sarin

In our model, there exist uncertain demand of new product and remanufactured product. Customers can choose the other product if their first choice product is out of stock. The quantity of remanufactured products is limited by the quantity of the collected cores. The budget consists of collection cost, and production cost for each products. We determine the optimal quantity of each products and analyze the effect of the substitution rate.

■ WB42

360A

Planning

Contributed Session

Chair: Zahra Banakar, University of Texas at Arlington, Arlington, TX, United States, zahra.banakar@mavs.uta.edu

1 - Evaluating System Quality in Healthcare Industry by using Hybrid MCDM Methods

Maryam Soltanpour Gharibdosuti, Binghamton University, 62 Floral Ave, Apt 8, Binghamton, NY, 13905, United States, msoltan1@binghamton.edu

With the birth of electronic commerce, monitoring and enhancing the electronic service quality (e-sq.), hospitals use it as an appropriate media to facilitate information exchange between patients and providers, to improve their offered services This paper presents a quality evaluation model for measuring the performance of hospitals' web sites. The model is developed on the basis of a conceptual framework, which consists of three major e-service quality dimensions, including reliability, responsiveness and quality of information, which are main issues of Web sites. A hybrid multi criteria decision-making methods are used in the evaluation procedure.

2 - Cultivation of Soft Skills in the Construction Industry

Mahdi Safa, Assistant Professor, Lamar University, 5350 Old Dowlen Rd, Apt. 127, Beaumont, TX, 77706, United States, msmahdisafa@gmail.com, Kelly Weeks, Jeff Dyson, Shiblee Shakik Ahmed

Success in the construction industry largely depends on an amalgamation of technical skills and soft skills. Construction companies striving to survive on limited budgets and tight profit margins are looking for ways to improve workforce productivity. A key consideration for the workforce productivity improvement is to identify key soft skill gaps that need to be prioritized for training and development of professionals. Hence, a questionnaire based survey has been conducted with 250 professionals from Texas. The results show that among various soft skills, communication, time management, and work ethics have been identified as the most fundamental and relevant skills required to excel.

3 - A Parametric Activity Based Cost Estimation Framework Utilizing Conceptual Process Modeling

Zahra Banakar, P.h.D Candidate, University of Texas at Arlington, 2211 Twin Elms Dr, Arlington, TX, 76012, United States, zahra.banakar@mavs.uta.edu, Brian L.Huff

In order to have the most accurate production costs estimation, accurate cost information in a useful form is needed. This paper presents a cost estimation framework that integrates both activity and parametric cost estimation methods to increase the ease, accuracy, and speed of producing cost estimates for a family of products or services. The paper will discuss how process description capture methods can be used to identify the activities that drive cost. Also, a costing model based on the conceptual system description method will provide a more generic costing tool.

■ WB43

360B

Strategic Decisions in Humanitarian Setting: Empirical and Analytical Approaches

Sponsored: Public Sector OR

Sponsored Session

Chair: Mahyar Eftekhar, Arizona State University, Tempe, AZ, 85287, United States, eftekhar@asu.edu

1 - A Multi-attribute Simulator for Policy Evaluation in Humanitarian Fleet Management

Liyi Gu, University of Maryland, 7621 Mowatt Ln, College Park, MD, 20742, United States, lgu@rhsmith.umd.edu, Ilya O. Ryzhov, Mahyar Eftekhar

We develop a stochastic, dynamic multi-attribute simulation framework for fleet management in humanitarian development programs, which encompasses purchase, sale and vehicle assignment decisions. We empirically estimate demand (mission distances) and vehicle operational costs, and build a simulator to compare different policies. Preliminary results are discussed.

2 - Antecedents of Financial Recovery Effectiveness from Floods: A Structural Econometric Analysis of Flooding in Thailand

Niratcha Tungtisanont, Clemson University, 100 Sirrine Hall, Management Dept, Clemson, SC, 29634, United States, ntungti@g.clemson.edu, Aleda Roth, Bernardo F. Quiroga

Using a sample survey of approximately 34,000 households in Thailand with data pre-, during- and post-flood disaster in 2011. Taking a service operations lens, our study aims to identify where and how in the flood cycle can various stakeholders—individuals, communities and governments act to increase the likelihood of a successful service recovery. More specifically, this research asks the question of what type of strategic actions can policy makers take in order to better allocate precious resources in pre-, during-, and post-flood phases to improve the overall effectiveness of the recovery process?

3 - Volunteer Management in Charity Storehouses

Gloria Urrea, Universita della Svizzera Italiana, Lugano, Switzerland, gloria.urrea@usi.ch, Alfonso J. Pedraza-Martinez, Maria Besiou

We study volunteer management at a large faith-based organization that operates a steady aid delivery system. The whole supply chain operates exclusively with volunteers (from supply to delivery). We study the preparation of beneficiaries' orders by volunteers in the storehouse as a function of volunteer experience and warehouse congestion. Using empirical data, we build a simulation model to explore the drivers of on-time order fulfillment at the storehouse level.

4 - Proactive and Reactive Supply Management for Emergency Relief Period: Effects of Demand and Supply Uncertainties and Budget Limit

Mahyar Eftekhar, Arizona State University, BA 433, Main Campus, P.O. Box 874706, Tempe, AZ, 85287, United States, eftekhar@asu.edu, Jeannette Song, Scott Webster

To fulfill beneficiaries' demands, humanitarian organizations should design a cost-efficient and time-effective procurement policy. We consider and analyze two common supply management policies: pre-positioning and local-purchasing. Our analysis takes demand, supply, and budget uncertainties into account.

■ WB44

360C

Operations Management/Marketing Interface

Contributed Session

Chair: Tuhin Sengupta, Indian Institute of Management-Indore, Indore, India, f13tuhins@iimidr.ac.in

1 - Aligning Price Adjustment Protection with Return Policy

Moutaz J.Khouja, University of North Carolina-Charlotte, BISOM.Department, College of Business, Charlotte, NC, 28223, United States, mjkhouja@uncc.edu, Haya Ajjan, Xin Liu

Retailers provide a return policy because it reduces the risk customers might perceive in purchasing. Retailers also provide price adjustment protection policy under which the retailer promises to refund consumers the difference between the full price and the discount price, should the product's price drop within a specified duration of time after purchase. We identify the optimal duration of the two policies. We also examine their effect on optimal inventory and pricing decisions.

2 - Self Price Beating in a Market with Preference Interdependence and Uncertainty

Ting Luo, California State University Fullerton, 800 N State College Blvd, Fullerton, CA, 92831, United States, ting.luo@fullerton.edu, Lijia Shi, Upender Subramanian

Self price beating pricing strategy promises the early buyers that if the seller lowers the price in the later period, an ex post price refund that is more than the price difference will be refunded to them. We study self price beating as a pricing policy when there is market externality and uncertainty. We find this strategy blends advantages of both price commitment and no price commitment, and it produces the highest total profit as well.

3 - Designing Product Rollovers and Managing Style Obsolescence

Esma Koca, PhD Candidate, Imperial College Business School, PhD Students Postbox, Tanaka Building, Level 2, Imperial College Business School, London, SW2 7AZ, United Kingdom, e.koca13@imperial.ac.uk, Tommaso Valletti, Wolfram Wiesemann

When releasing a new version of a durable product, a firm should consider whether to convince its consumer base to upgrade while attracting new consumers. To this end, the firm designs a rollover strategy, which selects the price of the new product, as well as whether to continue the sales of the old product at a discount (dual rollover) or not (solo rollover). We argue that the effectiveness of a rollover crucially depends on the consumers' perception of the obsolescence of the old version, and that the firm can influence obsolescence by a prudent timing of the new product launch. We explore the impact of the timing decision in solo and dual rollovers in markets consisting of myopic and strategic consumers.

4 - Product Quality and Incentives in Handicraft Supply Chain

Tuhin Sengupta, Indian Institute of Management-Indore, Rau-Pithampur Road, Indore, 453331, India, f13tuhins@iimidr.ac.in

In this article, we study how retailers, taking into account customer preferences, design its product to meet its objectives. We study how preferences of different customer segments and the degree of customer knowledge about the handicraft products drive the quality and pricing decisions of a retailer. Furthermore, we examine the implications for a manufacturer in the cooperative setting against the profit maximizing private setting.

■ WB45

360D

Retail Management

Contributed Session

Chair: Ameera Ibrahim, Saint Mary's College of California, Moraga, CA, United States, ai7@stmarys-ca.edu

1 - Markdown Optimization using Randomized Decomposition Approach

Andrew Vakhutinsky, Consulting Member of Technical Staff, Oracle, 35 Network Dr., Burlington, MA, 01803, United States, andrew.vakhutinsky@oracle.com, Kresimir Mihic, Su-Ming Wu

Despite the fact that markdown optimization problem has been known for more than twenty years, it still presents certain challenges for the real-life instances due to non-linearity of the demand function and complex side constraints. We present a new approach to solving MDO called randomized decomposition (RD). RD solver randomly selects subsets of the decision variables and finds an optimal solution for the variables in each subset, keeping all other variables fixed. We describe the results of our computational experiments comparing different solution approaches including MILP-based formulations based on the linearization of the demand function.

2 - Multi-location Multi-product Substitution with Strategic Consumers

Chengfan Hou, Tsinghua University, Beijing, 100084, China, houcf16@mails.tsinghua.edu.cn, Tianhu Deng, Qiankai Qing, Jianghua Zhang, Simin Huang

In this paper, we explicitly model when does a customer prefer to purchase at another store an item that is out of stock at a given store, rather than substituting it with a different item at the same store. From the perspective of a retail chain owner, we found the following: First, under a constant service level, the effective demand rate is higher when a product's inventory is spread over more stores. Second, this relative increment increases with increase in cost of visiting a store and consumer valuation of the substitute product, but decreases with service level and consumer valuation of the primary product. Third, the results still hold when extended to an exogenous model.

3 - A Randomized Pricing Strategy with Price Guarantee

Jianghua Wu, Professor, Renmin University of China, 59 Zhongguancun Street, Beijing, 100872, China, jwu@ruc.edu.cn, Xian Wu, Yunjie Wang

This study proposes a randomized pricing strategy with posterior price guarantee for online retailers. We assume there are two segments of consumers with different valuations to the product. The price variation is set as a Markov process in which theprice randomly switches between high level and low level. Given the price guarantee, once the retailer offers promotion within the guarantee period, the retailer has to pay the price difference back to those who buy at regular price and claim the guarantee. This price strategy encourages consumers to buy instantly at the high price instead of waiting for the low price. we derive the optimal prices promotion probability, and length of guarantee period.

4 - Optimal Bundle-size Pricing

Ameera Ibrahim, Assistant Professor, Saint Mary's College of California, 1928 Saint Mary's Road, Moraga, CA, 94575, United States, ai7@stmarys-ca.edu

We analyze the bundle-size pricing problem in retail. Consumers can choose N goods, from a larger pool of J goods, for a fixed price that depends on the number of goods in the bundle. With the objective of maximizing the total profit, the retailer decides on the optimal assortment of bundles and their prices. We propose a mixed-integer nonlinear model that is then reformulated into a mixed-integer linear model and its computational tractability is demonstrated. Managerial insights are derived based on the computational results.

■ WB46

360E

Project Management

Contributed Session

Chair: Yigal Gerchak, Tel Aviv University, Tel-Aviv, Israel, yigal@post.tau.ac.il

1 - Moral Hazard Problem and Incentive Contract in Engineering Procurement and Construction Project

Wanshan Zhu, Tsinghua University, Dept of Industrial Engineering, Shunde Building #613, Beijing, 100084, China, zhuws@tsinghua.edu.cn, Zhenzhen Chen, Pascale Crama, Xiaobo Zhao

In Engineering Procurement Construction (EPC) projects, the End User contracts with the main contractor on the overall quality of the project, while the main contractor subcontracts the project to several subcontractors. The subcontracting stage may incur moral hazard problem due to the unobservable efforts of the subcontractors. We study the optimal incentive contracts between the main contractor and several sub-contractors from the main contractor's perspective, aiming to motivate the sub-contractors to exert high efforts. As a result, the project can obtain a high overall quality, and the main contractor gains high profit.

2 - Research on Government Guarantees of Highway Public-private Partnerships Projects

Zhenyao Wu, Southwest Jiaotong University, China, NO.111 North of 2nd Ring Road, Chengdu, 610031, China, zhenyao2512@163.com, Bin Shuai, Peng Hu

In Public-private Partnerships (PPP) projects, government usually provides government guarantees to attract private sectors. This paper established model to value the government guarantees. The Monte Carlo simulation was adopted to simulate operating parameters in the model. Finally, the model was applied to a highway PPP project. The authors find that the impact of tariff on the net present value is greater than that of minimum traffic guarantee (MTG) in the project. In addition, the optimal option is a compound option of MTG and traffic cap. The research not only can help government develop reasonable guarantee policies but also can help private sectors to make better investment decisions.

3 - Moments and Distribution of the NPV of a Project

Stefan Creemers, IESEG School of Management, Rue de la Digue 3, Lille, 59000, France, sc@cromso.com Stefan Creemers, KU. Leuven, Naamsestraat 69, Leuven, 3000, Belgium, sc@cromso.com

We study the NPV of a project with multiple stages that are executed in sequence. A cash flow may be incurred at the start of each stage, and a payoff is obtained at the end of the project. The duration of a stage is a random variable with a general distribution function. For such projects, we obtain exact, closed-form expressions for the moments of the NPV, and develop a highly accurate closed-form approximation of the NPV distribution itself. Our work has direct applications in the fields of project selection, project portfolio management, and project valuation. In addition, our work is closely related to the work of CPM/PERT, however, whereas CPM/PERT deals with project completion time, we focus on NPV.

4 - A Multi-skill Approach to Property Maintenance Considering Spatial, Temporal and Resource Constraints

Anthony Vatterott, University of Missouri-Saint Louis, 6254 Walsh, Saint Louis, MO, 63109, United States, anthonygvatterott@gmail.com, Norman Womer, Haitao Li

This paper proposes the application of a novel mathematical model to aid in the scheduling and assignment of construction and maintenance tasks, considering the multi-skilled workforce. Data from a case firm was analyzed so that operational insights into the necessity of such a model could be considered. The optimization approach to multi-skilled resource allocation considers the temporal and spatial demands of a geographically dispersed property management portfolio. Generalization of this data allows a hierarchical framework of skill and task development that can be used to assign the best-capable worker to the most cost-efficient task, considering deadlines, priorities and availability.

5 - Comparison of Strategies of Assigning a Project to Agents where Activities Can Succeed or Fail

Yigal Gerchak, Professor, Tel Aviv University, Department of Industrial Engineering, Ramat-Aviv, Tel-Aviv, 69978, Israel, yigal@post.tau.ac.il, Christian Schmid

R&D projects consist of multiple activities which can fail, but all need to succeed for the project to succeed. Should each activity be assigned to a different agent, or all activities to one agent, where in the latter case several agents are working on the entire project in parallel, and it is sufficient if one of them succeeds? We consider the effect of advantageous specialization, of a deadline, and of heterogeneous activities.

■ WB47

360F

Business Applications

Contributed Session

Chair: Dongdong Ge, Shanghai University of Finance and Economics, Shanghai, China, dongdong@gmail.com

1 - Fraud Detection in Sports Based on Quantitative Compliance

Leif Meier, Professor, HS.Bremerhaven, An der Karlstadt 8, Bremerhaven, 27568, Germany, lmeier@hs-bremerhaven.de

Compliance Management describes the management of regulations in business operations, driven by qualitative analysis in the past. A quantitative Compliance view is highly required to manage restrictions and obligations from regulations and to identify outliers in a massive number of transactions from automated and global business operations. Latest national and international business scandals and corruption in sports have led to a significant reputational and also financial damage, which could destroy industries. This work presents an OR approach for Fraud Detection in Sports from Quantitative Compliance with similar models used in Finance for Anti-Money-Laundering identification.

2 - Inventory Decision Support for a Glass Fabricator

Matthew D. Dean, Associate Professor of Business Administration, University of Southern Maine, School of Business, 113 Luther Bonney Hall, Portland, ME, 04104, United States, matthew.d.dean@gmail.com

We describe a project that is helping a local glass and metal fabricator improve its inventory replenishment system. Historically, it relied on a manual inventory system controlled by a single person with many years of experience. We developed a user-friendly web-based application with an embedded linear programming model that recommends purchasing decisions to the buyer.

3 - Key Performance Metrics for Successful Business Initiatives

Suchitra Veera, Strategy and Analytics Consultant, Snayu Inc, 4512 Dartmoore Lane, Colleyville, TX, 76034, United States, suchitra.veera@gmail.com

The objective of this session is to present the topic of the use of performance measurement and tracking metrics for successful business initiatives delivery. Various types of metrics used in measurement of project/program and initiative delivery success will be discussed including cost, schedule and scope related metrics such as earned value, CPI, SPI along with those that are used in agile and lean projects.

4 - Extending the Role of Information Technology Capability and Impact on Firm Performance using New Metrics and Industry Sector Analysis

Chuan Tian, University of Oklahoma, Norman, OK, United States, chuan.tian-1@ou.edu, Radhika Santhanam, Pascal Nitiema

The linkage between IT (Information Technology) capability and the firm performances remains to be an academic focus. Earlier studies revealed conflicting results. Drawing on Resource Based View (RBV) and incorporating the new features of IT application, this paper empirically investigates the impact of IT capability on firms' performances based on data from 2008 to 2012. Further, the study finds that firms with advanced IT capability are less volatile compared with companies without. Last, the study validates the positive moderating effect of ICT intensity on the pair of relationship. The result of this study is an important enrichment and extension of the original theoretical framework.

5 - Regularized Estimation for High-dimensional Multi-block Vector Autoregressive Models and its Applications

George Michailidis, University of Florida, UF Informatics Institute, 432 Newell Drive, Gainesville, FL, 32611-8545, United States, gmichail@ufl.edu

Dynamical systems comprising of multiple components originate in many scientific areas. A pertinent example examines interactions between equity markets and the potential for contagion during crisis periods. We consider a multi-block system with Granger-causal ordering between blocks, wherein the blocks temporal dynamics are described by vector autoregressive processes and are influenced by blocks higher in the system hierarchy. We briefly discuss estimation and inference issues in a high-dimensional setting. We illustrate the model by examining log-returns of the S&P 100 and the Euro Stoxx 50 components stocks for the 2002-2016, to understand linkages between the two equity markets.

6 - Challenges and Opportunities for Operations Research in China in the A.I. Era

Dongdong Ge, Professor, Shanghai University of Finance and Economics, School of Information management and eng, 777 Guoding Road, Shanghai, 200433, China, dongdong@gmail.com

This talk shares the speaker's experience, confusion and efforts to answer the recent challenges in teaching and research arising from OR/OM fields due to the coming A.I. era. We try to explain from our observation what happened and what is happening in real industry in China, what are business trends and research opportunities we shall pay attention to, how we shall position OR/OM in a competition with CS, Statistics and other subjects.

■ WB48

361A

Psychology of Queueing G++—^{a}—-+ and Hand Hygiene

Sponsored: Behavioral Operations Management

Sponsored Session

Chair: Kenneth Schultz, Air Force Institute of Technology, Air Force Institute of Technology, WPAFB, OH, 45433, United States, kschultz@afit.edu

1 - Beyond Fixed Effects: A Psychological Perspective on Servers' Operational Performance in Service Queuing Systems

Ahmad M. Ashkanani, Kuwait University, Shuwaikh, Kuwait, aashk965@gmail.com, Benjamin B.Dunford

Previous research in service queuing literature has treated servers' psychological factors as fixed effects, which limits our understanding of the behavioral drivers of servers' operational performance. Using longitudinal data from servers in a call center with pooled queuing system and limited financial incentives, we find that these factors are more important than currently understood. We find servers reduce their service rate as workload increases, suggesting a social-loafing behavior. However, intrinsically motivated servers were more resilient to workload effects. Finally, we find no evidence for a relationship between extrinsic motivation and servers' productivity in our setting.

2 - Managing Hand-hygiene as a Prospective Memory Task

Reidar Hagtvedt, PhD, University of Alberta School of Busines, 3-23 Business Building, Edmonton, AB, AB T6G 2R6, Canada, hagtvedt@ualberta.ca, Kenneth Schultz, Trish Reay, Sarah Forgie

Hand-hygiene is governed by Standard Operating Procedures in health-care settings, but is notable for low adherence. We use prospective memory to provide a theoretical framework for the use of cues, time, and disruptions to prompt hand-hygiene. Using data from a hospital, we use survival analysis to test our hypotheses, and find e.g. that accumulated cues impact adherence.

3 - An Empirical Study of Customer Patience and Abandonment in Online Wait for Customer Service: the Role of Delay Announcements and Customer Meandering

Galit Yom-Tov, Technion - Israel Inst of Technology, Haifa, Israel, gality@technion.ac.il, Anat Rafaeli, Monika Westphal

We study the impact of delay announcements, and shifting focus to another web location (meandering) on customer patience and abandonment during online wait. 3 experimental studies (n=3329) show that announcing a delay decreases the likelihood to abandon, and that 20% of the customers balk regardless of the delay announced. Also, customers anchor on the delay content, and this affects their likelihood to abandon. Lastly, customer meandering decreases the likelihood to abandon. Our findings carry important implications for the study of queue wait and the management of service operations.

4 - Load Effects on Service Times

Kenneth Schultz, Air Force Institute of Technology, Department of Operational Sciences, 2950 Hobson Way, WPAFB, OH, 45433, United States, kschultz@afit.edu, Mohammad Delasay, Armann Ingolfsson, Bora Kolfal

We develop a general framework to analyze the influence of system load on service times in queueing systems. Our framework unifies previous results and ties them to possible future studies to help empirical and analytical researchers to investigate and model the ways in which load impacts service times.

■ WB49

361B

Behavioral Operations

Contributed Session

Chair: Mohammad S. Jalali, Massachusetts Institute of Technology, Cambridge, MA, United States, jalali@mit.edu

1 - The Price of Privacy: Experimental Evidence for the Value of Privacy

Rachel Cummings, California Institute of Technology, 1200 E California Boulevard, MC 305-16, Pasadena, CA, 91125, United States, racheladcummings@gmail.com
Rachel Cummings, Georgia Institute of Technology, Atlanta, GA, United States, racheladcummings@gmail.com, Katrina A. Ligett, Ori Heffetz

We measure people's willingness to pay for privacy, through a series of multi-player behavioral experiments where we vary the information that players see about the actions of others. In each session, many pairs of participants play a Dictator Game in the same room. After all decisions are made, we reveal a noisy signal about the Dictator's contribution to their partner that is correct with some (pre-determined) probability, and a random contribution otherwise. By varying the information sharing policy, we can measure how people trade off money for privacy. We show that people's value for privacy does not match the monotone, linear model that is typically assumed in theory.

2 - Considering Human Decision Making in Revenue Management Given Diverse Decision Tasks

Claudia Schuetze, RWTH Aachen University, Kackertstrasse 7, Aachen, 52072, Germany, claudia.schuetze@rwth-aachen.de, Catherine Cleophas

Revenue management is a crucial success factor for many service industries. To complement automated revenue management systems, firms employ revenue analysts. Therefore, we investigate human decision making to draw conclusions for the design of decision support systems. Analysts are tasked to balance multiple objectives. As automated revenue management systems rarely consider multiple criterias, we analyse how well analysts are able to do this. Furthermore, analysts influence system parameters rather than accepting individual customer requests. We test this type of analysts' task, given aspects of anchoring and algorithm trust.

3 - The Combination and Estimation Uncertainty in the Determination of Airlines Personalizing Recommendations

Mengxi Chen, Shanghai Jiao Tong University, Huashan Road No.1954, Shanghai, 200030, China, mengxi1002@126.com

Strategy of consumer choice are now of increasing significance in both academia and practice for the aviation market. We hope to find out some kind of relationship between variables to gain insight about passengers' choices in situations where data are sufficiently available in order to fix best personalized contents to each individual passenger. We use data mining for predicting air passengers' choice, than, an application to the real case of China Airline. We conclude passengers' dynamic decision making processes provide aviation industry better understanding of the passengers' choices and develop effective strategies to maintain customer relationship.

4 - A Dynamic Simulation Game for Cybersecurity Capability Development

Mohammad S. Jalali, Research Faculty, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States, jalali@mit.edu, Zhen Fang

Despite the rise of frequency and intensity of cyber attacks, many organizations are still negligent in the management of their cybersecurity practices. As a response to this failing, we developed a simulation game intended to help managers make investment decisions for building cybersecurity capabilities. Experienced professionals in cybersecurity from different industries and non-experienced students participated in the simulation game. We compared their performances and observed several types of behaviors in the results of the simulation runs.

■ WB50

361C

Autonomous Systems Optimization I

Invited: TSL, Urban Transportation

Invited Session

Chair: Alireza Talebpour, Northwestern University, 600 Foster Street, Transportation Center 3rd Floor, Evanston, IL, 60208, United States, atalebpour@civil.tamu.edu

1 - Platooning in the Presence of a Speed Drop: A Generalized Control Model

Sina Arefizadeh, Graduate Student, Texas A&M.University, College Station, TX, 77843, United States, sinaarefizadeh@tamu.edu, Alireza Talebpour, Igor Zelenko

Designing an autonomous vehicle platooning strategy for tracking a reference velocity profile can improve travel time reliability. Accordingly, this study introduces a generalized control model to track a desired velocity profile, while ensuring safety in the platoons of autonomous vehicles. Defining appropriate error terms, we changed the tracking velocity profile problem into a stability problem. Considering the error term in tracking the velocity profile coupled with error term associated with keeping safe distance from the leader, the proposed method controls the maximum of the two error terms for each vehicle. We showed that the error terms remain bounded throughout the time and space. Two scenarios were simulated, with and without initial perturbations, and results confirmed the effectiveness of the proposed control model in tracking the speed drop, while ensuring safety and string stability.

2 - Design and Operations of Autonomous Vehicle Car-Sharing Systems (AVCS)

Zhiheng Xu, Ph.D, University at Buffalo, Buffalo, NY, 14228, United States, zhihengx@buffalo.edu

We present a time-space optimization model for design and operations of future Autonomous Vehicle Car-Sharing Systems (AVCS). In addition to design and operations decisions, the proposed model explicitly considers empty vehicle relocation and demand shift between AVCS and privately owned autonomous vehicles.

3 - Microscopic Traffic Modeling of Collisions with the Incorporation of Connected and Autonomous Vehicles

Claire E. Silverstein, George Washington University, Washington, DC, United States, csilvs@email.gwu.edu, Samer H.Hamdar

Interactions between individual drivers and error in the decision-making process have been recognized as major sources of unsafe and unstable traffic conditions. Two main avenues that reduce/remove human error from the driving experience are being pursued. Autonomous vehicles utilize sensing technology to take over the driving task, while connected vehicles incorporate vehicle-to-vehicle and vehicle-to-infrastructure communication to obtain and share information, allowing the driver/vehicle to make improved driving choices. This research tests the traffic safety of different market penetration rates (MPRs) of connected and autonomous vehicles on the microscopic level with collision formation. This leads to the optimization of MPRs of the various vehicle types based on safety. The inclusion of lateral trajectory during the lane-changing process allows for more robustness when analyzing vehicular movements and angled collisions.

4 - Collaborative Platooning of Automated Vehicles using Variable Time-Gaps

Aria HasanzadeZonuzy, Texas A&M.University, College Station, TX, United States, azonuzy@tamu.edu, Srinivas Shakkottai, Alireza Talebpour, Sina Arefizadeh, Swaroop Darbha

Connected automated vehicles could be coordinated to safely attain the maximum traffic flow, such as those engendered by the merger of two strings of vehicles. Strings of vehicles have to be shaped correctly in terms of the inter-vehicular time-gap and velocity to ensure that such operation is feasible. However, controllers that can achieve such traffic shaping over the multiple dimensions of target time-gap and velocity over a region of space are unknown. The objective of this work is to design such a controller, and to show that we can design candidate time-gap and velocity profiles such that it can stabilize the string of vehicles in attaining the target profiles. Our analysis is based on studying the system in the spatial rather than the time domain, which enables us to study stability as in terms of minimizing errors from the target profile and across vehicles as a function of location.

■ WB51

361D

Disruption Management

Contributed Session

Chair: Churlzu Lim, UNC-Charlotte, Charlotte, NC, United States, clim2@uncc.edu

1 - A Bi-objective Optimization Model for System Resilience

Daniel Hernando Romero, University of South Florida, Tampa, FL, 33613, United States, danielromero@mail.usf.edu, Aritra Pal, Alex Savachkin

Most system resilience optimization models have a single objective based on a specific resilience metric. There is a need to expand such approaches to offer solutions based on different metrics or dimensions of resilience. We offer a bi-objective model to analyze two main dimensions of system resilience, the absorptive and restorative capacities. The model provides a Pareto front of non-dominated solutions enabling a decision maker to select suitable hardening and recovery strategies.

2 - Vulnerability Analysis of Critical Infrastructures under Disruptions using Monte Carlo Method

Chao Fang, Associate Professor, Wuhan University, Economics and Management School, Wuhan, 430072, China, chao.fang@whu.edu.cn

Reliable and safe critical infrastructures are essential for the sustainable development of modern societies. Considerable attention has been paid to analyzing and mitigating the vulnerability of critical infrastructures, especially against the increasing occurrence of disruptive events such as man-made or natural disasters. In this paper, we use Monte Carlo method to simulate the disruptions attacking the modelled infrastructure network. The innovation is that new metrics based on flow information are proposed in order to predict the propagation of consequences. The application to China High-Speed Rail illustrate the approach with respect to enhancing the system's reliability.

3 - Facility Protection Model for the Supply of Emergency and Perishable Products

Girish Chandra Dey, IIT.Kharagpur, Qtr No. EM/G-18, IIT.Khargpur Campus, IIT.Khargpur Campus, Kharagpur, 721302, India, deygirish@gmail.com, Mamata Jenamani

We present facility protection model considering the importance of maximum distance limits for the supply of emergency products like medical supplies or perishable products during the disruptions. We formulate it as a tri-level mixed integer problem, which considers capacitated facilities, interdiction, and fortification budget limits simultaneously. Then we reformulate it to a bi-level problem and solve it by implicit enumeration (IE) algorithm performed on a binary tree. We report computational results obtained from 64 randomly generated test instances.

4 - Applying Stackelberg-game Model under Credit Guarantee Mechanism with Information Asymmetry

Cheng-Feng Wu, Hubei University of Economics, No.8 Yang Qiaohu Road, Jiangxia, Wuhan, 430205, China, wuchengfeng@hbue.edu.cn

The strait of capital shortage in small and medium enterprises(SMEs) causes them difficult to fulfill orders. Furthermore, a buyer is concerned about supplier disruption when placing an order with his SME supplier. Therefore, obtaining and operating financial support for SMEs is a significant issue. The supplier thoughtfully allocates its borrowed money to production and technology after buyer promises the financial institution a commitment in credit guarantee. This study tries to develop the model to examine the issue of sourcing model under Stackelberg-game with credit guarantee scheme.

5 - Minimization of Restoration Time for Disrupted Power Distribution Network

Churlzu Lim, Associate Professor, UNC-Charlotte, 9201 University City Boulevard, Charlotte, NC, 28223-0001, United States, clim2@uncc.edu, Bhavish G. Golla, Badrul Chowdhury, Andrew N.Kling

This study considers scheduling repair crews to restore power distribution systems that are affected by a high impact low frequency event. Given a set of information pieces including locations of faults, estimated repair times for faults, available resources, and estimated travel times between fault locations, the goal is to assign repair jobs to each repair crew team in a specific sequence that minimizes the system restoration time. Two alternative mixed integer programming formulations as well as a heuristic method are presented and numerically compared in solution qualities and efforts.

■ WB52

361E

Environmental Operations

Contributed Session

Chair: Christine Shoemaker, National University of Singapore, Singapore, Singapore, ceesca@nus.edu.sg

1 - Firm's Multi Periodic Decision Making about Carbon Emission Reduction under Cap & Trade

Yuan Baiyun, Henan Polytechnic University, 2001 Century Avenue, jiaozuo, China, yuanbaiyun@hpu.edu.cn

Under the government's Cap and Trade pilot policy, multi-period dynamic optimization about carbon emissions reduction of enterprises is discussed. Considering the policy that government limits the total amount of enterprise's carbon emissions and allows that the carbon emissions quota can be traded among enterprises in multi-period, we study enterprise's optimal carbon emission reduction strategy to maximize the sum of discounting profit per year by optimal control theory, and analyze how some parameters affect enterprise's optimal carbon emission reduction strategy of each period, such as the trading prices of carbon emissions quota and initial carbon emission quotas.

2 - Automation's Effect on Green Production: Does it Translate to Improved Competitiveness?

Kelly Weeks, Assistant Professor, Lamar University, 4400 MLK Blvd., Beaumont, TX, 77110, United States, kweeks1@lamar.edu, Mahdi Safa

This research builds upon and, as recommended, expands the work of Rao and Holt (2005). This paper will provide a longitudinal study of the impact of automation in a manufacturing setting. We will then try to determine automations impact, perhaps even inadvertently, on green production, the overall supply chain and ultimately upon competitiveness. This study provides multiple international samples, which few predecessors, if any, have done.

3 - Parallel Surrogate Multi Objective Optimization of Computationally Expensive Problems with Environmental Applications

Christine A. Shoemaker, Distinguished Professor, National University of Singapore, office E1A 06-12, Singapore, 14853, Singapore, ceesca@nus.edu.sg, Taimoor Akhtar

A "Multi-Objective Population-based Parallel Local Surrogate-Assisted" candidate search algorithm (MOPLS) is proposed for efficient and parallel multi-objective optimization of computationally expensive simulation optimization problems. Application to test problems and a 15-dimensional watershed model, and comparison against GOMORS, ParEGO and AMALGAM, shows that MOPLS is more efficient within a limited evaluation budget, especially when parallel speed-up is considered.

■ WB54

362A

Simulation

Contributed Session

Chair: Di Wu, Georgia Institute of Technology, Atlanta, GA, United States, dwu80@gatech.edu

1 - Computation Methods for Simulation Optimization using Gaussian Markov Random Fields

Eunhye Song, The Pennsylvania State University, 310 Leonhard Building, The Pennsylvania State University, Room C210, University Park, PA, 16802-4400, United States, eunhyesong2016@u.northwestern.edu, Mark Semelhago, Barry L. Nelson, Andreas Waechter

At the core of Gaussian Process (GP) regression-based simulation optimization algorithms is a GP representing knowledge about the objective function whose conditional distribution is updated as more of the feasible region is explored. Computing the conditional distribution requires inverting a large, dense covariance matrix whose size grows as more solutions are sampled. When a GP is a Gaussian Markov Random Field, then it is particularly suited for a problem with discrete solutions since updating its conditional distribution involves a very sparse precision matrix. In this talk, we discuss how to exploit this sparse-matrix structure to reduce the computation overhead even further.

2 - A Simulation Optimization for Two Stage Decision Making

Wei Xie, Assistant Professor, Rensselaer Polytechnic Institute, 110 8th Street, CII, Room 5207, Troy, NY, 12180, United States, xiew3@rpi.edu, Yuan Yi

To support the dynamic decision making, we study discrete two-stage optimization with the unknown objective estimated by simulation. We introduce a global-local metamodel-assisted approach that can efficiently use the simulation resource to solve for the first- and second-stage decisions. The local metamodel allows us to solve a set of deterministic recourse problems sharing the same first stage action. Then, the global metamodel accounting for the errors introduced in the second-stage optimization can efficiently search for the optimal first-stage decision. Our algorithm is global convergent, and numerical study indicates it achieves substantial efficiency and accuracy.

3 - A Simulation Calibration Framework for the Production Control

Wei Xie, Assistant Professor, Rensselaer Polytechnic Institute, 110 8th Street, CII, Room 5207, Troy, NY, 12180, United States, xiew3@rpi.edu

A simplified stochastic simulation model can be used to guide real-time decision making for a complex real system. To support a reliable guidance, we propose a simulation calibration framework for the production control. The calibrated simulation system is able to capture the dynamic behaviors in the historical output data and predict the future outputs for the real system. The proposed framework delivers credible intervals for calibration parameters and also a prediction interval for the future output. Empirical studies demonstrate efficacy of our approach.

4 - Optimal Robust and Tolerance Design for Computer Experiments with Mixture Proportion Inputs

Mei Han, City Unversity of Hong Kong, Hong Kong, meihan2-c@my.cityu.edu.hk, Matthias Hwai Yong Tan

Computer experiments often have inputs that are proportions of components in a mixture. In these mixture computer experiments, it can be of interest to perform robust and tolerance design on the mixture proportions. Traditionally, manufacturing of mixture products is controlled via interval tolerances for mixture amounts. In this paper, an optimal tolerance region for proportions, which gives optimal quality cost among all possible tolerance regions for mixture proportions with the same acceptance probability, is proposed for integrated parameter and tolerance design in mixture computer experiments. Real examples are given to demonstrate the advantages of the optimal tolerance region.

5 - An Efficient Power Network Damage Assessment via UAVs under Uncertain Environments

Hoyoung Na, PhD Candidate, University of Arizona, Tucson, AZ, 85721, United States, nhy4201@email.arizona.edu, Jaeyoung Cho, Young-Jun Son

This study proposes a novel meta-algorithm for efficient power network damage assessment using unmanned aerial vehicles (UAVs) in the events of power failures. A genetic programming-based hyper-heuristic (GPHH) as an offline path planner is developed to generate the paths of UAVs, which are expected to minimize the total operating cost and the damage assessment completion time under uncertain environments (e.g., wind speed and direction, remaining battery times). The effectiveness of the proposed algorithm is demonstrated for a power network system in Roanoke, VA, USA which is represented by physics-based real time simulation model in Unity3D.

6 - Fixed Budget Ranking and Selection under Input Uncertainty

Di Wu, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30318, United States, dwu80@gatech.edu, Enlu Zhou

Ranking and selection has been studied mostly under the assumption of accurate input model. When there is input uncertainty, a direct application of traditional algorithms may result in poor probability of correct selection. We consider a new problem where a finite budget is available for collecting input data as well as running simulation. Four algorithms are developed to select the best system for single-stage and multistage scenarios. We also investigate the large deviations property in a fixed allocation asymptotic regime, and reveal that the probability of false selection still enjoys exponential decay even in the presence of input uncertainty.

■ WB55

362B

Economics

Contributed Session

Chair: Fernando Garcia Freitas, National Confederation of Services, Sao Paulo, Brazil, fernando.garcia.freitas@gmail.com

1 - Approximate Random Allocation Mechanisms

Mohammad Akbarpour, Assistant Professor, Stanford University, Stanford, CA, United States, mohamwad@stanford.edu, Afshin Nikzad

We extend the scope of random allocation mechanisms, where the mechanism first identifies a feasible "expected allocation" and then implements it by randomizing over nearby feasible integer allocations. Previous literature had shown that the cases in which this is possible are sharply limited. By introducing a new rounding algorithm, we show that if some of the feasibility constraints can be treated as goals rather than hard constraints then, subject to weak conditions that we identify, any expected allocation that satisfies all the constraints and goals can be implemented by randomizing among nearby integer allocations that satisfy all the hard constraints exactly and the goals approximately.

2 - A Complete Asset Market Approach to the Determination of Equilibria for Incomplete Asset Markets

Chuangyin Dang, City University of Hong Kong, Dept of Systems Eng & Eng Mgmt, 83 Tat Chee Avenue, Kowloon, Hong Kong, mecdang@cityu.edu.hk

In incomplete asset markets, there are an insufficient number of contingent claims instruments to provide households with all potentially desirable credit arrangements. This insufficiency can cause discontinuity of the excess demand function at prices for which the asset return matrix loses its full rank. To overcome this discontinuity, we make use of the product of the asset return matrix and its transpose as a new asset return matrix. With the introduction of an extra variable and a convex combination of the new asset return matrix and an identity matrix, we establish an artificial complete asset market, which assures the existence of a smooth path to an economic equilibrium.

3 - E-commerce Platforms and International Trade: A Large-scale Field Experiment

Xiang Hui, MIT, Cambridge, MA, 02139, United States, xianghui@mit.edu

Information technology has enabled businesses of all sizes to sell globally. Exploiting a site-wide randomized experiment on eBay, I show that an e-commerce platform could further increase on-site international trade by 2.9% in the short run and 12.3% in the long run through integrating an existing service of handling customs clearance and international shipping. The increase comes from "disadvantaged" groups (small and medium sellers, distant countries, and less profitable products). Foreign consumers benefit from an 8.3% larger product variety. I discuss the role of "nudging" and reducing export entry costs for facilitating exports from small firms.

4 - Generalized Additive Model with Embedded Variable Selection for Bankruptcy Prediction

Laura María García, University De Los Andes, Bogota, Colombia, garcia.lm@uniandes.edu.co, Carlos Felipe Valencia Arboleda, Sergio Andrés Cabrales

In this study, we explore the trade-off between interpretability and predictive performance in the problem of bankruptcy prediction using finantial ratios. We propose a generalized additive model with an innovative embedded variable selection methodology that selects zero, linear or non-linear effects through penalization. Our experimental results demonstrate that the proposed model performs well in terms of predictive power and generalization, providing a good balance between flexibility and interpretability. The findings of this research show that non-linear methods are necessary to understand the behavior of the retail industry in Colombia.

5 - Cost-efficiency of Brazilian Water Distribution and Sewage Collection Services: Some Recent Evidence

Fernando Garcia Freitas, Advisor, National Confederation of Services, Saint Hilaire, 118 - 22, Sao Paulo, 01423040, Brazil, fernando.garcia.freitas@gmail.com

This paper discusses the determinants of production costs in residential water distribution and sewage collection in Brazil. We estimate two distinct stochastic cost frontier models Aigner, Lovell and Schmidt (1977) and Battese and Coelli (1995) for a sample of 23,329 observations from 2009 to 2014. A translog specification is adopted for both models. Cost depends on the relative price of inputs and the level of services provided. Estimations reveal statistically significant parameters for most of variables in the two distinct models and that inefficiency is heterogeneous among groups of firms. The main result obtained is that open capital firms are more efficient than closed capital ones.

■ WB57

362D

Scheduling

Contributed Session

Chair: ZhenTao Hu, HUST, Wuhan, China, gentlehzt@163.com

1 - Multiple Objective Optimization for Bus Scheduling Problem in Vietnam

Ho Thanh Phong, International University, Ho Chi Minh City, Vietnam, KP6, Linh Trung, Thu Duc Dist., Ho Chi Minh City, Viet Nam, htphong@hcmiu.edu.vn, Nguyen Thanh Phong

The multi-objective transit network design and frequency setting problem (TNDFSP) involves finding a set of routes constituting a public transit network with three objectives, namely, minimizing user cost, minimizing operator cost and minimizing the congestion score. A Genetic Algorithm (GA) was applied to solve that multi-objective problem, resulting the selection of the "best compromise" solution among the non-dominated transit network solutions. The research was applied and expected to improve the bus service in Ho Chi Minh city, Vietnam.

2 - Scheduling Software Updates for Connected Cars with Limited Availability

Carlos E.De Andrade, AT&T Labs Research, 200 Laurel Avenue South, A5-1E33, Middletwon, NJ, 07748, United States, cea@research.att.com, Simon D.Byers, Vijay Gopalakrishnan, Emir Halepovic, David J. Poole, Lien Tran, Chris Volinsky

The number of connected cars has increased over the past years, and they became an important component of Internet-of-Things. Such vehicles use the cellular networks for several activities, and among them, the Firmware Over-The-Air updates could be potentially challenging to the network. With millions of connected cars expected to be deployed over the next years, it is important to understand their impact on cellular networks, as much as create schedules for such downloads. We present a new scheduling model that accommodates the constraints for such scenario, which usually does not appear in other scheduling problems in the literature, and comment the peculiarities of such solution.

3 - Reallocatable Multi-skilled Resource Constrained Project Scheduling Problem: Mathematical Modeling and Solution Approaches

ZhenTao Hu, HUST, Wuhan, China, gentlehzt@163.com

In this paper we propose an extension of the multi-skilled resource constrained project scheduling problem(MSRCPSP): the Reallocatable multi-skilled resource constrained project scheduling problem(RMSRCPSP). In the RMSRCPSP the resources in use are allowed to be replaced by other resources that master skills the processing activities need. To solve this problem, we apply a priority-based heuristic algorithm, which makes use of resource weight and extend the parallel scheme by introducing a resource shifting procedure. A series of computational tests including small scale and large scale instances shows that the heuristics algorithm is very effective.

■ WB58

362E

Facility Location II

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Tan C Miller, Rider University, 12 Winding Way, Morris Plains, NJ, 07950, United States, tanjean@verizon.net

1 - The Mean-var Median Problem on a Network with Probabilistic Demand Weights

Jiamin Wang, Professor, Long Island University, Post Campus, Roth Hall 202, 720 Northern Boulevard, Brookville, NY, 11548-1300, United States, jiamin.wang@liu.edu, Chunlin Xin

We consider a network facility location problem where the number of potential customers at each node is a random variable. The classical median problem is extended to minimize the expected network length subject to a value-at-risk constraint. Different risk measures are compared to motivate the study. We analyze the property of the optimal solution and identify a finite set of dominant points. Efficient solution procedures are then developed to solve the model. The solutions to the problem are also examined to get managerial insights.

2 - A Cutting Plane Method for Competitive Facility Location under Random Utility Maximization Models

Tien Anh Mai, Postdoctoral researcher, CP 6128 Succursale Centre-Ville, Apt 8, Montreal, QC, H3W1C5, Canada, maitien86@gmail.com

This work concerns the facility location problem in competitive market, where the demand of users is captured by a random utility maximization model. Existing approaches often use the logit model, and formulate the problem in a mixed-integer linear programming model. In this paper, we formulate the problem under the mixed logit model, which is more general and fully flexible. We propose a new approach based on a cutting plane method to exactly and quickly solve the nonlinear problem. We test our algorithm and show that our algorithm is much faster, compared to existing approaches.

3 - Optimizing Product Allocation in a Milkrun Picking System

Jelmer Pier van der Gaast, Postdoctoral Researcher, Rijksuniversiteit Groningen, Nettelbosje 2, Groningen, 9747 AE, Netherlands, j.p.van.der.gaast@rug.nl

In a milkrun order picking system, an order picker picks orders that arrive in real time during the picking process; by dynamically changing the stops on the picker's current picking route. The advantage of milkrun picking is that it reduces order picking set-up time and worker travel time compared to conventional systems. We study order throughput times of multi-line orders and model the system as a cyclic polling system with simultaneous batch arrivals. This allows us to study the effect of different product allocations in an optimization framework for a real-world application.

4 - Effective Methods for Solving the Bicriteria Pcenter Pdispersion Problem

Golbarg Kazemi Tutunchi, Senior Operations Research Specialist, SAS.institute Inc., 100 SAS.campus Dr., Cary, NC, 27513, United States, golbarg.tutunchi@sas.com, Yahya Fathi

We propose an IP model for the bi-criteria p-center and p-dispersion problems via the set covering and the node packing problems. We further study the structure of the proposed model, and we introduce a new family of valid inequalities to solve this IP model more effectively. Through a limited computational experiment we demonstrate the effectiveness of the proposed valid inequalities.

5 - A Manufacturing Network Design and Contingency Planning Model

Tan C. Miller, Director of Global Supply Chain Management Program, Rider University, 12 Winding Way, Morris Plains, NJ, 07950, United States, tanjean@verizon.net, Renato De Matta

We enhance a traditional network facility location manufacturing and distribution model to provide extensive contingency and scenario planning capabilities. Specifically, we develop and test a combination strategic network design model that in addition to solving for the optimal profit maximizing locations, also facilitates trade-off analyses between different levels and costs of manufacturing capacity investments and inventory investments.

■ WB59

362F

Aviation Applications

Contributed Session

Chair: Dan Larsen, University of Cincinnati, 1807 Sycamore Valley Drive, Apartment T2, Reston, VA, 20190-4561, United States, asel.dan@msn.com

1 - A Novel Approach to Model and Solve Discrete Truss Sizing Problems

Mohammad Shahabsafa, Lehigh University, 200 West Packer Ave,, Bethlehem, PA, 18015, United States, mos313@lehigh.edu, Tamas Terlaky, Ali Mohammad-Nezhad, Luis F.Zuluaga, Sicheng He, Joaquim Martins

We consider various mathematical optimization models for the truss topology design problem with the objective to minimize the weight of the structure. The non-convex Euler bucking constraints and Hooks law are also considered. We are interested in truss design problems when the cross sectional areas of the bars take only discrete values. We propose Mixed Integer Linear Optimization Model (MILO) reformulation of the non-convex models. The resulting MILO models are not solvable with existing MILO softwares. We propose a solution methodology to solve the MILO models, and present numerical experiments to demonstrate the performance of the methodology.

2 - Capacity Modeling of Mixed-mode Runway Operations

Rajesh Piplani, Associate Professor, Nanyang Technological University, School of MAE, 50 Nanyang Avenue N3-2C-84, Singapore, 639798, Singapore, mrpiplani@ntu.edu.sg, Wai Lun Cheung

Capacity estimation of airports (defined by runway capacity) is important in planning to meet the long-term growth of air traffic as seen by most regions around the world. In this research, we develop analytical models for capacity estimation (maximum throughput) of a runway operating in mixed-mode. Existing models only consider certain arrival-departure sequences whereas our models take into account optimized arrival departure sequences developed as part of a sister project. We plan to extend the models to two or more runways arranged in different configurations, and also plan to study the relationship between delay and realized throughput, which in turn is affected by traffic mix.

3 - Deliver or Not?: Revenue Management for Future Drone-based Delivery Services

Heng Chen, University of Nebraska-Lincoln, CBA 250, 1240 R.Street, Lincoln, NE, 68588, United States, heng@unl.edu, Senay Solak

Drones are expected to fulfill future commercial delivery services for retailers and courier companies. We study some revenue management problems for these companies to determine when the drone-based delivery options should be enabled under stochastic demand. A dynamic programming model is developed. Both analytical and numerical analyses are provided.

4 - Natural Language Processing

Dan Larsen, The MITRE Corpororation, 7525 Colshire Dr, MS.N329, McLean, VA, 22102, United States, dalarsen@mitre.org

Free-form, natural language aviation safety reporting narratives are an integral part of aviation safety analysis. However, it is difficult to apply machine learning algorithms to domain-specific natural language data using libraries trained on edited English-language sources, such as news wire articles. We demonstrate the application of rule-based processes and open-source Natural Language Processing libraries on a domain-specific corpus in a closed-loop system. This process standardizes references to common aviation terms such as SIDs and STARs, abbreviations, misspellings, and key phrase identification.

■ WB60

370A

Forecasting

Contributed Session

Chair: Fabian Taigel, University of Wuerzburg, Wuerzburg, Germany, fabian.taigel@uni-wuerzburg.de

1 - Spare Parts Planning under Uncertain Demand Rates

Erwin van Wingerden, PhD Student, Eindhoven University of Technology, Eindhoven, Netherlands, e.v.wingerden@tue.nl, Tarkan Tan, Geert-Jan Van Houtum

In this paper we consider a multi-item inventory problem with a backorder constraint. Demand follows a Poisson distribution but instead of assuming the demand rate is given, as is commonly done, we allow for uncertainty in the demand rate. When dealing with new products and a lack of data, the demand rate commonly based on estimates and uncertain. First we show that uncertainty of the demand rate is similar to an uncertain lead time. Next, we show that base stock levels and costs are always higher in the case when there is more uncertainty regarding the demand. Finally, we present numerical results where we consider different distributions for the demand rate among which uniformly distributed demand rates.

2 - Event Forecasting in Call Centers

Ger M. Koole, Vrije Universiteit Amsterdam, Department of Mathematics, De Boelelaan 1081A, Amsterdam, 1081 HV, Netherlands, ger.koole@vu.nl

In this talk we will present recent advances in call center forecasting, especially those related to the forecasting of events such as holidays, billions, and marketing actions. We show how this leads to highly accurate and accountable forecasts.

3 - On Estimation of Cross Elasticity of Demand to Forecast Sparse Time-series Data for E-commerce Applications

Arash Pourhabib, Walmart Labs, 10 Pacific Bay Cir, Apt 204, San Bruno, CA, 94066, United States, apourhabib@walmartlabs.com, Antony Joseph, John Bowman, Jagtej S. Bewli

Cross elasticity characterizes the change in demand for an item as a result of a change in price, or any other features, for another item. Accurate demand forecast hinges upon accurate estimation of cross elasticity, which is a challenging task in eCommerce operations, mainly due to the existence of a large number of low-selling items.

We propose a data-driven method to estimate cross elasticity by taking into account the sparse structure of the eCommerce data. We use an error correcting model approximation to a system of differential equations. We demonstrate that such an approach improves the accuracy of demand forecast.

4 - Hierarchical Forecasting and Multiple Aggregation Prediction Algorithm Combined Intermittent Demand Forecasting and Inventory Control

Li Shalang, Peking University, Beijing, 100078, China, 1301110862@pku.edu.cn, Lei Ming, G.Keong Leong, Honghui Deng

This paper reviews the intermittent demand forecasting methods and compares hierarchical forecasting methods and multiple aggregation prediction algorithm forecasting methods and then proposes a new forecasting method by combining these two methods. We use the procurement data of the State Grid Corporation of China to study these demand forecasting methods. In terms of forecasting performance, we use two forecasting error measurements as well as a real data based inventory simulation experiment. The results of the case study indicate that forecasting methods will generate smaller forecasting error and are better than the previous forecasting methods in terms of inventory performance.

5 - Prescriptive Analytics in Practice - Integrating Machine Learning with Inventory Management for a Fast-casual Restaurant

Fabian Taigel, University of Wuerzburg, Wuerzburg, Germany, fabian.taigel@uni-wuerzburg.de, Jan Meller

We propose a new, integrated approach for data-driven inventory management by combining tree-based machine learning techniques with the well-known newsvendor logic. We compare our model with various competing methods from the literature and benchmark it in a real -world application for a restaurant chain. We obtain very promising first results and provide relevant insights both for practice and theory, as we are able to identify fundamental drivers of the model's performance and apply our approach to a real world data set.

■ WB61

370B

Finance, Banking and Insurance

Contributed Session

Chair: Markku Kallio, Aalto University School of Business, Helsinki, Finland, markku.kallio@aalto.fi

1 - Evaluating Size Effect on Cost Inefficiency of Commercial Banks with DEA

Jean-Raymond Fontin, Student, National Taiwan University of Science and Technology, No.43, Sec. 4, Keelung Rd., Da'an Dist.,, Taipei City, 10607, Taiwan, d10501812@mail.ntust.edu.tw

This study evaluates the determinants of size effect on cost inefficiency of commercial banks in low income countries using undesirable outputs DEA models. It covers a total of 9 countries and 108 banks over the period of 2013-2015. The results have shown that small banks are more efficient, and also support the "skimping" hypothesis; contrary to what most researchers have found. Small inefficient banks suffer from bad management problem that leads to cost inefficiency. Aggressive and well-capitalized small inefficient banks devote excessive resources to optimize their asset quality management and increase their investment portfolio to compensate for their costs.

2 - Financing Multiple Suppliers in Assembly Systems Buyer vs. Bank Financing

Shiming Deng, Professor, Huazhong University of Science and Technology, 4318 Collins Court, Apt 5, Mountain View, CA, 94040, United States, dengsm@gmail.com, Chaocheng Gu, Gangshu Cai, Li Yanhai

This paper compares buyer finance with bank finance in a supply chain with one assembler and multiple heterogeneous capital-constrained component suppliers. We characterize the equilibrium solutions for different financing schemes. We show that in buyer finance the assembler should charge the suppliers the lowest possible interest rate, which may be even below its own unit capital cost. The assembler may offer buyer finance even if its own unit capital cost is higher than banks' risk-free interest rate. We also identify the conditions under which buyer finance is better than bank finance, and demonstrate how initial capitals, costs, and heterogeneity affect the selection of financing scheme.

3 - Cooperative Mitigation of Contagion in Financial Networks

Markku Kallio, Professor (emeritus), Aalto University School of Business, Pohjoiskaari 17 D.17, Helsinki, FIN-00200, Finland, markku.kallio@aalto.fi, Aein Khabazian

We examine the financial network as a cooperative game. Governments can act as facilitators enforcing incentives for banks to cooperate and prevent the escalation of a financial crisis. To determine the characteristic function of the cooperative game, we develop clearing payment models for alternative coalitions competing in the market and show that the proposed models have unique equilibrium solutions satisfying the clearing conditions. As a solution concept, we use nucleolus which implies a possible subsidizing pattern among the banks. For a demonstration we use major European banks and a scenario which is linked to the adverse economic scenario used in 2016 EU-wide stress testing.

■ WB62

370C

Reliability

Contributed Session

Chair: Rachel Ravid, ORT Braude College, Kamon, Israel, ravidmichael@gmail.com

1 - Bandwidth Sharing with Phase-type File Size Distributions

Weina Wang, Postdoc, University of Illinois at Urbana-Champaign, Urbana, IL, United States, weinaw@illinois.edu, Siva Theja Maguluri, R. Srikant, Lei Ying

We study a connection-level model for bandwidth sharing among data transfer flows due to Massoulié and Roberts, where file sizes have phase-type distributions and proportionally fair bandwidth allocation is used. We analyze the expected number of files in steady-state by setting the steady-state drift of an appropriately chosen Lyapunov function equal to zero. We obtain asymptotically tight bounds on the expected number of files in the system in the heavy-traffic regime. Our results show that the expected number of files under proportionally fair bandwidth allocation is insensitive to file size distributions, thus complementing the diffusion approximation result of Vlasiou, Zhang, and Zwart.

2 - Approximation Methods to Analyze Merge Configurations of Open Queueing Networks with Multiple Servers and Blocking

Guy L.Curry, Senior Professor, Texas A&M.University, MS-3131, College Station, TX, 77843, United States, g-curry@tamu.edu

Open queueing networks that contain merge configurations with blocking result in combinatorial sequencing for waiting jobs to enter the merge queue. Lee and Pollock developed a methodology for decomposing the system and analyzing individual queues. The merge queue with after-service blocking of the predecessor machines can be aggregated and the probabilities easily calculated. The Lee and Pollock approach is extended in this paper to multiple machines with non-identical servers.

3 - Queueing System with Feedback Vacations and Disasters

George Mytalas, CUNY, New York, NY, United States, george.mytalas@brooklyn.cuny.edu, Michael A. Zazanis

A queueing system with batch Poisson arrivals and Bernoulli feedback which is subject to disasters and repairs is analyzed. Further, the server, when idle, takes repeated vacations of random length. We analyze this system using the supplementary variables technique and we obtain the probability generating function of the stationary queue length distribution, the Laplace transform of the busy period distribution. We also provide expressions for performance measures and we present a delicate method to derive waiting times.

4 - Waiting Time Analysis in Network of Polling Queues

Ravi Suman, University of Wisconsin-Madison, 2302 University Avenue, Apartment #207, Apartment #207, Madison, WI, 53726, United States, rsuman@wisc.edu, Ananth Krishnamurthy

We analyze a network of polling queues with multiple products and multiple stations. We assume that external arrivals to the network follow a Poisson process, and that each station can be modelled as single server queue with exponentially distributed service times for each product. We establish a stochastic model to analyze this system and develop a procedure to estimate mean waiting times at each station under different service disciplines.

5 - A New Look on the Shortest Queue System with Jockeying

Rachel Ravid, Dr, ORT Braude College, Doar Na Bikat Beit Hakerem, Kamon, 20112, Israel, ravidmichael@gmail.com

We introduce a Markov queueing system with Poisson arrivals, exponential services and jockeying between two parallel and equivalent servers. An arriving customer admits to the shortest line, (when the lines are equal the customer admits to any line with probability 1/2). Every transition, of only the last customer in line, from the longer line to the shorter line is accompanied by a certain fixed cost. Thus, a transition from the longer queue to the shorter queue occurs whenever the difference between the lines reaches a certain discrete threshold (T =2,3, ...). In this study we focus on the stochastic analysis of the number of transitions of an arbitrary customer.

■ WB63

370D

Repair Planning and Disruption Management

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Kazuaki Okubo, Ehime University, Matsuyama, 0, Japan, okubo@cee.ehime-u.ac.jp

1 - An MIP Approach for Planning Pothole Repairs

Fatemeh Aarabi, University at Buffalo, 4280 Chestnut Ridge Road, Apt F3, Amherst, NY, 14228, United States, faarabi@buffalo.edu, Jee Eun Kang, Rajan Batta

Potholes degrade the functionality of roadway networks (throughput of traffic flow) in addition to concerns of safety and vehicle damages. A suitable repair planning strategy is developed to minimize total traffic flow throughput degraded over time. The proposed MIP model determines the optimal decisions of repair segment, type, and timing given limited resources. We apply the proposed model to a New York City case study.

2 - A Reliability based Planning Model for Bridge Maintenance under Different Management Agencies

Kazuaki Okubo, Associate Professor, Ehime University, 3 Bunkyo Machi, Matsuyama City, Matsuyama, 790-8577, Japan, okubo@cee.ehime-u.ac.jp, Pang-jo Chun, Haruna Suzuki

We develop a bridge maintenance and repair planning model based on the traffic assignment model with variable demand. The objective is minimizing social cost, the sum of road network user cost, maintenance and repair cost , with considering potential bridge failures and the differences in management agencies of each bridge. We show the numerical results by using the bridge inspection data in Shikoku region, Japan.

■ WB64

370E

Machine Learning Algorithms and Applications in Dynamic Environments

Sponsored: Data Mining

Sponsored Session

Chair: Seoung Bum Kim, sbkim1@korea.ac.kr

1 - Dynamic Adjustment of Dispatching Rule Selection
Sangmin Lee, Korea University, Seoul, Korea, Republic of, smlee5679@gmail.com, Seoung Bum Kim

In the semiconductor industry, dispatching rule selection is a challenging task because of high uncertainty caused by a gap between planned capacity and actual capability. This study presents a dynamic dispatching rule selection method with multivariate multiple regression. To demonstrate the effectiveness and applicability of the proposed method, we conduct simulation study using real data from semiconductor fabrication plant in one of the leading semiconductor companies in South Korea.

2 - Label Propagation Algorithm with Consensus Matrix
Jaehong Yu, Korea University, Seoul, Korea, Republic of, dreamer77445@gmail.com, Seoung Bum Kim

This paper proposes a consensus matrix-based label propagation algorithm for semisupervised classification. The proposed algorithm constructs a consensus matrix to accommodate various characteristics of data and propagates label information using the iterative label fitting algorithm. The experimental results confirm that the proposed algorithm demonstrated superior performance compared to the competitors.

3 - Multi-co-training for Document Classification using Multi-views
Donghwa Kim, Korea University, 145 Anam Roo, Seoul, 02841, Korea, Republic of, donghwa89@korea.ac.kr, Deokseong Seo, Suhyoun Cho, Pilsung Kang

The purpose of document classification is to assign the most appropriate label to given documents. The main difficulties of document classification are insufficient label information and irreversible document representation. In this paper, we propose a multi-co-training based of different representations to improve the performance of document classification. In order to increase the difference of feature sets, we transform a document based on three different representation methods: term frequency-document frequency (TF-IDF) based on bag-of-words scheme, topic distribution based on latent Dirichlet allocation (LDA), and neural network-based document embedding known as Doc2Vec.

4 - Autoregressive Forests for Multivariate Time-series Modeling
Kerem Tuncel, Boaziçi University, Istanbul, Turkey, keremsinantuncel@gmail.com, Mustafa Gokce Baydogan

Multivariate Time Series (MTS) modeling has received significant attention in the last decade. E cient representations are required to deal with the high dimensionality of MTS. However, most of the traditional approaches assume independence or linear dependence between the variables of MTS which is unrealistic. To handle these problems, we propose an autoregressive tree based ensemble approach that can model the nonlinear behavior embedded in the time-series. An error-based representation based on the learned models is the basis of the proposed nonparametric vector autoregression approach. This is very similar to time series kernels used for multivariate time series classification problems.

■ WB65

370F

Freight Transportation Planning and Design

Sponsored: TSL, Freight Transportation & Logistics

Sponsored Session

Chair: Monica Gentili, IPAT, Georgia Institute of Technology, 75 5th Street NW, Suite 600, Atlanta, GA, 30308, United States, mgentili@unisa.it

1 - An Online Cost-sharing Mechanism for Horizontal Supply Chains
Maged M. Dessouky, University of Southern California, 3715 McClintock Avenue, GER.240, Los Angeles, CA, 90089-0193, United States, maged@usc.edu, Han Zou, John Gunnar Carlsson

This research addresses the cost allocation problem in a real-time cost sharing transportation system, which results from horizontal cooperation among multiple suppliers. We formulate the cost allocation problem for the dynamic vehicle routing environment, where only part of the customers are known in advance, and the rest become known in real time. We propose an online cost-sharing mechanism coupled with specially designed cost functions. The mechanism can be incorporated with a look-ahead dynamic vehicle routing framework that explicitly forecasts future customer requests.

2 - Investigating the Impacts of Information Sharing on Intermodal Infrastructure Investment Decision-making Process under Demand Uncertainty
Irina Benedyk, Purdue, 2411 Neil Armstrong Drrive, # 2A, West Lafayette, IN, 47906, United States, birina@purdue.edu, Srinivas Peeta

We investigate the impacts of investment-related information shared between private sector (that is, timing, expansion and operational strategies) on intermodal infrastructure investment decision-making process under demand uncertainty. In addition, we study the impacts of public-private partnership arrangements (which include risk allocation, financial burden and asset ownership) on intermodal infrastructure investment behavior of private sector under market competition. The study findings will help to understand the value of information in intermodal infrastructure investment decision and its impact on investment related uncertainties that affect the return of the investment.

3 - Reliable Facility Location Design under Disruption Risks and Congestion in Continuous Spaces
Zhaodong Wang, University of Illinois, 502 E Michigan Ave, Apt 21, Urbana, IL, 61801, United States, zwang137@illinois.edu, Siyang Xie, Yanfeng Ouyang

This paper develops analytical methods to evaluate the expected system performance with considerations of facility disruptions under a class of continuous traffic equilibrium. Closed-form solution can be evaluated in polynomial time for heterogeneous independent disruptions. A Lagrangian-relaxation-based optimization framework is proposed based on the analytical results to optimize the facility location design.

4 - Best and Worst Values of the Optimal Cost of the Interval Transportation Problem
Monica Gentili, University of Louisville, JB Speed Building, Room 304, Louisville, KY, 40292, United States, monica.gentili@louisville.edu, Raffaele Cerulli, Ciriaco D'Ambrosio

We study the transportation problem with interval supply and demand parameters (ITP), that is, the transportation problem where supply and demand are uncertain and vary in given ranges. We are interested in determining the best and the worst values of the optimal cost of ITP among all the realizations of the uncertain parameters within the intervals. We prove some general properties of the best and the worst optimum values and propose efficient algorithms to determine them.

■ WB66

371A

Traffic and Pedestrian Modeling

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Rui Ma, University of California, Davis, 1930 Sycamore Ln, #10, Davis, CA, 95616, United States, drma@ucdavis.edu

1 - A Comprehensive Assessment of Various Factors on Driving Ability of Individuals
Maxim A. Dulebenets, Florida A&M.University-Florida State University, 2300 Bluff Oak Way, Apt. 8408, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com, Olumide Abioye, Eren Erman Ozguven, Ren Moses, Walter Boot, Thobias Sando

The majority of models used in transportation planning for estimating travel time and other performance indicators are primarily based on the traffic flow and roadway geometric characteristics. However, in reality there is a variety of other factors that have to be considered (e.g., driver characteristics, weather conditions, temporary attributes, etc.). This study performs a state-of-the-art review of the academic literature to identify a wide spectrum of different factors that may affect the driving ability of individuals.

2 - Investigating Drivers' Perception of Travel Time Reliability using a Full-scale Driving Simulator
Zohreh Rashidi Moghaddam, Morgan State University, 1700 E Cold Spring Ln, Baltimore, MD, 21251, United States, zoras1@morgan.edu, Mansoureh Jeihani

This study investigates travelers' perception of travel time reliability using a full-scale high-fidelity driving simulator. Participants in this study experienced driving in a realistic network in Maryland to make a route choice decision in different scenarios based on the travel time information shown on a Variable Message Sign. Driving experience was also accompanied by a stated preference (SP) survey with similar scenarios to determine their willingness to detour on a Likert scale. Multinomial Probit Model and Ordinal regression has been applied to model travelers route choice behavior and their willingness to detour respectively.

3 - A Stochastic Program Approach for Path Reconstruction Oriented Sensor Location Model

Ning Zhu, Tianjin University, Tianjin, Weijin Road no. 92, China, Tianjin, China, zhuning@tju.edu.cn, Fu Chenyi, Ma Shoufeng

Path flow identification is of particular interest for a number of traffic applications. We propose a scenario based two stage stochastic programming framework which considers the uncertainty of the link-path matrix. The first stage model aims to minimize the total traffic sensor installation cost and the expected penalty for uncovered and undifferentiated paths. The second stage model attempts to minimize uncovered and undifferentiated paths for a given sensor location pattern and a specific scenario. A branch and bound based integer L-shaped algorithm is presented. Extensive numerical experiments are conducted to verify the effectiveness of the proposed models and algorithm.

4 - Investigating Significant Features Contributing on Safety of Pedestrians at Intersections Over the Years

Hamidreza Ahady Dolatsara, Auburn University, 311 West Glenn Ave., Apt. 28, Auburn, AL, 36830, United States, hamid@auburn.edu

The objective of this study is investigating factors affect safety of pedestrians over the years. For this purpose Machine learning algorithms will utilize to extract the important features and predicting crash frequencies at intersections.

5 - The Morning Commute Problem with Ridesharing and Dynamic Parking Charges

Rui Ma, University of California, Davis, 2041 Academic Surge, University of California, One Shields Avenue, Davis, CA, 95616, United States, drma@ucdavis.edu, Michael Zhang

We study the traffic flow patterns in a single bottleneck corridor with a dynamic ridesharing mode and dynamic parking charges. Besides the scheme with constant parking charges and ridesharing payments, dynamic parking charges and ridesharing payments are derived to achieve congestion-free traffic in the corridor. With the dynamic ridesharing ratios, it is found that genuinely nonlinear departure rates and travel time functions can be generated in certain ridesharing cases, which was not observed in the traditional ADL model (Arnott et al., 1990) for the morning commute problems without ridesharing or with constant ridesharing ratios.

■ WB67

371B

Data Analytics to Advance the Science of Health Care Delivery

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Devashish Das, Mayo Clinic, Rochester, MN, 55901, United States, das.devashish@mayo.edu

1 - Data Analytics Framework for Online Chronic Disease Management Based on Remote Health Information Systems with a Case Study in Smart Asthma Management

Junbo Son, University of Delaware, 303 Alfred Lerner Hall, Newark, DE, 19716, United States, junboson@udel.edu, Shiyu Zhou, Patricia Brennan

An array of advancements in information technology has resulted in a next-generation health information system based on remote patient monitoring technology and such system is especially emphasized in chronic disease management because of the system's consistent monitoring capability. In this paper, we first discuss some pitfalls of analyzing data from the remote health systems that may mislead patients and their care providers. Then, we introduce a set of principles that enables more effective data analytics based on remotely acquired patient data. We believe the discussion in this paper is crucial for unleashing a new era of technology-enabled and data-driven chronic disease management.

2 - Impact of Resuscitation Activations on Patients Left Behind in an Emergency Department

Xiaochen Xian, 936 Eagle Heights Apt C, Madison, WI, 53705, United States, xxian@wisc.edu, Mustafa Y Sir, Devashish Das, Kalyan Pasupathy

In the Mayo Clinic Emergency Department, a level one trauma center, a resuscitation team is formed by pulling resources from different treatment areas on a rotational basis to respond to incoming trauma patients. This impacts the care delivery process of patients that are left behind by the staff members responding to the resuscitation activation. We use a functional regression model to study the impact of these activations and system recovery time. This model can help design a workload-based resuscitation model instead of a rotation-based model.

3 - Personalizing Depression Treatment Follow-up via Rule-based Method

Ying Lin, University of Houston, Houston, TX, United States, ylin58@uh.edu, Shuai Huang, Shan Liu

Depression is a common mental illness with complex and heterogeneous progression dynamics. Risk grouping of depression treatment population based on their longitudinal patterns has the potential to enable cost-effective monitoring policy design. This study aimed at identifying a set of risk-predictive longitudinal patterns that predict depression progression and segment population into subgroups with different risk implications using rule-based method. We applied the rule-based method on an electronic health record dataset of depression treatment population and identified 12 rules that provide better individual prognostics and enable cost-effective monitoring policy design.

4 - Improving Accuracy of Non-invasive Hemoglobin Monitors: A Functional Regression Model for Streaming SPHB Data

Devashish Das, Mayo Clinic, 2015, 41st Street NW, F47, Rochester, MN, 55901, United States, das.devashish@mayo.edu, Kalyan Pasupathy, Nadeem N. Haddad, Susan Hallbeck, Martin Zielinski, Mustafa Y. Sir

In this article, we propose a method of improving accuracy of SpHb monitors, which are non-invasive hemoglobin monitoring tools with potential to improve critical care protocols in trauma care. The proposed method is based on fitting smooth spline functions to SpHb measurements collected over a time window and then use a functional regression model fit to predict the adjusted SpHb measurement for the end of the time window. The accuracy of the proposed method is compared to traditional methods.

■ WB68

371C

Uncertainty Analysis in Modeling, Control, and Optimization

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Du Dongping, Texas Tech University, Lubbock, TX, 79409, United States, dongping.du@ttu.edu

1 - Generalized Polynomial Chaos-based Uncertainty Propagation in Multi-scale Modeling of Cardiac Electrophysiology

Zhiyong Hu, Texas Tech University, Lubbock, TX, United States, zhiyong.hu@ttu.edu, Dongping Du

Cardiac modeling has been widely used in physical experiments and clinical studies to uncover disease mechanism and investigate treatment strategies. Cardiac functions involve many uncertainties resulting from intrinsic variability. However, most of the existing cardiac models cannot efficiently quantify the effect of uncertainty on model prediction. This study develops a Generalized Polynomial Chaos based uncertainty propagation technique to propagate parametric uncertainties across multi-scale organizational level of cardiac ion channel, cell, and tissue. The method shows superior performance, compared with the Monte Carlo method, in computational efficiency and accuracy.

2 - Porosity Analysis for Additive Manufacturing by Augmented Spatiotemporal Point Process

Chenang Liu, Virginia Tech, 837 Claytor Square, Blacksburg, VA, 24060, United States, lchenang@vt.edu, Jia Liu, Zhenyu Kong, Prahalad Rao

Porosity is one major defect in additive manufacturing (AM) process. The research on modeling, forecasting, and control of porosity is critical to improve AM part quality. Using spatial and temporal correlations of pores due to layer-wise building, an augmented spatiotemporal point process is proposed to identify and forecast areas prone to pores on next layers. By this method, the distribution of pores captured from CT scan images is effectively represented by the proposed augmented point patterns incorporating morphological features of pores. This method is demonstrated by a real AM part with CT scan images.

3 - Physics-driven Spatiotemporal Regularization for High-dimensional Predictive Modeling

Bing Yao, Pennsylvania State University, 801 B6 Southgate Dr, University Park, PA, 16802, United States, bzy111@psu.edu, Hui Yang

Rapid advancement of distributed sensing and imaging bring a lot of high-dimensional spatiotemporal data in complex systems. Traditional regression fails to describe the spatial and temporal correlation of these data, and is not generally applicable for predictive modeling in these systems. This talk presents a physics-driven spatiotemporal regularization (STRE) method for high-dimensional predictive modeling in complex dynamic systems. This model is implemented to predict the electric potentials on the heart surface from the ECG data on the body surface. The model performance is evaluated and validated in both a simulated two-sphere geometry and a realistic torso-heart geometry.

4 - Blending of Computer Experiment Models with and with out Tuning Parameters

Patxi Fernandez-Zelaia, Georgia Institute of Technology, Atlanta, GA, United States, pfz3@gatech.edu, Rui Tuo, V. Roshan Joseph

This work focuses on the building of efficient statistical models from different classes of complex computer simulations and cheap analytical solutions. The computer experiments considered are deterministic yet contain numerical errors associated with real-valued tuning parameters. Additional errors corresponding to different computer code classes may be associated with the physical granularity or solution algorithm found in each code. Following recent work nonstationary Gaussian Process models are employed to blend predictions across tuning parameters. Blending of cross-class computer codes and analytical solutions is achieved utilizing unknown latent tuning parameters.

■ WB69

371D

Optimization, Convex

Contributed Session

Chair: Tao Wu, Dow Chemical, Midland, MI, United States, danielwu9999@gmail.com

1 - Robust Optimization: Sensitivity to Uncertainty in Scalar and Vector Case

Giovanni Paolo Crespi, Associate Professor, Universita' degli studi dell'Insubria, Via Monte Generoso, 71, Varese, 21100, Italy, giovanni.crespi@uninsubria.it, Matteo Rocca, Daishi Kuroiwa

How robust solutions react to changes in the uncertainty set? We prove their location w.r.t. the magnitude of a possible decrease in uncertainty, i.e. when the uncertainty set shrinks. Uncertainty may arise from incomplete information about people's (stakeholders, voters, etc.) perception about a specific issue. When the decision maker (DM) has to look for approval, they might need to define the strategy that displeases the minority. Robust optimization allows such a solution. Nevertheless, such a solution might be far from the strategy that the DM wishes to uphold betraying the DM's goals. Our results allow such a distance to be measured and to steer the robust solution closer to the desirable one.

2 - Advances in Pseudo-cut Strategies for Global Optimization

Christopher Riley, Assistant Professor of Management, Delta State University, Cleveland, MS, United States, criley@deltastate.edu, Leon S.Lasdon, Fred W. Glover, Cesar Rego

Pseudo-cuts are linear cutting planes that provide temporary, but possibly invalid, restrictions on the solution space of complex optimization problems, to guide a solution process toward a global optimum. We provide new pseudo-cuts for nonlinear optimization using scatter search and tabu tunneling mechanisms, and present computational results showing the merit of our approach.

3 - An Approach for Robust Multiobjective Optimization Through a Superiority and Robustness Tradeoff Framework

Adham Mohammed, Research and Teaching Assistant, Cairo University, Faculty of Engineering at Cairo University, Cairo University Avenue, Giza, 12613, Egypt, adham@cu.edu.eg, Mohamed Gadallah, Sayed Metwalli

This paper introduces an approach for Robust Multi-Objective Optimization that considers the two aspects of solution merit: performance superiority and robustness. A multi-objective formulation is proposed, combining the Performance Superiority Objectives with derived Performance Robustness Objectives. The multi-objective analysis is carried out and the Pareto frontier is obtained. This Pareto is then perturbed via Monte Carlo simulation and Feasibility Robustness is used for selecting a reduced Pareto. An Absolute Minimization Index is finally used to select the best single solution from this reduced Pareto. A results comparison with Goal Programming is provided through test problems.

4 - Surrogation Based Tight Bounds for Indefinite Separable Multiconstrained Quadratic Programs

Jaehwan Jeong, Assistant Professor, Radford University, Department of Management, P.O. Box 6954, Radford, VA, 24142, United States, jjeong5@radford.edu, Chanaka Edirisinghe

A linear-time bounding algorithm is developed for indefinite separable quadratic programs. It surrogates multiple constraints to form a single constraint within an iterative scheme to generate a sequence of indefinite knapsack sub-problems that are solvable based on our previous research. The computational analysis with two-constraint case shows the superiority of our method relative to CPLEX.

5 - Analytics Optimization for Lot Sizing

Tao Wu, Data Scientist, Dow Chemical, 7109 Arrowhead Circle, Midland, MI, 48642-8110, United States, danielwu9999@gmail.com

We develop an analytics optimization method for lot sizing where the information is utilized for an analytics-based branching and selection procedure to fix setup variables. Comparisons with other methods indicate that the optimization method is computationally tractable and can obtain better results.

■ WB70

371E

Data Mining

Contributed Session

Chair: Muhammed Sutcu, Abdullah Gul University, Kayseri, Turkey, muhammed.sutcu@agu.edu.tr

1 - Sentiment Analysis of Blog Text Based on CNN and OCC Model

Peng Wu, Professor, Nanjing University of Science &Technology, No.200, Xiaolingwei Road, Nanjing, Jiangsu, 210094, China, wupeng@njust.edu.cn, Heng wang Liu, Si Shen

This paper proposed a Sentiment Analysis model based on OCC (Ortony, Clore, and Collins) model and Convolution Neural Network(CNN)model from the perspective of cognition. A system of fuzzy inferential rules of blog users' emotion is formulated based on OCC model. The blog texts are represented by vectors and are used for training a polarity classification model based on CNN model. The competence of the proposed model is assessed through experiments on both Chinese and English online user' blog texts. The results shows the OCC model can improve the accuracy of the annotation the emotion tendency, and the analyzing results of CNN is significantly higher than the method of SVM(Support Vector Machine).

2 - A Doubly Adaptive Inferential Method for Monotone Graph Invariants

Junwei Lu, Princeton University, Princeton, NJ, United States, junweil@princeton.edu, Matey Neykov, Han Liu

We aim to infer some graph invariants in graphical models (e.g., the maximum degree, the number of connected subgraphs, the number of singletons). We propose a new inferential framework called skip-down for testing nested multiple hypotheses and constructing confidence intervals of the unknown graph invariants under undirected graphical models. Compared to perfect graph recovery, our methods require significantly weaker conditions. Theoretically, we prove that the length of the obtained confidence intervals are optimal and doubly adaptive.

3 - Flipping Out: Exploring Motion Classification Methodologies

Destie Provenzano, Deloitte, Arlington, VA, 22209, United States, destie@destie.com, Joel Bock

The classification of real-time movement from video data using empirically-based learning algorithms is difficult. This study explored methods to simplify the feature construction process, and accelerate learning to predict physical maneuvers from a database of gymnastics videos. Beyond classifying movements, assessment of how well a maneuver has been executed is enabled by this novel approach. Salient results from these numerical experiments will be presented, including increased precision and sensitivity as compared to previous methods.

4 - A New Rational Classification Approach by using the Novel Mixed Data Binarization Method

Muhammed Sutcu, Abdullah Gul University, Endustri Muhendisligi Bolumu, Kayseri, 38060, Turkey, muhammed.sutcu@agu.edu.tr, Omer Batuhan Kizilisik

In this study, we propose a new methodology for classifying the similar customers in same classes and then find the most suitable class for the new coming customer. First, we determine the classes from available data and then we classify the new instances into these predetermined classes by using the new novel data binarization approach. We show how the each step of this algorithm could be performed efficiently.

■ WB71

371F

Optimization, Linear Programming

Contributed Session

Chair: Xianfei Jin, Sabre, Southlake, TX, United States, Xianfei.Jin@sabre.com

1 - Complete Enumeration of Non-isomorphic Minimally Aliased Response Surface Designs using Integer Programming an d High-throughput Computing

Jose Nunez Ares, PhD candidate, KU. Leuven, Kasteelpark Arenberg 30 - bus 2456, Leuven, 3001, Belgium, jose.nunezares@kuleuven.be, Peter Goos, Jeffrey T. Linderoth

Response Surface Designs (RSDs) are statistical designs widely used in process industries. We enumerate 3-level Minimally Aliased RSDs, which are {-1,0,1} matrices with desirable statistical properties. Our branch-and-prune algorithm exploits the inherent symmetry of the design matrices. The enumeration is parallelized to run on a large-scale, heterogeneous and non-dedicated computing environment. Our novel load-balancing scheme relies on phases of breadth-first search along with a statistical estimation of the size of the enumeration tree rooted at child nodes to achieve efficiency. We find many new statistical designs of size significantly larger than previously known.

2 - Steps to Success in Training Neural Networks by Second-order Algorithms

Xi He, Lehigh University, 223 Summit Street, Bethlehem, PA, 18015, United States, xih314@lehigh.edu

We move forward from the common used stochastic gradient based methods to stochastic Hessian-based approaches. They show capabilities to escape saddle points which are crucial in training neural networks, and also help achieve faster convergence rate and better model generalization. We investigate Hessian evolution along iterations to provide insights on neural network training. It motivates us to add elegant extra line-search and momentum to our proposed methods for better optimization performance. Numerical experiments show that our proposed methods can be more successful in practice at optimizing neural networks than several other fine-tuned first order learning algorithms.

3 - Applying Multidisciplinary Design Optimization to Service Network Design Problems

Leah J. Ruckle, PhD Candidate, Georgia Institute of Technology, 270 Ferst Drive, Atlanta, GA, 30332, United States, leruckle@gatech.edu, Dimitri Mavris

Multidisciplinary Design Optimization (MDO) is an optimization field that takes a "divide-and-conquer" approach to solving large and complex optimization problems. It is primarily used within the aerospace and mechanical engineering communities for the design of complex physical systems such as aircraft, automobiles and wind turbines. Up to this point, MDO has not been applied to logistical systems such as the Service Network Design Problem (SNDP). This presentation studies the suitability of applying multidisciplinary design optimization approaches to SNDPs and compares their performance to more traditional decomposition methods.

4 - Aircraft Recovery Problem Considering Airport Capacity and Maintenance Flexibility

Xianfei Jin, Sabre, Southlake, TX, United States, Xianfei.Jin@sabre.com, Xiongwen Qian, Zhe Liang, Lei Zhou, Sureshan Karichery, Xuehua Lu

Disruptions have a huge financial impact on the airline industry. When disruptions happen, airlines need to re-schedule flights and re-assign aircraft in real time with minimized recovery cost. In most previous works, airport capacity and flexible maintenance are not considered simultaneously via an optimization approach. To bridge this gap, we propose a column generation framework to solve the problem. Computational experiments show that the framework solves real-life problems with small, usually zero, optimality gap in very short run time.

■ WB72

372A

Optimization, Network

Contributed Session

Chair: Jean-Paul Arnaout, Lebanese American University, School of Engineering-101F, P.O. Box 36, Byblos, Lebanon, jparnaout@lau.edu.lb

1 - Minimizing Vessel Service Costs in Berth Scheduling via Evolutionary Computation with Deterministic Parameter Control

Maxim A. Dulebenets, Florida A&M.University-Florida State University, 2300 Bluff Oak Way, Apt. 8408, Tallahassee, FL, 32311, United States, mdlbnets@gmail.com

This study focuses on the seaside operations of marine container terminals and proposes a novel Memetic Algorithm with a deterministic parameter control to facilitate the berth scheduling and minimize the total vessel service cost. Unlike canonical Evolutionary Algorithms, the developed algorithm uses a local search heuristic and adjusts the mutation rate values based on a deterministic parameter control strategy for more efficient exploration and exploitation of the search space. Computational experiments demonstrate efficiency of the developed algorithm.

2 - Storage Location Assignment for Rectangular Items Beneath a Gantry Crane

Roya Ghorashi, University of Wisconsin- Milwaukee, 3200 N Cramer St, EMS1062, Milwaukee, WI, 53211, United States, ghorashi@uwm.edu, Matthew Petering

Storage location assignment problems are critical to increasing productivity in many industries. In this paper we consider the problem of locating rectangular items in a temporary storage area beneath a gantry crane. We develop a mixed-integer linear programming model of the problem and devise a metaheuristic method that quickly obtains good solutions to large problem instances. Experimental results obtained via CPLEX and C++ demonstrate the effectiveness of the proposed methods.

3 - Cross Dock Scheduling of Inbound and Outbound Trucks for Fresh Products

Fei Pan, East China University of Science and Technology, 130# Meilong Road, Shanghai, 200237, China, 1004841702@qq.com

Cross dock is a warehouse management concept which can reduce inventories, lead time and customer response time. One of the most fundamental issues is how well the trucks can be scheduled. Aiming at the feature of fresh products, we address three objectives respectively to optimize, the total operation time, the total deterioration of fresh products and the total products passing through temporary storage. Furthermore, we propose a mathematical model and design a genetic algorithm for real size applications. Through comparing the optimal scheduling sequence for trucks based on three objectives, we conclude that optimization of total deterioration can make three objectives low simultaneously.

4 - Solving the Modular Fixed Charge Transportation Problem – A Polyhedral Approach

Faiz Hamid, Assistant Professor, Indian Institute of Technology, Kanpur, 208016, India, fhamid@iitk.ac.in, Yogesh K. Agarwal

In this paper we study a variant of the fixed-charge transportation problem where the capacity can be installed only in integer multiples of a fixed module capacity. The problem is referred as modular fixed charge transportation problem in this paper. The problem arises frequently in practice, for example in supply chain vehicle dispatching problems. However, the problem itself has not been studied in the literature so far to the best of our knowledge. We formulate the problem as a mixed integer linear program, propose different valid inequalities to strengthen the formulation, and present some preliminary computational results.

5 - A Worm Optimization Algorithm to Minimize the Makespan on Unrelated Parallel Machines

Jean-Paul Arnaout, Associate Professor, Gulf University for Science & Technology, West Meshref, 00965, Kuwait, jeanpaularnaout@gmail.com

This paper addresses the unrelated parallel machine scheduling problem with setup times, with an objective of minimizing the makespan. A Worm Optimization (WO) algorithm is introduced and is applied to this NP-hard problem. The novel WO is based on the behaviors of the worm, which is a nematode with only 302 neurons. Nevertheless, these neurons allow worms to achieve several intricate behaviors including finding food, interchanging between solitary and social foraging styles, alternating between dwelling and roaming, and entering a type of stasis/declining stage. WO's performance is evaluated by comparing its solutions to solutions of other known metaheuristics.

■ WB74

372C

Robust and Data-Driven Optimization

Sponsored: Computing

Sponsored Session

Chair: Phebe T. Vayanos, University of Southern California, Los Angeles, CA, 90089, United States, phebe.vayanos@usc.edu

1 - Simulation Optimization via Parametric Robust Optimization

Chaithanya Bandi, Northwestern University, 2001 Sheridan Road, Suite 566, Evanston, IL, 60208, United States, c-bandi@kellogg.northwestern.edu

In this work, we build on data driven uncertainty sets and parameteric robust optimization to simulate and optimize complex stochastic systems such as queueing networks.

2 - Worst-case Demand Distributions in Vehicle Routing

Mehdi Behroozi, Assistant Professor, Northeastern University, Boston, MA, 02115, United States, m.behroozi@neu.edu, John Gunnar Carlsson

A recent focal point in research on the vehicle routing problem (VRP) is the issue of robustness in which customer demand is uncertain. In this paper, we conduct a theoretical analysis of the demand distributions whose induced workloads are as undesirable as possible. We study two common variations of VRP in a continuous approximation setting: the first is the VRP with time windows, and the second is the capacitated VRP, in which regular returns to the vehicle's point of origin are required.

3 - Two-stage Robust Optimization with Decision-dependent Information Discovery

Jiachuan Chen, University of Southern California, Los Angeles, CA, United States, jiachuac@usc.edu, Phebe T. Vayanos

We consider two-stage robust optimization problems with decision-dependent information discovery in which some of the here-and-now decisions correspond to (costly) measurement variables that determine the portion of the uncertain parameters that will be observable in the recourse stage. We propose a solution approach based on the popular K-adaptability framework. We illustrate the performance of our approach on several stylized problems, including a variant of the capital budgeting problem from the literature.

■ WB75

372D

Optimization Methodology

Contributed Session

Chair: Bisheng Du, Ningbo University, Zhejiang, China, dubisheng@nbu.edu.cn

1 - Socially Conscious Product Development: Impact of Costs, Market Growth, and Changes to Brand Image Perception

Hannan Sadjady Naeeni, PhD Candidate in Supply Chain Management, University of Houston, Houston, TX, 77096, United States, hsadjady@bauer.uh.edu, Nickolas Freeman, Powell Robinson

We propose a game-theoretic duopoly model to identify conditions where one, none, or both of the firms make commitments to socially responsible products at equilibrium. Our analysis shows how the firms' commitment to socially responsible products depends on the marginal cost differences and degree of market growth, as well as the indirect effect of the product's social attribute on the consumer's perception of brand image.

2 - Recovery Optimization Decision-making for Sustainable Manufacturing in the Presence of Demand Uncertainty

Kai Meng, Nanjing University of Aeronautics and Astronautics, Nanjing, 210016, China, nuaamk@126.com
Kai Meng, Jiangsu Key Laboratory of Precision and Micro-Manufacturing Technology, Nanjing, China, nuaamk@126.com, Peihuang Lou, Peihuang Lou, Xianghui (Richard) Peng, Victor R. Prybutok

This research examines recovery optimization in a hybrid recovery system with demand uncertainty. Both dismantling and remanufacturing are addressed. The proposed multi-objective optimization model provides the optimal recovery yield and strategies for a batch of product returns to ensure sustainability. We develop an evolutionary algorithm solution and investigate how demand impacts the recovery decisions.

3 - Retailer Strategies to Encourage Reduced Packaging Adoption: A Threshold Perspective

Olga Pak, University of South Carolina, 105 Carolina Ridge Drive, Columbia, SC, 29229, United States, opak@email.sc.edu

A majority of CPG manufacturers continue to resist reduction of product packaging because such packaging is associated with several marketing/product positioning risks, like diminished product visibility and lower perceived value. We explore the tools retailers can use to mitigate such concerns, and, thus, convince manufacturers to make their packaging more compact and less wasteful, which has both operational efficiency and sustainability implications.

4 - Flexible Refund on Consumer Return for Customized Products

Bisheng Du, Associate Professor, Ningbo University, School of Business, Ningbo University., Fenghua Rd 818, Jiangbei District, Zhejiang, 315211, China, dubisheng@nbu.edu.cn, Guiping Li

The mismatch between consumer's growing demand for customized products and supply side's increasing leftover inventory, bring many new business models in the real practice, for instance, C2M (Customer to Manufactory). In this study, we analytically study the flexible refund policy instead of full refund (or no refund) for the customer return with respect to their modularity levels. Our intension is to analyze the analytical performance of C2M system and the customer utilities.

■ WB76

372E

Theoretical and Computational Advances in Mixed Integer Programming

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Manish Bansal, Virginia Tech., Blacksburg, VA, 24060, United States, bansal@vt.edu

1 - Maximizing Reduced-cost-based Fixing

Andre Augusto Cire, University of Toronto Scarborough, Department of Management, UTSC, 1265 Military Trail, Toronto, ON, M1C-1A4, Canada, acire@utsc.utoronto.ca, Louis-Martin Rousseau, Omid Sanei

Reduced-cost-based fixing is a key computational methodology that cuts out part of the solution space that does not lead to an optimal solution. This technique is, however, dependent on the dual values available at the moment of pruning. We investigate the value of picking a set of dual values which maximizes the amount of fixing that is possible. We test this new variable-fixing methodology for arbitrary mixed-integer linear programming models, and show that the resulting method can be naturally incorporated into existing solvers. Preliminary results suggest that the method can e ectively reduce solution times on hard instances with respect to a state-of-the-art commercial solver.

2 - N-step Cutset Inequalities for Multi-module Capacitated Network Design Problem

Haochen Luo, Texas A&M.University, 3131 TAMU, College Station, TX, 77840, United States, hcluo@tamu.edu, Kiavash Kianfar

We present our results of studying the multi-module cutset polyhedron, a relaxation of the multi-module capcitated network design (MMND) polyhedron. We give a new class of cutset inequalities for MMND based on the n-step MIR concept, referred to as the n-step cutset inequalities. We show that many cutset-based inequalities introduced in the literature are special cases of our inequalities. In addition, n-step cutset inequalities introduce new classes of strong inequalities for MMND which are facet-defining for the multi-module cutset relaxation of the problem. Our computational experiments demonstrate that our inequalities are very effective in solving MMND instances.

3 - Online Estimation of the Size of the Branch and Bound Tree in MIP Solvers

Pierre Le Bodic, Monash University, Clayton, Australia, pierre.lebodic@monash.edu, Gleb Belov, Samuel Esler, Dylan Fernando, George L.Nemhauser

We present an online method that estimates the final size of the branch-and-bound tree in Mixed-Integer Programming solvers. This in turn allows to estimate the total running time. The method combines an old sampling method due to Knuth (1975) and recent work on branching by Le Bodic and Nemhauser (2017). This method is implemented in the MIP solver SCIP and its results are displayed as an extra column.

4 - Facets for Single-module and Multi-module Capacitated Lot-sizing Problems

Manish Bansal, Virginia Tech., 227 Durham Hall, 1145 Perry Street, Blacksburg, VA, 24060, United States, bansal@vt.edu

We provide sufficient conditions under which the (k,l,S,I) inequalities of Pochet and Wolsey (1993), the mixed (k,l,S,I) inequalities, derived using mixing procedure of Gunluk and Pochet (2001), and the paired (k,l,S,I) inequalities, derived using sequential pairing procedure of Guan et al. (2007), are facet-defining for the single-module capacitated lot-sizing problem without backlogging. We also provide conditions under which the inequalities derived using the sequential pairing and the n-mixing procedure of Sanjeevi and Kianfar (2012) are facet-defining for the multi-module capacitated lot-sizing problem without backlogging.

■ WB77

372F

Optimization, Integer Programming

Contributed Session

Chair: Richard Forrester, Dickinson College, Carlisle, PA, United States, forrestr@dickinson.edu

1 - Nonlinear Model for Failure Cost Assessment of Drone Delivery Network

Maryam Torabbeigi, University of Houston, 4655 Wild Indigo St, apt 255, Houston, TX, 77027, United States, mtorabbeigi@uh.edu, Gino J. Lim

A delivery network is considered in which some products are delivered to the customers by drones. It is possible that UAV fails during the flight and therefore, some part of the products will be lost. The amount of lost demand depends on UAV failure function and failure location. A new mix integer nonlinear programming (MINLP) model is proposed to minimize the failure cost. The minimum required number of drones is also calculated based on flight time or load capacity or both of them. By solving the model, the path of each UAV, the assigned customers to them, and also the arrival time at each customer and the probability of failure before reaching them are determined while the network failure cost is minimized.

2 - On the Performance of NLP Solvers within Global MNILP Solvers

Benjamin Mueller, Zuse Institute Berlin, Takustr 7, Berlin, 14195, Germany, benjamin.mueller@zib.de

Solving mixed-integer nonlinear programs (MINLPs) to global optimality efficiently requires fast solvers for continuous sub-problems. These appear in, e.g., primal heuristics, convex relaxations, and optimization-based bound tightening. Two of the best performing algorithms for these sub-problems are Sequential Quadratic Programming (SQP) and Interior Point Methods. In this talk we present the impact of different SQP and Interior Point implementations on the most important MINLP solver components that solve a sequence of similar NLPs. We use the constraint integer programming framework SCIP for our computational studies on instances of the MINLPLib2 instance library.

3 - Sparse Nonlinear Regression Pushing the Envelope using Modern Optimization

Bart Paul Gerard Van Parys, Affiliate Researcher, MIT, Room E40-154, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States, vanparys@mit.edu, Dimitris Bertsimas

We present a novel method for nonlinear sparse regression which is able to scale to real-life problems consisting of up to 10,000 observations for a few 1,000 inputs. The ability of our method to identify all relevant nonlinear features is shown empirically to experience a phase transition. In stark contrast to existing heuristics, the same transition also presents itself in our ability to reject all obfuscating features as well. In the regime where our method is statistically powerful, its computational complexity is interestingly on par with Lasso based heuristics. The presented work fills a void in terms of a lack of disciplined nonlinear sparse regression methods in high-dimensional settings.

4 - Global Optimization of Mixed Integer Nonlinear Programs via Adaptive Tightening of Convex Relaxations

Harsha Nagarajan, Staff Scientist, Los Alamos National Laboratory, 3000 Trinity Drive, Apt 8, Los Alamos, NM, 87544, United States, harsha@lanl.gov

We propose a two-stage approach to strengthen piecewise convex relaxations for MINLPs with multi-linear terms. In the first stage, we apply bound contraction methods based on SDP relaxations to iteratively until a fixed point with respect to the bounds are achieved. In the second stage, we partition the variables using an adaptive multivariate partitioning scheme and valid partition elimination strategies. Thus, we construct sparser partitions yet tighter relaxations by adaptive partitioning in combination with cutting plane methods on locally convex regions. We demonstrate the superiority of the algorithm on MINLPLib and (large) Pooling instances w.r.t commercial global opt. solvers.

5 - Construction of Test Problems for the 0-1 Quadratic Knapsack Problem

Richard Forrester, Professor of Mathematics, Dickinson College, Department of Mathematics, College and Louther Street, Carlisle, PA, 17013, United States, forrestr@dickinson.edu, Peixin Sun

Most researchers of the 0-1 quadratic knapsack problem (QKP) assess the performance of their solution methods by performing computational experiments on randomly generated instances. In this talk we examine different factors that can influence the difficulty of randomly generated instances and develop different methods for constructing test problems. In particular, we introduce a technique for generating instances of the QKP with a specified correlation between the objective and knapsack coefficients. We provide a detailed computational study to show how both heuristic and exact solution methods perform on our new problem sets.

■ WB78

381A

Plug-in Electric Vehicle Charging Planning and Operations

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Wei Qi, McGill University, McGill University, Montreal, QC, H3A 1G5, Canada, qiwei.0216@gmail.com

1 - Joint Planning of Electric Vehicle Fast-charging Network and Distributed Photovoltaic Generation

Wei Qi, McGill University, 1001 Sherbrooke Street West, Montreal, QC, H3A 1G5, Canada, qiwei.0216@gmail.com, Hongcai Zhang, Scott Moura, Zechun Hu, Yonghua Song

Integration of plug-in electric vehicles (PEVs) with distributed renewable resources will decrease PEVs' well-to-wheels greenhouse gas emissions, promote renewable power adoption and defer power system investments. We propose a multidisciplinary approach to jointly planning PEV fast-charging stations and distributed photovoltaic (PV) power plants on coupled transportation and power networks. We develop models of 1) PEV fast-charging stations; 2) highway transportation networks under driving range constraints; 3) PV power plants with reactive power control. Then we formulate a stochastic mixed integer second order cone program and decomposition algorithms to solve this problem.

2 - Electric Vehicle Charging Behavior and Infrastructure Availability are Critical to Accurately Assess the Promise of EVS for the Smart Grid

Colin Sheppard, Lawrence Berkeley National Laboratory, Berkeley, CA, 94720, United States, colin.sheppard@lbl.gov, Anand Gopal, Rashid Waraich, Julia Szinai, Nikit Abhyankar, Sangjae Bae, Alexei Pozdnukhov, Andrew Campbell

Vehicle electrification is a critical component of most pathways to deeply decarbonize the transportation sector. Through highly detailed simulation modeling with BEAM (the modeling framework for Behavior, Energy Autonomy, and Mobility), we examine the relationship between driver behavior and the use of charging infrastructure in the context of current day and projected plug-in electric vehicles (PEV) adoption. We demonstrate the importance driver behavior when analyzing the spatiotemporal distribution of electricity demand from PEVs, as well as the potential for PEVs to provide flexibility services to the electric grid.

3 - Recharging Electric Vehicle Sharing Fleet

Xin Wang, Assistant Professor, University of Wisconsin-Madison, 8916 Red Beryl Drive, Middleton, WI, 53562-4278, United States, xin.wang@wisc.edu, Long He, Guangrui Ma, Wei Qi

Electric vehicles have been considered as key to cutting carbon emissions in urban transportation. Several cities have welcomed electric vehicle (EV) sharing services and supported them by building charging infrastructure. Despite the efforts of the cities and operators, it remains challenging to recharge the fleet due to limited charging facilities. Such operational difficulty discourages the use of EV in the sharing fleet and forces operators to switch to gas-powered cars or even cease their operations. In this paper, we address the charging infrastructure planning problem in joint with fleet repositioning and recharging operations in the context of EV sharing.

■ WB79

381B

Forestry I - Forest Management

Sponsored: Energy, Natural Res & the Environment Forestry

Sponsored Session

Chair: Peter Rauch, BOKU-Univ of Natural Resources & Life Sciences, BOKU-Univ of Natural Resources & Life Sciences, Wien, 1180, Australia, Peter.rauch@boku.ac.at

1 - Optimal Deployment of Firefighting Aircrafts for Wildfire Initial Attack Planning

Joao Zeferino, University of Coimbra, Coimbra, Portugal, zeferino@dec.uc.pt

The success of the initial attack is crucial to wildfire fighting efficiency. An optimization model for aerial firefighting fleet deployment planning is presented. The model aims to find a solution for the aircrafts location that maximizes the coverage of different areas according to their wildfire susceptibility and hazard. It takes into account the different forests within a region, the available airport facilities and the aircrafts characteristics. The model potentialities are illustrated through a national-scale case study.

2 - Ascending and Descending Satellite Observation of Forest Fires

Aaron Bradley Hoskins, United States Naval Research Laboratory, 7220 Briarcliff Drive, Springfield, VA, 22153, United States, abh318@msstate.edu, Hugh Medal

We investigate the monitoring of a forest fire by a constellation of satellites. Each satellite is maneuvered to observe the forest fire twice per day. The location of the forest fire is unknown at the time of launch. The problem is formulated as a stochastic programming problem where the initial orbital configuration is the first-stage decision and the satellite maneuver sequence is the second-stage decision. The problem is solved using a Sample Average Approximation Algorithm. The proposed solution is compared through simulation to the current operational paradigm.

3 - Simulating Multi-modal Wood Supply Chains including Risks Agents

Peter Rauch, BOKU-Univ of Natural Resources & Life Sciences, Feistmanteistr 4, Wien, 1180, Austria, Peter.rauch@boku.ac.at, Christoph Kogler

Increasing natural disturbances lead to supply chain risks and seasonal irregularities in wood harvest and transport. A discrete event simulation model supporting manager decisions and contributing to a better understanding of the multimodal wood supply chain was developed. Simulating collaborative supply chain control strategies enhances the development of advanced risk management improving supply chain resilience. The supply chain covers wood harvest, precarriage and storage in terminals, transhipment to rail waggons or vessels and final transport woodworking plants.

4 - An Exact Approach for Spatial Prioritization of Conservation Actions

Jordi Garcia-Gonzalo, Researcher, Centre Tecnològic Forestal de Catalunya (CTFC)., Solsona, Spain, j.garcia@ctfc.es

Limited conservation budgets require prioritizing which management actions to implement and where to maximize the long-term persistence of biodiversity. Recently a heuristic approach has been used to find the combination of actions that remediate threats to species at the minimum cost while considering connectivity among actions through the planning area. We present a mixed integer programming model to prioritize actions to address threats to freshwater fish species in the Mitchell River catchment, northern Australia. We compared our results with the heuristic approaches and found our approach delivered more efficient solutions for different connectivity requirements.

■ WB80

381C

Joint Session PSOR/ENRE: Models for Energy Policy 2

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Erin Baker, University of Massachusetts-Amherst, Amherst, MA, 01003, United States, edbaker@ecs.umass.edu

Co-Chair: Zana Cranmer, Bentley University, Waltham, MA, United States, zanacranmer@gmail.com

1 - Analysis of Competitive Energy Prices when Transportation is Capacitated

Ian Yihang Zhu, University of Toronto, 144A, 60 Harbord Street, Toronto, ON, M5S3L1, Canada, i.zhu@mail.utoronto.ca, Timothy Chan, Michael Pavlin

We study the effect that infrastructure and transportation constraints have on prices in a competitive energy market. In particular, we note the potential that these constraints have in creating market segmentation and localized markets in an otherwise perfectly competitive economy. We apply our model to the gasoline market, where we use inverse optimization to study the movement of prices across different states.

2 - Demand Response Aggregation with Satisficing Consumers in Electricity Markets

Daniel E. Olivares, Assistant Professor, Pontificia Universidad Catolica de Chile, Vicuna Mackenna 4860, Macul, Santiago, Chile, dolivaresq@ing.puc.cl, Florian Salah, Rodrigo Henriquez, George Wenzel, Matias Negrete-Pincetic

This talk discusses the impact of consumers' behaviour on the portfolio design of a Demand Response (DR) aggregator. We develop an optimization model to decide the optimal portfolio of DR contracts for an aggregator participating in the electricity market, where consumers' decisions are modeled using elements of satisfying theory. The model determines the premiums to be offered to consumers in order to obtain a DR portfolio that maximizes the aggregator's operating surplus while satisfying the aspiration levels of participating consumers. Several simulations are performed to obtain insights on the value of the DR resource, and the importance of parameters used to model the consumers' behavior.

■ WB81

382A

Multistage Risk-Averse and Robust Stochastic Programming

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Lewis Ntaimo, Texas A&M University, College Station, TX, 77843, United States, ntaimo@tamu.edu

1 - Decomposition for Risk-averse Multistage Stochastic Programs with Expected Conditional Risk Measures

Lewis Ntaimo, Texas A&M.University, 3131 TAMU, College Station, TX, 77843, United States, ntaimo@tamu.edu, Maryam Khatami, Bernardo Pagnoncelli

We present a study of decomposition algorithms for risk-averse multistage stochastic programs (MSLPs) with expected conditional risk measures (ECRMs). The ECRMs have the advantage of being nested and time consistent. We study ECRMs in the context of both quantile and deviation mean-risk measures.

2 - Stochastic Decomposition for Risk-averse Multistage Stochastic Linear Programs

Prasad Parab, Texas A&M.University, 1901 Holleman Drive W, #403, College Station, TX, 77840, United States, prasaddparab@tamu.edu, Lewis Ntaimo, Bernardo Kulnig Pagnoncelli

Risk-averse multistage stochastic linear programs (MSLPs) can be hard to solve not only because of their large-scale nature, but also due to the risk measure being used. In this talk, we present a study of stochastic decomposition for MSLPs with quantile and deviation risk measures.

3 - The Application of Stochastic Optimization in Chemical Engineering Process

Hanxi Bao, University of Florida, baohanxi@ufl.edu, Zhiqiang Zhou, Guanghui Lan, Zhaohui Tong

Chemical engineering problems often involve uncertainty such as randomness in materials, reactions, and operations. In this work we establish a multistage stochastic programming model for the optimization and control of chemical processes under this type of uncertainty. We then discuss the implementation of a stochastic dual dynamic programming (SDDP) algorithm to compute an optimal solution for this problem.

4 - Robust Affine Control over Finite Time Horizon: The Stochastic Case

Georgios Kotsalis, Georgia Intitute of Technology, Atlanta, GA, United States, gkotsalis3@gatech.edu, Guanghui Lan, Arkadi Nemirovski

We provide a computationally tractable design procedure of affine policies for the constrained multistage robust optimization problem as it pertains to linear regime-switching systems that are subject to quadratic constraints while being affected by uncertain initial state and disturbances. We derive our results under the general assumptions of Markovian evolution of the stochastically switching signal and provided that the initial state and external disturbances lie within some nominal range expressed as the intersection of ellipsoids centered at the origin.

■ WB83

382C

Optimization, Stochastic

Contributed Session

Chair: Xiaoyi Ma, Tongji University, Shanghai, China, 18917288185@163.com

1 - Co-optimizing the Interplan Between Micro and Macro Grids

Luckny Zephyr, Postodoctoral Associate, Cornell University, 308 E Court Street, Apt 3, Ithaca, NY, 14850, United States, lz395@cornell.edu

The increase in renewable resource penetration in bulk power systems introduces challenges in operations, due to the inability to confidently predict resource availability. The result of inaccurate forecasting is a reduction in reliability, with volatility in prices, line flows and voltages on the power transmission network. However, the ability of microgrids to be operated in both interconnected and islanded modes shows potential to leverage these smaller systems to manage disturbances in the bulk network, contributing to the integration of renewables in the power system. We will present our in-progress work to co-optimize the interaction between the main network and microgrids.

2 - Development of Variable Speed Limit System under Uncertain Driver Behaviour

Nadia Moshahedi, University of Calgary, Calgary, AB, T3A2E1, Canada, nadia.moshahedi2@ucalgary.ca, Lina Kattan

variable Speed Limit (VSL) is an Intelligent Transportation System solution that enables dynamic changing of speed limit in an attempt to improve mobility. Performance of these systems is highly influenced by fluctuation in traffic flow, which is caused by factors such as driving behaviour. To develop a proper VSL system uncertainty must be quantified as a part of optimization framework. In this work, we develop a Model Predictive Control VSL under uncertain driver behaviour. A stochastic MPC VSL system that minimizes total system travel time while constraining the change in speed limit over space and time is developed and tested in VISSIM simulation software using a rolling horizon approach.

3 - Scenario Group Approach for Risk Averse Mixed Integer Multi Stage Stochastic Programming Problems with Dynamic Mean CVAR

Ali Irfan Mahmutogullari, Bilkent University, Ankara, Turkey, a.mahmutogullari@bilkent.edu.tr, Ozlem Cavus, Selim Akturk

We propose a scenario tree decomposition approach, namely scenario grouping, to obtain different lower and upper bounds for risk-averse mixed-integer multi-stage stochastic programming problems with dynamic mean-CVaR objective. The method requires no assumption such as convexity, linearity, and complete recourse. For the case where the first-stage decision variables are binary, we also propose an exact solution algorithm by using the obtained bounds iteratively. We conduct computational experiments to observe the quality of the obtained bounds and the efficiency of the proposed algorithm.

4 - Safe Approximations of Chance Constrained Programs

Xiaoyi Ma, Tongji University, Shanghai, China, 18917288185@163.com, Zhaolin Hu

Chance constrained programs (CCP) are important models in stochastic optimization. In this paper, we seek to construct some approximations of the chance constraints. We show that the approximation problems are sometimes more tractable than the original CCPs. Our approach provides a new idea of balancing the conservativeness and the tractability of the CCPs.

Wednesday, 12:30 - 2:00PM

■ WC01

310A

Group Decision Making

Sponsored: Decision Analysis

Sponsored Session

Chair: Yanling Chang, Texas A&M University, 1550 Crescent Pointe Parkway, College Station, TX, 77845, United States, yanling.chang@tamu.edu

1 - Developing a Process to Rapidly Illuminate Potential Solutions
Simon Goerger, Director, United States Army, 102 Windsong Cv, Ridgeland, MS, 39157-8736, United States, simon.r.goerger@usace.army.mil, Niki C. Goerger, Christina Rinaudo

The SPRINTS (Systems Process for Rapid Illumination of Numerous Tentative Solutions) was developed to facilitate workshops within the Engineer Research and Development Center and with diverse groups from numerous Department of Defense organizations. This process facilitates rapid collection of stakeholder feedback to create new processes, enhance existing processes, and identify crucial capabilities requirements within an operational context. This presentation provides an overview of the SPRINTS process with particular examples from real world applications.

2 - The Effect of Shared Leadership on Team Cohesion
Jie Wu, Xi'an Jiao Tong University, Xi'an, China, wujie2016@xjtu.edu.cn

The existing environment with uncertainties and crises and the rise of self-management team, cross-functional team make shared leadership on the way. With the data from 54 teams composed of 284 participants analyzed by SPSS 24.0 and Mplus7.0, we explore the function of affect-and cognitive trust in team level as a bridge between shared leadership and team cohesion and discuss the different role of affect-and cognitive trust in team level between shared leadership and team output respectively. Further, shared leadership has the larger effect on team outputs in ad hoc team than established team.

3 - Voting Rules and Manipulated Evidence
Youzong Xu, Xi'an Jiaotong-Liverpool University, 111 Ren'ai Road, Business Building 423B, Suzhou, 215123, China, xu.youzong@wustl.edu, Bo Li

A group of voters must make a group decision based on the evidence strategically provided by a sender. The voters can choose what voting rule they use to make the group decision. We find that, if the sender can manipulate the evidence he provides, a majority rule is always superior for the voters than the unanimous rule is, because 1) the sender will provide more informative evidence under a majority rule than under the unanimous rule; 2) voters will receive greater expected utilities under a majority rule than under the unanimous rule; and 3) information equivalence can be achieved under a majority rule but not under the unanimous rule.

4 - Effectiveness-equity Tradeoffs in the Aggregation of Preferences
Luis J. Novoa, The George Washington University, 2201 G Street, NW, Funger Hall, Washington, DC, 20052, United States, ljnovoa@gwu.edu, Srinivas Y. Prasad

We consider the problem of aggregating preferences of a group of individuals over a set of discrete alternatives. We develop models for analyzing effectiveness equity tradeoffs using a number of different equity measures, and study how well the models conform to actual choices made by individuals in empirical studies.

5 - Value of Communication for A One-leader, Two -follower Partially Observed Markov Game
Yanling Chang, Texas A&M.University, 1550 Crescent Pointe Pkwy, Apt 1206, College Station, TX, 77845, United States, yanling.chang@tamu.edu, Matthew Keblis, Ran Li

We consider a partially observed Markov game with three agents, a leader and two followers. We analyze how the leader's performance is affected by changes in the quality of the communication between the two followers. Assuming each agent uses a stationary finite memory policy and that the probability of inaccurate communication between the followers is sufficiently small, we present a procedure to determine when leader may consider to modulate the communication quality between the two followers and which follower's communication is optimal to modulate first. The intent of this research is to shed light on whether a lead agent should invest in modulating the quality of communication among followers.

■ WC02

310B

Decision Analysis Arcade

Sponsored: Decision Analysis

Sponsored Session

Chair: William A. Brenneman, Procter & Gamble, 8700 Mason-Montgomery Road, Mason, OH, 45040, United States, brenneman.wa@pg.com

1 - On Data-driven Methods for Learning Graphical Models
Somayeh Sojoudi, University of California-Berkeley, 1543 Delaware Street, Berkeley, CA, 94703, United States, sojoudi@berkeley.edu, Salar Fattahi

Learning graphical models from data is of fundamental importance in data science, and has a wide range of applications in neuroscience, social science, biology, computer science and engineering. In this talk, we develop an optimization-based mathematical framework for three purposes: (i) comparing different data-driven methods, (ii) finding the best method from a set of candidates for a given application, and (iii) designing the best model using the selected method by optimizing the tunable parameters of the algorithm. In particular, we show that Graphical Lasso, as a popular learning technique, has a closed-form solution for sparse graphs.

2 - Comparing Machine Learning Models on Data From Wearable Sensors to Model Physical Fatigue Occurrence
Zahra Sedighi, Graduate Research Assistant, Auburn University, 257 S.Gay st, apt 301B, Auburn, AL, 36830, United States, zzs0016@auburn.edu, Fadel Mounir Megahed, Lora Cavuoto

In this paper, we discuss how human physical fatigue can be classified using analytical models. Best subset selection method was used to filter and identify the important features for classification. Then popular machine learning techniques were used for classification. The performance of the proposed methods was evaluated to choose the optimal classifier and prediction model. The results show that the ensemble learning outperformed the other machine learning both in prediction performance and more importantly in feature reduction.

3 - Evaluating Detection Change in a Multivariate Poisson Process
Hossein Najmi, University of North Texas, Denton, TX, United States, hossein.najmi@unt.edu, Robert Pavur

Multivariate control charts have been extensively studied to signal an out-of-control process. In this study, a root transformation method on multi-attribute processes that follow a multivariate Poisson process is explored so that as to detect a change in the process using control limits. This methodology is evaluated using a simulation experiment in which a relatively stable process has a change point. Correlated quality characteristics are generated and the time of a step-change are approximated in the simulation study. The proposed method is designed to estimate the change point and find the cause for a shift in the process more effectively.

4 - Monitoring and Improving Quality via Consumer Comments
William A.Brenneman, Research Fellow, Procter & Gamble, 8700 Mason-Montgomery Road, Cincinnati, OH, 45040, United States, brenneman.wa@pg.com, Alex Gutman

Procter & Gamble (P&G) receives millions of consumer comments each year and requires an efficient data-mining algorithm to identify products with unexpectedly high complaint counts, as these suggest potential quality or safety issues (aka "signals"). This talk will present an overview of P&G's adopted signal detection method, the Multi-Item Gamma Poisson Shrinker (MGPS), an empirical Bayesian method for disproportionality analysis. It will also discuss the application of text mining on consumer comments to find misclassified adverse events and identify fraudulent complaints.

■ WC03A

Grand Ballroom A

Machine Learning and Applied Probability

Sponsored: Applied Probability

Sponsored Session

Chair: Daniel Russo, daniel.russo@kellogg.northwestern.edu

1 - On the Capacity of Information Processing Systems
Kuang Xu, Stanford Graduate School of Business, Stanford, CA, United States, kuangxu@stanford.edu, Laurent Massoulie

We study an information processing system where jobs are to be inspected by a set of experts. Inspections produce noisy results depending on the jobs' hidden labels and the expert types, and an inspection occupies an expert for one time unit. The manager's objective is to assign inspections so as to uncover the jobs' hidden labels, using a minimum number of experts. Our main result is an asymptotically optimal inspection policy as the probability of error tends to zero.

2 - Pivotal Estimation and Confidence Bands for High-dimensional Linear Models with Error-in-variables

Alexandre Belloni, Duke University, Fuqua School of Business, 100 Fuqua Drive, Durham, NC, 27708, United States, abn5@duke.edu, Victor Chernozhukov, Abhishek Kaul, Mathieu Rosenbaum, Alexandre B. Tsybakov

We study high-dimensional linear models with error-in-variables. In addition to the high dimensionality, these models are challenging because of the need to account for measurement errors to avoid non-vanishing biases and its impact on regularization parameters. We propose a new estimator that is pivotal despite of possible heteroskedastic errors. It is defined as the solution of a convex program with second order cone constraints which allows the use of efficient algorithms. We also construct simultaneous confidence regions for the parameters in such models. We show its validity despite of model selection mistakes, and allowing for the number of parameters to be larger than the sample size.

3 - Matrix Completion Has No Spurious Local Minima

Jason Lee, University of Southern California, Los Angeles, CA, United States, jasonlee@marshall.usc.edu

Matrix completion is a fundamental machine learning problem with wide applications in collaborative filtering and recommender systems. Typically, matrix completion are solved by non-convex optimization procedures, which are empirically extremely successful. We prove that the symmetric matrix completion problem has no spurious local minima, meaning all local minima are also global. Thus the matrix completion objective has only saddlepoints an global minima. This is joint work with Rong Ge and Tengyu Ma.

■ WC03C

Grand Ballroom C

Consumer Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Vinayak Deshpande, University of North Carolina, Kenan Flagler Business School, Chapel Hill, NC, 27599, United States, Vinayak_Deshpande@kenan-flagler.unc.edu

1 - Price Competition in Differentiated Products Markets: When Do Structural Estimation Frameworks Work or Fail?

Chungseung Lee, The University of Texas at Dallas, Richardson, TX, United States, cxl143430@utdallas.edu, Metin Cakanyildirim

We address a conjecture underlying structural estimation frameworks that account for price endogeneity to analyze differentiated products markets. The conjecture claims that the model has a pure strategy Nash equilibrium(NE) and that observed prices constitute the NE. For demand models with a mixture of multinomial logits, we present conditions under which the NE-assumption holds and NE is unique. The price-sensitivity parameters of the demand model differ across products and market segments. Thus, our existence conditions are widely applicable, and yet are milder than those in existing studies. We conclude by discussing the implications of our results for the structural estimation methods.

2 - Exploiting Complementarities in an Online Advertising Supply Chain

Changseung Yoo, The University of Texas at Austin, 2110 Speedway Stop B6500, CBA 5.202, Austin, TX, 78712, United States, csyoo@utexas.edu, Anitesh Barua, Genaro J. Gutierrez

We examine channel structures and pricing models in an online advertising supply chain using a proprietary dataset. We develop analytic as well as structural econometric models that enable us to quantify synergy effects between them. While the extant literature emphasizes choosing between pricing models, we show that using multiple models in concert yields higher overall profitability due to strategic complementarities among the pricing schemes. We then explore the operating implications of the complementarities and their impact on profits and supply chain efficiency, and devise information/profit sharing contracts that boost the supply chain profit towards the benchmark scenario.

3 - Don't Call Us, We'll Call You: An Empirical Study of a Call Center that Offers Automated Callbacks

Vinayak Deshpande, University of North Carolina, Chapel Hill, NC, United States, Vinayak_Deshpande@kenan-flagler.unc.edu, Brett Hathaway, Seyed Emadi

We empirically study the behaviors of callers in a banking call center that offers callers the opportunity to wait offline and receive an automated callback if current waiting times are sufficiently long. Using a structural estimation approach, we model callers' callback decisions. We use the recovered parameters of our model to run a series of counterfactual routing and staffing experiments, which provide managers guidance in determining when to offer automated callbacks.

■ WC04

320A

Behavioral Research on Sustainability and Environmental Operations

Sponsored: Manufacturing & Service Oper Mgmt, Sustainable Operations

Sponsored Session

Chair: Luyi Gui, The Paul Merage School of Business, UC Irvine, Irvine, CA, 92697-3125, United States, luyig@uci.edu

Co-Chair: Mahdi Mahmoudzadeh, Scheller College of Business, Georgia Institute of Technology, Atlanta, GA, United States, mahdi.mzh@scheller.gatech.edu

1 - Framing Effects and the Non-equivalence of Trade-ins and Upgrades: Theory and Evidence

Mahdi Mahmoudzadeh, Georgia Institute of Technology, Scheller College of Business, 800 West Peachtree Street NW, Atlanta, 30308, Georgia, mmahmoudzadeh3@gatech.edu

Manufacturers of durable goods often buy back used products to return them back into remanufacturing systems, and to induce customers to switch to new versions. Trade-ins and upgrades are mechanisms that tie these together through replacement purchases. We provide experimental evidence that, in contrast to the classical theory's view, these mechanisms are not equivalent, and that the framing effect induces consumers to change which prices they anchor to, as their reference points, in arriving at their willingness-to-accept for their used products. We then show how the existence of reference dependence among consumers overturns key predictions of the classical model of trade-ins and upgrades.

2 - The Impact of Environmental Certification on Customer Booking Behavior in Hospitality

Matthew Walsman, Rutgers Business School, 28 Cambridge Dr, Berkeley Heights, NJ, 07922, United States, mwalsman@business.rutgers.edu

There is some evidence that suggests that LEED certification boosts financial performance in the hospitality industry. The reason for this superior performance however, remains unclear. In this study we attempt to answer this question by investigating the behavioral decisions customers make when booking lodging and whether environmental certification influences customer booking decisions.

3 - Relative Performance Transparency: Effects on Sustainable Purchase and Consumption Behavior

Yanchong Zheng, Massachusetts Institute of Technology, Cambridge, MA, United States, yanchong@mit.edu, Ryan Buell, Shwetha P. Mariadassou

We study how transparency into the levels and changes of relative sustainability performance affects consumer behavior. In a series of online consumer choice experiments, we find that in the product purchase domain, transparency into a firm's relative performance levels has a stronger impact on purchase behavior than transparency into the firm's relative changes in performance. In the energy consumption domain, transparency into the consumer's relative changes in performance is more dominant in motivating energy conservation than transparency into the consumer's relative performance levels. We use structural equation models to identify the mechanisms underlying these results.

4 - How Does Precision Affect the Adoption of Energy Efficiency Practices? - Evidence From the Field and Laboratory Data

Suresh Muthulingam, Assistant Professor, The Pennsylvania State University, Smeal College of Business, 460 Business Building, University Park, PA, 16803, United States, suresh@psu.edu, Saurabh Bansal

We investigate whether precision affects the adoption or non-adoption of energy efficiency practices. An econometric analysis of data on energy efficiency recommendations made by the DOE shows that recommendations with precise costs and savings exhibit higher adoption rates than other recommendations. We use three laboratory experiments to isolate the precision effects and to identify the mechanism by which precision affects the adoption decisions. We find that credibility is an important moderator of the precision effect and that the impact of precision is more pronounced with budgetary constraints.

■ WC07

322A

Scheduling and Capacity Planning in Health Care

Sponsored: Health Applications

Sponsored Session

Chair: Jonathan Patrick, University of Ottawa, 55 Laurier Avenue East, Ottawa, ON, K1N 6N5, Canada, patrick@telfer.uottawa.ca

CChair: Antoine Sauré, University of Ottawa, 55 Laurier Avenue East, Ottawa, ON, K1N 6N5, Canada, antoine.saure@telfer.uottawa.ca

1 - Flexible Simulation Platform for Scheduling and Capacity Planning in a Radiotherapy Center

Nadia Lahrichi, Ecole Polytechnique de Montreal, Cp6079 Succ. Centre-Ville, Montreal, QC, H3C3A7, Canada, nadia.lahrichi@polymtl.ca, Yosra El Abed, Louis-Martin Rousseau

The objective of this work is to develop a flexible simulation platform that model several trajectories of patients in a radiotherapy center. Their interactions with resources are detailed and all processes are described. We use two practical cases to evaluate our platform and the literature to evaluate several organisation strategies: scheduling of patients, scheduling of resources and prioritization of tasks.

2 - Setting Patient Wait Time Targets in a Multi-Class Clinical Setting

Vusal Babashov, University of Ottawa, 55 Laurier Ave E, Ottawa, ON, K1N 6N5, Canada, vusal.babashov@uottawa.ca, Antoine Saure, Jonathan Patrick

In Canada, wait time targets for health care services are government-mandated. We believe that in the current setting patients wait longer than needed for no practical benefit to clinics in terms of the efficient use of resources. We aim to develop a methodology for determining the smallest possible wait time target for each patient class as well as to determine optimal regular-hour capacity for a clinic. To the best of our knowledge, this is the first study that attempts to determine appropriate wait time targets and capacity requirements simultaneously in a multi-priority clinical setting.

3 - Capacity Planning for a Network of Community Care Services

Jonathan Patrick, University of Ottawa, 55 Laurier E, Ottawa, ON, K1N 6N5, Canada, patrick@telfer.uottawa.ca

Community services have become increasingly important to health care delivery as people live longer but with chronic disease. We developed a queuing network model with blocking to determine the blocking probabilities within a network of services. We then utilize these to derive an optimal capacity plan through a simulated annealing approach. Results are verified through simulation. Transient behaviour of the system as capacity is adjusted to the optimized allocation is also assessed through simulation.

4 - Improving Access to Radiation Therapy Treatment Through Enhanced Patient Appointment Scheduling

Claire Ma, MSc, British Columbia Cancer Agency, Vancouver, BC, Canada, Claire.Ma@bccancer.bc.ca, Ingeborg Bikker, Nathaniel Horvath, Antoine Sauré, Scott Tyldesley, Aneeta Kassam, Martin L. Puterman

We develop a decision support framework for radiation therapy appointment scheduling consisting of two parts. The first part assigns treatment dates and units to incoming patients, using policies derived from a discounted infinite horizon Markov model. The second part then assigns specific appointment times within each treatment date, using a mixed integer programming model. This framework provides a systematic way of allocating treatment capacity to incoming demand while improving patient satisfaction and service levels in a cost effective manner. The benefits of the proposed approach are evaluated by simulating its performance in a practical scenario based on operational data.

5 - Dynamic Advance Patient Scheduling with Resource Compatibility Restrictions

Antoine Sauré, Assistant Professor, Telfer School of Management, University of Ottawa, 55 Laurier Avenue East, Ottawa, ON, K1N.6N5, Canada, antoine.saure@telfer.uottawa.ca, Ingeborg Bikker, Xiang Claire Ma

We consider an advance patient scheduling problem in which patients require one or multiple appointments with one of several medical resources. We formulate the problem as a discounted infinite-horizon Markov decision process and solve it using approximate dynamic programming techniques. The main purpose of this model is to identify good policies for allocating available service capacity to incoming demand, while reducing patient wait times in a cost-effective manner. The benefits from the proposed method are evaluated by simulating its performance for two practical examples based on data provided by the British Columbia Cancer Agency.

■ WC08

322B

Learning

Contributed Session

Chair: Waldyn Martinez, Miami University, Oxford, OH, United States, martinwg@miamioh.edu

1 - Learning Travel Times in Traffic Networks under Noisy Observations

Emily A. Meigs, MIT, 70 Pacific Street, Rm 243, Cambridge, MA, 02139, United States, emeigs@mit.edu

We study the effects of unknown congestion based latency functions in road traffic networks on how users act over time. Specifically, we look at the convergence of knowledge under noisy observations in a nonatomic routing game. We characterize under what reasonable conditions and learning models will the users in the system converge to the full information Wardrop equilibrium.

2 - An Analysis of Base Learning Algorithms for Ensembles

Waldyn Martinez, Assistant Professor of Business Analytics, Miami University, 117 Country Club Dr., Oxford, OH, 45056, United States, martinwg@miamioh.edu

Ensembles are hybrid models composed of classifiers generated by a base-learning algorithm. Current available research is very limited in comparing the advantages and disadvantages of using different base-learners. Practitioners in several areas including finance, medical research, marketing, among others use ensembles as predictive models, but are limited to using decision trees as the main base-learning algorithm, given that most commercial packages and open-source software rely on the use of decision trees as ideal base-learners. The proposed research is an extensive comparison of base-learners within the most commonly used ensemble methods.

■ WC09

330A

Flexibility in Manufacturing and Service Operations

Sponsored: Manufacturing & Service Oper Mgmt

Sponsored Session

Chair: Hoda Bidkhori, University of Pittsburgh, Pittburgh, PA, 15206, United States, bidkhori@pitt.edu

1 - Analysis of Process Flexibility Designs under Disruptions

Erfan Mehmanchi, University of Pittsburgh, 1025 Benedum Hall, 3700 O'Hara Street, Pittsburgh, PA, 15261, United States, ERM83@pitt.edu, Hoda Bidkhori, Oleg A. Prokopyev

We examine the worst-case performance of flexibility designs under demand and supply uncertainties. Supply uncertainty is considered in the form of plant and link disruptions. In particular, we establish results that allow the decision-maker to compare the performance of different designs. We also discuss fragility of various designs that is defined as the impact of disruptions on their performance.

2 - Stability in Multi Professional and Multi Skilled Services

Hoda Bidkhori, University of Pittsburgh, Dept of Industrial Engineering, Pittburgh, PA, 15206, United States, bidkhori@pitt.edu, Sriram Dasu, Reza Ahmadi

Consider a system where we have different types of multi professional skilled workers. Each professional worker can be flexible to do different tasks which require different skills. Training multi skilled professional workers is costly. We first discuss the optimal flexibility and the learning in such system

3 - Fair Implementation of Interruptible Demand Response Programs

Ali Fattahi, UCLA, Los Angeles, CA, United States, ali.fattahi.1@anderson.ucla.edu, Sriram Dasu, Reza Ahmadi

Direct load control programs are very popular among utility companies for curtailing electricity consumption during peak load periods. These programs require that the participating customers reduce their consumption, by a predetermined amount, a few times during a year. We study fairness in the assignment of interruptions to customers.

4 - Service Systems with Dependent Service Times and Patience Times

Chenguang Wu, Northwestern University, Evanston, IL, United States, chenguangwu2013@u.northwestern.edu, Achal Bassamboo, Ohad Perry

Motivated by recent empirical evidence, we consider a large service system in which the patience time of each customer depends on his service requirement. We show even moderate dependence has significant impacts on system performance, so considering the patience and service times to be independent when they are in fact dependent can lead to large errors. Since the dependence renders exact analysis intractable, we employ a stationary fluid approximation that is based on the entire joint distribution of the service and patience times. We propose a novel framework, incorporating fluid model with bivariate dependence orders, to study the impact of the dependence on key performance measures and capacity decisions.

■ WC10

330B

Auctions/Mechanism Design

Contributed Session

Chair: Xi Shan, University of Texas at Dallas, Richardson, TX, United States, xxs130630@utdallas.edu

1 - Multi-dimensional Auctions, Public Contests and the Winner's Curse

Bernardo F. Quiroga, Assistant Professor of Operations Management, Clemson University, College of Business & Behavioral Science, Department of Management, 100 Sirrine Hall, Clemson, SC, 29634, United States, bfquirog@gmail.com

We study the effect of multi-dimensional auction bidding complexity in the presence of common values, where suppliers don't learn their true production cost until after the auction has taken place. The traditional presence of the Winner's Curse, where a winning bid yields a negative profit to the supplier under sealed-bid-first-price auctions, can be allowed to a partial off-set of the "curse" when bidders are contracted on score levels as opposed to price-quality combinations, and are allowed to ex-post adjustments that are score invariant.

2 - Truth and Regret in Online Scheduling

Rad Niazadeh, Postdoctoral Researcher, Stanford University, Palo Alto, CA, United States, rad@cs.cornell.edu, Shuchi Chawla, Nikhil Devanur, Janrdhan Kulkarni

We consider mechanism design for clouds, where a service provider has multiple units of a resource available over time. Selfish clients submit their jobs. The provider's goal is to implement a truthful online mechanism for scheduling jobs so as to maximize the social welfare. Recent work shows that under stochastic setting, there is a single-parameter family of mechanisms that achieves near-optimal social welfare. We show that given any such family of near-optimal online mechanisms, there exists an online mechanism that performs nearly as well as the best of this family. Our mechanism is truthful if the family members are truthful and prompt, and achieves optimal (within constant factors) regret.

3 - Make Your Elusory Supplier Manage Disruption Risk as You Wish

Xi Shan, University of Texas at Dallas, Richardson, TX, United States, xxs130630@utdallas.edu, Suresh P.Sethi, Chenglin Zhang

We consider the problem where one retailer and one supplier face supply chain disruption risk. The supplier has private information of his initial reliability and is able to improve that reliability with a hidden action, which we call an effort. Through the way of mechanism design, we find the contract menu to reveal the supplier's true type and the supplier's effort level that most benefits the retailer. We also show that it is never optimal to let the suppliers be perfect reliable.

■ WC11

332A

Innovative Business Models in Services

Sponsored: Manufacturing & Service Oper Mgmt, Service Operations

Sponsored Session

Chair: Serguei Netessine, University of Pennsylvania, Wharton School, Philadelphia, PA, 138676, United States, netessin@wharton.upenn.edu

1 - Impact of Tabletop Technology on Restaurant Performance

Fangyun Tan, Southern Methodist University, 6212 Bishop Blvd, Dallas, TX, 75275, United States, ttan@cox.smu.edu, Serguei Netessine

We analyze a large data set of transactions in a casual restaurant chain to understand the effect of implementing a tabletop technology on service performance (measured in sales and meal duration). We find the technology directly increases sales and significant reduces the meal duration. These effects are further moderated by customer-oriented, waiter-oriented and restaurant-oriented factors, respectively. We provide insights on how to manage technology in restaurant operations.

2 - Nudging Flexibility of Workforce: Empirical Evidence from Online Cleaning Services Platform

Ekaterina Astashkina, INSEAD, Boulevard de Constance, Fontainebleau, 77305, France, ekaterina.astashkina@insead.edu, Ruslan Momot, Marat Salikhov

This study focuses on platforms that facilitate matching of heterogeneous customers (tasks) with heterogeneous contractors. Centralized platforms (e.g. Uber) rigidly assign contractors to customers, while decentralized platforms (e.g. TaskRabbit) let contractors choose tasks they prefer. We compose the right personalized assortment of tasks that hybrid platforms should offer to its contractors. We build an econometric model of contractors' choice, which we estimate on a proprietary dataset of the cleaning platform (similar to HomeJoy). We then formulate platform's online optimization problem of assortment personalization and identify policies that achieve near-optimal performance.

3 - Platforms and Search Efficiency: Does Size Matter?

Serguei Netessine, University of Pennsylvania, Philadelphia, PA, 138676, United States, netessin@wharton.upenn.edu, Jun Li

Economic theory predicts that thicker/larger market increases matching efficiency. Using a natural experiment with a peer-to-peer housing rental platform we find that larger markets can be less efficient.

■ WC12

332B

Strategy/Strategic Planning

Contributed Session

Chair: Cristina Ruiz Martín, INSISOC, Valladolid, Spain, cruiz@eii.uva.es

1 - The Impact of Common Lenders to Both Sides of the Deal on the Acquisition Premium and the Acquirer's Market Valuation

JaSeung Koo, Associate Professor, Kobe International University, 9-1-6 Koyocho-naka, Higashinada-ku, Kobe, 6580032, Japan, koo.academic@gmail.com

This study investigates cases where both the acquirer and the target firms in M&As use a common lender. Specifically, the study examines the impact of the common lender and the lender's relationships on acquisition premiums and the acquirer's cumulative abnormal returns. The hypotheses are that: 1) a common lender will be negatively associated with the acquisition premium, and 2) with the acquirer's negative abnormal returns; 3) the strength of the relationship and the firms' dependency will result in the acquirer's positive abnormal returns, and 4) higher acquisition premiums. Using regression analyses on M&As in Japan between 1995 and 2012, three out of the four hypotheses were supported.

2 - The Customer-centric Logic of Strategic Firm Behavior

Lalit Manral, Professor, College of Business, University of Central Oklahoma, 100 North University Drive, Thatcher Hall # 224, Edmond, OK, 73034, United States, lmanral@uco.edu

We invoke a customer-centric logic to explain the heterogeneity in firms' demand-side operating expenses. That a variety of such expenses generate future benefits is widely accepted by scholars and practitioners alike. Yet, conceptual and methodological issues preclude a comprehensive understanding of the outcomes of such idiosyncratic expenses in terms of their asset value and thereby contribution to overall firm value.

3 - Flexibility Analysis on a Supply Chain Contract using Markov Process Model

Zhe Yuan, CentraleSupélec, Laboratoire Genie Industriel, CentraleSupélec, Chatenay-Malabry, 92290, France, zhe.yuan@centralesupelec.fr, Chengbin Chu

This research focuses on the quantity flexibility contract encompassing the uncertainty of customers' demands. We propose a Markov chain process for flexible coordinated contract design based on the stochastic demands from the view of a car manufacturer. The objective is to develop the optimal nominal order quantity and variation rate as to minimize the car manufacturer's total cost while hedging against the uncertainty of the demand for raw materials. The necessary stability condition for the inventory level is examined. Simulations are carried out to verify the optimal strategy and to evaluate the relationship of the expected total cost with the variation rate or the nominal quantity ordered.

4 - Impact of Business Intelligence in Organizational Resilience
Cristina Ruiz Martín, PhD Student, INSISOC, Valladolid, Spain, cruiz@eii.uva.es, Felix Villafañez, Adolfo Lopez Paredes, Gabriel Wainer

The aim of this work is to demonstrate that Business Intelligence (BI) is a key issue for organizations to achieve the capabilities and attributes of resilient organizations. In the last century, organizations focused on performance, but in today's changing environment, this is not enough: continued existence has become a key challenge. One of the main areas of Organizational Resilience research is to identify the characteristics of such organizations. BI aims to help organizations to develop sound strategies in order to survive and thrive taking advantage of data analysis. Organizations can benefit from a combined application of BI and Organizational Resilience.

■ WC13

332C

Decision Support Systems

Contributed Session

Chair: Majed Al-Shawa, Strategic Actions, Waterloo, ON, Canada, malshawa@strategic-actions.com

1 - Repair Scheduling using Generalized Additive Models
Grant Lents, United Technologies Research Center, 411 Silver Lane, East Hartford, CT, 06108, United States, lentsgn@utrc.utc.com

This work focuses on the scheduling of repairs for parts in a repair organization with multiple sites using machine learning techniques. The goal is to predict an ordinal score for each part based on the stage in which the part is between receiving and shipping and how close the part is to its promised turnaround time. The relationship between the score and explanatory variables was non-linear and a Generalized Additive Model (GAM) was fit to the data across all sites. In the second stage, a 2D assignment algorithm was used to group the sites and assign one GAM model to a group of sites. Our work provided site managers with a interpretable tool for consistent scheduling of the repairs for their parts.

2 - Evaluating and Selecting Data Center Fire Protection System with Analytical Hierarchy Process
Xiaojun (Gene) Shan, University of Houston-Clear Lake, Houston, TX, United States, shan@uhcl.edu, Noel S. Ellis

Fire protection systems are critical in protecting data center assets. This paper applies analytical hierarchy process (AHP) to evaluation and selection of a fire protection system for a data center. Expert opinions from multiple data center professionals was used to select the most favorable fire protection system. The selection alternatives were chosen from options that are accepted by the Life Safety Code of the National Fire Protection Association (NFPA). Results show that pre-action water sprinkler system is the preferred fire protection system. This study provides insights for data center managers in constructing new data centers or renovating of existing ones.

3 - Environmental, Health, and Safety Department Reorganization and Prioritization: using Analytical Hierarchy Process to Mitigate Scope Creep
Xiaojun (Gene) Shan, University of Houston-Clear Lake, Houston, TX, United States, shan@uhcl.edu, William Barton

Personnel changes often create a void in experience and knowledge of client processes, decreasing efficiency of client-oriented organizations. The objective of this paper is to demonstrate the use of analytical hierarchy process to establish core priorities of personnel tasks. This is novel to the industry because it allows users to prioritize daily tasks and to recalibrate priorities annually. Examples are given on how to use this tool to prioritize tasks, as the company goals and daily tasks change. The structure of the reorganized department centralizes tasks and reduces duplication. This framework is illustrated with a case study of an Environmental Health and Safety (EHS) department.

4 - Optimal Number of Choices in Rating Contexts
Sam Ganzfried, Assistant Professor, Florida International University, Miami, FL, United States, sam.ganzfried@gmail.com

In many settings people give numerical scores to entities from a small discrete set, e.g., attractiveness from 1-5 on dating sites and papers from 1-10 for conferences. We study the problem of understanding when using a different number of options is optimal. We study several natural processes for score generation. One may expect that using more options always improves performance, but we show that this is not the case, and that using fewer choices—even just two—can surprisingly be optimal. Our results suggest that using fewer options than typical could be optimal in certain situations. This would have many potential applications, as settings requiring entities to be ranked by humans are ubiquitous.

5 - Decision Making under Uncertainty
Srinivasa Prasanna, IIIT-Bangalore, 26/C, Hosur Road, Electronics City, Opposite Infosys Technologies, Bangalore, 560100, India, gnsprasanna@iiitb.ac.in, Abhilasha Aswal

In this presentation, we explore a novel framework for systematically analyzing alternative assumptions about uncertainty and for finding robust strategies under deep uncertainty. We present a tractable robust optimization approach where we model uncertainty as polyhedral sets that can be generated from historical data. This representation of uncertain data models has economic meaning and is intuitive to a decision maker, especially in applications like supply chains, finance, transportation etc.

6 - Is it Worth Fighting a Patent Troll? using the Constrained Rationality Framework to Model and Analyze the Showdown Between RIM and NTP, as an Example
Majed Al-Shawa, Strategic Actions, Waterloo, ON, Canada, malshawa@strategic-actions.com

The RIM vs. NTP holds many features of a classical strategic business conflict that real product innovators found themselves facing. We use Constrained Rationality, a formal value-driven strategic decision and conflict analysis framework with robust multi-agent decision support approach to: model the RIM vs. NTP strategic conflict; analyze the players options and strategies including the possible cooperation between RIM and NTP to settle, and the possible coalitions between NTP and RIM's competitors; and then elicit the most stable equilibrium end states of this conflict, and similar ones. We, finally, compare the produced stability and coalition analysis with how the conflict actually ended.

■ WC14

332D

Managing Capacity and Demand to Improve Efficiency in Healthcare Delivery

Sponsored: Manufacturing & Service Oper Mgmt, Healthcare Operations

Sponsored Session

Chair: Jonathan Helm, Indiana University, Bloomington, IN, 47405, United States, helmj@indiana.edu

1 - The Use of Teletriage in Healthcare Demand Management
Ozden Cakici, American University, 4400 Massachusetts Ave, Washington, DC, 20016, United States, cakici@american.edu, Alex Mills

Teletriage (TT) is offered by many healthcare providers to help patients get advice over the phone. This decision support should benefit patients and improve demand management in healthcare, but TT is not widely used despite a growing push for telemedicine. We use an MDP to model a patient's choice of providers during an illness episode where the illness severity is partially observable to the patient and when teletriage is subject to errors. Allowing TT may improve the patients' outcomes and reduce the rate of arrivals to the emergency department. We extend our analysis to patients who are gain seekers and loss averse. Interestingly, these patients may actually be better off without the option to use TT.

2 - Online Appointment Scheduling Problem with a Rolling Horizon Approach
Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, 2144 Glencoe Hills Drive, Apt 9, Ann Arbor, MI, 48108-1020, United States, keyvan@umich.edu, Cong Shi, Mark P. Van Oyen

We study an online appointment scheduling problem in which patients come one by one into a medical center in an online fashion. Upon arrival of each patient, the scheduler should choose both a surgeon and a day over a specific planning horizon without knowing the full information of the subsequent coming patients. We design an online optimization algorithm for this purpose and compute a suitable competitive ratio.

3 - Patient Centered Capacity Planning for Primary Care Appointment Scheduling
Ali Dogru, akdogru@crimson.ua.edu, Sharif Melouk

Motivated by patient-centered medical home principles, we develop a capacity planning model for appointment scheduling. Considering seasonal demand, patient preferences, no-shows, and lateness, we use stochastic optimization to determine the number of service providers and appointment slot durations to minimize unmet demand, patient waiting, and overage time. Experimentation provides managerial insights. Keywords: Capacity Planning, Appointment Scheduling, Stochastic Optimization, Patient-Centered Medical Home

4 - A Sequential Learning and Decision-making Methodology and its Application

Amirhossein Meisami, University of Michigan, Ann Arbor, MI, United States, meisami@umich.edu, Henry Lam, Mark P. Van Oyen

We study a sequential learning and decision-making methodology that integrates robust/stochastic optimization with regression-based prediction. We also study the uncertainty quantification of the resulting decision and optimality level. We discuss applications in digital marketing, patient discharge planning and readmission control.

■ WC15

332E

Performance Measurement

Contributed Session

Chair: Krishna Kalyanam, InfoSciTex Corporation, Dayton, OH, United States, krishnak@ucla.edu

1 - A New Approach for the Empty Container Repositioning with Uncertainties

Shaorui Zhou, Assistant Professor, Sun Yat-Sen University, 135 Xingang Xi Road, Guangzhou, China, zshaorui@126.com

In this paper, we propose a new hybrid learning algorithm for two-stage stochastic programs for empty container repositioning with uncertainties. This algorithm is a hybrid of a piecewise linear approximation method and a stochastic subgradient method. The piecewise linear functions are updated using stochastic sub-gradient information and sample information on the objective function itself. To achieve global optimum, a projection step implementing the stochastic sub-gradient method is performed to jump from local optimums. This algorithm is proven convergent for general two-stage stochastic programs. Numerical experiments demonstrate that the algorithm has a fast rate of convergence.

2 - Clustering Algorithms in Real-time Risk-averse Portfolio Optimization

Sitki Gulten, Stockton University, School of Business, 101 Vera King Farris Drive, Galloway, NJ, 08205, United States, sitki.gulten@stockton.edu

This study examines the application of risk-averse optimization techniques to high-frequency trading (HFT) in real-time portfolio management. First, I develop efficient clustering methods for scenario tree construction with large scale of returns data. Then, I construct a two-stage stochastic programming problem with conditional measures of risk. Finally, I present an extensive simulation study on both interday and high-frequency intraday real-world data of the methodology.

3 - Sequential Weapon Target Assignment under Error Prone Battle Damage Assessment

Krishna Kalyanam, Sr. Research Scientist, InfoSciTex Corporation, Dayton, OH, 45385, United States, krishnak@ucla.edu, David Casbeer

A single shooter with homogenous weapons engages, sequentially, a collection of targets that may vary in value. Upon firing, the target is either killed or not; there is no partial or cumulative damage. The shooter adopts a shoot-look-shoot strategy, where an error-prone BDA is available at each look. The BDA is a classifier that returns the live or dead status of the target and it is prone to both Type I and II errors. This is a generalization to Manor & Kress (NRL, 1997) wherein only a kill is confirmed with a certain probability. We provide a lower bound on the maximal difference between the probabilities of correctly identifying a killed and live target, such that a greedy shooting strategy is optimal.

■ WC16

332F

Simulation and Optimization

Contributed Session

Chair: Murat Testik, Hacettepe University, Ankara, Turkey, mtestik@hacettepe.edu.tr

1 - Efficient Simulation for Expectations Over the Region Outside a Convex Polytope

Dohyun Ahn, Korea Advanced Institute of Science and Technology, #2111, E2-2, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon, 34141, Korea, Republic of, dohyun.ahn@kaist.ac.kr, Kyoung-Kuk Kim

We consider the problem of estimating the expectation over the region outside a convex polytope. Such expectation arises in many applications including option pricing, stochastic activity networks, and financial networks. Assuming that random variables follow a multivariate elliptical distribution, we develop a conditional Monte Carlo method and prove its asymptotic efficiencies. We then demonstrate how this method can be applied to the above three examples.

2 - A Multi-agent Based Simulation Model for Pricing Vehicle Routes in the Physical Internet

Long Zheng, University of Louisville, 1407 Nightingale Road, Apt 4, Louisville, KY, 40213, United States, long.zheng@louisville.edu

In vehicle routing under the protocol of Physical Internet (PI), it is a critical decision making problem for carriers to set the price of shipment loads to maximize their revenues. In this study, we propose a multi-agent system structure for the PI-vehicle routing problem (PI-VRP). A multi-agent based simulation model is developed to demonstrate the pricing approach. For inputs of the model, we use real data in a PI-enabled logistics networks. To an end, results of the simulation model are compared with a mathematical pricing approach based on dynamic programming optimization so as to valid our modelling framework.

3 - Optimal Fire Station Relocation to Minimize the Response Time: Case of the City of Kingsville

Rutang Vijaykumar Shah, Texas A&M.University Kingsville, 1100 W. Corral Ave, Apt #14, Kingsville, TX, 78363, United States, rutang.shah@yahoo.com, Joon-Yeoul Oh, Hua Li

It is very critical to response on fire and emergency calls quickly. In cases of fire and emergency call, the average response time in the city of Kingsville is 278 seconds, which is 32 seconds more than the established NFPA standard, 240 seconds. The aim of this research is to reduce the response time by analyzing the data and ARENA simulation models. This research shows that a new location of the fire station can meet the NFPA standard with covering wider area than existing location. The new location is selected using NLP technique. Simulation results shows that the new proposed location provides a less average response time in more areas.Key words: Emergency response time, Fire station relocation, NLP.

4 - Simulation of Out-of-control Process Observations for Evaluating Effectiveness of Phase I Studies

Murat Caner Testik, Hacettepe University, Muhendislik Fakultesi, Endustri Muhendisligi Bolumu, Ankara, 06800, Turkey, mtestik@hacettepe.edu.tr, Christian H. Weiss, Yesim Koca, Ozlem Muge Testik

A Phase I study is an essential component of many statistical process control implementations. At this stage, a reference set of observations is searched for analysis. Accordingly, a Shewhart control chart with trial control limits is often used iteratively for identification of out-of-control observations. This dataset is then used for estimation of unknown parameters. Although this is a common practice recommended in textbooks, here we investigate its effectiveness by simulating different types of out-of-control processes. It is shown that one should be careful in using this approach since many out-of-control process observations may go unnoticed, resulting in poor parameter estimates.

■ WC17

340A

Stochastic Networks and Queueing in Applied Probability II

Sponsored: Applied Probability

Sponsored Session

Chair: Amarjit Budhiraja, University of North Carolina, Chapel Hill, NC, 27599, United States, budhiraj@email.unc.edu

1 - Asymptotically Optimal Control of N-systems with H_2^* Service Times under Many-server Heavy Traffic

Arka P. Ghosh, Iowa State University, Department of Statistics, 3216 Snedecor Hall, Ames, IA, 50011, United States, apghosh@iastate.edu, Keguo Huang

We are seeking an optimal control policy for a "N-system", under the Halfin-Whitt regime. A N-system has two customer classes and two server pools, where servers from one pool can serve both customer classes, while servers from the other pool can only serve one customer class. Also, impatient customers will renege from his queue if the waiting time exceeds his patient time. The service time distribution is only pool-dependent, not class-dependent, and it follows a special case of hyper-exponential distributions, H*2 distribution. A static priority policy is shown to be asymptotically optimal in minimizing the total cost caused by queue length growth and customer abandonment.

2 - Serve the Shortest Queue and Walsh Brownian Motion

Asaf Cohen, University of Michigan, Ann Arbor, MI, 48109, United States, shloshim@gmail.com

Motivated by internet applications, we study a multi-class M/M/1 queueing system under heavy-traffic with heterogeneous customers where priority is given to the shortest queue. Upon arrival, customers are kept in N buffers with infinite capacity in accordance to their classes. At any time instant, the first customer in the nonzero shortest queue is being served. We show that the workload process converges to a Walsh Brownian motion living in the union of the N non-negative coordinate axes in RN. Roughly speaking, this process behaves like a Brownian motion when it is away from 0, and when it reaches 0, it chooses its ray according to a fixed probability measure.

3 - Diffusion Approximations for Load Balancing Mechanisms in Cloud Storage Systems

Eric Friedlander, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599, United States, ebf2@live.unc.edu

Analysis of large-scale communication networks (e.g. ad hoc wireless networks, cloud computing systems, server networks etc.) is of great practical interest. The massive size of such networks frequently makes direct analysis intractable. Asymptotic approximations using hydrodynamic and diffusion scaling limits provide useful methods for approaching such problems. In this talk, we explore an application of these approximation techniques to a model for load balancing in large, cloud-based, storage systems using Maximum Distance Separable (MDS) codes to improve reliability and retrieval speed. This is joint work with Amarjit Budhiraja.

4 - Taylor-ed DPS: Between Dynamics Programming and Brownian Control Problems

Itai Gurvich, Associate Professor, Cornell University, Cornell Tech, New York, NY, 10025, United States, gurvich@cornell.edu, Junfei Huang, Anton Braverman

We propose an approximation to Dynamic Programs (DP) that is grounded in perturbation techniques that have been recently developed for the performance analysis of queues. These approximations, utilizing the so-called Stein's Method, work directly with the equations that characterize expected performance. This work seeks to move beyond the performance analysis of queues to develop "Taylor-ing" as a structured tool for dynamic optimization.

■ WC18

340B

Applied Probability

Contributed Session

Chair: Lisha Yu, City University of HongKong, Kowloon, Hong Kong, lishayu2-c@my.cityu.edu.hk

1 - Modeling Correlated Wind Speeds Through Stochastic Differential Equations

Rafael Zarate-Minano, Associate Professor, University of Castilla-La Mancha, Plaza Manuel Meca 1, Almaden, 13400, Spain, rafael.zarate@uclm.es, Miguel Carrion, Juan Miguel Morales

Decision making tools involving stochastic programming techniques are widely used for the operation of power systems with a significant penetration of wind power. The stochastic nature of the wind speed is usually considered through a set of plausible scenarios generated by means of time series. However, time series have shown limited accuracy to model correlations among wind speeds at different locations. This work analyzes the ability of stochastic differential equations to model correlated wind speeds. Models are constructed and tested on the basis of real-world wind speed measurements.

2 - High Dimensional Linear Regression: Mean Square Error and Phase Transitions

Ilias Zadik, PhD Candidate, MIT, Cambridge, MA, United States, izadik@mit.edu

In this talk we will discuss some new theoretical results on the topic of sparse high dimensional linear regression with Gaussian matrix and noise. In the literature, some remarkable papers by Wainwright and others have established that with enough samples LASSO and other efficient recovery mechanisms can recover the ground truth vector. On the other hand, the information theoretical results on the topic suggest that the vector is recoverable with much fewer samples than the one LASSO needs. We show that recovery of the ground truth vector is indeed possible with much fewer samples than the one LASSO needs and we prove this recovery becomes possible very suddenly as the sample size increases.

3 - Search in Discrete Locations with Two Search Modes

Kyle Y Lin, Naval Postgraduate School, 1411 Cunningham Rd, Monterey, CA, 93943, United States, kylin@nps.edu, Jake Clarkson, Kevin D. Glazebrook

An object is hidden in one of several locations. There are two search modes to search each location. The search time and the detection probability depend on both the location and the search mode. The goal is to minimize the expected total time to find the object. We study structure of the optimal policy, and design heuristic policies that deliver near-optimal performance in our numerical experiments.

4 - Stochastic Models for Optimal Resource Allocation and Scheduling of Biomanufacturing Projects

Yasemin Limon, University of Wisconsin-Madison, Madison, WI, 53706, United States, ylimon@wisc.edu, Ananth Krishnamurthy

We study the resource allocation and scheduling problem common in biomanufacturing operations, where purification projects need to be assigned to scientists with varying skill sets, and projects need to be repeated if the scientist is unable to achieve the desired yield and purity requirements. We develop stochastic models to analyze different resource allocation strategies and their impact on waiting times for projects and total system costs.

5 - Exponential Convergence Rates for Stochastically Ordered Markov Processes with Random Initial Conditions

Julia Romanski, Graduate Student, Massachusetts Institute of Technology, 77 Massachusetts Ave, Bldg. E40-103, Cambridge, MA, 02139, United States, romanski@mit.edu, Saurabh Amin, Patrick Jaillet

In this paper we extend the results of Lund, Meyn, and Tweedie (1996) on exponential convergence rates for stochastically ordered Markov processes to allow for a random initial condition that is also stochastically ordered. We find an explicit exponential convergence rate for an M/M/1 queue beginning in equilibrium and then experiencing a perturbation of its arrival or departure rates. In order to show the convergence bound we also prove a result on hitting times of differences of independent Poisson processes, known as Skellam processes. Finally, we comment on the applicability of our result to other stochastically increasing processes, such as Jackson networks with changing arrival rates.

6 - Detecting Node Propensity Changes in the Dynamic Degree Corrected Stochastic Block Model

Lisha Yu, City University of HongKong, 88 Tat Chee Avenue, Kowloon, Hong Kong, lishayu2-c@my.cityu.edu.hk

Many applications involve dynamic networks which are evolutionary networks with timestamps. Studying the evolution of node propensity over time is significant in exploring and analyzing these networks. In this paper, we propose a multivariate surveillance plan to monitor node propensity in dynamic social networks based on the degree-corrected stochastic block model. The method is flexible enough to detect anomalous nodes that arise from different mechanisms. Experiments on simulated and case study social network data streams demonstrate that our surveillance strategy can efficiently detect node propensity changes in the dynamic degree-corrected stochastic block model.

■ WC19

342A

Production and Scheduling

Contributed Session

Chair: Faisal Alfaiz, Oregon State University, Corvallis, OR, United States, alfaizf@oregonstate.edu

1 - The Timing of Investment on Market Share and Profitability with Financing Constraints

Kehong Chen, University of Science and Technology of China, Hefei, China, ckh0605@mail.ustc.edu.cn, Xiaohang Yue

Whether to invest in market share that can improve the future demand and thereby raise future profits and reduce the likelihood of bankruptcy is a key concern faced by many startups firms when facing with a financing stress. We first identify under which condition the firm with no capital constraint has the incentive to invest on the market expansion. As a benchmark, we then analyze the investing strategy and operational decision of the firm with constrained financing capital. Given the limited borrowed capital, the firm has to make a trade-off between creating short-term profits from the production to avoid bankruptcy and long-term growth from market size investment.

2 - On Finding Process Capacity

Yang Bo, Assistant Professor, The Chinese University of Hong Kong, New Territory, Hong Kong, boyang1102@gmail.com, Milind Dawande, Woonghee Tim Huh, Ganesh Janakiraman, Mahesh Nagarajan

Recently, Gurvich and Van Mieghem (2015) show that the OM textbook formula to calculate process capacity fails in general. We show that it is hard to compute process capacity exactly and also to approximate it within a reasonable factor. These results are based on a novel characterization, which we establish, of process capacity that relates it to the fractional chromatic number of the associated "collaboration graph". An important implication is that it is unlikely that we can replace the bottleneck formula with a simple but close approximation of process capacity. On the positive side, we show that capacity can be efficiently computed for processes for which the collaboration graph is a perfect graph.

3 - Analyzing the Efficiency and Interactions of Buffer Types for Robust Resource Allocations in Resource-constrained Multi-project Scheduling

Christian Fabig, Research Assistant, Technische Universität Dresden, Münchner Platz 3, Dresden, 01187, Germany, christian.fabig@tu-dresden.de, Thorsten Schmidt

We study the efficiency of buffer types for robust resource allocation under uncertainty. The schedule objective is to minimize the realized Average Project Delay (APD) in a worst-case scenario. We describe which buffer types are proposed in literature, how those buffers are allocated to a multi-project schedule, and how they can be combined efficiently. Therefore, the performance of buffer combinations and sizes with respect to the realized APD is analyzed using experiments on MPSPLib problem instances. Findings reveal that due to buffer interactions there exist efficient combinations, yielding significant performance gains compared to deterministic and single-buffer approaches.

4 - Assembly Line Sequencing using Scaled Process Times

Faisal Alfaiz, Graduate Research Assistant, Oregon State University, Corvallis, OR, United States, alfaizf@oregonstate.edu, Hector Vergara, David S. Kim

Job sequencing on synchronous serial assembly lines is examined when job processing times are not available and are replaced by a ranking on a fixed scale. The scaled job process times are determined by engineers, managers, and operating personnel. Properties of the scaled process times and their effect on throughput and work overload when job sequencing algorithms are utilized is examined.

■ WC20

342B

General

Contributed Session

Chair: Sundaravalli Narayanaswami, Indian Institute of Management-Ahmedabad, Ahmedabad, India, sundaravallin@iima.ac.in

1 - A Study on the Effects of Supplier Management System on Buyer Firm's Outsourcing Performance : Moderating Effects of Switching Cost

Mi Yeon Lee, Korea University Business School, 408 LG-POSCO.building, Korea University, Anam-ro, Seongbuk-gu, Seoul, 02804, Korea, Republic of, esther2761@naver.com, Jung Dawoon, Park Myungsub

This paper applied multi regression analysis, using 522 data collection in 2013 from Korea Productivity Research Center in general equipments, automotive, shipbuilding, and telecom equipments industries. Using the data, this study intends to empirically discover the effect of the types of Supplier Management System (support system and evaluation system) on the buying firm's performance under different levels of Switching Cost. The results of this study will provide key theoretical and practical insights on the relationship between supplier management system and success of outsourcing.

2 - Selection of Best Online Job Portal in the United States using Analytical Hierarchy Process

Xiaojun (Gene) Shan, University of Houston-Clear Lake, Houston, TX, United States, shan@uhcl.edu, Nikhitha Matta

Job seekers often need focus on one job portal among many alternatives to increase efficiency. This paper develops a framework to select the best online job portal from the perspective of job seekers with analytical hierarchy process. This paper is mainly for the job seekers in the domain of science, engineering, health and management although the framework could be adapted to other types of job seekers. The criteria are quality and performance, efficient search engine, relevant job description, privacy, ease of applying and appropriate features. The paper used Web-HIPRE to apply the framework and found that Indeed is the best one compared to Dice, Zip recruiter, Linkedin, and Glass door.

3 - Meals on Tracks: the Indian Railway Catering Services

Sundaravalli Narayanaswami, Indian Institute of Management Ahmedabad, Wing 15 B, Indian Institute of Management, Vastrapur, Ahmedabad, 380015, India, sundaravallin@iima.ac.in

Indian Railways (IR) is the largest state owned and operated transport services in the World with 7,137 stations, route length of 66,030 kms. and total track of 117,996 kms. The number of passengers carried everyday is 23 Millions with passenger earnings of INR 42190 crores. In this talk, we discuss the scope, social, managerial and administrative challenges of IR catering services operations.

■ WC21

342C

Sustainability

Contributed Session

Chair: Maneesh Reddy Ajjuguttu, Clemson University, Clemson, SC, United States, majjugu@g.clemson.edu

1 - Knowledge Sharing and Learning Among Smallholders in Developing Economies: Incentives and Reward Mechanism

Shihong Xiao, HKUST, Hong Kong, Hong Kong, sxiaoab@connect.ust.hk, Ying-Ju Chen, Christopher S. Tang

In developing economies, smallholders use their knowledge and effort to control their output of high quality crop. To improve farmers' productivity, various advocating knowledge sharing and learning platforms are advocated so that farmers can share with and learn from each other various farming techniques. Putting altruism aside, we examine the economic implications for heterogeneous farmers to share their private farming knowledge voluntarily with other farmers under implicit competition. By analyzing a multi-person sequential game, we provide a plausible reason to explain why knowledge sharing can be beneficial even when each farmer's profit depends on the total output.

2 - Development and Evaluation of Product Architecture for Remanufacturing and Product Service System Synergy

Johnson Adebayo Fadeyi, Graduate Teaching Assistant, Wayne State University, 690 Martin Luther King Jr. Blvd, Apt 2005, Detroit, MI, 48201, United States, kontaktjohnson@gmail.com, Johnson Adebayo Fadeyi, Leslie Monplaisir

Currently, about 80% of manufactured products end as wastes. Product service system (PSS) and remanufacturing are concepts that remedy this problem. In order to enhance the criteria that are essential for successful PSS and remanufacturing, an optimization model is developed to identify viable product architecture from several product alternatives. The implementation yields multiple optimal product configurations. Consequently, multi-criteria decision-making technique is applied, and the sensitivity analyses provide comparative advantages of all viable product configurations. The study provides modular product architecture decision guide to the original equipment manufacturers.

3 - Comparative Analysis of Economic and Environmental Impacts of Online and Conventional Retailing

Arda Yenipazarli, Associate Professor of Operations Management, Georgia Southern University, 2224 College Of Business Administration, Department of Logistics & Supply Chain Mgnt, Statesboro, GA, 30460, United States, ayenipazarli@georgiasouthern.edu

Online shopping is growing fast and claims are made about its positive environmental impact relative to traditional shopping. We study competing retailers that can operate dual channels (bricks and clicks), and examine the implications of the additional Internet outlet for their channel and pricing decisions, and the environment.

4 - Optimal Adoption Strategies of Electric Vehicles in Commercial Fleets

Osman Alp, University of Calgary, Haskayne School of Business, 2500 University Drive, Scurfield Hall 120, Calgary, AB, T2N1N4, Canada, osman.alp@ucalgary.ca, Titi Sari, Tarkan Tan, Maximiliano Udenio

In this talk, we analyze optimal electric vehicle adoption strategies in commercial delivery and distribution fleets to reduce carbon footprint of supply chain operations. We develop a model and solution approach to optimize timing and scale of investments in vehicles and charging infrastructure by explicitly considering potential advancements in charging technology, prospective savings in operating costs and carbon emissions, desired service levels, and long-term sustainability targets. We analyze and compare alternative scenarios under plug-in charging model and battery swap model separately.

5 - A Study on Firms' Response to the Environmental Regulations of the Government

Tae Hyung Kim, KAIST, 85, Hoegi-ro, Seoul, 02455, Korea, Republic of, kth8907@kaist.ac.kr, Bowon Kim

Effective environmental regulation is necessary for both the social and economic aspects, since it provides the foundation for sustainable environment. However, ineffective or excessive regulation often leads to side effects such as corporate fraud or moral hazard of corporate, which brings significant loss in society. Therefore, in this paper, we try to analyze the cause and effect of this phenomenon by using system dynamics simulation method. Based on the simulation result, we will investigate the ways to complement existing environmental regulations.

6 - Operational Transparency and Slow Fashion
Maneesh Reddy Ajjuguttu, Clemson University, 515 Calhoun Dr, Sirrine Hall, Room # 400, Clemson, SC, 29634, United States, majjugu@g.clemson.edu, Aleda Roth

This study addresses the effects of operational transparency on the fashion sector. In particular, we examine the consumer buying behaviors on the emerging movement called "slow fashion". Slow fashion is a strategy that aims to reduce the toxic and non-toxic wastes that accrue through the supply chains, which are causing havoc to the environment.

■ WC22

342D

Data-Driven Approaches in Pricing and Revenue Management

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Mikhail Nediak, Queen's University, Kingston, ON, K7L 3N6, Canada, mnediak@business.queensu.ca

Co-Chair: Yuri Levin, Queen's University, Kingston, ON, K7L 3N6, Canada, ylevin@business.queensu.ca

1 - Data-driven Approaches to Live Market Test Design
Gabrielle Shklovsky, Senior Operations Research Consultant, Revenue Analytics, 300 Galleria Parkway Suite 1900, Atlanta, GA, 30339, United States, GShklovsky@revenueanalytics.com

A live market test of a new pricing strategy or revenue management system is often used to measure the impact of the strategy or system before a full roll out. The success or failure of a market test is highly influenced by its design - what time period is used, what is assigned to test vs control, what metrics are used for evaluation - and these design decisions can be tricky, especially when business or operational constraints prevent full randomization. This talk will demonstrate how statistical simulations can be used to design market tests that increase the likelihood of success by maximizing signal and minimizing noise.

2 - Network Revenue Management in Contractual Setting
Akram Khaleghei, Scotiabank, 40 King's West, Toronto, ON, Canada, Akram.Khaleghei@scotiabank.ca, Mikhail Nediak, Ivan Sergienko

We consider an allocation problem for a collection of limited divisible resources. The decision maker observes booking requests from finite set of clients for different type of products and has to commit resources to generate revenue. Once resources are committed, they have to remain committed until a specified maturity date. Requests arrive randomly over time with an intensity that depends on acceptance/rejection of customer previous requests. We are interested in finding the acceptance policy that maximizes the total expected revenue over a finite time horizon.

3 - Integrated Risk Management in the Airline Industry
David Pyke, University of San Diego School of Business, San Diego, CA, 92110, United States, davidpyke@sandiego.edu, Ruixia Shi, Soheil Sibdari, Wenli Xiao

We study integrated decision making in the airline industry. Most airlines make decisions about hedging fuel cost, capacity, and airfare pricing in a decentralized way. We model the benefits that accrue to a firm that maximizes its profit by integrating these decisions. We study the impact of economic conditions, stochastic market demand, consumer price sensitivity, and stochastic fuel cost on the three decisions.

■ WC23

342E

Topics in Revenue Management and Pricing 2

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Stefanus Jasin, University of Michigan, Ann Arbor, MI, 48105, United States, sjasin@umich.edu

1 - Dynamic Pricing for Hotel Rooms when Customers Request Multiple-day Stays
Yun Fong Lim, Singapore Management University, Lee Kong Chian School of Business, 50 Stamford Road, 04-001, Singapore, 178899, Singapore, yflim@smu.edu.sg, Selvaprabu Nadarajah, Qing Ding

We study the dynamic pricing problem faced by a hotel that maximizes expected revenue from a single type of rooms. Demand for the rooms is stochastic and non-stationary. Our Markov decision process formulation of this problem determines the optimal booking price of rooms (resources) for each individual day, while considering the availability of room capacity throughout the multiple-day stays (products) requested by customers. We develop an approximate linear programming based pricing policy, which outperforms both a fixed-price heuristic and a single-day decomposition approach. Specifically, it generates up to 7% more revenue than the single-day decomposition approach.

2 - Strategic Surge Pricing and Communication on On-demand Service Platforms
Harish Guda, University of Texas-Dallas, 2700 Waterview Parkway, #4424, Richardson, TX, 75080, United States, hxg131530@utdallas.edu, Upender Subramanian

On-demand platforms often rely on the gig-economy, a pool of independent workers who work at their convenience, to serve consumers at short notice. To ensure that workers are at the right locations at the right times, on-demand platforms typically adopt two strategies: sharing market forecasts with workers and surge pricing. We jointly examine both strategies, explicitly accounting for workers' incentives to move between market locations, and the platform's incentive to share market information truthfully. Contrary to conventional wisdom, we show that surge pricing can be profitable for the platform even at a location where supply exceeds demand.

3 - Spatial Pricing and Inventory Allocation
Long He, National University of Singapore, Mochtar Riady Building, BIZ1 8-73, 15 Kent Ridge Drive, Singapore, 119245, Singapore, longhe@nus.edu.sg, T. Tony Ke

We study how an online retailer of multiple products should allocate its product inventories to facilitate spatial price discrimination. We consider two common spatial pricing policies: free on board (FOB) pricing that charges each consumer the exact amount of shipping cost, and uniform delivered (UD) pricing that provides free shipping. From the analysis of a stylized model and numerical experiments of optimization models, we find that compared with UD, FOB pricing yields higher profit—-the average relative profit difference between FOB and UD pricing is about 13%, when the inventory allocation is jointly optimized.

4 - Real-time Dynamic Pricing for Revenue Management with Reusable Resources and Deterministic Service Time Requirements
Yanzhe (Murray) Lei, University of Michigan, Ann Arbor, MI, United States, leiyz@umich.edu, Stefanus Jasin

We study a dynamic pricing problem where a firm faces price-sensitive customers arriving stochastically over time. Each customer consumes one unit of resource for a deterministic amount of time, after which the resource can be immediately used to serve new customers. We develop two heuristic controls and show that both are asymptotically optimal in the regime with large demand and supply. We further generalize both of the heuristic controls to the settings with multiple service types requiring different service times and with advance reservation.

■ WC24

342F

Joint Session Auctions/RMP: Mechanism Design, Networks, and New Markets I

Sponsored: Revenue Management & Pricing

Sponsored Session

Chair: Santiago Balseiro, srb43@duke.edu

Co-Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States, ozan.candogan@chicagobooth.edu

1 - Pricing Network Effects under Noisy Network Information
Ankur Mani, University of Minnesota, 808 Berry Street, Apt 410, Saint Paul, MN, 55114, United States, amani@umn.edu, Jiali Huang

We study the problem of a firm that uses social network information to optimally provide personalized pricing customers based upon their position in the network. We show that in large random networks such discriminative pricing may not have much advantage as compared to uniform pricing and may even underperform when the network is noisy. We propose simple implementable pricing policies with guarantees on expected profit.

2 - A Case for Independent Campaign Management in Online Display Advertising
Amine Allouah, Columbia University, 520 W 122nd Street, Apt24, New York, NY, 10027, United States, mallouah19@gsb.columbia.edu, Omar Besbes

In many auctions, buyers can be represented by an intermediary that manages their bidding process, along with the bidding process of other buyers, leading to some form of collusion. We propose a framework to analyze the implications of such an active/centralized role by intermediaries in a general market.

3 - Revenue Optimization under a Preannounced Dynamic Price Function

Dana Pizarro, University of Chile, Santiago, Chile, danapizarro@gmail.com, Jose Correa, Gustavo Jose Vulcano

We consider a dynamic game between a seller and a single buyer. The seller operates over an infinite time horizon. At the beginning of the horizon the seller commits to a price function p(t) . The buyer arrives according to a general random process, has a private valuation for the item, and decides when to buy in order to maximize his expected utility. The seller's problem is to determine the price function p(t) to maximize her expected revenue. We analyze this dynamic game and provide numerics to show the achievable revenue performance.

4 - Multi-stage Intermediation in Display Advertising

Huseyin Gurkan, Duke University, Fuqua School of Business, PO Box:337, Durham, NC, 27708, United States, hg67@duke.edu, Santiago Balseiro, Ozan Candogan

We consider a setting where an advertiser seeks to acquire an impression from an advertising exchange through a chain of intermediaries, and provide a game theoretic model to study the mechanisms offered by strategic intermediaries when the advertiser's value is private. We characterize the equilibrium of the game among intermediaries within a practically relevant class of mechanisms.

■ WC25

350A

New Product Development

Contributed Session

Chair: Yingchao Lan, Ohio State University, Columbus, OH, United States, lan.63@osu.edu

1 - Fairness and Competition in Supply Chains

Chi Xie, The Chinese University of Hong Kong, Hong Kong, cxie@se.cuhk.edu.hk, Jin Qi, Yaozhong Wu

In supply chain transactions, a retailer may exhibit fairness concerns when he compares his own profit with that of the supplier. We consider a supply chain setting where a supplier sells substitutable products through two retailers, each or both of whom have fairness concerns. We analyze how a retailer's fairness concern affects each supply chain member's behavior and performance. Our results show that in contrast to a non-competitive setting the impact of a retailer's fairness on his own performance can be negative.

2 - First Discussion About the Information Sharing of Cost Management in the Horizontal Strategic Alliance under Chinese Business Environment

Zhiduan Xu, Xiamen University, 422 Siming South Road, School of Management, Xiamen, 361005, China, zhiduanx@xmu.edu.cn, Danxia Guo, Yingzi Xiong, Shaoqin Ye

Nowadays, horizontal strategic alliances have become a new form of organizing. The success of horizontal strategic alliance relies on information sharing, especially the area of cost management. In China, the development of horizontal strategic alliances is nascent. The horizontal strategic alliance has its own features and aims. We propose a framework on information sharing in the cost management under a horizontal strategic alliance from the perspectives of partner selecting, the system design of cost management, the protection of private knowledge. This essay cuts into a brand-new field which needs more studies and researches and offers a guide and an introduction to this new research area.

3 - An Empirical Study on Residents' Consciousness of Use of Car-sharing

Di Wang, Tianjin University, Tianjin,China, China, 1317854994@qq.com, daozhi Zhao

The "Internet +" has had a revolutionary impact in all walks of life, especially in travel, the Car-sharing has become the market hot spots. In China's big cities, there are traffic congestion, driving restriction and vehicle purchase restriction and many other conditions. However, because of Car-sharing use environmentally friendly energy, no restrictions of driving restriction and use or return it whenever you like, it solve many travel pain points and bring convenience to residents. This study seeks to empirically identify the intentions toward car-sharing by residents. Propose an integrated model combining the theory of planned behavior to examine the intentions of car-sharing by residents.

4 - Collaboration Networks in Integrated Health Care Delivery: Evidence from Accountable Care Organizations

Yingchao Lan, Ohio State University, 2100 Neil Avenue, Fisher Hall 252C, Columbus, OH, 43210, United States, lan.63@osu.edu, Aravind Chandrasekaran, Daniel Walker

ACOs are collaborative networks of physician practices, hospitals, and other health care providers who voluntarily take joint responsibility for the quality and cost of care for a defined patient population. Previous studies have been inconclusive on the benefits of ACOs due to their ignorance of collaboration structures. In this research, we look at two dimensions of such structures-horizontal and vertical networks. Analyzing three years of data on 2987 hospitals and 394 ACOs, we first find empirical benefits to a hospital's decision to join ACOs. Our study further shows that such benefits are contingent on the ACO structures.

■ WC26

350B

Simulation and Optimization

Contributed Session

Chair: Yunzhe Qiu, Washington University in St. Louis, St. Louis, MO, United States, qiuyunzhe@wustl.edu

1 - Modeling Individual Fear Factor with Optimal Control in a Disease Dynamic System

Yuyang Chen, PhD Student, Kansas State University, 2061 Rathbone Hall, 1701 D. Platt St., Manhattan, KS, 66502, United States, cyy@ksu.edu, Kaiming Bi, John C.Wu

This research proposes a new, information-transmission-based behavior-switch that applies the individual fear factor (IFF) to describe how information regarding current disease epidemics can cause human behavior change in a disease-dynamic system. This research is a first attempt to mathematically model how an individual's emotions influence behavior. This novel modeling approach shows that information transmission influence individual fear, resulting in a variety of human behaviors and leading to numerous disease consequences.

2 - Comparison of Static Ambulance Location Models

Pieter van den Berg, Rotterdam School of Management, Burgemeester Oudlaan 50, Rotterdam, 3062 PA, Netherlands, vandenberg@rsm.nl, Theresia van Essen

Over the years, several ambulance location models have been discussed in the literature. Most of these models have been further developed to take more complicated situations into account. However, the existing standard models that are often used in case studies have never been compared computationally according to the criteria used in practice. In this paper, we compare several ambulance location models on coverage and response time criteria. In addition to six standard ambulance location models from the literature, we also present four models that balance coverage and average response times.

3 - A Simulation Optimization Approach for Budget Allocation of an Emergency Department using Response Surface Methodology

Maryam Soltanpour Gharibdosuti, Student, Binghamton university, 62 Floral Ave, Apt. 8, Binghamton, NY, 13905, United States, msoltan1@binghamton.edu, Dae Hon Won, Mahboobeh Hejazibakhsh

In this paper, we propose a simulation optimization algorithm to find the best allocation of budget in order to improve the performance of an emergency department (ED). Considering the constraints associated with budgeting, D-optimal design of response surface methodology (RSM) is employed to minimize the total system processing time and queue length for two type of patients namely outpatients and ambulance patients. The proposed simulation model is run to obtain the total processing time of the ED at current staff level. Subsequently, the D-optimal design of RSM is applied to find the best allocation of limited budget to identify the optimum staff level which leads to minimum total time and queue.

4 - A Simulation Optimization on the Hierarchical Health Care Delivery System Patient Flow Based on Multi-fidelity Models

Yunzhe Qiu, Washington University in St. Louis, 1 Brookings Dr., St. Louis, MO, 63130, United States, qiuyunzhe@wustl.edu, Jie Song, Zekun Liu

The imbalanced development among different levels of healthcare facilities in China's urban healthcare system has raised the uneven patient flow distribution. We develop a method integrating the simulation, the multi-objective optimization and the simulation budget allocation together to comprehensively improve the overall system performances by finding the approximate Pareto patient flow distribution in the hierarchical healthcare system. A case study based on the real data shows the recommended Pareto optimal patient flow distribution can improve the overall hierarchical system performances and our methodology is qualified as a quantitative decision tool for decision makers.

■ WC28

350D

Supply Chain, Optimization

Contributed Session

Chair: Chaitanya Kaul, Pennsylvania State University-University Park, State College, PA, United States, csk19@psu.edu

1 - How Cost Learning Effect Affects the Channel Decisions
Fen Lu, Huazhong University of Science and Technology, 1037 Luoyu Road?Hongshan Distri, Wuhan, China, Wuhan, 430074, China, lufen@hust.edu.cn

Based on a supply chain with a manufacturer and a retailer, we construct two-stage Stackelberg game models with a cost-learning effect in different modes (traditional channel mode and dual-channel mode). Backward induction is used to identify the equilibriums of the games. We find that the manufacturer, customers and the whole supply chain always benefit from the cost-learning effect, but the retailer is hurt in the dual-channel mode. Contrast with the traditional channel mode, we find that the optimal production quantity increases and price decreases in the second period in the dual-channel mode.

2 - Aligning the Design of Chemical Multiproduct Batch Plants with the Supply Chain Strategy of the Company
Trijntje Cornelissens, Professor, University of Antwerp, Prinsstraat, 13,, Antwerpen, 2000, Belgium, trijntje.cornelissens@uantwerpen.be

For chemical batch plants, strategic plant design primarily concerns the number, size and connectivity of raw material, production and storage tanks, and is mostly driven by the capital costs of this equipment. However, the production strategy defines how such a plant is operated, e.g. by dedicating tanks to product families and defining campaign modes. According to SCOR, this production strategy must align with the company's supply chain strategy and meet the predefined objectives for asset efficiency, cost effectiveness, reliability, responsiveness and flexibility. The aim of this research is to introduce these objectives into plant design models, and study the impact on the plant layout.

3 - An Improved Mathematical Model for Truck Scheduling in Cross Dock Problems with Dock Repeat Truck Holding Pattern
Maryam Keshtzari, Graduate Part Time Instructor, Texas Tech University, Lubbock, TX, United States, maryam.keshtzari@ttu.edu, Sasan Khorasani

Cross-docking is a material handling and distribution concept.In cross-docking systems, items are transferred directly from receiving dock to shipping dock, i.e. the items will not be stored in a warehouse. In this study, an improved mixed-integer programming model (MILP) is introduced to minimize the makespan of the operations. In fact, the model gives us the best sequence of both inbound and outbound trucks that minimizes total completion time. Furthermore, this model determines the assignment of the items in inbound trucks to outbound trucks. This study endeavors to present a model which is able to solve large scale problems with less computational time compared to the current existing model.

4 - An Agent-based Modelling Approach for Optimizing the Last-mile Logistics Problem
Chaitanya Kaul, Pennsylvania State University-University Park, 1926 Waddle Road, Apartment 3, State College, PA, 16803, United States, csk19@psu.edu, Dan Finke

The last mile logistics refers to the last leg of delivery in a supply-chain transportation network. More transporters and delivery runs required to fulfil the demand and hence make the last-mile logistic a highly inefficient and time-consuming segment of a supply chain. In our work, we present the formulation of the last mile logistics problem, model it as an agent-based optimization problem and solve it using a heuristic approach. In the problem critical entities like transporters, customers, orders etc. are represented and modelled as a community of agents.

■ WC29

350E

Operations/Finance Interface

Contributed Session

Chair: Christian Mandl, Technical University-Munich, Munich, Germany, Christian.Mandl@tum.de

1 - Performances of the Supply Chain under Trade Credit with Random Yield
Feng Lin, Xi'an Jiaotong University, Xi'an, China, lfxddz@stu.xjtu.edu.cn, Tao Jia, Y.K., Richard Fung

Previous models always adopt stochastic demand to investigate the optimal solutions of the supply chain under trade credit. However, random yield may lead to the contradiction between supply and demand, and obstruct the integration of material flow and cash flow. Thus, this paper studies the performance of the supply chain under trade credit with random yield. A Stackelberg game model is formulated where the supplier plays the dominated role and determines the wholesale price. And then the retailer announces the order quantity. Via theoretical results, random yield is verified to be negatively associated with the expected profit of the supply chain under trade credit.

2 - Equilibrium Financing in a Supply Chain under Uncertainty Reduction Efforts
Qiang Li, The University of Hong Kong, Hong Kong, liqiang@connect.hku.hk, Lap Keung Chu

We examine a supply chain consisting of one manufacturer and one retailer, in which the retailer is capital-constrained and can be funded either by a competitive bank, or by the supplier in the form of trade credit. We investigate how the financing equilibrium is affected by the demand variability and the cost associated with reducing demand uncertainty.

3 - Equilibrium Decision of Credit Guarantee and Capital Constraint Supply Chain under Different Ordering Patterns
Xiuli He, Associate Professor, UNC-Charlotte, 9201 University City Blvd., Charlotte, NC, 28277, United States, xhe8@uncc.edu

We consider a supply chain with a retailer and a capital-constrained manufacturer. The retailer uses credit guarantee to support manufacturer. We derive optimal production and ordering decisions for make to order and make to stock systems.

4 - Data-driven Raw Material Purchasing under Price Volatility
Christian Mandl, Technical University-Munich, Munich, Germany, Christian.Mandl@tum.de, Stefan Minner

Increasing price volatility at commodity markets requires efficient risk management for commodity-processing firms. We propose a new approach that integrates price prediction and procurement optimization (i.e., contracting decisions) considering real-time causal data like weather and economic indicators. We show that a MILP-based data-driven hedging strategy can lead to significant cost savings for risk-neutral and risk-averse decision makers. However, we observe that the benefit of data-driven optimization strongly depends on model selection. Hence, we additionally combine data-driven optimization with methods from machine learning to increase the out-of-sample performance.

■ WC30

350F

Politics/Voting

Contributed Session

Chair: Joachim Arts, Luxembourg University, Luxembourg, j.j.arts@tue.nl

1 - Optimal Selective Maintenance of Networked Systems with Multiple Missions using Approximate Dynamic Programming
Liuquan Li, Tsinghua University, Department of Industrial Engineering, Tsinghua University, Beijing, 100084, China, lq-li16@mails.tsinghua.edu.cn, Chi Zhang

Many industrial and military systems have breaks during performing a sequence of missions, which can be utilized for maintenance to ensure the reliability of accomplishing the following mission. However, only a limited number of system components can be maintained during each break due to the limitation of resources, such as time and manpower. We propose a stochastic dynamic programming to study the maintenance of a networked system with general structures, while performing multiple missions. To deal with its complexity, the approximate dynamic programming (ADP) approach is employed.

2 - Determining Aerospace Electronic System Reliability using Regression Methods and MVO
Lida Haghnegahdar, PhD Student, State University of New York, Schiller, Binghamton, NY, 13905, United States, lhaghne1@binghamton.edu, Yong Wang, Daniel Trembley

The aerospace industry has a long-standing history of embracing new technologies built on predecessor systems of the same function. This research focuses and studies the reliability data of aerospace systems. In this research, three different data sets are considered for analysis by using statistical methods of ridge regression, LASSO, and MVO (Multi-verse optimizer). Ridge regression and LASSO are used to determine trends within the data to enhance prediction of design and component faults. In this paper, we propose the combination of feature selection methods of regression and a meta-heuristic algorithm (MVO) for intelligent optimization.

3 - Fast Replacement or Low Purchase Prices: An Optimal Definition of Line Replaceable Units

Joachim Jacob Arts, Associate Professor, Luxembourg University, P.O. Box 513, Luxembourg, j.j.arts@tue.nl, Joni Driessen, Geert-Jan Van Houtum

When an asset fails, the broken Line Replaceable Unit (LRU) needs to be replaced. A LRU is a collection of parts that is replaced when a part in the LRU fails. A LRU can decrease the costs for replacements, as faster replacements may be possible. On the other hand, the company purchases new LRUs and typically large LRUs are more expensive to purchase. Thus, the objective is to determine an optimal definition of LRUs such that the total costs of purchasing and replacement downtime are minimized. We prove this problem non-linear integer program is NP-hard and provide an efficient column generation algorithm.

■ WC32

351B

Procurement and Purchasing Management

Contributed Session

Chair: Hyunhong Choi, Seoul National University, Seoul, 010greenday@gmail.com

1 - Planning Accumulated Employee Vacations under Varying Workload and Contractual Restrictions

Ayyuce Aydemir-Karadag, Asst. Prof., Cankaya University, Eskisehir Yolu 29. km, Mimar Sinan Cd. No. 4, Yukariyurtcu Mh., Etimesgut, Ankara, 06790, Turkey, aykaradag@cankaya.edu.tr, Gonca Yildirim

Accumulation of past years' contractual vacation days is one of the common problems observed in workplaces such as hospitals and banks, where some employees may not be able to use their vacation periods completely due to recurring busy periods, followups required, contractual restrictions on vacation periods, or simply because of the insufficient workforce. We develop an integer programming formulation that will maximize the total usage of contractual vacation days over a year, taking into account realistic vacation restriction policies for associated classes of employees who are eligible to do some tasks grouped according some predetermined criteria.

2 - Affordability Analysis using a Capability Roadmap Optimization Approach

Michael Lehocky, Operations Research Analyst, U.S. Coast Guard Research and Development Center, 1 Chelsea St, New London, CT, 06320, United States, mlehocky@cathward.com

In organizations with acquisition projects supporting the recapitalization of assets that are near or beyond the end of their economic life, extending, deferring or canceling construction could force disproportionate impacts on capabilities, either through reduction in operating capacity or diversion of operating funds from direct support to emergency maintenance or service-life extension. Affordability analysis in these cases should consider total capability roadmap cost rather than just procurement outlays. This study examines an example affordability analysis approach using a capability roadmap optimization of the U. S. Coast Guard's offshore cutter fleet recapitalization.

3 - Modeling for Efficient Assignment of Multiple Demand Zones to Distribution Centers for the Equitable and Effective Distribution of Donated Food

Md Hafizul Islam, North Carolina State University, 111 Lampe Drive, Daniels Hall 373, Raleigh, NC, 27695, United States, mislam5@ncsu.edu, Julie Simmons Ivy

Satisfying hunger of food unsecured people with limited supply is a challenge for the local food bank. Food bank seeks to distribute donated foods equitably so that each county receives food proportional to its demand while minimizing the undistributed food donations. The food bank also wants to identify appropriate distribution branches to maximize the accessibility of the counties to donated food. An assignment and distribution model is developed to minimize the cost of maintaining a user specified cap on the maximum inequity in food distribution.

4 - Designing Sustainable Transportation Policy: Considering Substitution Pattern for Different Vehicle Types

Hyunhong Choi, Seoul National University, 1 Gwanak-ro Gwanak-gu, Seoul, 08826, Korea, Republic of, 010greenday@gmail.com, Yoonmo Koo

Transport sector is being pointed out as one of the main contributors of air pollution problems. To cope with such problems, many countries are employing various type of incentive programs to promote environmentally friendly vehicles such as electric vehicles. However, to design an effective policy, we need to analyze how consumers choose and substitute their vehicles. In this study, we present a model which can capture the substitution patterns of consumers considering which type of vehicle they currently own. Using the model, we can analyze how each type of car owners react to different type of promotion policies. With the results of simulation analysis, we provide some policy implications.

■ WC34

351D

Networks and Graphs

Contributed Session

Chair: Mingxian Zhong, Columbia University, New York, NY, United States, mz2325@columbia.edu

1 - Modeling of the Growing Processes of Connectivity of the Components for Networks Based on Analysis of Coupling Coefficients Changes

Jianjun Lu, Professor, China Agricultural University, Haidian District, 17 Qinghuadong Road, Beijing, 100083, China, ljjun@cau.edu.cn

This paper describes connectivity analysis by using a model of the coupling coefficient change between the components by edge snapping in the network and its applications. When the coupling is formed between the network components, we formulate the synchronization by using edge snapping. As a method of synchronizing analysis in this modeling, we propose the optimization of the connections' relation between the fluctuant constituent units, by optimizing the connection and non-connection of the branches that connect the constituent units. The model is a mechanism of smoothly changing the coupling coefficient according to the second-order fluctuation system with respect to the time delay.

2 - The K-cardinality Assignment Problem Applied for the Analysis of Split Networks

Ivan Belik, Norwegian School of Economics, Helleveien 30, Bergen, 5045, Norway, ivan.belik@nhh.no

In terms of social networks, split graphs correspond to the variety of interpersonal and intergroup relations. We analyze the interaction between cliques (socially strong and trusty groups) and independent sets (fragmented and non-connected groups) as the basic components of any split graph. Based on the semi-Lagrangean relaxation for the k-cardinality assignment problem, we show the way of minimizing socially risky interactions between cliques and independent sets within social networks.

3 - The Influence of Structural Properties of Social Networks on Information Diffusion

Xu Dong, Research Assistant, University of Miami, 1251 Memorial Drive, Coral Gables, FL, 33146, United States, x.dong3@umiami.edu, Nazrul I.Shaikh

The scale and scope of the information diffusion are strongly impacted by the topological properties of the social network on which it takes place. However, the effects of these properties are usually nested and mutually correlated. Using principle component analysis (PCA), we decompose the effect of network topology into several independent structural characteristics, i.e. clustering, cohesiveness, density, etc., and identify the pattern of how they collectively affect certain information diffusion.

4 - Obstructions for Three-coloring and List Three-coloring H-free Graphs

Mingxian Zhong, Columbia University, New York, NY, 10027, United States, mz2325@columbia.edu

A graph G is called H-free (k +1)-vertex-critical if G does not contain H as an induced subgraph and the chromatic number of G is k +1, but every induced proper subgraph of G is k-colorable. We characterize all graphs H for which there are only finitely many H-free 4-vertex-critical graphs. This solves a problem posed by Golovach et al. As a second result, we characterize all graphs H for which there are only finitely many H-free minimal obstructions for list 3-colorbility. This is joint work with M. Chudnovsky, J. Goedgebeur and O. Schaudt.

■ WC35

351E

Supply Chain, Closed Loop

Contributed Session

Chair: Thomas Nowak, Vienna University of Economics and Business, Vienna, Austria, thomas.nowak@wu.ac.at

1 - Managing Closed Loop Supply Chain under Returns and Demand Uncertainty

Ravi Shankar, Indian Institute of Technology Delhi, Vishwakarma Bhawan, Shaheed Jeet Singh Marg, Hauz Khas, New Delhi, 110016, India, ravi1@dms.iitd.ac.in, Sushil Punia

A multi-echelon supply chain comprising a manufacturer producing new products as well as re-manufactured products, and a retailer dealing with multi-products is considered. Using interval programming, a comprehensive decision model under uncertain returns and uncertain demand environment is developed for the optimal acquisitions of products and components. Simple and easy-to-use solution techniques are used instead of complex meta-heuristics.

2 - Optimal Production and Collection Strategies for Hybrid Remanufacturing with Technology Licensing

Yanting Huang, Phd Candidate, Huazhong University of Science and Technology, 1037 Luoyu Road, Wuhan, 430074, China, ythuang4028@hust.edu.cn

This paper investigates a closed-loop supply chain where the manufacturer cooperates with the distributor and the third party under technology licensing to collect and remanufacture used products. We adopt the Stackelberg game to obtain the equilibrium strategies and discuss the impact of remanufacturing ability on chain members' decisions and environmental sustainability. We find that, each chain member can reach the largest profit in the case where remanufacturing activities is undertaken by himself. And a higher remanufacturing ability is beneficial for the environment.

3 - Effects of Modular Designs: A Closed-loop Supply Chain Perspective

Thomas Nowak, Postdoctoral Researcher, Vienna University of Economics and Business, Welthandelsplatz 1, Vienna, 1020, Austria, thomas.nowak@wu.ac.at, Fuminori Toyasaki, Tina B. Wakolbinger

This study analyzes effects of product modularity from a closed-loop supply chain perspective. Based on two optimization models, we explore the effects of supply chain strategies and consumers' attitude towards new or refurbished as well as integral or modular products on a manufacturer's production decision problem. While the first optimization problem considers a company following a reactive strategy with no demand uncertainty but high production costs, the second optimization problem considers a company following an anticipatory strategy with demand uncertainty but lower production costs.

■ WC36

351F

Service Science

Contributed Session

Chair: Yuncheol Kang, Hongik University, Seoul, yckang@hongik.ac.kr

1 - Designing Lean Systems to Improve Government Agencies' Performance

Elizabeth Ayala-Medina, Graduate Student, University of Puerto Rico-Mayagÿez, Mayagüez, Puerto Rico, elizabeth.ayala@upr.edu, Betzabé Rodríguez

Driven by a strong social commitment our institution has evaluated areas of opportunity to collaborate with highly influential sectors such as government agencies. One of the proposed methods for improving agency performance is implementing lean systems that will provide for more efficient services, more satisfied customers, and a sustainable improvement.

2 - Single-commodity Flow-based Formulations and Accelerated Benders Algorithms for the High-multiplicity Asymmetric Traveling Salesman Problem and its Extensions

Maichel M. Aguayo, Universidad de Concepcion, Concepcion, 4030000, Chile, maichelaguayo@udec.cl, Subhash C. Sarin, Hanif Dostmahomed Sherali

We present a single-commodity flow-based formulation for the high-multiplicity asymmetric traveling salesman problem, which is an extension of the asymmetric traveling salesman problem (ATSP) wherein a city can be visited multiple times. We show that even though this formulation is not as tight as the best known formulation for the HMATSP, it is faster and easier to use for direct solution by CPLEX, and can be used to model several variants or extensions of the HMATSP that have not been studied in the literature. Furthermore, we propose effective accelerated Benders algorithms that are demonstrated to solve instances of the HMATSP and its extensions involve up to 1001 cities within an hour of CPU time.

3 - Enabling Online Staff Scheduling Applications: Algorithms and Deployment Strategies for Online Courier Scheduling to Deliver Perishable Foods

Henry Tominaga, Senior Decision Scientist, Grubhub Inc, 1300 Southampton Rd. Apt 186, Benicia, CA, 94510, United States, htominaga@grubhub.com, Dan Wigrizer

We address the less developed area of online algorithms for staff scheduling applications by solving the courier resource planning and real-time management problems required to deliver perishable foods. Our solution involves online estimation to predict near-future courier supply requirements. In addition, we adopt fine-grained schedule adjustment algorithms, automated selection and incentives, and online control algorithms to efficiently adjust courier resources to meet supply requirements, while maximizing financial benefits and convenience for individual couriers.

4 - A Joint Production and Delivery Schedule for a Single-vendor Single-buyer System Over Finite Horizon

Fangzhou Sun, Virginia Tech, 1740 Donlee Dr, Blacksburg, VA, 24060, United States, fangzhou@vt.edu, Subhash Sarin

We address a joint production and delivery scheduling problem in which a single vendor supplies goods to a single buyer over a finite horizon. Vendor's production rate and buyer's demand rate are dynamic and are known in advance. The objective is to determine a production/shipment schedule that minimizes the total cost incurred due to production setup, shipment, and inventory holding (both at vendor and buyer). We first develop an approach to solve the single-period problem with prescribed starting and ending inventory. We, then, embed this approach into a dynamic programming framework for the multi-period problem, and also propose two fast and effective heuristic methods.

5 - Optimizing the Pipeline Scheduling System for Fuels at ENAP

Martin Quinteros, Empresa Nacional del Petroleo, San Jose de la Sierra 50 depto 1202, Lo Barnechea, Santiago, 7710088, Chile, martinq46@gmail.com
Martin Quinteros, University of Chile, Santiago, Chile, martinq46@gmail.com, Andres P. Weintraub, Monique Guignard-Spielberg

In the oil & gas industry the distribution of refined oil products is critical. This work addresses the problem of optimizing the schedule of a multi product pipeline that transports 6 products from the refinery to demand points. The size and contents of each batch injected should consider the arrival times at the demand points and volumes required. Having no physical separation between consecutive batches, in their contact surface they mix and these mixes are collected for reprocessing. In order to minimize the overall operating and reprocessing cost a MIP model decides the scheduling for the ENAP's pipeline achieving successful economical and operational results for Chilean company.

6 - A Futuristic Logistics Service System using Reinforcement Learning and Real-time Route Scheduling

Yuncheol Kang, Assistant Professor, Hongik University, T904 Wausanro-94, Mapo-gu, Seoul, 04066, Korea, Republic of, yckang@hongik.ac.kr, Seokgi Lee

The purpose of this study is to develop a framework for a futuristic logistics service system in which large-scale, on-demand, real-time and just-in-time logistics services are required. For this, we integrate service request control planning using reinforcement learning, and real-time service scheduling algorithm using continuous variable feedback control. Additionally, this logistics service system aims at a green transportation paradigm by minimizing gas emissions of delivery vehicles.

■ WC37

352B

Retail and Service Analytics

Sponsored: Service Science

Sponsored Session

Chair: Paul R. Messinger, University of Alberta, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca

1 - The Analytics of Product Return Episodes in Retailing

Paul R. Messinger, University of Alberta, Faculty of Business, 3-20e Faculty Of Business Bldg, Edmonton, AB, T6G 2R6, Canada, paul.messinger@ualberta.ca, Michele Samorani, Aydin Alptekinoglu

We analyze product returns as part of a search process: Upon returning a product, customers may immediately purchase an alternative one, which they may later replace with another product, and so on, until they either ultimately keep their last purchase (Keep outcome) or not (No-keep outcome). We call such a sequence of transactions a product return episode. In this work, we study customer keep and return abuse behavior using episodic metrics. We show that analysis of product returns with episodic metrics provides insights that differ from, and go beyond, analyses with transactional metrics.

2 - Efficiency and Risk in Airport Security Processes – A Queueing Analysis Approach

Mehmet Aydemir, Carnegie Mellon University, Pittsburgh, PA, United States, maydemir@andrew.cmu.edu, Alexandre Jacquillat

As recently as last year, waiting times at security queues in airports hit record high of 3 hours, causing many flights to be missed. Due to budget constraints quick and safe response to this tumult was not possible for the authorities. In this study, we aim to look for design and operational improvements of airport security queues.

■ WC39

352D

Multicriteria Decision Making

Contributed Session

Chair: Jawad Hassan, Kuwait University, Kuwait City, Kuwait, j.hassan@ku.edu.kw

1 - Green New Products Investment Based on Consumer's Utility
Xiaojun Lu, Xi'an Jiaotong University, Xi'an, China, looxiaojun@163.com, Jun Lin

This paper explores whether a firm should invest in the new green product to improve their product line based on the direct and spillover utility of green products for consumers, and how the consumers' utilities affect the green product investment and pricing. The results show that with the increase of consumers' green attentions, the firm should invest in green product; without spillover effect, consumers' direct utility will affect the optimal decision. The firm will use low-priced green product to maximize profits when the direct effect is large enough, otherwise with a high-priced green product to maximize profits; when considering spillover effect, the firm will use high-priced green product.

2 - Blockbusters of Video Games: Pricing and Quality Decisions in Two-stage Launch of Triple a Games
Gulver Karamemis, University of Rhode Island, 7 Lippitt Rd. 207 Ballentine Hall, Kingston, RI, 02881, United States, gkaramemis@uri.edu, Yuwen Chen, Hee Yoon Kwon

In video gaming industry, AAA games are considered to have the highest development costs offering different quality levels in the beta version and launch version of the product. We investigate the developer's pricing and quality decisions in the two-stage launch of the product.

3 - Decision Optimization on the Cloud
Sebastien Lannez, Principal Engineer, FICO, Birmingham, United Kingdom, sebastienlannez@fico.com

With FICO Decision Optimizer a strategy analyst can graphically define and optimize decision problems. The interactions between decisions and constrained metrics enables a simple visualization of the assignment of actions to customers, such as investment options or transaction authorizations. The availability of the software within a cloud based environment allows for simple integration into complex IT environments, and offers the ability to exchange and process large amounts of data using sampling and segmentation.

4 - Managing Software Product Innovations Through Versioning
Ishwar K.Murthy, Professor, Indian Institute of Management, 103NF Block IIM.Campus, Bannerghatta Road., Bangalore, 560076, India, ishwar@iimb.ernet.in, Giri Kumar Tayi

In this research we examine the issue of introducing a new software product into the market. First, we examine a monopoly situation, wherein the firm considers the option of versioning the new product, simply to learn the market potential. This typically entails an initial period of 'learning' followed by value extraction. The question is how to learn about the market potential through versioning. We present a dynamic programming framework to determine the optimal timing of when to introduce which versions. We examine the same problem in the presence of competition.

5 - Excel Based Tool for Interactive Optimization Models
Anthony Downward, University of Auckland, Level 3, 70 Symonds Street, Auckland CBD, Auckland, 1024, New Zealand, a.downward@auckland.ac.nz

In this talk we will demonstrate a new tool for creating interactive optimization problems in Excel using Javascript.

We will show examples of scheduling and routing applications utilizing the SolverStudio modelling framework for Excel.

6 - Integrated Parameter and Tolerance Designs with Manufacturing and Marketing Considerations
Jawad Hassan, Assistant Professor, Kuwait University, Kuwait City, Kuwait, j.hassan@ku.edu.kw, M. Jeya Chandra

Parameter and tolerance designs are major components of product design and development. Existing models for product design from each of the two fields of manufacturing and marketing lack the required rigor in assessing the other field's input to their models. Generally, pricing and market dynamics are not included in most of the models found in the manufacturing literature while product quality is overly simplified in many of the models found in the marketing literature. In this study, new integrated parameter and tolerance designs models are proposed that bridge the gap between manufacturing and marketing design considerations and decisions.

■ WC40

352E

Large-scale Network Modeling and Simulation

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Ehsan Jafari, University of Texas, Hart Lane, Austin, TX, 78731, United States, ejafari@utexas.edu

1 - Network Design Problem: A Decentralized Approach
Cesar Yahia, University of Texas, Austin, TX, 78731, United States, cesaryahia@utexas.edu, Ehsan Jafari, Stephen Boyles

We develop a decentralized algorithm for the transportation network design problem, based on a spatial partition of the network. In the master problem, a regional agent decides the funding allocation between subnetworks, and the subproblems are network design problems for each subnetwork. We develop a solution algorithm based on a sensitivity-analysis heuristic, and test it on two different networks. In addition to computational advantages, the proposed algorithm can be used to model the interactions between different entities with potentially conflicting objectives.

2 - Network Partitioning Algorithms to Reduce Computation Time for Parallel Traffic Assignment Problems
Cesar Yahia, University of Texas at Austin, Austin, TX, United States, cesaryahia@utexas.edu, Venktesh Pandey, Ehsan Jafari, Stepehn Boyles

Recent methods in the literature to parallelize the traffic assignment problem consider partitioning the network into subnetworks to reduce the computation time for large-scale networks. We propose several network partitioning algorithms which consider the impact of number of subnetworks and the choice of subnetwork boundary on the computation time. Our analysis compares the performance of proposed algorithms on different large-scale networks and makes recommendations on developing appropriate network partitions.

3 - Improving Incidence Responses on Large Network using Simulated Optimization Methods
Shanjiang Zhu, George Mason University, Nguyen Engineering Building, Suite 1300, 4400 University Drive Ms 6c1, Fairfax, VA, 22030, United States, szhu3@gmu.edu

Traffic incidents are a major cause of urban transportation congestion. Many incident response strategies, including opening of shoulder lanes, rerouting traffic through variable message signs, adjusting ramp metering rate, have been considered in the research and in practice. However, it is a challenge to efficiently identify the best incident response strategies among a large number of strategy combinations. This study combines the simulation-based optimization method and traffic simulation models to reduce the searching space and to efficiently identify the best response strategies.

■ WC41

352F

Optimization, Heuristic Programming

Contributed Session

1 - Resilient Design and Operation of Offgrid Microgrids with Generation Uncertainty
Sreenath Chalil Madathil, Clemson University, 324 Village Walk Ln, Clemson, SC, 29631, United States, schalil@g.clemson.edu, Harsha Nagarajan, Russell Bent, Scott J. Mason, Sandra D. Eksioglu

As demand for more renewable energy resources increases in remote communities to reduce carbon footprint, we focus on the design of reliable and cost-efficient offgrid microgrids. We consider the inherent uncertainty in wind and solar power generation. To address these uncertainties, we develop a stochastic model with N-1 security to analyze this challenging problem. We propose two decomposition algorithms and present experimental results using both the benchmark IEEE 13 node network and a real microgrid case study from Alaska. Our results demonstrate the efficacy of our rolling horizon approach.

2 - A Decomposition Method for Convex Optimization Problems the Bienstock Zuckerberg Algorithm Revisited
Renaud Pierre Chicoisne, Visiting Professor, University of Colorado denver, 1201 Larimer Street, Academic Building, Office AB1-4122, Denver, CO, 80204, United States, renaud.chicoisne@gmail.com

In this talk, we will briefly introduce the Bienstock-Zuckerberg algorithm as it originally appeared for open pit mining scheduling problems. We then discuss its equivalence with a specialized column generation scheme and how its framework can be generalized to solve convex optimization problems. We illustrate this generalization with a resource constrained nonlinear objective routing problem.

3 - An Incremental Quasi-Newton Method with Local Superlinear Convergence Rate

Aryan Mokhtari, University of Pennsylvania, Penn Engineering, 220 South 33rd Street, Philadelphia, PA, 19104, United States, aryanm@seas.upenn.edu, Mark Eisen, Alejandro Ribeiro

We present an incremental Broyden-Fletcher-Goldfarb-Shanno (BFGS) method as a quasi-Newton algorithm with a cyclically iterative update scheme for solving large-scale optimization problems. The proposed incremental quasi-Newton (IQN) algorithm reduces computational cost relative to traditional quasi-Newton methods by restricting the update to a single function per iteration and relative to incremental second-order methods by removing the need to compute the inverse of the Hessian. A local superlinear convergence rate is established and a strong improvement is shown over first order methods numerically for a set of common large-scale optimization problems.

4 - A Heuristic Algorithm for Solving Toll Optimization Problems

Stan Uryasev, University of Florida-Gainesville, Gainesville, FL, 32611, United States, uryasev@ufl.edu, Viacheslav Kalashnikov, Vladik Kreinovich, Jose G. Flores-Muniz, Nataliya I. Kalashnykova

The problem of assigning optimal tolls to the arcs of a multi-commodity transportation network is formulated as a bilevel mathematical program. We describe an algorithm based on the allowable ranges to stay optimal (ARSO) resulting from sensitivity analysis applied to the lower level problem. In this way, one can analyze possible changes in the coefficients of some variables in the objective function within these allowed ranges without affecting the optimal solution. In addition, when stuck to a local maximum solution, the "filled function" technique helps one "jump" to another local maximum (if such does exist) or stop the search. Numerical experiments confirm the robustness of our heuristics.

5 - On the Stability of Distributed Gradient-based Consensus Methods under Communication Delays

Thinh Doan, University of Illinois, 1308 W Main Street, Urbana, IL, 61801, United States, ttdoan2@illinois.edu, Carolyn L.Beck, Rayadurgam Srikant

Motivated by applications in machine learning, we study distributed algorithms for optimization problems defined over a network of processors. The objective function is composed of a sum of local functions where each function is known by only one processor. We study here the convergence rate of a popular distributed gradient algorithm in the presence of network delays, which has been identified as a significant open problem. Our main contribution is to show that convergence occurs at rate O(exp(a)ln(t)/sqrt(t)) where a is the uniform delay between processors. We also provide a lower bound to show that the exponential dependence on delay is inevitable.

■ WC42

360A

Organization Theory

Contributed Session

Chair: Adams Wei Yu, Carnegie Mellon University, Pittsburgh, PA, United States, adamsyuwei@gmail.com

1 - A Three Stage Stochastic Programming Model for Managing EV Charging Stations During Major Power Disruption

Mohannad Kabli, Mississippi State University, 21 Crenshaw Lane, Apt. 10, Starkville, MS, 39759, United States, mrk297@msstate.edu, Mohammad Marufuzzaman

This study considers the planning and management of charging stations when major disruptions in the power system occur. A three-stage stochastic programming model is presented, where the first-stage decides which charging stations to install and expand power supply units and renewable energy sources. Then, when the disruption occurs in the second-stage, repairs in power system and charging stations take place ahead of the arrival of "panicked" population. Finally, as demand is unveiled, managerial and operational decisions at the charging stations are made in the third-stage. We have used the infrastructure of Washington DC as a testing ground to validate our proposed optimization model.

2 - Memory-efficient Kernel Methods in Online Settings

Alec Koppel, U.S. Army Research Laboratory, 2800 Powder Mill Rd., Adelphi, MD, 20783, United States, aekoppel314@gmail.com, Garrett Warnell, Ethan Stump, Alejandro Ribeiro

Popular perception is that kernel methods do not scale to streaming data due to an intractable growth in the amount of storage they require. To solve this problem in a memory-affordable way, we consider functional stochastic gradient descent in tandem with supervised sparsification based on greedy function subspace projections. The method, parsimonious online learning with kernels (POLK), provides a controllable tradeoff between its solution accuracy and memory requirements. We establish almost sure convergence of POLK as well as bound its memory requirements. We evaluate POLK for several learning tasks, and demonstrate a state of the art trade off between test accuracy and sample complexity.

3 - On using Markov Chance-decision Processes in Stochastic Programming

Sudarshan Rajan, Texas A&M.University, College Station, TX, United States, srajan@tamu.edu, Natarajan Gautam

We explore the use of Markov chance-decision process algorithms to solve certain Markov decision processes by analyzing the merits and demerits from a computation and accuracy standpoint. Further, we use the approach in the second stage of two-stage stochastic programs and evaluate its performance.

4 - Reconfigurable Optimization

Prateek Raj Srivastava, PhD Student, University of Texas at Austin, 204 East Dean Keeton Street, Engineering Training Center I I.(ETC), Austin, TX, 78712, United States, prateekrs@utexas.edu, Nedialko Dimitrov, David L. Alderson

We develop a modeling framework for a class of optimization problems in which operational decisions need to be altered as a system transitions stochastically between states of the world. Our framework addresses the multi-objective problem of minimizing reconfiguration costs associated with changing the operational decisions and ensuring good quality solutions in each individual state. We compare and contrast this framework with existing modeling frameworks like Markov decision processes, stochastic programming, and robust optimization.

5 - Optimal Selection from a Sequence of Relatively Best Objects

Mitsushi Tamaki, Professor, Aichi University, Hiraike, Nakamura, Nagoya, 453-8777, Japan, tamaki@vega.aichi-u.ac.jp

A known number n of rankable objects appear sequentially in random order. An object is called a candidate if it is relatively best and we are allowed to choose one candidate. The payoff is a(k) if we choose the kth last candidate, k=1, 2, n. We wish to find a selection rule which maximizes the expected payoff. A generalization to multiple choices is also made.

6 - Stochastic Optimization for Deep Neural Networks

Adams Wei Yu, PhD Student, Carnegie Mellon University, Pittsburgh, PA, 15213, United States, adamsyuwei@gmail.com

In this paper, we introduce an efficient stochastic optimization algorithm to train deep neural network.

■ WC44

360C

Remanufacturing

Contributed Session

Chair: Jinfu Zhang, Tsinghua University, Beijing, China, zhangjf16@mails.tsinghua.edu.cn

1 - Joint Optimization of Production Scheduling and Condition-based Maintenance Planning

Bram de Jonge, Dr., University of Groningen, P.O. Box 800, 9700 AV, Groningen, Netherlands, b.de.jonge@rug.nl

We consider the joint optimization of production scheduling and condition-based maintenance planning for a single machine that is subject to deterioration and that needs to process incoming jobs of various lengths. We formulate the problem as a Markov decision process (MDP) and determine optimal policies that indicate when to process which job and when to perform maintenance. We provide insights on how production scheduling and maintenance planning interact.

2 - Condition-based Maintenance Policies under the Gamma Degradation Process

David Han, University of Texas at San Antonio, Management Science & Statistics, College of Business, San Antonio, TX, 8249-0632, United States, david.han@utsa.edu

Condition-based maintenance is an effective method to reduce unexpected failures as well as the O&M costs. This talk discusses the condition-based maintenance policy with optimal inspection points under the gamma degradation process. A random effect parameter is used to account for population heterogeneities and its distribution is continuously updated at each inspection epoch. The observed degradation level along with the system age is utilized for making the optimal maintenance decision, and the structure of the optimal policy is examined.

3 - Reliability and Economic Analysis of IP Cameras with Shielding Devices

Rodolfo Lozano, Texas A&M.University-Kingsville, Kingsville, TX, United States, rudylozanoiv@gmail.com, Hua Li, Kai Jin, Yue Zhang

The utilization of sophisticated outdoor IP surveillance cameras has led to significant increases in waste electrical and electronic equipment (WEEE) due to the degradation associated with direct insolation, thermal cycling and inclement exposure. This study seeks to apply a patent pending shielding device to IP cameras in a school district to attain the difference of operating temperatures between shielded and unshielded IP cameras. The failure rates of the hardware elements related to temperature are derived to conduct a reliability study. The results from reliability studies are used to investigate the economic benefits associated with installing the shielding devices.

4 - Multi-objective Optimization Model for Designing Reliable Networks

Seyedmohsen Hosseini, University of Southern Mississippi, 730 East Beach Boulevard, Long Beach, MS, 39560, United States, mohsen.hosseini@usm.edu

Network design problem (NDP) is a well-known combinatorial NP-hard which involves selecting a subset of network edges with respect to different objectives such as maximizing the network reliability and/or minimizing the network cost. This work presents a multi-objective optimization model to solve NDP. An adapted Non-dominated sorting genetic algorithm is proposed to deal with complexity of NDP. An illustrative example is worked out to illustrate the performance of proposed algorithm.

5 - ALT with Hyperbolically Changing Stress Durations under Cost Constraint

David Han, University of Texas at San Antonio, Management Science & Statistics, College of Business, San Antonio, TX, 78249-0632, United States, david.han@utsa.edu

When designing ALT, several variables such as the allocation proportions and stress durations must be determined carefully because of constrained resources. This talk discusses the optimal decision variables based on the popular optimality criteria under the constraint that the total cost does not exceed a pre-specified budget. A general scale family of distributions is considered to accommodate different lifetime models for flexible modeling with hyperbolically decreasing stress durations.

6 - Joint Optimal Pricing and Two Dimensional Warranty Policy for New Products in a Dynamic Market

Jinfu Zhang, Tsinghua University, RM.413 BLDG 14#, Tsinghua University, Beijing, 100084, China, zhangjf16@mails.tsinghua.edu.cn, Chi Zhang

Warranty can be used to promote sales of a product, but may incur high servicing cost. An optimal warranty policy that can well balance the two is thus desired. Considering that customers usually use the same type of products under different usage rates, we seek to design a two-dimensional warranty policy that takes both the covering time length and customer usage into account. The revenue earned by selling a product is also influenced by its price. Thus, we propose a model to jointly optimize a product's price, warranty length and usage for maximizing the total profit in a dynamic market.

■ WC45

360D

Sustainability

Contributed Session

1 - Impacts of Consumer Awareness, Government Penalty and Retailer's Responsibility on Upstream Pollution in a Supply Chain

Jeong Eun Sim, Korea Advanced Institute of Science and Technology, KAIST Business School, 85 Hoegiro Dongdaemoon, Seoul, Korea, Republic of, jesim@kaist.ac.kr, Bowon Kim

We study the impact of diverse stakeholders that may influence manufacturer's polluting emission in a supply chain. Specifically, we examine which one between the two key forces, i.e., consumers' environmental awareness and government penalty, is more effective in reducing pollution and whether they are substitutes or complements. Furthermore, we investigate the effect of retailer's environmental responsibility on the upstream pollution. To this end, four differential game models are developed depending on consumer awareness and supply chain strategy.

2 - Tax or Subsidy? An Analysis of Environmental Policies in Supply Chains

Xuan Zhao, Associate Professor, Wilfrid Laurier University, 877 Creekside Dr., Waterloo, ON, N2V. 2S7, Canada, xzhao@wlu.ca, Junsong Bian

This paper investigates the impacts of two environmental policies: pollution abatement subsidy and pollution emission tax, to a government-manufacturer-retailers supply chain, where the manufacturer invests in a pollution abatement technology.

3 - Characterizing the Association Between U.S. Domestic Water Consumption Patterns over 2005-2010 and Socioeconomic Factors

David Yang, Winston Churchill High School, 13430 Bissel Lane, Potomac, MD, 20854, United States, david121yang@yahoo.com, Roshanak Nateghi

Water consumption sustainability is a major national and global issue. Analyzing the United States Geological Survey (USGS) data shows that after a long period of steady increase in domestic water use, there was a decrease from 2005 to 2010, despite increased population. In this research, we focused on domestic water use per capita in 2005 and 2010 and found California, Nebraska, Nevada and Texas had the largest decrease. We leveraged statistical learning methods to identify socioeconomic factors that may influence domestic water use. Our analysis indicated that land area, household size and age of houses built are key factors in characterizing change of domestic water consumption.

■ WC46

360E

Project Management

Contributed Session

Chair: Yongcheng Fu, The University of Manchester, Manchester, United Kingdom, yongcheng.fu@postgrad.mbs.ac.uk

1 - Parents' Management Control Over International Joint Ventures for Overseas Infrastructure Investment

Leijie Han, Tianjin University, 92 Weijin Road, Tianjin, China 300072, Tianjin, 300072, China, sherry_hlj@163.com, Shuibo Zhang

We examine how goal incongruence between international joint venture (IJV) parents and task interdependence between parents and IJVs affect parents' investment in management control mechanisms: behavior, output and clan. We then explore the balance of control investment and residual risk under environmental uncertainty. The results from an empirical research show positive relationships between all these control mechanisms and goal incongruence, while only behavior and clan control are positively related to task interdependence. Besides, environmental uncertainty weakens the relationships related to behavior and output control, but enhances the relationships related to clan control.

2 - The Importance of Project Management to Drive Competitive Advantage in Data Analytics and Research Organizations

Mou Dutta, Strategic Analytics Leader, Genpact, 29 Hoyt Street, Stamford, CT, 06905, United States, drimjhim36@gmail.com

Data analytics is transforming the business end to end with smart intelligent insights challenging the conventional thought process and enabling the leaders to optimize their business strategy. While analytical methodologies have been widely used in traditional project management arena of agile software industry, the growing importance of managing the scope creep and implementation uncertainty calls for a robust project management framework for successful deployment of analytics engagements. This paper discusses the challenges in analytics operations posed by complex business environments and how effective project management can drive competitive advantage and strategic value chain.

3 - Early Termination Compensation under Demand Uncertainty in Public-private Partnership Projects

Jinbo Song, Professor, Dalian University of Technology, Dalian, 116024, China, songjinbo@dlut.edu.cn, Yanzhu Yu, Lulu Jin, Zhuo Feng

In the early termination of public-private partnership (PPP) projects, compensation is considered a core issue that greatly affects the interests of both the government and private sector. To address the early termination that is frequently caused by government default or voluntary buyback, this paper proposes an ex-ante compensation mechanism by using the cumulative probability that a given demand could be realized to determine the early termination compensation under demand uncertainty. The proposed compensation mechanism hopefully avoids time-consuming negotiations and high ex-post costs and provides a win-win outcome for both parties to manage the early termination of PPP projects.

4 - Addressing Project Complexity: the Role of Contractual Functions

Nan Gao, Tianjin University, TIanjin, China, gona1219@126.com, Yongqiang Chen

Project complexity leads to transaction risks in interorganizational exchanges and can negatively affect performance if appropriate governance mechanisms are absent. Though the contract prevails in construction projects to address transaction risks, its role in coping with complexity-related risk has not yet been fully investigated. Empirical results in this paper show that contractual coordination can deal with risks induced by technical, organizational and environmental complexity, while the adaptation function can address environmental complexity-related risk. However, contractual control is ineffective when either technical or environmental complexity is high.

5 - Collective Choice Impact on Organizational Performance: Why Do Megaprojects (Seem to) Fail?

Yongcheng Fu, The University of Manchester, Manchester, United Kingdom, yongcheng.fu@postgrad.mbs.ac.uk, Nuno Gil

This study investigates the impact of collective choice on organizational performance. Our empirical motivation is a long-standing puzzle about the root causes of the performance slippages which are endemic to megaprojects. By piecing together organizational structure and performance data for the life-cycle of three megaprojects, we show that: i) cost escalation is positively correlated with the disputes endemic to the growth of a pluralistic actor-network throughout planning; and ii) cost hikes are negatively correlated with the growth of a buyer-supplier network throughout implementation. A recurrent neural network was further developed to predict cost.

6 - Designing under Pluralism: the Value of Slack to Reconcile Private Interests in Collective Choices

Yongcheng Fu, The University of Manchester, Manchester, United Kingdom, yongcheng.fu@postgrad.mbs.ac.uk, Nuno Gil

This study develops a theoretical perspective on how slack resources affect value creation in 'pluralistic' product developments—settings where the project promoter shares decision-making authority over design choice with multiple autonomous actors with differing subgoals. We argue that, under some circumstances, the slack carried by the promoter enables to reconcile differing private interests, but the actual use of slack rarely benefits all participants alike. We illustrate this tension by drawing on data for a new railway network, High-Speed 2 in the UK. We further derive formal boundary conditions for creating and distributing collective value using a game theoretic representation.

■ WC47

360F

Business Applications

Contributed Session

Chair: Haidar Almohri, Wayne State University, Ann Arbor, MI, United States, almohrih@yahoo.com

1 - Practical Applications of Predictive Models

Suchitra Veera, Strategy and Analytics Consultant, Snayu Inc, 4512 Dartmoore Lane, Colleyville, TX, 76034, United States, suchitra.veera@gmail.com

The objective of this session is to present the topic of the practical applications of predictive model and to help the audience understand the use of predictive models in business and management. The presentation will discuss the use of predictive models in Finance, Human Resources, Marketing and Finance. It will allow attendees to take away ideas about the use of predictive models in business and how this is facilitated through the increasing availability of data through many different sources.

2 - Identifying Sources of Assignable Error via Process Pattern Mining

Bhupesh Shetty, PhD Candidate, University of Iowa, 707 Oakcrest Street, Apt E, Iowa City, IA, 52246, United States, bhupesh-shetty@uiowa.edu, Nick Street, Jeffrey W. Ohlmann

We apply pattern mining techniques to event logs generated by a manufacturing process in order to identify the root causes of product defects. We use an association-based method algorithm to generate the frequent patterns and then use correlation measures to identify the patterns of interest. For a varying levels of target pattern complexity, we compare the effectiveness of correlation measures for varying sample sizes with and without knowledge of the underlying process map.

3 - Busting the Bracket Toward an in Depth Predictive Analysis of College Mens Basketball Tournaments

Jie Tao, Assistant Professor in Information Systems, Fairfield University, 1073 N.Benson Rd, 100 Silliman St APT1A, Fairfield, CT, 06824, United States, jtao@fairfield.edu, Michael Mitchell, Kanlun Wang

The NCAA Division I basketball tournament attracts significant attention each year. In this study, we aim at developing models to predict outcomes of tournament games. Compared to previous studies, our results rely solely on the matchups rather than any pre-established rating systems. The contribution of this study is tri-fold: we develop predictive models for the tournament - yielding satisfactory results; we also select several predictors for developing a new rating system; lastly, we use unsupervised learning to investigate how erroneous predictions would reveal stochastic factors in predictive results. Our findings can be applied to other related scenarios such as elections and polls.

4 - A Data Driven Analysis on Automotive Dealership Management

Haidar Almohri, PhD Candidate, Wayne State University, 2833 Catalpa Circle, Ann Arbor, MI, 48108, United States, almohrih@yahoo.com, Ratna Babu Chinnam, Mark Colosimo

Automotive dealership management is challenging in that they have to run their business for producing profit, while keeping the OEM happy with selling new vehicles. In this work, a deep data-driven study and analysis for dealership management is performed to find the key driving factors for different departments in a dealership. The model-based clustering and recommendation methodology developed seeks to maximize the dealer profit while satisfying sales targets from the OEM.

■ WC49

361B

Behavioral Operations

Contributed Session

Chair: Julie Niederhoff, Syracuse University, Syracuse, NY, United States, jniederh@syr.edu

1 - Screening Out Biased Managerial Decisions to Interfere with Automatic Store Replenishment

Antti Tenhiala, IE Business School, Calle Maria de Molina 12, piso 5, Madrid, 28006, Spain, antti.tenhiala@ie.edu, Shivom Aggarwal

We study managerial decisions to deviate from automatic store replenishment (ASR) proposals using multi-store data from a European supermarket chain. After controlling for the drivers of this behavior already identified in the existing research (including package sizing, shelf space considerations, product margins, forecast errors, demand seasonality, transit lags, item durability, and others), we find support for the prevalence of the basic decision-making biases of anchoring and demand chasing. We further find that these biases strongly predict unsuccessful replenishment decisions and suggest a way to incorporate a warning system in ASR software to discourage biased decision making.

2 - Experimental Analysis of the Newsvendor Problem with Minimum Order Quantity Contracts

Özge Tüncel, Student, Singapore University of Technology and Design, 8 Somapah Rd, Singapore, 487372, Singapore, tuncel_ozge@mymail.sutd.edu.sg, Niyazi Taneri, Sameer Hasija

Experiments between human suppliers and automated retailers revealed that the cognitive burden associated with MOQ contract is lower and the profits are higher than with either buyback or revenue-sharing contracts. Moreover, when given a choice, subjects tend to pick the MOQ contract more often, and make quicker and better decisions.

3 - An Experimental Study of Fair Transitivity in a Three-tier Supply Chain

Junlin Chen, Associate Professor, Central University of Finance and Economics, 39 South College Road, Haidian District, Beijing, 100081, China, chenjunlin@cufe.edu.cn

We study a three-tier supply chain consisting of a supplier, a manufacturer, and a retailer. We conducted experiments to investigate the sequential bargaining process between tiers, in high and low demand markets. We measure how the underlying three-tier structure influences the profit distribution across the supply chain. We find that the structural issue blocks access to people's social preferences. Most suppliers behave few fairness concerns, and always set a high wholesale price close to the rationally theoretical value. Most manufactures follow a high wholesale price when the received offer is not kind. Our data also show that a high demand market will not promote people to be kind.

4 - How Newsvendors Reduce Cognitive Efforts
Ehsan Elahi, Associate Professor, University of Massachusetts, Boston, 100 Morrissey Blvd, Boston, MA, 02125, United States, ehsan.elahi@umb.edu, Mahdi Malek, Babak Rezaee

We introduce Order Clustering Preference and address supply chain coordination contracts. The effect of framing, free-item, feed-back and individual features (education and nationality) have been examined. Considering clustering tick-sizes and test results, this behavioral bias remains strongly stable. Our concluding remarks address cognitive driver and future studies.

5 - Supply Chain Decision Making under Financial Constraints
Julie Niederhoff, Assistant Professor, Syracuse University, 721 University Avenue, Syracuse, NY, 13244, United States, jniederh@syr.edu, Panos Kouvelis, Wenhui Zhao, Ying Rong

Capital availability creates constraints for decision makers. We consider the role of these constraints on the ordering behavior of decision makers in a behavioral study.

■ WC50

361C

Transportation Modeling with Social Media Data and GIS

Sponsored: TSL, Urban Transportation

Sponsored Session

Chair: Samiul Hasan, University of Central Florida, Orlando, FL, 32816, United States, samiul.hasan@gmail.com

1 - Activity Patterns Exploration and Location Recommendation
Ying Chen, Northwestern University, 600 Foster St, Evanston, IL, 60208, United States, y-chen@northwestern.edu

Location-based Social Networks (LBSN) allow users to check where their friends are and where their friends visited, to search location-tagged content, like notes and photos within their social connections, and to meet others nearby. Using data from two online LBSNs, the aim of this paper is to investigate the relationship between friendship and distance, the possible influence of friendship in travelers' destination choices, and the importance of this factor in choosing a destination.

2 - Joint Inference of User Communities and Interest Patterns in Social Interaction Networks
Arif Mohaimin Sadri, Valparaiso University, 149 Arnold Drive, Apt 12, West Lafayette, IN, 47906, United States, sadri.buet@gmail.com

We present a modeling approach for characterizing social interaction networks by inferring user communities and interests based on social media interactions. We present several pattern inference models: i) Interest pattern model (IPM) captures population level interaction topics, ii) User interest pattern model (UIPM) captures user specific interaction topics, and iii) Community interest pattern model (CIPM) captures both community structures and user interests. We test our methods on Twitter data from Purdue University community and observed the interaction topics and communities related to two big events ,Purdue Day of Giving and Senator Bernie Sanders' visit to Purdue University.

3 - Inferring Tourist Travel Behavior from Location based Social Media Data
Md. Mehedi Hasnat, University of Central Florida, Orlando, FL, United States, hasnat@Knights.ucf.edu

Location based information sharing platforms of social media have made it possible to extract individual activity records in time and space. Growing increase in the use of Twitter have opened a cost-effective and significant data source to track tourists' travel activity. This research proposes a methodology to use geo-tagged tweets in order to infer travel behavior of tourists within Central Florida region of Florida, USA. Two major challenges addressed in this work include identifying tourists from local residents and extracting their most popular destinations in the study region.

4 - Quantifying the Quality of Mobility: Development of a Comprehensive Accessibility Metric
Ambarish Nag, National Renewable Energy Lab (NREL), Golden, CO, United States, Ambarish.Nag@nrel.gov, Josh Sperling, Stan Young, Venu Garikapati

The concept of mobility is difficult to quantify as it is only relevant in relation to the endpoints to be connected. The recent Department of Energy Vehicle Technology program area for Energy Efficient Mobility Systems uses the mantra 'Maximizing Mobility while Minimizing Energy'. Whereas energy is objectively measured, mobility is more difficult to quantify, much less maximize. Traditional transportation engineering which focuses primarily on the National Highway System and associated urban roadways primarily characterizes the efficiency of roadways to carry the designed capacity. Measures like travel time and reliability reflect the relative health of a link on the roadway or set of links.

■ WC52

361E

Environmental Operations

Contributed Session

Chair: Sining Song, Arizona State University, Tempe, AZ, 8, United States, sining.song@asu.edu

1 - The Different Roles of Self-inspections and External Inspections in the Pipeline Industry
Sehwon Kang, University of Minnesota, 321 Nineteenth Avenue South, Suite 3-150, Minneapolis, MN, 55455, United States, kangx584@umn.edu

Operators and government agencies in pipeline industry have striven to reduce incidents through inspections: self-inspections by operators and external inspections by government agencies. Using econometric analysis with data sets from more than 800 pipeline operators, this study examines the differing role of self-inspections and external inspections on future incidents.

2 - Strategic Environmental Quality Investment in a Multi-tier Supply Chain
Ozgen Karaer, Middle East Technical University, Endustri Muhendisligi Bolumu, Inonu Bulvari ODTU, Ankara, 06800, Turkey, okaraer@metu.edu.tr, Pinar Yalcin, Tim Kraft

We study a buyer's strategies to incentivize environmental quality investment in a three-tier supply chain. Environmental quality of the end product depends on the environmental performances of both the tier 1 and the tier 2 supplier. A higher environmental quality produces an increased demand for the end product; and hence for the whole supply chain. In this setting, we compare the effectiveness of delegation vs. full control strategies from the buyer's cost-sharing perspective.

3 - The Future of Indian Aviation Network in the Wake of a Prospective Carbon Tax Regime
Himanshu Rathore, Indian Institute of Management, Rohtak, MDU. Rohtak, 124001, Rohtak, 124001, India, himanshu.rathore13@gmail.com, Shirsendu Nandi

India will be the third largest aviation market in the world by 2020 and has witnessed the world's highest growth rate of 20.3% in 2015-16. The emissions from aviation have been growing exponentially and would double up in the next decade if no actions are taken. EU-ETS has also been pushing for carbon tax on aviation. India is opposing the proposed carbon tax on apprehensions that its growth rate would be inhibited. We test this apprehension by building a mixed possibilistic low carbon integrated hub location model which takes into account the landing and take-off cycle of the aircraft by using M/G/s queuing model. The results deliberate on the impact of prospective carbon tax on aviation network strategy.

4 - Greenhouse Gas Emissions and Supply Chain Spillovers
Sining Song, Arizona State University, Tempe, AZ, United States, sining.song@asu.edu, Yan Dong, Thomas Kull, Craig Carter, Kefeng Xu

Using public secondary data, we empirically investigate the relationship between emissions reduction programs of a firm and the GHG emissions of the firm's supply chain. Our results suggest a supply chain spillover effect of a firm' emissions reduction.

■ WC53

361F

Statistical Methods in Traffic Simulation and Estimation

Sponsored Session

Chair: Yudi Yang, UC Davis, 1420 Lake Boulevard, Apartment 17, Davis, CA, 95616, United States, ydyang@ucdavis.edu

1 - Improvement of Estimation Method of the Nested Logit Model
Siyu Tao, Southwest Jiaotong University, Cheng Du, China, siyu.tao@okstate.edu, Lisha Wang, Qiyuan Peng, Kuniaki Sasaki

Because of the drawbacks of conventional method, nowadays researchers prefer to use discrete model to forecast traffic demand. And nested logit model is widely used on the simulation of discrete model.However, when we use R language to estimate, we have to do step by step. If the logsum terms or t-test values aren't valid, we must establish another structure to estimate again, which makes estimation become burdened. Because if there are n dimensions, then the number of possible structures is n!. This thesis focus on realizing this work automatically by using R language and bootstrap.

2 - Sparse Travel Time Estimation from Streaming Data
Deepthi Mary Dilip, New York University-Abu Dhabi, Abu Dhabi, United Arab Emirates, deepthi.dilip@nyu.edu, Saif Eddin G. Jabari

We address two shortcomings in travel time distribution estimation methods. The first is the determination of the number of modes of the distribution. The second is the use of Gaussian kernels, which can assign positive probabilities to negative travel times. We develop a sparse kernel density estimation technique using asymmetric kernels. Sparsity promotes parsimony and helps avoid the need for a predefined number of mixture components. We present an adaptive approach to infer both the location and the scale parameters of the kernels and we propose a generalization of Gamma kernels.

3 - Analytical Calculation of Travel Time Reliability Indices with Minimal Statistical Data
Marcelo Ricardo Figueroa, Rutgers University, 93 Marvin Lane, Piscataway, NJ, 08854, United States, marcelo.figueroa@rutgers.edu

We present an analytical parametric model to approximate the travel time distribution of vehicles traversing a freeway corridor which experiences random quality of service degradations. Our models are validated by using traffic speed and flow data for a freeway corridor in Milwaukee, Wisconsin coupled with relevant weather events and traffic incidents as the main cause of service degradation. We show how the models can be calibrated using minimal statistical information on traffic conditions. We provide travel time (un)reliability measures for various scenarios illustrating the impact of incident duration, frequency, and degradation level.

4 - Statistical Inference of Travel Demand with Complex Mapping
Yudi Yang, Postdoc Researcher, University of California, Davis, 1420 Lake Boulevard, Apartment 17, Davis, CA, 95616, United States, ydyang@ucdavis.edu, Yueyue Fan, Johannes Royset

We study a novel problem of inferring the joint probability density function (pdf) of O-D demand variables by integrating hard data of observed traffic counts and potential soft information on demand features. Without being restricted by any particular distributional assumption, our moment matching method produces a nonparametric epi-spline density estimate. Based on sampling instead of solving inverse problems, the proposed solution process can be easily paralleled and is computationally tractable when a complex mapping is assumed between trip rates and traffic flow, including those based on optimization and simulation.

■ WC55

362B

Accounting

Contributed Session

Chair: Pei-Cheng Liao, National Taiwan University, No 1 Sec 4 Roosevelt Road, Taipei, 10617, Taiwan, pcliao@ntu.edu.tw

1 - The Usefulness of Forward-looking and Backward-looking Information in the Capital Market
Yue Wang, University of Texas-Austin, 2110 Speedway, Stop B6400, Austin, TX, 78712, United States, yue.wang@mccombs.utexas.edu

We investigate circumstances in which forward-looking or backward-looking financial information is more useful in the capital market. The choice between forward-looking and backward-looking information reflects a tradeoff between "relevancy" and "reliability." We use conference call transcript to analyze the frequency of forward-look and backward-looking sentences, as it provides effective communication and interaction between managers and sell-side analysts. The results will be potentially helpful to regulators and preparers of financial statements who wish to provide useful information to investors.

2 - Official Visits and Corporate Employee Scale
Wang Yanping, doctor, Tongji University, Yangpu District Zhangwu Road NO1 1822, Shanghai, China, wangyanpingchina@163.com

Through the official visit statistics of Fortune 500 global corporations, we find that different from the developed market economy countries, the Chinese officials visit the corporation frequently, forming "Chinese Characteristics" visit phenomenon. As to employment issue, the empirical findings show that Chinese officials are inclined to visit the corporations which can absorb more employees. Chinese official visits can increase the number of employees, especially for employees with college degree or below, thus incurring redundant employee. This relation is much stronger in state-owned enterprises.

3 - The Effect of Top Managers' Regulatory Focus on Firm Behaviors
Jacob Do-Hyung Cha, Seoul National University, Room 313, 58-dong, Seoul National University, Gwanak-gu, 150-742, Korea, Republic of, research.dohyung@gmail.com, Hye-Jin Cho

Individuals pursue goals via either a prevention focus (sensitive to gains and a desire for accomplishment and growth) or a promotion focus (sensitive to losses and a desire for safety and security). This study investigates whether individual managers' such motivational traits are associated with corporate behavior and performance. I use linguistic features to develop a measure of managers' regulatory focus - prevention or promotion foci - from corporate documents, that is, Form 10-K's management discussion and analysis section. The results indicate that managers' regulatory focus affect differently financing choices, investment choices, and firm operating performance.

4 - The Stewardship Role of Conservatism
Pei-Cheng Liao, Professor, National Taiwan University, No 1 Sec 4 Roosevelt Road, Taipei, 10617, Taiwan, pcliao@ntu.edu.tw, Guang Ma, Suresh Radhakrishnan

We consider conservative reporting and investment decisions when the hidden-information problem of unknown manager-types as well as the hidden-action problem of diversion of resources exist. When either the hidden-information problem or the hidden-action problem exists, conservative reporting is not optimal. When both the hidden-information and hidden-action problems exist, conservative reporting is optimal for the high-type manager. Specifically, conservatism as part of the menu targeted for the higher productivity manager mitigates the problem of diversion of resources by the lower productivity manager and thus is part of the steward role of accounting.

■ WC56

362C

Logistics

Contributed Session

Chair: Murat Karatas, University of Texas-Austin, Austin, TX, United States, mkaratas@utexas.edu

1 - Optimization of Supply Chain Tracking Capability under Various Market Contexts
Bin Dai, Professor, Wuhan University, Bayi Road, Wuhan, China, dbbudstar@gmail.com, Yongzhe Zhang

Traceability system has been widely used to alleviate the impact of product recall on supply chain performance, particularly the product recall cost. In this paper, we optimize the supply chain tracking capability under various market contexts such as oligopoly, simutaneouly move competition and sequential move competition, and then the optimal tracking capability and pricing strategies are compared.

2 - Benders Decomposition for Inventory Routing Problem with Perishable Product
Faisal M.Alkaabneh, Cornell University, Stewart Ave, Building 516; Room, Ithaca, NY, 14850, United States, fma34@cornell.edu

In this work we consider a Perishable products Inventory vehicle Routing Problem in the context of Cold supply chain. We explicitly model Green House Gases emissions due to transportation activities depending on the vehicle load during delivery. The problem is modelled as a mixed integer mathematical program that is difficult to solve directly. To this end, we developed a solution methodology based on Benders decomposition. Benders decomposition algorithm convergence rate was accelerated through the addition of valid inequalities and symmetry breaking cuts to the Master Problem, upper bound heuristic, Pareto optimal cuts and trust region.

3 - A Decomposition Heuristic for a Production Routing Problem in Furniture Companies
Pedro Miranda, Federal University of São Carlos, São Carlos, Brazil, pmiranda@dep.ufscar.br, Jean-François Cordeau, Deisemara Ferreira, Raf Jans, Reinaldo Morabito

We propose a decomposition heuristic to solve a production routing problem arising in the context of furniture companies. The heuristic decomposes the problem into two subproblems that are solved iteratively. The first subproblem makes production and distribution decisions using approximations of the routing costs and travel times. The second subproblem determines vehicle routes based on the decisions made by the first subproblem. These routes are used to update the approximations of routing costs and travel times for the next iteration. Computational results show that our iterative approach provides better solutions in less computing times than a state-of-the-art commercial solver.

4 - Multi-warehouse Package Consolidation for Split Order Fulfillment in Online Supermarkets
Yuankai Zhang, Dalian University of Technology, Office Room A1214 Innovation Park Building, Dalian University of Technology No.2 Linggong, Dalian, 116024, China, ykzhang6635@126.com, Xiangpei Hu, Weihua Lin

The split-order fulfillment problem has been a new key issue for multi-item order fulfillment in Chinese online supermarkets. We propose a powerful order fulfillment method - package consolidation - in which two or more stock keeping units in the sub-orders of one order will be packed into fewer packages. We formulate a multi-commodity network flow model to make the package consolidation decisions for split orders between multiple warehouses, and propose a computationally efficient algorithm for solving it.

5 - Joint Location and Inventory Analysis in IoT-based Service Parts Logistics Systems

Murat Karatas, University of Texas-Austin, Austin, TX, 78703, United States, mkaratas@utexas.edu, Erhan Kutanoglu

We investigate a joint location and inventory problem in service parts logistics (SPL) taking advantage of data on equipment condition via Internet of Things (IoT) technology. Continuous condition data may make replacing the parts before failure possible, potentially saving time and money, as opposed to the conventional approach of issuing replacement parts upon failures. We propose a model that captures the optimum balance between increased demand due to parts replaced more frequently and time/cost savings due to non-emergency shipments. Our preliminary results quantify the effects of this tradeoff on location and inventory decisions as well as time-based service levels.

■ WC57

362D

Scheduling

Contributed Session

Chair: Mansoor Shekarian, North Carolina A&T State University, Greensboro, NC, United States, mshekarian@aggies.ncat.edu

1 - Total Earliness and Tardiness in a Two-machine Flowshop

Jeffrey Schaller, Eastern Connecticut State University, 83 Whindham Street, Dept of Business Administration, Willimantic, CT, 06226-2295, United States, schallerj@easternct.edu, Jorge Valente

This paper considers the problem of scheduling jobs in a two-machine permutation flow shop with the objective of minimizing total earliness and tardiness. Unforced idle time is considered in order to reduce the earliness of jobs.

2 - Utility Based Priority Dispatching Rules in Complex Dynamic Job Shops: the Case of Customer Balking

Kevin D.Sweeney, Assistant Professor, Sam Houston State University, Box 2056, Sam Houston State University, Huntsville, TX, 77341, United States, ksweeney@shsu.edu, Stanislaus Solomon, William A. Ellegood

We investigate the performance of utility based priority dispatching rules in a reactive complex job shop environment. In particular, we focus on job shops defined by two characteristics: (1) customers that can potentially balk to an alternative job shop if a certain threshold for service or utility is not met, and (2) job shops characterized by heterogeneous classes of jobs which each receive different amounts of utility from the job shop. Within these job shops, we look at the impact of using different priority dispatching rules under different ratios of utility of heterogeneous classes of jobs, processing times of different classes of jobs, and a range of attractiveness levels of the alternative.

3 - A Decision Model for Two Objective Job Shop Scheduling Problem with Sequence Dependent Setup Times

Mansoor Shekarian, Graduate Student, North Carolina A&T State University, 3100 N Elm St, Apt #22L, Greensboro, NC, 27408, United States, mshekarian@aggies.ncat.edu, Adel Aazami, Mahour Parast

The job shop scheduling problem (JSP) is one of the most difficult problems in traditional scheduling problems. When an operation happens in a machine, it is necessary to consider a sequence-dependent setup time (SDST). This research develops a two-objective model, including minimizing the Makespan and maximum tardiness. The proposed mixed integer nonlinear programming (MINLP) model is converted into a MILP to achieve a globally optimal solution. The -constraint method is used to solve the model. A set of numerical data from a real case study is investigated to show the model's efficiency and flexibility. These results have a great value for managers, especially in a manufacturing industry.

■ WC58

362E

Applications of Facility Logistics - II

Sponsored: TSL, Facility Logistics

Sponsored Session

Chair: Francisco Jose Aldarondo, University of Michigan, 3512 Green Brier Boulevard, Apartment 497C, Ann Arbor, MI, 48105, United States, faldaron@umich.edu

1 - Solving the Quadratic Assignment Problem using Graphics Processing Unit Clusters on the Blue Waters Supercomputer

Rakesh Nagi, U. of Illinois at Urbana-Champaign, Department of Industrial & Enterprise Systems, 117 Transportation Building, MC-238, Urbana, IL, 61801, United States, nagi@illinois.edu, Ketan Date

We discuss parallel implementations of RLT2 formulation and branch-and-bound algorithm for solving the Quadratic Assignment Problem (QAP). Our parallel architecture consists of NVIDIA Graphics Processing Unit (GPU) clusters on the Blue Waters supercomputer at the University of Illinois at Urbana-Champaign. We propose a "distributed" Dual Ascent algorithm for the GPUs, which shows excellent parallel speedup, and can effectively solve some of the well-known QAPs from the literature.

2 - Comparing Two Goods-to-person Order Picking Systems for Online Retailing

Francisco Jose Aldarondo, PhD Candidate, University of Michigan, 3512 Green Brier Boulevard, Apartment 497C, Ann Arbor, MI, 48105, United States, faldaron@umich.edu

Using simulation modeling and an on-line retail setting, we compare the performance of two types of goods-to-person order picking (OP) systems, namely, the Kiva system and the Miniload-AS/RS with a conveyor loop (to connect the pick stations). The two systems are compared on the basis of quantitative factors such as expected throughput (line items picked per hour), expected picker and material handling equipment utilization, and order completion times. We also compare the two systems in terms of qualitative factors that are relevant for OP systems.

3 - An Integrated Supply Chain Design for Additively Manufactured Products

Sudipta Chowdhury, Mississippi State University, 260 McCain Engineering Building, ISE Department, Starkville, MS, 39762, United States, sc2603@msstate.edu, Mohammad Marufuzzaman, Linkan Bian

Despite the promising features of AM technologies, make-or-buy decisions are not straightforward. Moreover, decision regarding the optimal number of layers for the AM product is also an issue that has not been addressed before. Based on the budget or quality requirements, number of layers for the product may vary which affect the supply chain cost. A stochastic model is proposed to quantify both the process and supply-chain level costs associated with the production of AM parts. Two algorithms, i.e., hybrid Sample Average Approximation (SAA) and Progressive Hedging Algorithm (PHA) and hybrid SAA and Adaptive Large Neighborhood search (ALNS) based algorithm are developed to solve the problem.

4 - Solving the Student Assignment and School Bus Routing Problems

Sunderesh S. Heragu, Oklahoma State University, 322 Engineering North, School of Industrial Engineering & Management, Stillwater, OK, 74078, United States, sunderesh.heragu@okstate.edu, Harshwardhan Rathod

In this presentation, we address the assignment of students to bus stops as well as the school bus routing (SBRP) problems. The student assignment problem (SAP) is solved using a specialized branch-and-bound algorithm. The result is provided as input to the SBRP. The latter is solved using a meta heuristic. We then apply both the SAP and SBRP to the Stillwater middle student assignment and school bus routing problems.

■ WC60

370A

Forecasting

Contributed Session

Chair: YoungJun Park, Seoul National University, Seoul, pyjoon90@snu.ac.kr

1 - Predicting Customer Activity by Cumulative Purchase Quantity and Consumption Rate

Huan Yu, PhD candidate, University of Science and Technology of China, Hefei, China, huany@mail.ustc.edu.cn, Yugang Yu, Hanqin Zhang

When analyzing customer activity, usually one assumes that the independence between inter-purchase time, purchase quantity and lifetime. However, many data sets we have collected demonstrate that this independence assumption may not hold. For example, inter-purchase time and purchase quantity may depend on each other through customer consumption rate, and lifetime and inter-purchase time may depend on each other through cumulative purchase quantity. Considering these dependences, we propose a new stochastic model of predicting customer activity. The proposed model can formulate our data sets very well, which cannot be fitted by the existing models that assume the independence assumption.

2 - Conditional Value at Risk as SVR Minimization
Emre Eryigit, Middle East Technical University-Ankara, Ankara, 06800, Turkey, emreryigit@gmail.com, Cem Iyigun, Ozlem Cavus Iyigun

We study Support Vector Regression (SVR) to forecast electricity load in short term. Our algorithm includes Conditional Value at Risk measure and the optimization model behind the forecasting algorithm minimizes the risk measure while minimizing the forecasting result. Our preliminary results are promising in comparison to SVR without risk parameter.

3 - BBQ Time Series and Optimal Control
Joshua Woodruff, University of Texas, 4509 Rio Robles Dr, Austin, TX, 78746, United States, jwoodruff@optimizedfinancialsystems.com, Dragan Djurdjanovic

Cooking truly exemplary Texas pit BBQ requires maintaining the perfect temperature over 8 to 12 hours. Making this type of BBQ in an offset smoker requires constant attention to the wood added, vent openings, and outside temperature. In this session we present a tutorial on time series modeling in R and optimal control using CPLEX.

4 - Forecasting the Automobile Market Equilibrium in Consideration of the Externalities of Transport Sector
YoungJun Park, Seoul National University, Seoul, Korea, Republic of, pyjoon90@snu.ac.kr, HyungBin Moon

Countries are implementing different political measures to manage and alleviate the greenhouse gas emissions from the transportation sector. The present study forecast the automobile market equilibrium by considering the fuel cost and the external cost related to the transportation sector. In particular, the study constructs a linkage among the changes in fuel costs, market shares of different vehicle types, and the external costs to estimate the market equilibrium according to the changes in consumer behavior. Based on the estimation, the study derives the principle rules on how to reflect the external costs of transportation sector that satisfy the goal of greenhouse gas emission reduction.

■ WC61

370B

Finance, Banking and Insurance

Contributed Session

Chair: Aein Khabazian, University of Houston, Houston, TX, United States, akhabazian2@uh.edu

1 - Data Mining and Machine Learning Role in Insurance Business
Xiaoguang Tian, University of North Texas, 1155 Union Circle, Denton, TX, 76203-5017, United States, xiaoguang.tian@unt.edu

The insurance industry is facing unprecedented challenges and opportunities in the data-driven paradigm. The incoming big data and technologies are transforming the traditional insurance business model and pushing the new generation of insurers to rethink their business strategies and then to make better decisions. In this study, the author will discuss challenges that insurance industry is encountering, and review the existing data mining and machine learning techniques that can be applied in insurance management across the business value chain. Two ongoing data mining projects will be introduced by using real-world data.

2 - Bank Risk Assessment using Unstructured Text Disclosures
Xiaodi Zhu, PhD Candidate, Stevens Institute of Technology, Hoboken, NJ, 07030, United States, xzhu@stevens.edu, Aparna Gupta, Steve Yang

Bank risk has become an important focus of financial regulators and investors after the 08-09 financial crisis. Banking sector risks are usually measured by quantitative information from structured financial disclosures. This study analyzes the textual risk disclosures that presumably provide forward looking information about firms' future risks. We extract risk factors from banks' risk disclosures using a sentence based dynamic topic modeling approach. Using data from both FDIC and the SEC, we find significant correlation between the unstructured risk topics and the conventional risk measures. Moreover, we demonstrate the predictive power of risk factors on bank's future risk.

3 - Modeling Psycho-financial Profiles of Italian Bank Customers
Galina Andreeva, Associate Professor, University of Edinburgh, 29 Buccleuch Place, Edinburgh, EH8 9JS, United Kingdom, galina.andreeva@ed.ac.uk, Caterina Liberati

We investigate the relationship between psychometric measures obtained through the survey, personal/demographic and financial characteristics of the account holders of an Italian bank. The main objective of the analysis is to explore the latent structure of different types of variables that the dataset contains via factorial representation. We also detect presence of the natural groups by means of explorative unsupervised classification, and comment on different types of customers' profiles from psychological and financial behavior perspectives.

4 - Assessment and Control of Systemic Risk
Aein Khabazian, University of Houston, 5465 Braesvalley Dr. APT.566, Houston, TX, 77096, United States, akhabazian2@uh.edu, Jiming Peng

In this work, we assess the systemic risk based on the optimization model introduced by Eisenberg and Noe (2001), where only partial information regarding the liability matrix is revealed. We develop an algorithm to identify the most vulnerable structure in the network. Numerical experiments illustrate that the contagious risk in the identified vulnerable network is more significant than what underestimated in the literature. Second, we develop an algorithm to identify the most stable network structure, and use it to develop a strategy for systemic risk mitigation. We evaluate the performance of the new strategy.

■ WC62

370C

Reliability

Contributed Session

Chair: Douglas King, University of Illinois at Urbana-Champaign, Urbana, IL, United States, dmking@illinois.edu

1 - Enforcing Contiguity in Branch and Bound Algorithms to Solve Geographical Districting Problems
Rahul Swamy, PhD Student, University of Illinois at Urbana-Champaign, 205 E.Clark St, Apt 303, Champaign, IL, 61820, United States, rahulswamy91@gmail.com, Sheldon H. Jacobson, Douglas M. King

The class of Geographical Districting Problems has been modeled in the literature as a combinatorial graph partitioning problem. Enforcing contiguity is typically the bottleneck in exact methods, since it is hard to do so without avoiding an exponential set of constraints. We present a method to enforce contiguity using Geo-Graphs in branch and bound algorithms, where the special planar structure of the districting problem is used for improved efficiency. This is done so dynamically while evaluating potential contiguity of partial solutions. Theoretical and computational results are presented.

2 - Practical Mathematical Methods for Political Redistricting and Competitive and Fair Elections
Hsiao-Shen Jacob Tsao, Professor, San Jose State University, 1 Washington Square, San Jose, CA, 95192-0085, United States, jacob.tsao@sjsu.edu, Royce Lin

A reason for the current political polarization in the US is partisan political redistricting or "gerrymandering" for congressional elections. Population equality, contiguity and compactness for any district are required by the Constitution. Political reforms for decreasing partisan influence will not suffice; the commission staff needs software tools to help achieve these requirements and to explore or achieve fair representation, competitiveness, etc. However, the mathematical solution processes produced so far have not been practical for such use. We propose a new approach that is mathematically rigorous, easier for the staff to understand and practical for software implementation.

3 - Scalable Contiguity Assessments in Practical Political Districting
Douglas M.King, University of Illinois at Urbana-Champaign, 117 Transportation Building, 104 S.Mathews Avenue, Urbana, IL, 61801, United States, dmking@illinois.edu, Sheldon H. Jacobson, Edward C. Sewell

Practical political districting involves the creation of contiguous districts from small discrete units. When the number of units is large, ensuring contiguity poses a substantial computational burden. This talk applies scalable contiguity algorithms based on the geo-graph framework to the creation of United States Congressional Districts in four states.

■ WC65

370F

Special Settings of Vehicle Routing Problems

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Xiangfei Meng, USC, 2801 Orchard Ave, Apt 10, Los Angeles, CA, 90007, United States, xiangfem@usc.edu

1 - An Adaptive Large Neighborhood Search for Real-world Vehicle Routing Problems
Haoyuan Hu, Zhejiang Cainiao Supply Chain Management Co., Ltd., Hangzhou, China, haoyuan.huhy@cainiao.com, Ying Zhang, Wenjia Ma, Kunpeng Han, Guotao Wu

Along with the rapid growth of online shopping, real-world vehicle routing problems (VRP) arise in city logistics. We propose an adaptive large neighborhood search heuristic for the VRP and some of its realistic variants. Problem specific

destroy/repair operators are designed. We then study a number of real-world problems: the split delivery with multi-dimensional demand, the time-uncritical delivery with T + n possibility, the urban delivery with density consideration and the generalized VRP with multiple available locations for each node. Those tests illustrate its effectiveness and applicability to practical industrial situations, e.g., 20 thousands orders can be solved in 5 minutes.

2 - Traveling Salesman Problems with Multiple-product Mixing

German Paredes-Belmar, Assistant Professor, Universidad Andres Bello, Quillota 980, Viña del Mar, 2390457, Chile, german.paredes@unab.cl, Armin Lüer-Villagra, Vladimir Marianov

The traveling salesman problems with multiple-product mixing are generalizations of the known Traveling salesman problem (TSP), where a set of products needs being transported between depots and customers at minimum cost. Those products can be carried in the same vehicle. The mix of two products can become a third product, which has an impact on the routes and on the objective function (e.g., cost, profit, risk). We propose an integer formulation to solve different instances of TSP with multiple-product mixing.

3 - A Hybrid Algorithm for Class of Vehicle Routing Problems with Loading Constraints

David Alvarez Martinez, Assistant Professor, Universidad de Los Andes-Colombia, Cra 1 No 18A- 12, Bogota, Colombia, d.alvarezm@uniandes.edu.co, Luis Miguel Escobar

In this paper we present a hybrid algorithm for a class of Vehicle Routing Problems with Loading Constraints. The routing problem is solved through sequential Set Partitioning models, the columns correspond to routes found through an ILS algorithm, which can interact with the MIP solution process. It was implemented a reactive GRASP algorithm in order to verify all the packing constraints established and in this way only valid columns are incorporated into the solution process. The algorithm was tested using instances of the following variants: (i) CVRP (ii) 2D Loading Problem and (iii) 3D Loading Problem. The results obtained were quite competitive in comparison with those found by the previous works

4 - Scheduling Periodic Deliveries with Heterogeneous Vehicles and Driver Consistency

Soheyl Zehtabiyan, The University of Alabama, 317 Bidgood Hall, Tuscaloosa, AL, 35401, United States, zehtabiyan@gmail.com, Mesut Yavuz

This study is concerned with minimizing the total fleet cost in a direct-shipment setting with a single supplier and many customers. The customers require perfectly periodic deliveries, as well as a minimally acceptable vehicle type and / or driver consistency. We provide an IP model covering four versions of the problem and devise a constructive heuristic to solve them.

5 - Asymptotic Analysis of the Generalized TSP

Xiangfei Meng, USC, 2801 Orchard Ave, Apt 10, Los Angeles, CA, 90007, United States, xiangfem@usc.edu

In this work, we will analyze the asymptotic behavior on a generalized version of the TSP, which we call the Generalized Travelling Salesman Problem (GTSP), in which the goal is to select one point each from multiple sets of points and come up with a tour with the minimum length. Two different limiting cases are examined: one is the case where the number of point sets goes to infinity, and the other is the case where the number of points in each set goes to infinity. Numerical simulations confirm that our analysis is valid when applied to simulations in the Euclidean plane and on a road network.

■ WC66

371A

Robust and Resilient Facility Location

Sponsored: Transportation Science & Logistics

Sponsored Session

Chair: Mengtong Wang, Tsinghua University, Zhongguancun Street, Beijing, 100084, China, mengtong321@163.com

1 - Secure Transportation in Dangerous Zones

Azar Sadeghnejad Barkousaraie, University at Buffalo, 93 Pepper Tree Dr, Apt 4, Amherst, NY, 14228, United States, azarsade@buffalo.edu

In order to secure transportation of goods and passengers in dangerous areas usage of escort vehicles is sometimes necessary and inevitable. However due to resource limitation the assignment of security vehicles to each transportation unit in a timely manner is not always applicable, it may result in either long waiting time for customers or overusing of resources. In this research we study the effect of resting areas for limited number of escort vehicles to secure the transportation of customers in order to minimize the response time to the transportation units in dangerous areas.

2 - Robust Optimization for Service Network Design and Hub Location Problem under Uncertain Capacities and Demand

Mengtong Wang, Tsinghua University, Zhongguancun Street, Beijing, 231567, China, wmt15@mails.tsinghua.edu.cn

We propose a novel two-stage robust optimization model for the service network design and hub location problem with stochastic capacities and demand, in which a freight operator needs to determine the locations and capacities of hubs, allocation of non-hub nodes to hubs, and the number of vehicles to purchase and rent for multi-modal network with minimum total cost. A two-level cutting plane based method is developed, which includes an algorithm to generate lower bound inequalities in the outer level, and a hybrid algorithm in the inner level. A number of numerical experiments are offered to test the efficiency of the proposed solution algorithm and the robustness of the novel robust mode.

■ WC67

371B

Data Science for Reliability and Quality Assurance

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Mingyang Li, Tampa, FL, 33647, United States, mingyangli@usf.edu

1 - Multi-state Reliability Demonstration Tests

Suiyao Chen, University of South Florida, 4202 E. Fowler Avenue, Tampa, FL, 33620, United States, suiyaochen@mail.usf.edu, Lu Lu, Mingyang Li

Reliability demonstration tests (RDTs) are important reliability assurance activities to ensure product quality over time and safeguard market competitiveness. Conventional binomial RDTs become inadequate to meet diverse reliability requirements of the consumers. This work proposes multi-state RDTs to demonstrate product reliability at multiple time periods or involving multiple failure modes. The design strategies allow the incorporation of prior knowledge to reduce test sample sizes and realize simultaneous demonstration of multiple objectives to ensure customer satisfaction. Two case studies are used to demonstrate the effectiveness of the proposed methods.

2 - Weighted Band Depth for Functional Data Outlier Detection

Xudong Zhang, University of Iowa, Iowa City, IA, United States, xudong-zhang@uiowa.edu, Yuxing Hou, Yong Chen

The use of depth has shown great usefulness in robust analysis of functional data, such as producing robust location estimators of sample curves, or detecting various outliers. In this paper, we focus on using depth for detecting outliers in functional data, which are considered as coming from a different process compared to normal curves. We propose a new depth concept for function data called weighted band depth (WBD), which improves the performance of the band depth proposed in the literature. Numerical studies based on simulated signals and application to a real data example are used to evaluate the performance of proposed depth methods and other existing depth notions.

3 - Projection Based Outlier Detection in Functional Data

Nan Chen, National University of Singapore, Department of Industrial and System Eng, 1 Engineering Drive 2, Singapore, 117576, Singapore, isecn@nus.edu.sg

To detect outliers in functional data, we developed a procedure based on a high-breakdown mean function estimator. The robust estimator is obtained from a clean subset of observations, excluding potential outliers, by minimizing the least trimmed squares of the projection coefficients after functional principal component analysis. A threshold rule is constructed based on the asymptotic distribution of the functional-score-based distance. The thresholding robustly controls the false positive rate and detects outliers effectively. Further power improvement is proposed by adding a one-step reweighting procedure.

4 - Sequential Test Planning for Polymer Composites

Yili Hong, Professor, Virginia Tech, Blacksburg, VA, United States, yilihong@vt.edu, Ichen Lee, Sheng-Tsaing Tseng, Tirthankar Dasgupta

Polymer composite materials are widely used in areas such as aerospace and alternative energy industries, due to their lightweight and comparable levels of strength and endurance. To ensure that the material can last long enough in the field, accelerated cyclic fatigue tests are commonly used to collect data and then make predictions for the field performance. In this paper, we propose a sequential strategy for test planning, and use a Bayesian framework for the sequential model updating. We also use extensive simulations to evaluate the properties of the proposed strategy. Our results show that the proposed strategy is more robust and efficient, as compared to traditional optimum designs.

5 - Spectral Graph Theoretic Sensor-based Monitoring in Laser Powder Bed Fusion Process

Prahalada Rao, rao@unl.edu, Mohammad Montazeri, Brandon Lane, Jarred Heigel

The goal of this work is to monitor the laser powder bed fusion (LPBF) additive manufacturing (AM) process using heterogeneous sensors incorporated inside the machine. This will allow opportune preventive action to avert propagation of build defects across multiple layers. In pursuit of this goal, a commercial LPBF machine was integrated with three types of sensors, namely, a photodetector, high-speed video camera, and SWIR thermal camera with the following objective: to develop and apply a spectral graph theoretic approach to monitor the LPBF build status from the data acquired by the three sensors.

■ WC68

371C

Quality and Reliability Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Young Myoung Ko, Pohang University of Science and Technology, Pohang, 790-784, Korea, Republic of, youngko@postech.ac.kr

1 - A New Multi-response Optimization Approach using Bayesian Seemingly Unrelated Regression Model

Jianjun Wang, Associate Professor, Nanjing University of Science and Technology, Nanjing, 210094, China, jjwang@njust.edu.cn

This paper presents a new multi-response optimization (MRO) approach integrating a quality loss function with a posterior predictive function in a single framework of Bayesian seemingly unrelated regressions (SUR) modeling and optimization. The proposed approach not only measures the conformance probability through the posterior predictive function, but also takes into account the expected quality loss with the quality loss function. The results show that the proposed approach may give more reasonable results than the existing approaches when both conformance probability and quality loss are important issues.

2 - Hard Failure Prediction with Stochastic Degradation Signals using Wiener Process

Jianing Man, City University of Hong Kong, Dept of SEEM, General office, Room P6600,6/F, AC1,City U. of Hong Kong, Kowloon Tong, Kowloon, Hong Kong, jianinman2-c@my.cityu.edu.hk, Qiang Zhou

Remaining useful life is one of the most important part for the conditional based maintenance (CBM) and prognostics and healthy management (PHM). In this paper, we consider the stochastic process for the degradation path using wiener process to predict the RUL for hard failure, with degradation signals and time-to-event data. The time-to-event data is modeled by the proportional hazards (PH), by considering the stochastic feature of the degradation signals. The simulation studies and a case study are conducted to show the performance of the method.

3 - Introducing Randomness into Control Chart Sampling Strategies to Better Protect Against Cyber-physical Attacks on Production Systems

Lee Wells, Western Michigan University, 2827 Daventry Ave., Portage, MI, 49024, United States, lee.wells@wmich.edu, Ahmed Elhabashy, Bill Woodall, Jaime Camelio

With recent technological advancements, production systems have become more susceptible to cyber-attacks. Such attacks can be designed to both alter product dimensions and avoid detection by current Statistical Process Control tools. This work discusses a novel approach to better detect attacks against manufacturing, which is based upon introducing randomness into control chart sampling strategies. Several different random sampling strategies will be introduced and their performances under varying attack scenarios will be analyzed. In addition, this work will propose new control chart performance metrics for analyzing situations where cyber-physical attacks are possible.

4 - Condition-based Selective Maintenance Optimization for a Large-scale Non-Markovian System

Euihwan Lee, Pohang University of Science and Technology, 77, Cheongam-Ro, Nam-Gu, Pohang, 790-784, Korea, Republic of, euihwan.lee@postech.ac.kr, Young Myoung Ko, Eunshin Byon

We consider selective maintenance that repairs severely degraded units in the system consisting of massive units. Under the assumption that units degrade independently in a finite number of states, we derive a fluid model that approximates the mean behavior of the system's health condition. Our simulation study indicates that even if only a subset of units gets repaired, the system would asymptotically become a regenerative process as the maintenance operations are repeated over time. Based on this observation, we optimize the maintenance scheduling that triggers the maintenance operations based on the fraction of units at each degradation state in order to minimize long-run maintenance costs.

■ WC69

371D

Optimization, Convex

Contributed Session

Chair: Matthew Saltzman, Clemson University, Clemson, SC, United States, mjs@clemson.edu

1 - Optimization Based Heuristics for the Graph Partitioning Problem

Ali Hassanzadeh Kalshani, Graduate Student, University of California-Irvine, 1723, Verona Place, Irvine, CA, 92617, United States, ahassan2@uci.edu, Emre Alper Yildirim

The graph partitioning problem is concerned with partitioning the vertices of a graph into a pre-specified number of clusters, so as to minimize the total weight of the edges cut. We use optimization formulations to design two approximation algorithms that can be used in large scale graph partitioning problem. Using valid inequalities and lower bounds play an important role in strengthening the solution of the Linear Programming relaxation of the problem which has been used in these two proposed methods.

2 - Optimal Number of Inspection and Rework Servers for Feed-back Queues in Steel Pipe Manufacturing

Shahriar J. Hossain, Graduate Research Assistant, Louisiana State University, 4141 Burbank Dr. Apt. 3, Baton Rouge, LA, 70808, United States, msjhossain1@gmail.com, Bhaba R. Sarker

This research aims to find the optimum number of inspection and rework servers in a steel pipe manufacturing system. If a repairable defect is detected at the inspection station, the pipe is sent to the rework station, while the reworked pipes are fed back to the inspection station for re-inspection. Thus, two intertwined queues of pipes are generated. The size of queues and number of servers are constrained by the availability of space. The total cost function is formulated as a nonlinear programming problem. The model is solved optimally to minimize the total cost.

3 - Irregular Shape Nesting via Branch and Bound using Custom Relaxations

Akang Wang, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States, akangw@andrew.cmu.edu, Christopher Hanselman, Chrysanthos Gounaris

We present a custom-built linear relaxation and an associated branch-and-bound (BB) approach for solving irregular shape nesting problems to global optimality. We utilize a novel branching scheme based on circle-packing constraints, and we integrate a dynamic circle-adding procedure into our BB implementation, in order to enforce shape non-overlap. We also utilize a domain reduction scheme to speed up our algorithm. Extensive computational studies are performed on benchmark instances.

4 - Lagrangian Relaxation of the Defender Attacker Defender Constrained Shortest Path Problem

Gary Lazzaro, Permanent Military Professor, United States Naval Academy, 1903 Baltimore Annapolis Blvd., Annapolis, MD, 21409, United States, lazzaro@usna.edu, Matt Carlyle

The first application of tri-level Defender Attacker-Defender (DAD) optimization models to the constrained shortest path (CSP) problem. The side constraint in DAD CSP breaks the network structure of a shortest path problem into a challenging tri-level integer program. We create new solution procedures by merging the attacker model with Lagrangian relaxation of the operator model into a single formulation that can obtain fast heuristic solutions. We combine our heuristic algorithm with traditional methods to obtain provably optimal or near-optimal solutions. Our results on medium and large networks show that our innovations can significantly outperform traditional nested decomposition.

5 - Open-source Solvers for Quadratic Assignment and Related Problems

Matthew J. Saltzman, Associate Professor, Clemson University, Dept of Mathematical Sciences, Martin Hall Box 340975, Clemson, SC, 29634-0975, United States, mjs@clemson.edu, Peter M. Hahn, Amir Roth, Monique Guignard

A recent COIN-OR poject makes available exact solvers for the QAP and related problems of increasing interest, with wide application, and for which exact solution is very challenging. These problems address economic issues in the location and design of factories, hospitals, depots, transportation hubs and military bases.Our exact solvers produce strong bounds using Adams-Sherali RLT and include techniques to speed up branching and fathoming of search trees. We describe these codes and suggest a taxonomy and framework for combining existing methods and computer tools that can be modified and extended to make inroads in solving this growing class of optimization problems.

■ WC70

371E

Biotechnology/Bioinformatics

Contributed Session

Chair: Da Lin, Coventry University, Cantol, United Kingdom, lind7708@gmail.com

1 - Exact Multiple Sequence Alignment by Synchronized Multivalued Decision Diagrams

Amin Hosseininasab, Tepper School of Business, 5562 Hobart St, Apt 605, Pittsburgh, PA, 15217, United States, aminh@andrew.cmu.edu, Willem-Jan Van Hoeve

We study an exact solution method for the Multiple Sequence Alignment (MSA) problem in computational biology. Our approach uses Multivalued Decision Diagrams (MDD) to model all possible pairwise sequence alignments (PSA). PSA MDDs are synchronized using side constraints to solve the MSA problem, for the first time, in polynomial space complexity. We use filtering techniques to reduce the size of our MDDs, both in PSA, and MSA. In MSA filtering, we develop for the first time, an upper bound to reduce the search space. Finally decomposition techniques are used to solve the synchronized MDDs.

2 - Integer Linear Programming Models for Protein Structure Prediction in Lattice Models

Seyed Mojtaba Hosseini, University of California, Irvine, 67306, Verano Place, Irvine, CA, 92617, United States, smhosse1@uci.edu, Ceydu Oguz

Protein structure prediction (PSP) consists of predicting the native structure of a protein from its sequence of amino acids by minimizing an energy function. The problem is of vital importance in medical science and molecular biology. In this study, we develop several integer linear programming (ILP) models for PSP problem abstracted to hydrophobic-polar model under cubic and square lattices, along with variety of valid inequalities and symmetry-breaking techniques. Next, we demonstrate that our ILP models are more efficient than the state-of-the-art models. We also establish that our models are effective in finding tight lower bounds via their linear programming relaxations.

3 - A Novel Combinatorial Approach for Cell Identification in Calcium Imaging Movies

Quico Spaen, PhD Student, University of California-Berkeley, Etcheverry Hall, Berkeley, CA, 94720, United States, qspaen@berkeley.edu, Roberto J. Asín-Achá, Dorit Simona Hochbaum

Calcium imaging has emerged as a workhorse method in neuroscience to investigate patterns of neuronal activity. We present HNCcorr, a novel algorithm for cell identification in calcium imaging movies based on combinatorial optimization. The algorithm identifies cells by finding distinct groups of highly similar pixels in correlation space, where a pixel is represented by the vector of correlations to other pixels. The HNCcorr algorithm achieves the best known results for the Neurofinder cell identification benchmark, and guarantees an optimal solution to the underlying optimization model.

4 - Feature Selection for Biomarker Identification in DNA Methylation

Haluk Damgacioglu, PhD Candidate, University of Miami, 1251 Memorial Drive McArthur Engr Bldg Room 305, Coral Gables, FL, 33146, United States, haluk.damgacioglu@miami.edu, Emrah Celik, Nurcin Celik

DNA methylation plays a critical role in regulating genome functions and abnormal methylation levels associate with various diseases such as cancer. Recent advances in genetic engineering provide high-dimensional DNA methylation data and it makes feature selection algorithms crucial to find the best subset of attributes for learning methods. Here, we introduce a curve-fitting based feature selection algorithm on the ordinal transformed methylation levels to handle the high-dimensionality. The performance of the proposed algorithm is demonstrated through six real DNA methylation datasets.

5 - Metafrontier Frameworks for the Study of Firm Level Efficiencies and Technology Ratios

Da Lin, professor, Coventry University, Cantol, United Kingdom, lind7708@gmail.com, Swaki Kindos

Since strategic alignment first rose to prominence with Henderson and Venkatraman's (1993) seminal paper, research has tended to focus on the extent of fit between IT and business strategy at the firm level. Although useful, a firm-level view of alignment could mask what firms are doing to realize intellectual alignment between business and IT strategy and whether their actions will likely succeed. In this study, we build on an emergent stream of research that considers alignment between IT and business strategy at the process level.strategy and whether their actions will likely succeed. In this study, we build on an emergent stream of research that considers alignment between IT and

■ WC71

371F

Optimization, Linear Programming

Contributed Session

Chair: Victoria Ellison, TiVo Research and Analytics, Carrboro, NC, United States, vmelliso@ncsu.edu

1 - Quantifying the Potential Therapeutic Benefit of Spatiotemporal Dose Modulation in Radiotherapy

Ali Adibi, Wichita State University, 1845, Fairmount street, Wichita, KS, 67260-0004, United States, aliadibi.ie@gmail.com, Ehsan Salari

It is clinically known that altering the radiation dose distribution over treatment sessions in fractionated radiotherapy may enhance the probability of tumor control without increasing the risk of normal-tissue complications. This research aims at quantifying the extent of this potential gain using a spatiotemporally integrated radiotherapy planning approach, which requires solving a class of large-scale non-convex QCQP problems. Global optimization techniques will be used to obtain near-optimal radiotherapy plans that vary over the treatment course.

2 - Taxi Planning: Branch and Price Approach

Angel Marin, Universidad Politécnica de Madrid, ETS.Ingeniería Aeronáutica y del Espacio, Plaza Cardenal Cisneros 3, Madrid, 28040, Spain, angel.marin@upm.es, Luis Marin, Luis Ibáñez

Taxi Planning has been formulated as a binary multicommodity flow network representing the aircraft ground movements from the runways to gates and vice versa. The flow capacities and other side constraints have been defined to represent the conflicts between aircrafts in the limited airport capacity. Branch and Price methodology has been adapted to take advantage of the Taxi Planning constraints. The computational tests have been run using data from Madrid-Barajas airport. The computational tests have been oriented to comparing the different methodologies.

3 - Benders Cuts for a Robust Disaster Preparedness Model to Facilitate Fair and Effective Response

Gökalp Erbeyoglu, Boazici University, Dept. of Industrial Engineering, Bebek, stanbul, Turkey, gokalp.erbeyoglu@boun.edu.tr, Umit Bilge

Decisions made in the preparedness stage of disaster management are critical since they set the frame for all further post-disaster operations. Having strategically located storage and distribution centers is the key that enables effective and fair response to a disaster. The preparedness model we propose selects locations and inventory levels of these facilities in a way to help achieving fairness in the response stage, and it ensures demand satisfaction under any disaster scenario. The Benders decomposition approach proposed to solve this hard problem uses continuous and logic-based cuts, and produces optimal or good solutions to cases with realistic sizes within a reasonable time-frame.

4 - Integrating Fleet Assignment with Passenger Mix Models

Xiaodong Luo, Sabre Holdings Inc, 3150 Sabre Drive, Southlake, TX, 76092, United States, Xiaodong.Luo@sabre.com

We consider the integration of fleet assignment with various passenger mix models. The passenger mix models address network effect, demand recapture characteristics, the randomness in demand as well as the revenue managementconsiderations. We implemented some simple warm start techniques,heuristic fixing techniques as well as decomposition techniques. Using data from one of our client, we compare performanceof some of these models, under various scenarios. Weuse Monte Carlo simulation to verify the revenue profit savings.

5 - Personnel Scheduling with Employees Transfer Between Departments

Monia Rekik, Associate Professor, Universite Laval, 2325 rue de la Tterrasse, Quebec, QC, G1V. 0A6, Canada, monia.rekik@cirrelt.ca, Sana Dahmen, Francois Soumis, Guy Desaulniers

We address a personalized multi-department multi-day shift scheduling problem where employees can be transferred between departments. A two-stage solution approach is proposed. Our computational results prove the high performance of the proposed approach on a large set of generated instances.

6 - A Hierarchical Consensus Clustering Extension of the Minimum Cluster Ratio Problem Applied to Gene Expression Profile Data

Victoria Ellison, TiVo Research and Analytics, Carrboro, NC, 27510, United States, vmelliso@ncsu.edu

We propose a divisive hierarchical consensus clustering algorithm that we show is a natural extension of the minimum cluster ratio problem. A linear parametric programming-based heuristic for this algorithm returns nested consensus clusterings from diverse clusterings derived from gene expression profile data. Numerical tests showed that most of the returned nested consensus clusterings sets contained the optimal solution to the Median Partition problem, thereby providing the 'optimal' answer to the consensus clustering problem as well as reflecting the nested nature of consensus clusters.

■ WC72

372A

Optimization, Combinatorial

Contributed Session

Chair: Yaping Wang, University of Houston, Houston, TX, United States, ypwang@uh.edu

1 - Data-driven Two-stage Adaptive Optimization: A Multi-policy Approach

Shimrit Shtern, Postdoctiral Associate, Massachusetts Institute of Technology, 77 Massachusetts Ave., E40-154, Cambridge, MA, 02139, United States, sshtern@mit.edu, Dimitris Bertsimas, Bradley E. Sturt

Consider a general two-stage linear problem with uncertainty. In real life, historical data is available and can be used to estimate future uncertainty. We propose a novel approach to the problem of two-stage adaptive optimization, in which we find multiple recourse policies that fit a data-driven uncertainty set. Our framework generates a tractable model (e.g., SOCP) that can also incorporate integer variables. We prove the framework has finite and asymptotic optimality guarantees, and show that it empirically performs better than existing methods on out-of-sample data.

2 - Forecasting the Workload with a Hybrid Model to Reduce the Inefficiency Cost

Xinwei Pan, University of Kentucky, Lexington, KY, United States, bluebridge1905@163.com

Operating Room managers want to allocate the block time to surgical groups according to an accurate estimation of workload. If overestimating the workload, it generates idle time, which is a waste of resources; if underestimating the workload, it generates over-utilize cost. To avoid these two cases, we construct a hybrid model combining Auto-Regressive Integrated Moving Average with Artificial Neural Networks, and a filter structure is integrated to obtain more accurate and stable prediction values when applied to multi-steps-ahead forecasting. Case studies with data from the University of Kentucky HealthCare indicate that our model outperforms other models in different conditions.

3 - A Predictor-corrector Algorithm for Projection-based Derivative-free Optimization

Ishan Bajaj, PhD Student, Texas A&M.University, 503 Cherry St., College Station, TX, 77840, United States, ishan.bajaj@tamu.edu, Faruque Hasan

We present a derivative-free method to minimize a general black-box function f(x), where xL ≤ x ≤ xU Rn, by projecting the original objective function onto a one-dimensional t-space given by linear combination of xi. We identify a special function G(t) which is the lower envelope of all the objective function values on t-space. We propose a projection-correction algorithm to find the minima of G(t) since it also corresponds to the minima of f(x). The algorithm is applied to a suite of more than 400 test problems and performs superior relative to model based solvers such as ORBIT and SNOBFIT.

4 - From Predictions to Prescriptions in Multistage Optimization Problems

Christopher G. McCord, Massachusetts Institute of Technology, Cambridge, MA, United States, mccord@mit.edu, Dimitris Bertsimas

In this paper, we introduce a framework for solving multistage optimization problems under uncertainty in the presence of auxiliary data. We assume the distribution of the uncertainties is unknown, but samples from this distribution, along with observations of auxiliary covariates, are available. We utilize effective predictive machine learning methods, including nearest neighbor regression and random forests, to develop specific methods for prescribing decisions. We demonstrate that our methods are asymptotically optimal, and we establish finite sample guarantees. Finally, we demonstrate the practicality of our approach with computational examples.

5 - Matching Two-resolution Metrology Data with Symmetric Features

Yaping Wang, Instructional Assistant Professor, University of Houston, 4722 Calhoun drive, Houston, TX, 77204, United States, ypwang@uh.edu, Erick Moreno-Centeno, Yu Ding

Research showed combining two metrology datasets with different resolutions makes better surface feature predictions of manufactured parts. The goal is to match the two datasets with arbitrary initial misalignment. A two-stage matching framework (TSMF) was previously developed to solve real-life problems efficiently. However, TMSF can lead to incorrect correspondences for part surfaces with symmetric features because the alignment performance metrics of TSMF cannot differentiate between correct correspondences and incorrect but seemingly correct ones. To solve this, a filtering procedure is proposed to select a correct solution from a properly generated pool of plausible candidates.

■ WC74

372C

Solution Approaches for Bilevel Programming and Interdiction Problems

Sponsored: Computing

Sponsored Session

Chair: Osman Yalin Ozaltin, North Carolina State University, Raleigh, NC, 27695, United States, oyozalti@ncsu.edu

1 - The Shortest Path Interdiction Problem with Hidden Arcs: Network Interdiction with Asymmetric Info

Timothy Holzmann, Clemson University, SC, United States, tholzma@g.clemson.edu

Network interdiction problems frequently assume that both attacker and follower have full knowledge of the network. We present the shortest path interdiction problem with hidden arcs (SPIP-HA). In the SPIP-HA, the competing objectives have a common formulation but vary a parameter in the inner problem constraints, which results in competing objective function values. After presenting the theoretical considerations of a Stackelberg game with asymmetric information, we consider solution techniques for Pareto front of the SPIP-HA.

2 - A Branch-and-cut Algorithm for Mixed Integer Bilevel Linear Optimization Problems and its Implementation

Sahar Tahernejad, Lehigh University, Bethlehem, PA, United States, sat214@lehigh.edu

We describe a comprehensive algorithmic framework for solving mixed integer bilevel linear optimization problems (MIBLPs) by a generalized branch-and-cut approach. The framework presented merges features from existing algorithms (for both traditional mixed integer optimization and MIBLPs) with new techniques to produce a flexible and robust framework for solving bilevel optimization problems. The framework has been fully implemented in the open source solver MibS. We also describe the algorithmic options offered by MibS and present computational results evaluating the effectiveness of the various options for the solution of a number of classes of instances from the literature.

3 - A Branch-and-cut Algorithm for Discrete Bilevel Linear Programs

Junlong Zhang, North Carolina State University, Apt 102, 3515 Ivy Commons Dr, Raleigh, NC, 27606, United States, jzhang56@ncsu.edu

We present a branch-and-cut algorithm for solving bilevel linear programs where the upper-level variables are all binary and the lower-level variables are all integral or all binary. The algorithm iteratively performs local search in the neighborhood of an upper-level solution and generates cuts to eliminate upper-level solutions that have been explored. Instead of repeatedly solving similar bilevel integer problems in the local search, we derive properties of the value functions of bilevel integer programs and propose three algorithms for constructing them. Preliminary computational results show that our solution approach can solve instances with up to 200 variables and 150 constraints.

4 - Bilevel Optimization Models and Risk-averse Decision Making

Deniz Eskandani, Rutgers University, Piscataway, NJ, 08904, United States, deniz.eskandani@rutgers.edu, Jonathan Eckstein

We describe a bilevel programming technique to time-consistently formulate 3-stage stochastic programs without using nested risk measures. We apply our technique to applications in portfolio optimization and scheduling of a hydrothermal generating system, and compare our results with standard approaches.

■ WC75

372D

Operations/Sustainability

Contributed Session

Chair: Ling-Fei Cai, Beijing Institute of Technology, Beijing, China, 461714207@qq.com

1 - Understanding Concepts of Proactive Services and Cases

Youngmi Han, Korea University Business School, 408 LG-POSCO.building, Korea University, Anam-ro, Seongbuk-gu, Seoul, 02804, Korea, Republic of, 55835729@hanmail.net, Chulok Ahn, Hosun Rhim

Customer needs are constantly increasing. While reactive behavior of enterprise does not satisfy the changing customer needs, proactive behavior prevents potential problems and creates values. We define proactive services, and classify them into three types. We introduce companies that have implementing proactive services.

2 - Optimal Channel Structure for Refurbished Products
Narendra Singh, Indian School of Business, Knowledge City, Sector 81, SAS.Nagar, Mohali, 140 306, India, narendra_singh@isb.edu, Ahmed Timoumi

We study a supply chain where a manufacturer produces new products and refurbishes used products. The manufacturer sells new products through a retailer and decides whether to sell refurbished products directly or through the same retailer or through a different retailer. We examine whether and when should the manufacturer choose a particular channel for the refurbished products.

3 - Secondary Market Operational Strategy of OEM: the Impact of Inertia and Forward-looking Consumer
Ling-Fei Cai, Beijing Institute of Technology, Zhongguancun South Street No.5, Beijing, 100081, China, 461714207@qq.com, Xuan Shi

The thriving of secondary market has leaded to huge impact to durable good OEMs. In this paper, we consider a monopolist market with single manufacturer, discuss operational strategy which include pricing and secondary market control strategy, with the impact of inertia and forward-looking consumer. We show that, forward-looking consumer will not lead to cannibalization effect when the cost and durability of the product is high enough. The consumer constitution make great impact to the pricing and secondary market control strategy when the cost and the durability are modest, OEM should adopt high price and open up secondary market only when the proportion of forward-looking consumer is high enough.

■ WC76

372E

Three Facets of Integer Programming

Sponsored: Optimization, Integer and Discrete Optimization

Sponsored Session

Chair: Aleksandr M. Kazachkov, Carnegie Mellon University, Pittsburgh, PA, 15213-3890, United States, akazachk@cmu.edu

1 - Parametric Inequalities and the Solution of Multi-stage Optimization Problems
Ted K. Ralphs, Lehigh University, Industrial and Systems Engineering, 200 W. Packer Avenue, Bethlehem, PA, 18015, United States, ted@lehigh.edu

In this talk, we'll discuss the theoretical framework underlying solution algorithms based on the generation of so-called parametric valid inequalities for a general class of optimization problems that includes multi-stage and multi-level problems. We describe the theory of such inequalities, present methods for generating them, and describe a generalized branch-and-cut framework that incorporates them.

2 - Optimizing Truck Dispatching Decisions in Open-pit Mining using Integer Programming
Amanda Smith, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States, asmith28@wisc.edu, Jeff T. Linderoth, Jim R. Luedtke

We present a novel approach to the open-pit mining truck-dispatching problem that employs mixed-integer programming (MIP). The dispatching problem is challenging because it requires real-time decisions of a large-scale system with competing objectives. We propose an optimization-driven approach to solving the dispatching problem in the form of a MIP model. The model is difficult to solve directly within time constraints due to its large size. Therefore, we propose heuristic algorithms to quickly produce high quality feasible solutions to the model and present computational results demonstrating the effectiveness of the heuristics.

3 - Vehicle Routing Problems with Time Windows and Convex Node Costs
Qie He, University of Minnesota, 111 Church Street SE, Minneapolis, MN, 55455, United States, qhe@umn.edu, Yongjia Song

We study a problem of routing several vehicles to serve a set of customers within desired time windows and minimize the total customer inconvenience cost. We model the inconvenience cost of each customer as a convex function of her service starting time. We propose a set partitioning formulation for this problem, and apply a branch-and-price framework to solve this formulation. The computational study shows the effectiveness of our algorithm compared to state-of-the-art mixed integer convex programming solvers on an extensive set of instances with quadratic inconvenience costs.

4 - Learning to Run Heuristics in Tree Search
Elias Khalil, Georgia Institute of Technology, 1062 Hemphill Avenue NW, Atlanta, GA, 30318, United States, lyes@gatech.edu, Bistra Dilkina, George Nemhauser, Shabbir Ahmed, Yufen Shao

Primal Heuristics are a key contributor to the improved performance of branch-and-bound solvers for integer programming. We study the problem of deciding at which node a heuristic should be run, such that the overall primal performance of the solver is optimized. We present a theoretical framework for analyzing this decision-making process in a simplified setting, and use Machine Learning to predict whether a heuristic will succeed at a given node. Experimentally, our approach improves the primal performance of SCIP on MIPLIB2010 Benchmark and a family of hard Independent set instances.

■ WC77

372F

Optimization, Integer Programming

Contributed Session

Chair: Takeshi Tsuyuguchi, University of Colorado, Denver, CO, United States, takeshi.tsuyuguchi@ucdenver.edu

1 - A Branch and Cut Algorithm for the Set Covering Problem with Conflict Constraints
Saeed Saffari, North Carolina State University, Raleigh, NC, 27606, United States, ssaffar@ncsu.edu, Yahya Fathi

We consider the well-known set covering problem in which we have incompatibilities between certain pairs of columns, i.e., from each conflicting pair at most one column can occur in the optimal subset. We propose a branch-and-cut algorithm for solving this problem in which we employ appropriate valid inequalities derived from the corresponding conflict graph. We also introduce appropriate pre-processing techniques and a constructive heuristic algorithm in this context. We present the results of a limited computational experiment to demonstrate the effectiveness of the proposed methods.

2 - Solving Set Covering Problems via Benders Decomposition
Marcus V. Poggi, PUC-Rio, Rua M. S. Vicente 225, Rio de Janiero, 22591-900, Brazil, poggi@inf.puc-rio.br

We enhance Zou, Ahmed and Sun's 2016 work on Benders decomposition for stochastic programs with binary state variables with valid inequalities to reduce the integrality gap of the relaxation of the children problems. We apply the resulting algorithm to set covering problems with no special structure. We propose automatic decomposition strategies and focus the analysis on when certain strategies dominate others. Experiments are conducted over a series of well known literature set covering instances.

3 - Solving Clique Partitioning Problem: A Comparison of Models and Solvers
Takeshi Tsuyuguchi, University of Colorado, 4295 E Mexico Ave., Apt 206, Denver, CO, 80222, United States, takeshi.tsuyuguchi@ucdenver.edu, Gary Kochenberger, Haibo Wang

Finding optimal solutions to clique partitioning problems remains a computational challenge and is not practically possible. However, commercial solvers have improved tremendously in recent years, enabling acceptable, sometimes optimal, solutions for modest sized problems to be found in a reasonable amount of computer time. In this paper we explore and compare the use of four commercial solvers on a set of modest sized test problems. For each problem instance, a conventional linear model is compared with an alternative, equivalent quadratic model. Standard clique partitioning problems as well as those with minimum clique sized restrictions are considered.

■ WC78

381A

Power Network Transformation in Smart & Connected Communities

Sponsored: Energy, Natural Res & the Environment Electricity

Sponsored Session

Chair: Vignesh Subramanian, vigneshs@mail.usf.edu

Co-Chair: Tapas Das, das@usf.edu

1 - Harnessing Flexibleand Reliable Demand Response under Customer Uncertainties

Joshua Comden, Stony Brook University, Jericho, NY, 11753, United States, na, Zhenhua Liu

This work first models the problem of joint capacity planning and demand response program design by a stochastic optimization problem and then proposes online DR control policies based on the optimal structures of the offline solution. A distributed algorithm is developed for implementing the control policies without efficiency loss, which is further enhanced by allowing flexibilities into the commitment level. Numerical simulation results based on real-world traces demonstrate that the proposed algorithms can achieve near optimal social costs and significant social cost savings.

2 - Menu-based Pricing for Charging of Electric Vehicles with Vehicle-to-grid Service

Vaneet Aggarwal, Purdue University, 315 N. Grant St., West Lafayette, IN, 47906, United States, vaneet@purdue.edu, Arnob Ghosh

The paper considers a bidirectional power flow model of the electric vehicles (EVs) in a charging station where the EVs can inject energies by discharging via a Vehicle-to-Grid (V2G) service. However, frequent charging and discharging degrade battery life. A proper compensation needs to be paid to the users to participate in the V2G service. We propose a menu-based pricing scheme, where the charging station selects a price for each arriving user for the amount of battery utilization, the total energy, and the time (deadline) that the EV will stay. The user can accept one of the contracts or rejects all depending on their utilities. We explore social welfare and profit maximization strategies.

3 - Joint Strategies for Dynamic Pricing of Electricity and Demand Response in Smart and Connected Communities

Vignesh Subramanian, 5006, Bordeaux Village Pl, Apt #201, Tampa, FL, 33617, United States, vigneshs@mail.usf.edu, Tapas Das

A model-based methodology developed to aid policy makers to understand the joint behavior of the power producers, power systems operator, and S&CC aggregator. In this paper, we present a model that yields joint strategies for dynamic pricing (DP) and demand response (DR). The goal of DP is to offer consumers a stable advance price signals that are as close as possible to the real-time settlement price that results from the aggregator's cost minimizing DR decisions.

4 - Coordinating Procurement Decisions with a Dispatch Strategy

Mark Husted, Colorado School of Mines, 816 20th Street, Golden, CO, 80401, United States, mhusted@mines.edu

A optimization model designs and operates a hybrid power system consisting of diesel generators, photovoltaic cells and battery storage to minimize fuel use at remote sites subject to meeting variable demand profiles subject to the following constraints: (i) power generated must meet demand in every time period; (ii) power generated by any technology cannot exceed its maximum rating; and (iii) best practices should be enforced to prolong the life of the technologies. We solve instances of the model to within 2% of optimality and show that a model with minute time fidelity is able to meet highly variable energy demand using the procurement strategy dictated by a model with hourly time fidelity.

■ WC79

381B

Forestry II - Wildland Fire Management

Sponsored: Energy, Natural Res & the Environment Forestry

Sponsored Session

Chair: David L. Martell, University of Toronto, Toronto, ON, M5S 3B3, Canada, david.martell@utoronto.ca

1 - A MIP Model to Support the "Confine and Contain" Strategy in Large Fire Management

Yu Wei, Associate Professor, Colorado State University, Department of FRWS, Forestry 102, Fort Collins, CO, 80523, United States, yu.wei@colostate.edu, Matthew Thompson

We first delineate a landscape into potential fire control polygons (PCP) following potential fire control lines. We introduce a new mixed integer program (MIP) to optimally aggregate PCPs into a larger "box" with the expectation that, 1) a large fire would be contained within the box by fire line construction efforts along the box boundary; 2) point protection could be implemented in a box to protect homes and infrastructures. This model directly aggregates polygons into a contiguous patch. Test results illustrate how the size and shape of the box, along with the proportion of suppression effort devoted to line versus point protection activities, varies with ignition and weather scenarios.

2 - A Two-stage Model to Allocate Financial among Landowners for Controlled Burn

Hugh Medal, Mississippi State University, MS, United States, Medal, Hugh

This research aims to reduce the potential damage caused by a wildfire by encouraging controlled burns on private lands through a cost-share program. An agency having a limited budget offers financial assistance to the landowners with uncertainty about the landowner's decision of accepting or rejecting the offer. The objective is to optimally allocate the financial assistance among the landowners to minimize the expected total acreage burned. We model this problem as a two-stage stochastic program; the first-stage determines the agency's budget allocation decision among the landowners and the second-stage models the spread of fire through the landscape.

3 - Evaluating the Performance of the Aerial Forest Fire Detection System in the Province of Ontario, Canada

David L.Martell, University of Toronto, Faculty of Forestry, 33 Willcocks Street, Toronto, ON, M5S.3B3, Canada, david.martell@utoronto.ca

Forest fire management agencies often use fixed-wing detection aircraft that carry detection observers that search for undetected forest fires as the pilot flies planned routes. We describe how we used data collected by on-board GPS units that track the aircraft to estimate probability that a detection observer will find undetected fires and to evaluate the performance of the aerial detection system.

■ WC80

381C

Data-analytic Methods in Renewable Energy

Sponsored: Energy, Natural Res & the Environment, Energy

Sponsored Session

Chair: Andrea Staid, Sandia National Labs, Sandia National Labs, Albuquerque, NM, 87108, United States, astaid@sandia.gov

1 - Synchronicity Assessment for Wind Farm Siting: Wind Drought Dynamics with System Load

Kristen Schell, University of Michigan, 1891 Beal St., Ann Arbor, MI, 48109, United States, krschell@umich.edu, Seth Guikema, Brent McRoberts

There are over 10,000 individual wind turbines currently operating in the state of Texas. Tax credits have helped spur investment in the Texas wind industry, which anticipates a further 11 GW of new capacity additions in the near future. While this increase in wind capacity at times provides a remarkable percentage of load with renewable generation, variable wind power output is not often synchronous with peak demand, which raises the issue of its contribution to overall resource adequacy. Clustering the results of spectral analyses of wind droughts illustrate locations which can better contribute to resource adequacy, by providing wind power more highly synchronous with system load.

2 - Modeling Sustainable Energy Supply Case Study for Renewables and Natural Gas Synergy

Ebisa Wollega, Assistant Professor, Colorado State University Pueblo, 2200 Bonforte Blvd Room 260, Pueblo, CO, 81001, United States, ebisa.wollega@csupueblo.edu, Hiba Baroud, Vitor Winckler

The penetration of renewables into the power grids has significantly increased over the past decade. However, the supply uncertainty of the renewables results in complexities when modeling the supply and demand dynamics of power in the future. In this paper, we present a stochastic model of power networks in which we combine the renewables with natural gas through large scale data processing where the renewables are used as the main energy supply sources and the natural gas is used as a backup in order to minimize the supply uncertainty.

3 - Integrated Prediction of Wind Speed and Power Production

Jingxing Wang, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48109, United States, jeffwjx@umich.edu, Abdullah Alshelahi, Eunshin Byon, Romesh Saigal, Mingdi You

We present a new integrated prediction methodology for wind power production under the assumption that the underlying dynamics follow the Geometric Brownian Motion. The proposed predictive model is a novel integration of the sequential adaptive regularized learning power curve modeling, theories in real options and dual Kalman filtering. Our method provides promising results, achieving lower prediction errors than alternative methods.

4 - Data-driven Design and Market Participation of Energy Systems
Alexander W. Dowling, University of Notre Dame, Notre Dame, IN, 46556, United States, adowling@nd.edu, Farshud Sorourifar, Jose A. Renteria, Victor M. Zavala

We propose a multiscale optimization framework for economic assessment of energy systems (e.g., batteries, industrial demand response, large-scale solar) from historic electricity market prices. Our framework considers both energy and ancillary service transactions in day-ahead and real-time markets. Energy system physics are incorporated as constraints. We analyze over 1 trillion prices from the California electricity markets from 2015 and find strong incentives for fast dynamic flexibility. We show how co-optimizing design decisions (e.g., storage sizing, location) and market participation can reduce payoff periods from over 100 to less than 2 years for utility-scale batteries in CA.

■ WC82

382B

Robust Optimization Applications in Queueing and Data Centers

Sponsored: Optimization, Optimization Under Uncertainty

Sponsored Session

Chair: Chaithanya Bandi, c-bandi@kellogg.northwestern.edu

1 - A Robust Queueing Network Analyzer for a Series of Single-server Queues
Wei You, Columbia University, 100 Haven Ave, Apt. 18G, New York, NY, 10032, United States, wy2225@columbia.edu, Ward Whitt

Whitt and You (2016) developed a new Robust Queueing (RQ) algorithm to expose the impact of dependence on the mean steady-state workload of a single server queue. For the G/GI/1 model, that algorithm requires the index of dispersion for counts (IDC) and the rate of the arrival process. We show how that algorithm can be applied recursively to queues in series by (i) providing systematic ways to calculate or estimate the IDC for the external arrival process and (ii) developing an approximation for the IDC of a departure process. Extensive simulation experiments show that the algorithm is fast and accurate.

2 - Delay Performance of Scheduling Algorithms for Data Center Networks and Input Queued Switches
Siva Theja Maguluri, Georgia Institute of Technology, Atlanta, GA, United States, siva.theja@gatech.edu

Today's era of cloud computing is powered by massive data centers hosting servers that are connected by high speed networks. It is therefore desirable to design scheduling algorithms for data packets that have low computational complexity and result in small average packet delays. We consider the scheduling problem in an input-queued switch, which is a good abstraction for a data center network. We present low complexity scheduling algorithms that have optimal queue length (equivalently, delay) behavior in the heavy traffic regime. We also present bounds on the queue length in light traffic. These results are obtained using drift based arguments.

3 - Designing Optimal Priority Policies in Multi Class Queues via Robust Queueing Theory
Chaithanya Bandi, 2001 Sheridan Road, Suite 566, Evanston, IL, 60208, United States, chaitu1287@gmail.com

We consider the problem of dynamic resource provisioning and use tools from robust queueing theory and multi-stage optimization to present tractable solutions.

■ WC83

382C

Optimization, Linear Programming

Contributed Session

Chair: Sertalp Bilal Cay, Lehigh University, 200 West Packer Avenue, Department of Industrial and Systems Engineer, Bethlehem, PA, 18015-1582, United States, sertalpbilal@gmail.com

1 - Water with drawal and Consumption Reduction for Electrical Energy Generation Systems
Mohammad Hasan Balali, University of Wisconsin-Milwaukee, Milwaukee, WI, 53211, United States, mbalali@uwm.edu, Narjes Nouri

There is an increasing concern over shrinking water resources. Water use in the energy sector primarily occurs in electricity generation. A linear model is developed to minimize water consumption while considering several limitations and restrictions. California has planned to shut down some of its hydro and nuclear plants due to environmental concerns. Studies have been performed for various electricity generation and water saving scenarios, including no-hydro and no-nuclear plant and the results, are presented. Modifications to proposed different scenarios have been applied and discussed to meet the practical and reliability constraints.

2 - Aerial Autonomous Drones Optimal Allocation for Incident Detection
Houssam Ghandour, Student, Texas A&M.University, 1100 Hensel Drive, College Station, TX, 77840, United States, hmg06@tamu.edu, Luca Quadrifoglio

Traffic incidents contribute to 25% of the congestion in the US. Incidents are detected through inefficient methods which heavily depend on operators. Early detection would reduce the impact through faster response. This paper aims to utilize aerial autonomous drones as incident detectors. The drones fly through optimized paths in which they discover incident locations and send footage to the operators who benefit from the fast process. The main objective of the formulated algorithm is to minimize the total number of drones in the network along with optimizing the locations of the charging stations. Moreover, the algorithm integrates the average incident detection time as an input to the model.

3 - Multi-period Stochastic Optimization of a Second Generation Bioethanol Supply Chain
Atif Osmani, Assistant Professor, Minnesota State University Moorhead, 1104 7th Avenue South, 211F Hagen Hall, Moorhead, MN, 56563, United States, atif.osmani@mnstate.edu, Jun Zhang, Vinod Lall, Rachel Axness

This work proposes a multi-objective optimization model to design a sustainable multi-period second generation bioethanol supply chain under multiple uncertainties. The objective is to simultaneously maximize the economic, environmental, and social performance. The epsilon-constraint method is used to trade-off among the competing objectives and to achieve desired levels of sustainability. A solution approach involving sequential application of a Sample Average Approximation method and Benders decomposition is utilized to solve the optimization model efficiently and effectively.

4 - A Multiple Traveling Salesman Problem Model for Unmanned Aerial Vehicles Routing
Ashkan Mirzaee, Graduate Research Assistant, University of Missouri, 1133 Ashland Rd. Apt 1106, Columbia, MO, 65201, United States, amirzaee@mail.missouri.edu, Mohamed Awwad

Unmanned Aerial Vehicles (UAV) are gaining momentum in the field of commercial last-mile logistics. UAVs, commonly referred to as drones, can provide flexibility and efficiency for delivery of goods and services through aerial delivery. Finding the shortest delivery route between distribution center, docking stations and customers within the battery life window will considerably extend the drones' service level. This study considers Multiple Traveling Salesman Problem (mTSP) for UAVs' routing in the presence of a time window to find optimal set of routes for drones to traverse in a network of vertices that represent a distribution center, docking stations and customers.

5 - Application of Linear Programming in Optimizing the Procurement and Movement of Coal for an Indian Coal-fired Power Generating Company
Subrata Mitra, Professor, Indian Institute of Management Calcutta, Diamond Harbour Road, Joka, Kolkata, 700104, India, subrata@iimcal.ac.in, Balram Avittathur

In this paper, an application of linear programming (LP) in optimizing the procurement and movement of coal for an Indian coal-fired thermal power generating company is presented. Results show that there is immense potential not only for significant cost savings but also for reduced logistics between different coal source-power plant pairs. The issue of greenhouse gas (GHG) emissions from coal-fired power plants has also been addressed. The trade-off between the optimal total cost and GHG emission targets has been explored. Finally, recommendations and concluding remarks are presented.

6 - Warmstart of Interior Point Methods for Second Order Cone Optimization via Rounding over Optimal Jordan Frames
Sertalp Bilal Cay, PhD Candidate, Lehigh University, 200 West Packer Avenue, Department of Industrial and Systems Engineer, Bethlehem, PA, 18015-1582, United States, sertalpbilal@gmail.com, Imre Polik, Tamas Terlaky

Interior point methods (IPM) are the most popular approaches to solve Second Order Cone Optimization (SOCO) problems. In this talk, we present a novel warm-start method for IPMs to reduce the number of IPM steps to solve SOCO problems that appear in a Branch and Conic Cut (BCC) tree when solving Mixed Integer Second Order Cone Optimization (MISOCO) problems. Our method exploits the optimal Jordan frame of a subproblem and provides a primal-dual initial point for the self-dual embedding model by solving two auxiliary linear optimization problems. Numerical results on test problems in the CBLIB library show on average around 61% reduction of the IPM iterations for a variety of MISOCO problems."

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