DATA AND DECISIONS 2018

Thursday, November 1

7:45 – 8:10	**Continental Breakfast – Sabino Room**
8:10 – 8:15	Welcome Address Young-Jun Son (Department Head, Systems and Industrial Engineering, University of Arizona)
	Session: Optimization and Computation Chair: Pavlo Krokhmal
8:15 – 8:45	On the Limits of Computation in Non-convex Optimization Panos M. Pardalos (University of Florida)
8:45 – 9:15	Computational Operations Research Exchange (CORE) Suvrajeet Sen (University of Southern California)
9:15 – 9:45	The Solution Path of the Distributionally Robust SVMs Neng Fan (University of Arizona)
9:45 – 10:15	**Coffee Break**
	Session: Computer Experiments Chair: Jian Liu
10:15 – 10:45	Spatial-Temporal Kriging and Navier-Stokes Equations: A Prominent Example of Engineering Analytics Jeff Wu (Georgia Institute of Technology)
10:45 – 11:15	Pairwise Metamodeling of Multivariate Output Simulation Models Qiang Zhou (University of Arizona)
11:15 – 11:45	Experiment Designs for Inverse Approximations Russell Barton (Pennsylvania State University)
11:45 – 1:15	**Lunch – Kachina Lounge**

	Session: Optimization and Learning Chair: Jianqiang Cheng
1:15 – 1:45	Sequential Bilevel Linear Programming with Incomplete Information and Learning Oleg A. Prokopyev (University of Pittsburgh)
1:45 – 2:15	Efficient Pairwise Preference Elicitation Allowing for Indifference Juergen Branke (University of Warwick)
2:15 – 2:45	On the Inmate Transportation Problem Tamás Terlaky (Lehigh University)
2:45 – 3:15	**Coffee Break**
	Session: Advances in Quality and Reliability Engineering Chair: Qiang Zhou
3:15 – 3:45	High Dimensional Data Analysis for Anomaly Detection for Quality Improvements Jan Shi (Georgia Institute of Technology)
3:45 – 4:15	Missing Degradation Data Interpolation Elsayed A. Elsayed (Rutgers University)
4:15 – 4:45	Planning Sequential Accelerated Life Testing L.C. Tang (National University of Singapore)
4:45 – 5:15	Systems Monitoring and Personalized Health Management Kwok L. Tsui (City University of Hong Kong)
6:00 – 8:00	**Dinner – Agustin Kitchen**

Friday, November 2

8:00 – 8:30	**Continental Breakfast – Sabino Room**
	Session: Advances in Risk Averse Optimization Chair: Pavlo Krokhmal
8:30 – 9:00	Risk Management with POE, VaR, CVaR, and bPOE: Applications in Finance Stan Uryasev (University of Florida)
9:00 – 9:30	Partial Sample Average Approximation Method for Chance Constrained Problems Jianqiang Cheng (University of Arizona)

9:30 – 10:00 Distributionally Robust Models for Data-Driven Optimization of Reward-Risk Ratios
Miguel Lejeune (George Washington University)

10:00 – 10:30 **Coffee Break**

Session: Functional Data Analytics
Chair: Mohammed Shafae

10:30 – 11:00 Functional Linear Regression for Mixed Tensorial and Functional Predictors
Judy Jin (University of Michigan)

11:00 – 11:30 Detecting Bursts in Water Distribution Systems with Spatial-Temporal Data Analysis
Jian Liu (University of Arizona)

11:30 – 12:00 WCF-Approach for Complex System Reliability Assessment
Dan Yu (Chinese Academy of Sciences)

12:00 – 1:30 **Lunch – Tucson Room**

Session: Data and Networks
Chair: Matthias Poloczek

1:30 – 2:00 Inverse Optimization for Network Discovery
John R. Birge (University of Chicago)

2:00 – 2:30 Exact IP-based Solution Approaches for the Longest Induced Path Problem
Dmytro Matsypura (University of Sydney)

2:30 – 3:00 A Lagrangian Bound on the Clique Number and an Exact Algorithm for the Maximum Edge Weight Clique Problem
Sergiy Butenko (Texas A&M University)

3:00 – 3:30 **Coffee Break**

Session: Advances in Machine Learning
Chair: Neng Fan

3:30 – 4:00 High-Low Promotion Policies for Peak-End Demand Models
Georgia Perakis (Massachusetts Institute of Technology)

4:00 – 4:30 Interpretable AI
Dimitris Bertsimas (Massachusetts Institute of Technology)

4:30 – 5:00 Bayesian Optimization of Combinatorial Structures
Matthias Poloczek (University of Arizona)

5:00 – 5:30 Bayesian Optimization for Problems with Exotic Structure
Peter Frazier (Cornell University)

6:00 – 8:00 **Dinner – The Dutch Eatery & Refuge**

Experiment Designs for Inverse Approximations

Russell Barton | Pennsylvania State University

Joint work with Max Morris

Many simulation-based design optimization scenarios are driven by an underlying inverse problem. Rather than iteratively exercise the (computationally expensive) simulation to find a suitable design (i.e., match a target performance vector), one might instead iteratively exercise the simulation to fit an inverse approximation, and use the approximation to indicate designs meeting multivariate performance targets. This talk examines issues in defining optimal designs for fitting inverse approximations.

Russell Barton is Distinguished Professor of Supply Chain and Information Systems in the Smeal College of Business at Penn State, and was senior associate dean from 2013-1018. He holds a courtesy appointment in the Department of Industrial and Manufacturing Engineering. From 2010-2012 was Program Director for Manufacturing Enterprise Systems and Service Enterprise Systems at the U. S. National Science Foundation. From 2006-2010 he was Co-Director of the Master of Manufacturing Management degree program at Penn State. From 2002-2005 he served as Associate Dean for Research and Ph.D./M.S. Programs in the Smeal College of Business. He was a professor in the Department of Industrial and Manufacturing Engineering at Penn State for eleven years prior to joining Smeal. He began his academic career at Cornell University in the School of Operations Research and Industrial Engineering after eleven years in industry and consulting. He holds a B.S. in electrical engineering from Princeton University, and M.S. and Ph.D. degrees in operations research from Cornell University. Dr. Barton's research has focused on the interface between applied statistics, simulation, and product design and manufacturing. He has received thirty grants supporting research and teaching, and has 150 technical publications. He serves as associate editor for Operations Research and the IMA Journal of Management Mathematics. He is Vice President of INFORMS Sections and Societies, Chair of the INFORMS Subdivisions Council and a member of the INFORMS Board of Directors. He is a Fellow of IISE and Senior Member of IEEE. He is a Certified Analytics Professional , and serves on the Analytics Certification Board.

Interpretable AI

Dimitris Bertsimas | Massachusetts Institute of Technology

Joint work with Jack Dunn

We introduce a new generation of machine learning methods that provide state of the art performance and are very interpretable. We introduce optimal classification (OCT) and regression (ORT) trees for prediction and prescription with and without hyperplanes. We show that (a) Trees are very interpretable, (b) They can be calculated in large scale in practical times and (c) In a large collection of real world data sets they give comparable or better performance than random forests or boosted trees. Their prescriptive counterparts have a significant edge on interpretability and comparable or better performance than causal forests. Finally, we show that optimal trees with hyperplanes have at least as much modeling power as (feedforward, convolutional and recurrent) neural networks and comparable performance in a variety of real world data sets. These results suggest that optimal trees are interpretable, practical to compute in large scale and provide state of the art performance compared to black box methods.

Dimitris Bertsimas is currently the Boeing Professor of Operations Research, the co-director of the Operations Research Center, and faculty director of the Master of Business analytics at MIT. He received his SM and PhD in Applied Mathematics and Operations Research from MIT in 1987 and 1988 respectively. He has been with the MIT faculty since 1988. His research interests include optimization, machine learning and applied probability and their applications in health care, finance, operations management and transportation. He has co-authored more than 200 scientific papers and four graduate level textbooks. He is the editor in Chief of INFORMS Journal of Optimization and former department editor in Optimization for Management Science and in Financial Engineering in Operations Research. He has supervised 67 doctoral students and he is currently supervising 25 others. He is a member of the National Academy of Engineering since 2005, an INFORMS fellow, and he has received numerous research and teaching awards including the Morse prize (2013), the Pierskalla award for best paper in health care (2013), the best paper award in Transportation (2013), the Farkas prize (2008), the Erlang prize (1996), the SIAM prize in optimization (1996), the Bodossaki prize (1998) and the Presidential Young Investigator award (1991-1996).

Inverse Optimization for Network Discovery

John R. Birge | University of Chicago

Networks determine the behavior of many social, economic, and physical systems, but often their structure is not directly observed. Limited observations can however be used to infer that structure based on assumptions of optimizing agent behavior. This talk will discuss how to use these observations to recover network structure in general networks and specific examples in electricity markets, gasoline distribution, and international finance.

John R. Birge is the Jerry W. and Carol Lee Levin Distinguished Service Professor of Operations Management at the University of Chicago Booth School of Business. Previously, he was Dean of the McCormick School of Engineering and Applied Science and Professor of Industrial Engineering and Management Sciences at Northwestern University. He also served as Professor and Chair of Industrial and Operations Engineering at the University of Michigan, where he also established the Financial Engineering Program. He is former Editor-in-Chief of Mathematical Programming, Series B, former President of INFORMS, and current Editor-in-Chief of Operations Research. His work focuses on stochastic optimization methods and analysis as well as applications in multiple domains. His honors and awards include the CORS Harold Larnder Prize, IIE Medallion Award, the INFORMS Fellows Award, the MSOM Society Distinguished Fellow Award, the Harold W. Kuhn Prize, the George E. Kimball Medal, the William Pierskalla Award, and election to the US National Academy of Engineering. He received M.S. and Ph.D. degrees from Stanford University in Operations Research, and an A.B. in Mathematics from Princeton University.

Efficient Pairwise Preference Elicitation Allowing for Indifference

Juergen Branke | University of Warwick

Many methods in Multi-Criteria Decision Analysis rely on eliciting pairwise preference information in their attempt to efficiently identify the most preferred solution out of a larger set of solutions. That is, they repeatedly ask the decision maker (DM) which of two solutions is preferred, and then use this information to reduce the number of possibly preferred solutions until only one remains. However, if the solutions have a very similar value to the DM, the DM may not be able to accurately decide which solution is preferred. We present a method that extends Robust Ordinal Regression to allow a user to declare indifference in case the values of the two solutions do not differ by more than some personal threshold. Second, we propose and compare several heuristics to pick pairs of solutions to be shown to the decision maker in order to minimize the number of interactions necessary.

Juergen Branke is Professor of Operational Research at Warwick Business School, UK. His main research interests include metaheuristics, optimisation under uncertainty and multi-objective optimisation and decision analysis. Juergen has published over 180 papers in peer-reviewed journals and conferences and is Area Editor of the Journal of Heuristics and the Journal of Multi-Criteria Decision Analysis, and Associate Editor of IEEE Transactions on Evolutionary Computation and the Evolutionary Computation Journal.

A Lagrangian Bound on the Clique Number and an Exact Algorithm for the Maximum Edge Weight Clique Problem

Sergiy Butenko | Texas A&M University

Joint work with Seyedmohammadhossein Hosseinian and Dalila B.M.M. Fontes

We explore the connections between the classical maximum clique problem and its edge-weighted generalization, the maximum edge weight clique (MEWC) problem. As a result, a new analytic upper bound on the clique number of a graph is obtained and an exact algorithm for solving the MEWC problem is developed. The bound on the clique number is derived using a Lagrangian relaxation of an integer (linear) programming formulation of the MEWC problem. Furthermore, coloring-based bounds on the clique number are utilized in a novel upper-bounding scheme for the MEWC problem. This scheme is employed within a combinatorial branch-and-bound framework, yielding an exact algorithm for the MEWC problem. Results of computational experiments demonstrate a superior performance of the proposed algorithm compared to existing approaches.

Sergiy Butenko is a Professor and Donna and Jim Furber '64 Faculty Fellow in Industrial and Systems Engineering at Texas A&M University. He also serves as the Editor-in-Chief of Journal of Global Optimization. He received his B.S. and M.S. degrees in Mathematics at Kyiv National Taras Shevchenko University (Ukraine) and M.S. and Ph.D. degrees in Industrial and Systems Engineering at the University of Florida. His research focuses on discrete and global optimization, network analysis and network-based data mining, and graph theory. Applications of interest include biological, social, and financial networks, wireless ad hoc and sensor networks, transportation, and energy systems. His work has been supported by the Air Force office of Scientific Research, the U.S. Department of Energy, the National Science Foundation, and North Atlantic Treaty Organization, and the Office of Naval Research. In particular, he was a recipient of Air Force Office of Scientific Research Young Investigator Program Award in 2008.

Partial Sample Average Approximation Method for Chance Constrained Problems

Jianqiang Cheng | University of Arizona

In this talk, we present a new scheme of a sampling-based method, named Partial Sample Average Approximation (PSAA) method, to solve chance constrained programs. In contrast to Sample Average Approximation (SAA) which samples all of the random variables, PSAA only samples a portion of random variables by making use of the independence of some of the random variables for stepwise evaluation of the expectation. The main advantage of the proposed approach is that the PSAA approximation problem contains only continuous auxiliary variables, whilst the SAA reformulation contains binary ones. Moreover, we prove that the proposed approach has the same convergence properties as SAA. At the end, a numerical study on different applications shows the strengths of the proposed approach, in comparison with other popular approaches, such as SAA and scenario approach.

Jianqiang Cheng is an assistant professor in the department of Systems and Industrial Engineering at the University of Arizona. His research interests include stochastic programming, robust optimization, semidefinite and copositive optimization, and applications of stochastic programming in energy management. He is the recipient of the Bisgrove Scholar award from the Science Foundation of Arizona.

Missing Degradation Data Interpolation

Elsayed A. Elsayed | Rutgers University

Joint work with Changxi Wang

Degradation data is important in reliability and remaining life estimation. Missing data is a common problem due to failure of degradation data acquisition process or human errors. Accurate reliability prediction and estimation depends on data availability. In this presentation we develop approaches to interpolate the values of the missing data in order to improve reliability prediction. We propose stochastic approaches to bridge the missing data, they are nonlinear Brownian bridge, nonlinear Gamma bridge and inverse Gaussian bridge. The proposed approaches are validated with actual corrosion degradation data. Results show the three methods perform well in data interpolation of nonlinear degradation process.

E. A. Elsayed is Distinguished Professor of the Department of Industrial and Systems Engineering, Rutgers University. He served as Chairman of the Industrial and Systems Engineering, Rutgers University, from 1983 to 2001. He is also the Director of the NSF/ Industry/ University Co-operative Research Center for Quality and Reliability Engineering. His research interests are in the areas of quality and reliability engineering and Production Planning and Control. He is a co-author of Quality Engineering in Production Systems, McGraw Hill Book Company, 1989. He is also the author of Reliability Engineering, Addison-Wesley, 1996. These two books received the 1990 and 1997 IIE Joint Publishers Book-of-the-Year Award respectively. His recent book Reliability Engineering 2nd Edition, Wiley, 2012 received the 2013 Outstanding IIE Publication.

Dr. Elsayed is also a co-author of Analysis and Control of Production Systems, Prentice-Hall, 2nd Edition, 1994. His research has been funded by the DoD, FAA, NSF, Defense Logistics Agency and many industrial companies including Lockheed Martin and Cummins Filtration. Dr. Elsayed has been a consultant for AT&T Bell Laboratories, Ingersoll-Rand, Johnson & Johnson, Personal Products, AT&T Communications, BellCore and other companies. He served as a Member of the Panel on Theory and Applications of Reliability Growth Modeling to Defense Systems, National Research Council of National Academic. He also served as the Editor-in-Chief of the IIE Transactions and the Editor of the IIE Transactions on Quality and Reliability Engineering. Dr. Elsayed is the Editor of the International Journal of Reliability, Quality and Safety Engineering. He serves on the editorial boards of eight journals in different capacities. He served an external evaluator for many undergraduate and graduate programs.

Dr. Elsayed is a frequent keynote speaker in National and International Conferences and is the recipient of many awards including the Rutgers University Board of Trustees Award for Excellence in Research for the academic year 2015-2016, Golomski Award for the outstanding paper, several Best Paper awards, William Mong Distinguished Lecturers Award, David F. Baker Research Award of the Institute of Industrial and Systems Engineering for Research Contributions to the discipline, IISE (Institute of Industrial and Systems Engineering) Fellow Award, ASME (American Society of Mechanical Engineers) Fellow, Senior Fulbright Award and the Recipient of 2011 Thomas Alva Edison Award for US Patent 7,115,089 B2. Most recently, Dr. Elsayed was awarded the Doctor Honoris Causes from University of Agers, France in January 2018 for his achievements in the reliability engineering filed.

Dr. Elsayed's current research focuses on the reliability testing, modeling and estimation of spatially distributed and balanced systems, degradation modeling and testing of total artificial heart (TAH) and resilience and reliability of complex networks.

The Solution Path of the Distributionally Robust SVMs

Neng Fan | University of Arizona

Over the last several decades, many advanced technologies have been developed to collect and store data continuously, and data and decisions are more strongly linked together than ever before. In most cases, the data includes a lot of uncertainties, such as missing or incomplete information, measurement errors, communication errors, noise, etc. Traditional machine learning methods for decisions are dealing with the exact information of data. On the other hand, many learning algorithms require to set parameters before learning from and making predictions on data. Cross-validation is often used for parameter tuning but it can be very slow due to its repeatedly training process. To resolve these issues and to make robust and efficient classifications, we propose a distributionally robust optimization model with Wasserstein ambiguity set to generalize the classic support vector machines (SVMs), and a solution path algorithm based on active set methods to speed up parameter tuning. Numerical experiments will be performed to validate the generalized model and show the computational efficiency of the solution path algorithm.

Dr. Neng Fan is an assistant professor at Department of Systems and Industrial Engineering, University of Arizona. He received PhD degree from the Department of Industrial and Systems Engineering at University of Florida. Before joining UA, he worked in Los Alamos National Laboratory and Sandia National Laboratories. His research interests include optimization, applied operations research, machine learning, and their applications in power grid, water systems, healthcare and sustainable agriculture.

Bayesian Optimization for Problems with Exotic Structure

Peter Frazier | Cornell University

Bayesian optimization methods are designed to optimize black-box objective functions that take a long time to evaluate, such as those arising in tuning deep neural network architectures, A/B-testing-based design of mobile apps and online marketplaces, aerospace engineering, and materials science. The most widely-used Bayesian optimization method, expected improvement, works well under when we evaluate a noise-free objective without derivatives one point at a time. The one-step optimality analysis underlying expected improvement, however, does not generalize easily to other problem settings. In this talk, we present a new computational method, based on infinitessimal perturbation analysis and the envelope theorem, which allows efficient computation of one-step optimal knowledge-gradient procedures in a large class of exotic Bayesian optimization settings. We show how this leads to new methods with state-of-the-art performance for problems with parallel function evaluations; derivative observations; optimization of integrals and sums of expensive-to-evaluate integrands; and optimization with multiple fidelities and information sources. We also discuss applications of these methods at Yelp, Uber, and the Bayesian optimization startup company SigOpt.

Peter Frazier is an Associate Professor in the School of Operations Research and Information Engineering at Cornell University, and a Staff Data Scientist at Uber. His academic research focuses on optimal learning, including Bayesian optimization and incentive design for social learning, with applications in e-commerce, the sharing economy, and materials design. His research at Uber focuses on pricing, matching algorithms for carpooling, and marketplace design for driver flexibility. He is the winner of an AFOSR Young Investigator Award and an NSF CAREER award.

Functional Linear Regression for Mixed Tensorial and Functional Predictors

Jionghua (Judy) Jin | University of Michigan

This paper focuses on finding a mathematical relationship between a quality response variable and some process variables that are not necessarily scalar or functional. Indeed, some of the predictors are in the form of tensors in addition to the regular functional or scaler predictors. The developed model is called functional linear regression with tensorial predictor (FLRTP). The advantage of this methodology compared to classical functional data analysis and linear regression methods is that it can handle both functional and tensorial predictors without performing vectorization on the tensorial predictors. This is helpful since the multi-stream structure of the predictor is preserved and the number of parameters to be estimated is kept at a reasonable amount. The performance of all methods is evaluated using simulation and a real-world study.

Jionghua (Judy) Jin is currently a professor in the Department of Industrial and Operations Engineering and the Director of Manufacturing Engineering Program at the University of Michigan. She received her PhD in Industrial and Operations Engineering at the University of Michigan in 1999.

Dr. Jin's research focuses on developing new data fusion methodologies in quality engineering with broad applications in both manufacturing and service industries. She has received numerous awards including the Forging Achievement Awards, the NSF CAREER Award, and the prestigious Presidential (PECASE) Award, and 12 Best Paper Awards since 2000. She is currently the Focus Issue Editor for IIE Transactions on Quality Control and Reliability Engineering, and was Vice President of INFORMS and the President of QCRE division in IIE. She is a Fellow of IIE, a Fellow of ASME, an elected senior member of ISI, a senior member of ASQ, and a member of IEEE, INFORMS, and SME.

More information about Professor Judy Jin can be found at http://jhjin.engin.umich.edu/

Exact IP-based Solution Approaches for the Longest Induced Path Problem

Dmytro Matsypura | University of Sydney

Graph diameter, which is defined as the longest shortest path in a graph, is often used to quantify graph communication properties. In particular, the graph diameter provides an intuitive measure of the worst-case pairwise distance. However, in many practical settings, where vertices can either fail or be overloaded or can be destroyed by an adversary and thus cannot be used in any communication or transportation path, it is natural to consider a more general measure of worst-case distance. One such measure is the longest induced path. The longest induced path problem is defined as finding the subgraph of the largest cardinality such that this subgraph is a simple path. In contrast to the polynomially computable graph diameter, this problem is NP-hard. In this paper, we focus on exact solution approaches for the problem based on linear integer programming (IP) techniques. We first propose three conceptually different linear IP models and study their basic properties. To improve the performance of the standard IP solvers, we propose an exact iterative algorithm that solves a sequence of smaller IPs to obtain an optimal solution for the original problem. In addition, we develop a heuristic capable of finding induced paths in large networks. Finally, we conduct an extensive computational study to evaluate the performance of the proposed solution methods.

Dmytro Matsypura is a Senior Lecturer in the Discipline of Business Analytics at the University of Sydney Business School. His current research focus is on applications of convex and combinatorial optimisation in forecasting, graph theory, finance, transportation, and ecology.

Dr. Matsypura received a bachelor degree in Business Administration, with honours, in 1998, an MS degree in Information Systems, with honours, in 2000 from Kyiv Polytechnic Institute. He received his Ph.D. degree in Management Science from UMass Amherst in 2006. In 2007 he joined the Discipline of Business Analytics at the University of Sydney.

Dr. Matsypura is the author of many research articles and several book chapters. He currently teaches undergraduate courses in Applied Linear Algebra, Management Science and Optimisation. From 2004 through he also taught courses in Business and Economic Statistics, Operations Management, Management Science Applications and Game Theory. In 2010 he received the Wayne Lonergan Outstanding Teaching Award (Early Career) in the Business School and in 2008 and 2013, at the Discipline of Business Analytics Teaching Excellence Award.

Detecting Bursts in Water Distribution Systems with Spatial-Temporal Data Analysis

Jian Liu | University of Arizona

Bursts in water distribution systems (WDSs) are a special case of short-term, high-flow water loss that can be a significant component of a system's water balance. Continuous hydraulic data streams collected from automatic meter reading and advanced metering infrastructure systems make it possible to detect bursts in WDS based on data analytics. Existing methods based on conventional statistical process control charts may not be effective, as the spatial-temporal correlations imbedded in the data streams are not explicitly considered. In this research, a new control chart for burst detection based on spatial-temporal data analysis is proposed. The spatial-temporal correlations are modeled from empirical data stream continuously collected from the same WDS and their statistical properties are studied to reflect system inherent uncertainties induced by customers' daily use without bursts. The bursts are detected by comparing the new hydraulic data stream with the inherent uncertainties through statistical control charting. The new method will significantly reduce the rate of false alarm and miss detection. The effectiveness of the proposed method is demonstrated with a case study based on numerical simulation of a real-world WDS.

Dr. Jian Liu is an Associate Professor in the Department of Systems & Industrial Engineering at The University of Arizona. Dr. Liu's research specialty is in the fusion of multi-source, multi-scale and multi-level information in hierarchical and distributed systems for better system design, operation and maintenance. He serves as an Associate Editor of the Journal of Manufacturing Systems since 2017. He is a member of INFORMS and a member of IISE. He served as a Council Member of Quality, Statistics and Reliability Section of INFORMS from 2012 to 2014, a Board Director of the Quality Control and Reliability Engineering (QCRE) Division of IISE from 2013 to 2015, and the President of QCRE from 2016 to 2017. His research has been supported by NSF, AFOSR, among others.

Distributionally Robust Models for Data-Driven Optimization of Reward-Risk Ratios

Miguel Lejeune | George Washington University

Joint work with R. Ji

We study a class of fractional distributionally robust optimization problems that maximize ambiguous fractional functions representing reward-risk ratios. We derive a closed form to compute a bound on the size of the Wasserstein ambiguity ball and design a data-driven reformulation and solution framework. This class of models have wide applicability for the construction of financial portfolios based on risk-adjusted measures. We specify new ambiguous portfolio optimization models for the Sharpe and Omega ratios. The computational study shows the applicability and scalability of the framework to solve industry-relevant size problems, which cannot be solved in one day with state-of-the-art MINLP solvers.

Miguel Lejeune is a Professor of Decision Sciences at the George Washington University (GWU). His research interests are in stochastic programming, data-driven optimization, and financial risk. He is the recipient of the CAREER Award from the Army Research Office and of the IBM Smarter Planet Faculty Innovation Award.

On the Limits of Computation in Non-convex Optimization

Panos M. Pardalos | University of Florida

Large scale problems in engineering, in the design of networks and energy systems, the biomedical fields, and finance are modeled as optimization problems. Humans and nature are constantly optimizing to minimize costs or maximize profits, to maximize the flow in a network, or to minimize the probability of a blackout in a smart grid. Due to new algorithmic developments and the computational power of machines (digital, analog, biochemical, quantum computers etc), optimization algorithms have been used to "solve" problems in a wide spectrum of applications in science and engineering. But what do we mean by "solving" an optimization problem? What are the limits of what machines (and humans) can compute?

Panos Pardalos is a Distinguished Professor and the Paul and Heidi Brown Preeminent Professor in the Departments of Industrial and Systems Engineering at the University of Florida, and a world renowned leader in Global Optimization, Mathematical Modeling, and Data Sciences. He is a Fellow of AAAS, AIMBE, and INFORMS and was awarded the 2013 Constantin Caratheodory Prize of the International Society of Global Optimization. In addition, Dr. Pardalos has been awarded the 2013 EURO Gold Medal prize bestowed by the Association for European Operational Research Societies. This medal is the preeminent European award given to Operations Research (OR) professionals for "scientific contributions that stand the test of time." Dr. Pardalos is also a Member of the New York Academy of Sciences, the Lithuanian Academy of Sciences, the Royal Academy of Spain, and the National Academy of Sciences of Ukraine. He is the Founding Editor of Optimization Letters, Energy Systems, and Co-Founder of the International Journal of Global Optimization, and Computational Management Science. He has published over 500 papers, edited/authored over 200 books and organized over 80 conferences. He has a google h-index of 94 and has graduated 61 PhD students so far.

High-Low Promotion Policies for Peak-End Demand Models

Georgia Perakis | Massachusetts Institute of Technology

Joint work with Tamar Cohen-Hillel and Kiran Panchamgam

Promotions are a highly effective marketing tool that can have a significant impact on a retailer's profit. A strong understanding of how changes in the price affect consumers' purchasing behavior can lead to more effective promotions policies and as a result, to a substantial increase in profit for retailers. Incorporating important consumer behavioral effects in the demand model is crucial in order to better predict demand. In this talk, we will present a new demand model that relies not only on current and past period prices but more importantly, on the minimum price set within a set of past periods (bounded memory peak-end). Furthermore, using these as features and employing machine learning tools, we show that this new demand model predicts actual sales more accurately than current methods. We test our prediction approach on sales data from a large retailer and demonstrate that there is a 9% relative improvement in the precision of the demand prediction. This new demand model also allows us to determine the optimal promotion strategy more efficiently. That is, subsequently, we suggest a compact Dynamic Programming (DP) approach that uses the proposed demand model. We examine when this DP solves the problem optimally. That is, we establish when, for some commonly used demand models (including the one proposed in this talk), the proposed DP solves the promotion planning optimization problem exactly. In fact, we confirm a common practice by retailers, that is when and for what demand models, the optimal promotion strategy is to either promote (always at the same level of promotion) or not promote an item at all. For demand models where these conditions do not hold, we provide an analytical guarantee for our proposed DP and illustrate that still the proposed DP yields near optimal solutions fast. Furthermore, on the same sales data we tested our demand prediction approach on, we demonstrate that the proposed DP yields on average a 9.1% increase in profit relative to the retailer's current practices.

Georgia Perakis is the William F. Pounds Professor of Management and a Professor of Operations Research, Statistics and Operations Management at the MIT Sloan School of Management. She has been on the faculty at MIT Sloan since July 1998.

Perakis teaches courses and performs research on analytics, optimization, quantitative models for managers, dynamic pricing, and revenue management among others. At MIT over the years, she has taught in a variety of programs such as MBA, EMBA, undergraduate, MSc and PhD programs across MIT. For her teaching, Perakis won the Graduate Student Council Teaching Award in 2002 as well as the Jamieson Prize in 2014 for excellence in teaching and the Teacher of the Year award (among all faculty at the MIT Sloan School) in 2017.

In her research, she investigates the theory and practice of analytics. She is particularly interested on how to solve complex and practical problems in pricing, revenue management, supply chains, logistics and energy applications among others. She has widely published in some of the flagship journals of the field such as Operations Research, Management Science, POM, Mathematics of Operations Research and Mathematical Programming among others.

She has received the CAREER Award from the National Science Foundation and the PECASE Award from the Office of the President on Science and Technology. In 2016, she was elected as an INFORMS Fellow, that recognizes individuals for lifetime achievement to the field. In addition to the above, her work has received recognition with awards such as the TSL Best Paper Award, the Best Paper competition of the Informs Service Science Section several times as well as Best Application of Theory Award from NEDSI (Northeast Decision Sciences Institute) Conference. Her work on promotions with the Oracle RGBU was a finalist at the Practice Award of the RMP Section of INFORMS in 2015. In addition, her work on predicting demand for new products that was tested with Johnson and Johnson won first place at the Applied Research Challenge Competition in 2018.

Perakis has passion supervising PhD, masters and undergraduate students and builds lifelong relationships with them. So far, she has graduated twenty-one PhD and forty-seven Masters students. In 2012, she received the Samuel M. Seegal Award for inspiring student to achieve excellence.

From 2009 to July 2015, Perakis served as the Sloan faculty Co-Director of the Leaders for Global Operations (LGO) Program at MIT (joint program between the Sloan School and the School of Engineering). She has also served as the group head of the Operations Management group at MIT Sloan School from 2010-2017. Currently, and since July 2017, she has been serving as the faculty director of the Executive MBA (EMBA) program at MIT Sloan.

She also currently serves as an Associate Editor for the flagship journals of the field: Management Science, Operations Research and as a senior editor for POM. She has served as the chair of the RMP Section of INFORMS and as the VP of Meetings of the MSOM Society of INFORMS.

Perakis holds a BS in mathematics from the University of Athens as well as an MS in applied mathematics and a PhD in applied mathematics from Brown University.

Bayesian Optimization of Combinatorial Structures

Matthias Poloczek | University of Arizona

Joint work with Ricardo Baptista

The optimization of expensive-to-evaluate black-box functions over combinatorial structures is an ubiquitous task in machine learning, engineering and the natural sciences. The combinatorial explosion of the search space and costly evaluations pose challenges for current techniques in discrete optimization and machine learning, and critically require new algorithmic ideas.

In this talk we will propose Bayesian optimization of combinatorial structures (BOCS), that takes a novel approach to overcome these challenges. It is based on an adaptive scalable statistical model that is able to identify useful combinatorial structures even when data is scarce. BOCS' acquisition function pioneers the use of semidefinite programming to achieve efficiency and scalability. We will also discuss a comprehensive experimental evaluation that demonstrate that BOCS consistently outperforms other methods from combinatorial and Bayesian optimization.

Matthias Poloczek is an assistant professor in the Department of Systems and Industrial Engineering at the University of Arizona and the principal investigator for Bayesian optimization at Uber AI Labs. His research focuses on efficient algorithms with performance guarantees in machine learning and combinatorial optimization, in particular for applications in simulation optimization, aerospace engineering, and materials science. Before joining UA, he worked as postdoctoral researcher with David P. Williamson and Peter I. Frazier at Cornell University in Ithaca NY. His webpage is http://www.sie.arizona.edu/poloczek.

Sequential Bilevel Linear Programming with Incomplete Information and Learning

Oleg A. Prokopyev | University of Pittsburgh

Joint work with Juan Borrero and Denis Saure

We present a framework for a class of sequential decision-making problems in the context of bilevel programming, where a leader and a follower repeatedly interact. At each period, the leader allocates resources to disrupt the performance of the follower (e.g., as in defender-attacker or interdiction problems), who in turn minimizes some cost function over a set of activities that depends on the leader's decision. While the follower has complete knowledge of his problem, the leader has only partial information, and needs to learn about the cost parameters, available resources, and the follower's activities from the feedback generated by the follower's actions. We measure policy performance in terms of its time-stability, defined as the number of periods it takes for the leader to match the actions of an oracle with complete information. In this talk, we first focus on max-min problems for which we propose a class of greedy and robust policies that are weakly optimal, eventually match the oracle's actions, and provide a real-time certificate of optimality. Then we also discuss the case of the asymmetric bilevel problem. Here, the objective of the leader is not necessarily to maximize the disruption of the follower's performance and she might optimize some other objective function.

Dr. Oleg Prokopyev is a Professor in the Department of Industrial Engineering at the University of Pittsburgh. He received MS and PhD degrees in industrial and systems engineering from the University of Florida and BS and MS degrees in applied mathematics and physics from Moscow Institute of Physics and Technology (Moscow, Russia). Dr. Prokopyev's research interests are in the areas of combinatorial optimization, stochastic programming and applications of Operations Research in health care, bioinformatics, network analysis and military problems. His research has been supported by the National Science Foundation, Air Force Office of Scientific Research (AFOSR), Department of Veteran Affairs and the Defense Threat Reduction Agency. Dr. Prokopyev is a recipient of the AFOSR Young Investigator Program Award. He is the Co-Editor-in-Chief of Optimization Letters and serves on the editorial boards of IIE Transactions, Journal of Global Optimization and Omega.

Computational Operations Research Exchange (CORE)

Suvrajeet Sen | University of Southern California

Joint work with Yunxiao Deng, Carl Kesselman, and Jiajun Xu

The terms "big data", "data deluge" etc. are pervasive in today's conversations about data to decisions modeling. Yet, most OR methodology is still tested on instances which were created prior to widespread availability of large, practical data sets. In addition, computational testing, and reproducibility of computational results for optimization remain somewhat primitive. One could argue that most of the current computational infrastructure was developed prior to widespread availability of new software technology to support "plug-and-play portability". In the absence of such modern infrastructure, the science underlying computational experiments, and the evolution of optimization algorithms (in terms of survival of the fittest) is obviously jeopardized. In this talk we will provide an overview of the scope of CORE ...its data sets, as well as "data to decisions" workflow that can be supported via the new platform.

Suvrajeet Sen is a Professor in the Epstein Department of Industrial and Systems Engineering at the University of Southern California. His research interests are in Modeling, Optimization Research and Education (MORE), and its support through CORE. He works on research topics which lend themselves to R & R (rapping and rhyming).

High Dimensional Data Analysis for Anomaly Detection for Quality Improvements

Jianjun (Jan) Shi | Georgia Institute of Technology

Analysis and modeling of the large-scale high-dimensional streaming data is a very important and challenging problem. This talk focuses on modeling the high-dimensional data obtained from sensors for assessment of system performance, early detection of system anomalies, intelligent sampling and sensing for data collection and decision making to achieve optimal system performance. The developed methodology is efficient and scalable and can be applied for data with complex heterogeneous data structure to extract information or useful features. The talk will discuss four interrelated topics: (i) detect anomalies from high-dimensional image data by using smooth sparse decomposition (SSD), which exploits regularized high-dimensional regression to decompose an image and separate anomalous regions by solving a large-scale optimization problem; (ii) introduce spatio-temporal smooth sparse decomposition (ST-SSD) method for dimension reduction, denoising, and anomaly detection of high dimensional streaming video data; (iii) adaptive sampling for high-dimensional functional data to speed up the inspection and anomaly detection through an intelligent sequential sampling scheme integrated with fast estimation and detection. (iv) dynamic multivariate functional data modeling via sparse subspace learning to achieve automatic data segmentation and grouping for high-dimensional functional data with complex cross-correlation structure. All those topics presented above are research results from on-going funded projects with real industrial data. Examples and real case studies will be used to illustrate the new algorithms, methodologies, and validation results.

Dr. Jianjun Shi is the Carolyn J. Stewart Chair and Professor in School of Industrial and Systems Engineering, with a joint appointment in School of Mechanical Engineering, both at Georgia Institute of Technology. Prior to joining Georgia Tech in 2008, he was the G. Lawton and Louise G. Johnson Professor of Engineering at the University of Michigan. He received his B.S. and M.S. in Electrical Engineering from Beijing Institute of Technology in 1984 and 1987, and his Ph.D. in Mechanical Engineering from the University of Michigan in 1992.

Dr. Shi's research is in the area of data enabled manufacturing. His methodologies integrate system informatics, advanced statistics, and control theory, and fuse engineering systems models with data science methods for design and operational improvements of manufacturing and service systems. The technologies developed by Dr. Shi's research group have been widely implemented in a wide variety of production systems and produced significant economic impacts. Dr. Shi is the founding chair of the Quality, Statistics and Reliability (QSR) Subdivision at INFORMS, and currently serving as the Editor-in-Chief of the IISE Transactions, the flagship journal of the Institute of Industrial and Systems Engineers (IISE). He is a Fellow of IISE, ASME, and INFORMS, an Academician of the International Academy for Quality, and a member of National of Academy of Engineering (NAE).

Dr. Shi received numerous awards for his research and teaching, including the highest recognition in research (IISE David F. Baker Distinguished Research Award) and the highest recognition in education (the IIE Albert G. Holzman Distinguished Educator Award), both from IISE.

Planning Sequential Accelerated Life Testing

LC Tang | National University of Singapore

Many products are designed to last longer than the typical lifespan of human being. It is thus a challenge to validate the designed life through reliability tests even when testing is conducted under much harsher environment. Not only that test duration is usually constrained, but the samples available for testing may also be costly and/or limited in quantity. Statistically optimal plans will allow for efficient use of testing resources and yet derive the most information from the test. In this presentation, we shall discuss ideas related to designing test plans for both constant stress and step stress ALT; leading to the statistical optimal plan for sequential ALT. While that for constant-stress ALT is basically a Bayesian approach and requires numerical solutions, that for the step-stress ALT entails a dynamic programming formulation. For the latter, the formulation and optimal solutions are only available for exponential lifetime and there are rooms for further research.

Loon Ching Tang is Professor at the Department of Industrial & Systems Engineering (ISE) in National University of Singapore (NUS). He is currently Director of Temasek Defence Systems Institute, the elected Fellow of the International Society of Engineering Asset Management (ISEAM); member of the Advisory Board of the Singapore Innovation and Productivity Institute. He has served as the Head of ISE Department from 2008--2015.

LC Tang obtained his PhD in the field of operations research from Cornell University in 1992 under the NUS Overseas Scholarship. He has published widely in many leading international journals in the field of IEOM. He was presented the IIE Transactions 2010 Best Application Paper Award and the prestigious Ralph A. Evans/P.K. McElroy Awards for the best paper presented at 2011 Reliability and Maintainability Symposium.

LC Tang currently serve as the Editor for Quality and Reliability Engineering International published by John Wiley and has been on the editorial review board of the Journal of Quality Technology, the flagship journal of American Society for Quality, since 2006, among others. He is the main author of the book: Six Sigma: Advanced Tools for Black Belts and Master Black Belts (which won the inaugural Masing Book Prize by International Academy of Quality); and a coauthor of Markov-Modulated Processes and Semiregenerative phenomena. He is one of the founding members of Global Ports Research Alliance, IIE Asian Network and the steering committee of Logistics and Maritime Systems Conference Series; and has served as the General Chair of these conference series.

On the Inmate Transportation Problem

Tamás Terlaky | Lehigh University

Joint work with Mohammad Shahabsafa and Anshul Sharma

The Inmate Transportation Problem (ITP) is a common complex problem in any correctional system. We develop a weighted multi-objective mixed integer linear optimization (MILO) model for the ITP. The MILO model optimizes the transportation of the inmates within a correctional system, while considering all legal restrictions and best business practices. We test the performance of the MILO model with real datasets from the Pennsylvania Department of Corrections (PADoC) and demonstrate that the inmate transportation process at the PADoC can significantly be improved by using operations research methodologies.

Prior to his appointment at Lehigh U., where he served as the Chair of ISE 2008-2017, Prof. Terlaky has been professor in Hungary, The Netherlands, and Canada. At McMaster University he was a Canada Research Chair in Optimization, and also served as the founding Director of the School of Computational Engineering and Science.

Prof. Terlaky has published four books, edited over ten books and journal special issues and published over 180 research papers. Topics include theoretical and algorithmic foundations of mathematical optimization (e.g., invention of the criss-cross method, oriented matroid programming), design and analysis of large classes of interior point methods, computational optimization, worst case examples of the central path, nuclear reactor core reloading optimization, oil refinery and VLSI design and robust radiation therapy treatment optimization, and inmate assignment optimization.

Prof. Terlaky is Founding Honorary Editor-in-Chief of the journal, Optimization and Engineering. He has served as associate editor of ten journals and has served as conference chair, conference organizer, and distinguished invited speaker at conferences all over the world. He was general Chair of the INFORMS 2015 Annual Meeting, a former Chair of INFORMS' Optimization Society, Chair of the ICCOPT Steering Committee of the Mathematical Optimization Society, currently Chair of the SIAM Activity Group on Optimization, he is Fellow of the Fields Institute, and Fellow of INFORMS. He received the MITACS Mentorship Award for his distinguished graduate student supervisory record, and the Award of Merit of the Canadian Operations Research Society. November 2017 he received the Wagner Prize of INFORMS and the Egerváry Award of the Hungarian Operations Research Society. He is class of 2018 Fellow of SIAM.

His research interest includes high performance optimization algorithms, optimization modeling and its applications.

Systems Monitoring and Personalized Health Management

Kwok L. Tsui | City University of Hong Kong

Due to the advancement of computation power, sensor technologies, and data collection tools, the field of systems monitoring and health management have been evolved over the past several decades with different names under different application domains, such as statistical process control (SPC), process monitoring, health surveillance, prognostics and health management (PHM), engineering asset management (EAM), personalized medicine, etc. There are tremendous opportunities in interdisciplinary research of system monitoring through integration of SPC, system informatics, data analytics, PHM, and personalized health management. In this talk we will present our views and experience in the evolution of systems monitoring, challenges and opportunities, and applications in machine systems health management as well as human health management.

Kwok L. Tsui is chair professor in the School of Data Science and the Departmentof Systems Engineering and Engineering Management at City University of Hong Kong. Prior to the current position, Dr. Tsui has been professor/associate professor in the School of Industrial and Systems Engineering at Georgia Institute of Technology in 1990-2011; and member of technical staff in the Quality Assurance Center at AT&T Bell Labs in 1986-1990. He received his Ph.D. in Statistics from the University of Wisconsin at Madison. Professor Tsui was a recipient of the National Science Foundation Young Investigator Award. He is Fellow of the American Statistical Association, American Society for Quality, International Society of Engineering Asset Management, and Hong Kong Institution of Engineers; elected council member of International Statistical Institute; and U.S. representative to the ISO Technical Committee on Statistical Methods. Professor Tsui was Chair of the INFORMS Section on Quality, Statistics, and Reliability and the Founding Chair of the INFORMS Section on Data Mining. Professor Tsui's current research interests include data mining, surveillance in healthcare and public health, prognostics and systems health management, calibration and validation of computer models, process control and monitoring, and robust design and Taguchi methods.

Risk Management with POE, VaR, CVaR, and bPOE: Applications in Finance

Stan Uryasev | University of Florida

Joint work with Giorgi Pertaia

This paper compares four closely related probabilistic measures: Probability of Exceedance (POE), Value-at-Risk (VaR) which is a quantile, Conditional Value-at-Risk (CVaR), and Buffered Probability of Exceedance (bPOE).

The Probability of Exceedance (POE) is frequently used to measure uncertainties in outcomes. For instance, POE is used to estimate probability that assets of a company fall below liabilities. POE measures only the frequency of outcomes and ignores magnitude of outcomes. POE counts outcomes exceeds the threshold, and it "does not worry" about the amount by which each outcome exceeds the threshold. POE is lumping together all threshold exceedance events, potentially "hiding" quite large and very troublesome outcomes. Moreover, POE has poor mathematical properties when used to characterize discrete distributions of random values (e.g., when distributions are defined by observed historical data). POE for discrete distributions is a discontinuous function of control variables, making it difficult to analyze and optimize. POE is used for defining financial ratings of companies and financial derivative instruments (such as CDO).

This presentation discusses a new probabilistic characteristic called Buffered Probability of Exceedance (bPOE). With bPOE, it is possible to count outcomes close to a threshold value, rather than only outcomes exceeding the threshold. To be more precise, bPOE counts tail outcomes averaging to some specific threshold value. For instance, 4% of land-falling hurricanes in US have cumulative damage exceeding $50 billion (i.e., POE = 0.04 for threshold=$50 billion). It is estimated, that the average damage from the worst 10% of hurricanes is $50 billion. In terms of bPOE, we say bPOE=0.1 for threshold=$50 billion. bPOE shows that largest damages having magnitude around $50 billion have frequency 10%. bPOE can be considered as an important supplement to POE. We think that bPOE should be routinely calculated together with POE. This example shows that bPOE exceeds POE, which is why it is called Buffered Probability of Exceedance. The positive difference, bPOE-POE, can be interpreted as some "buffer." bPOE is an inverse function of CVaR and it inherits a majority of the exceptional mathematical properties of CVaR (which is a so called "coherent measure of risk"). Similar to CVaR, minimization of bPOE can be reduced to convex and Linear Programming.

We will discuss applications of bPOE concept. In particular, we consider the Cash Matching Problem of a Bond Portfolio.

Professor Stan Uryasev is director of the Risk Management and Financial Engineering Lab at the University of Florida. His research is focused on efficient computer modeling and optimization techniques and their applications in finance and military projects. He published three books (monograph and two edited volumes) and more than 130 research papers. He is a co-inventor of the Conditional Value-at-Risk, the Conditional Drawdown-at-Risk and Buffered Probability of Exceedance optimization methodologies. He developed optimization software in risk management area: VaR, CVaR, Default Probability, Drawdown, Credit Risk minimization.

Stan Uryasev is a frequent speaker at academic and professional conferences. He has delivered seminars on the topics of risk management and stochastic optimization. He is on the editorial board of a number of research journals and is Editor Emeritus and Chairman of the Editorial Board of the Journal of Risk.

Spatial-Temporal Kriging and Navier-Stokes Equations: A Prominent Example of Engineering Analytics

Jeff Wu | Georgia Institute of Technology

Most “learning” in big data is driven by the data alone. Some people may believe this is sufficient because of the sheer data size. If the physical world is involved, this approach is often insufficient. In this talk I will give a recent study to illustrate how physics and data are used jointly to learn about the “truth” of the physical world. It also serves as an example of engineering analytics, which in itself has many forms and meanings. In an attempt to understand the turbulence behavior of an injector, a new design methodology is needed which combines engineering physics, computer simulations and statistical modeling. There are two key challenges: the simulation of high-fidelity spatial-temporal flows (using the Navier-Stokes equations) is computationally expensive, and the analysis and modeling of this data requires physical insights and statistical tools. A surrogate model is presented for efficient flow prediction in injectors with varying geometries, devices commonly used in many engineering applications. The novelty lies in incorporating properties of the fluid flow as simplifying model assumptions, which allows for quick emulation in practical turnaround times, and also reveals interesting flow physics which can guide further investigations.

C. F. Jeff Wu is Professor and Coca Cola Chair in Engineering Statistics at the School of Industrial and Systems Engineering, Georgia Institute of Technology. He was the first academic statistician elected to the National Academy of Engineering (2004); also a Member (Academician) of Academia Sinica (2000). A Fellow of American Society for Quality, Institute of Mathematical Statistics, of INFORMS, and American Statistical Association. He received the COPSS (Committee of Presidents of Statistical Societies) Presidents’ Award in 1987, the COPSS Fisher Lecture Award in 2011, the Deming Lecture Award in 2012, the inaugural Akaike Memorial Lecture Award in 2016, the George Box Medal from ENBIS in 2017, and numerous other awards and honors. He has published more than 175 research articles and supervised 48 Ph.D.’s. Among his students, there are 20 Fellows of ASA, IMS, ASQ, IAQ and IIE, and three editors of Technometrics. He has published two books “Experiments: Planning, Analysis, and Parameter Design Optimization” (with Hamada) and “A Modern Theory of Factorial Designs” (with Mukerjee). He coined the term ”data science” in 1998.

WCF-Approach for Complex System Reliability Assessment

Dan Yu | Chinese Academy of Sciences

In this study, the issue of system reliability assessment (SRA) based on component failure data is considered. For industrial statistics, the central limit theory combined with delta method has been a popular approach for confidence interval approximation. For high reliability systems, usually the assessment is confronted with very limited component sample size, various multi-parameter lifetime models, and complex system structure. Along with strict requirement on assessment accuracy and computational efficiency, existing approaches hardly work under these circumstances, especially for highly reliable systems. In this paper, a normal approximation approach is proposed for determining the lower confidence limits of system reliability using components time-to-failure data. The polynomial adjustment method is adopted to construct higher-order approximate lower confidence limits, which is inspired by the Winterbottom-extended Cornish-Fisher (WCF) expansion in Winterbottom (1980). The main contribution of this work is constructing an integrated methodology for SRA, and the proposed approach has obvious advantages with small sample size and complex systems structure. Specifically, a reliability-based WCF (R-WCF) expansion method for log-location-scale family is elaborated. Numerical studies are conducted to illustrate the effectiveness of proposed approach, and results show that R-WCF approach is more efficient than delta method for highly reliable system assessment, especially with ultra-small sample size.

Dr. Dan Yu is a professor in statistics of Academy of Mathematics and Systems Science in the Chinese Academy of Sciences. He got his Bachelor degree in University of Science and Technology of China in 1984, his Mater degree in Peking University in 1991, and his Ph.D. in Chinese Academy of Sciences in 1996. His research interest lies in reliability statistics, focusing on important issues like systems reliability, incomplete data analysis, and accelerated testing. He has over 50 papers published in English or Chinese journals. He is now the domestic director of the center of quality and data science at the Academy of Mathematics and Systems Science in the Chinese Academy of Sciences.

Pairwise Metamodeling of Multivariate Output Simulation Models

Qiang Zhou | University of Arizona

This talk investigates the emulation of computer models with multivariate outputs using multivariate Gaussian process (MGP). With the large the sample data size and the number of model parameters, building an MGP model is computationally very challenging. Under a general MGP model framework with nonseparable covariance functions, we propose an efficient approach featuring a pairwise model building scheme. The proposed method has excellent scalability.

Qiang Zhou is an Assistant Professor at the Department of Systems and Industrial Engineering, University of Arizona. Before coming to UA, he was with the SEEM Department at City University of Hong Kong. Dr. Zhou received his B.S. and MS. degrees and in Automotive Engineering from Tsinghua University, Beijing, China, in 2005 and 2007, M.S. degree in Statistics, and Ph.D. degree in Industrial Engineering from the University of Wisconsin-Madison, in 2010 and 2011.His research focuses on advanced industrial data analytics for engineering decision making and system performance improvement.