Bethlehem, Pennsylvania, August 13–15

MOPTA 2014

Modeling and Optimization: Theory and Applications

Lehigh University, Department of Industrial and Systems Engineering

Welcome to the 2014 MOPTA Conference!

Mission statement

The Modeling and Optimization: Theory and Application (MOPTA) conference is planned as an annual event aiming to bring together a diverse group of people from both discrete and continuous optimization, working on both theoretical and applied aspects. The format will consist of a number of invited talks from distinguished speakers and selected contributed talks, spread over three days.

The goal is to present a diverse set of exciting new developments from different optimization areas while at the same time providing a setting which will allow increased interaction among the participants. We aim to bring together researchers from both the theoretical and applied communities who do not usually have the chance to interact in the framework of a medium-scale event. MOPTA 2014 is hosted by the Department of Industrial and Systems Engineering at Lehigh University.

Organization committee

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Department of Industrial and Systems Engineering

Lehigh University

Program Highlights

Wednesday, August 13

- 8:30am – 9:30am — Gérard Cornuéjols, plenary talk
- 11:30am – 12:30pm — Darinka Dentcheva, plenary talk
- 3:45pm – 4:45pm — Philip Gill, plenary talk
- 7:00pm – 9:00pm — Graduate student Social

Thursday, August 14

- 8:30am – 9:30am — Asu Ozdaglar, plenary talk
- 9:45am – 11:15am — AIMMS/MOPTA competition: Final presentations
- 11:30am – 12:30pm — Miguel Anjos, plenary talk
- 5:00pm – 6:00pm — Vahab Mirrokni, plenary talk
- 6:15pm – 7:15pm — Cocktail reception
- 7:15pm – 9:45pm — Conference banquet and competition results

Friday, August 15

- 8:30am – 9:30am — Andreas Wächter, plenary talk
- 11:30am – 12:30pm — Warren B. Powell, plenary talk

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Speaker Biographies

GÉRARD P. CORNUÉJOLS

Professor
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Gérard Cornuéjols is a professor at Carnegie Mellon University. He received the von Neumann Theory prize (2011) offered by INFORMS, the Dantzig prize (2009) offered jointly by the Math Optimization Society and SIAM, the SIAM Outstanding Paper Prize (2004), the Fulkerson Prize (2000) offered jointly by the American Math Society and the Math Optimization Society and the Lanchester prize (1977) offered by INFORMS. He was editor-in-chief of Mathematics of Operations Research from 1998 to 2003.

Title: Cut-Generating Functions
Date: Wednesday, August 13, 8:30am–9:30

Abstract: Cutting planes have become a key component of integer linear and nonlinear programming solvers. Some of the most successful cutting planes are generated through a formula obtained by applying a simple "cut-generating function". Gomory's mixed-integer cuts are a classical example. In this talk, we present our current understanding of the theory of cut-generating functions, relying largely on convex analysis. This talk is based on joint work with Conforti, Daniilidis, Lemarechal, Malick, Wolsey and Yildiz.

Darinka Dentcheva

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Darinka Dentcheva holds PhD and Doctor of Sciences (Habilitation) degrees from Humboldt University Berlin, Germany. Her current research interests are in the area of optimization under uncertainty and risk, in which she has co-authored a popular recent monograph. She is passionate about education and has developed a new graduate curriculum as well as many new courses on both graduate and undergraduate level.

Darinka Dentcheva is an Associate Editor of SIAM Journal on Optimization, SIAM Review, and the Journal on Control, Optimisation and Calculus of Variations of the French Society of Applied Mathematics (ESAIM). She is a member of the Publications Committee of the Mathematical Optimization Society and a past member of the Committee on Stochastic Programming of the Mathematical Optimization Society. She is the recipient of a DAAD (Deutche Academische Austausch Dienst) award, Davis Memorial Research Award, and Research Recognition Award of the Board of Trustees of Stevens Institute of Technology.

Title: Optimization Problems with Stochastic Order Constraints
Date: Wednesday, August 13, 11:30am–12:30

Abstract: Stochastic orders formalize preferences among random outcomes and are widely used in statistics and economics. We analyze stochastic optimization problems involving stochastic-order relations as constraints that relate performance functionals, depending on our decisions, to benchmark random outcomes.

We discuss the relation of univariate and multivariate stochastic orders to utility functions, conditional value at risk, and to coherent measures of risk. Necessary and sufficient conditions of optimality and duality theory for problems with stochastic order constraints involve expected utility theory, dual (rank-dependent) utility theory, and coherent measures of risk. The model provides a link between various approaches for risk-averse optimization. Some attention will be paid to the numerical solution of the problems. Several applications will be outlined.

PHILIP E. GILL

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Philip Gill holds the title of Distinguished Professor of Mathematics at the University of California, San Diego, where he also serves as a Co-Director of the Center for Computational Mathematics. He received his Ph.D. from Imperial College of Science and Technology, London University in 1974. Before joining the University of California in 1988, he held appointments at the National Physical Laboratory in Teddington, England, and the Systems Optimization Laboratory at Stanford University. Professor Gill works in the general area of computational science, with a special interest in numerical optimization. He is the coauthor of two books, *Practical Optimization*, and *Numerical Linear Algebra and Optimization*. He is also coauthor of the software packages NPSOL and SNOPT, which have been distributed to universities, research laboratories, and industrial sites around the world. Professor Gill has served on the organizing committee of eight national and international conferences on optimization, and he was the Program Director for the SIAM Activity Group on Optimization from 1995-98. He has served on the Editorial Board for the SIAM Journal on Optimization, the SIAM Journal on Matrix Analysis, and Mathematical Programming Computation. He was elected SIAM Fellow in 2014.

Title: Sequential Quadratic Programming Methods for Nonlinear Optimization
Date: Wednesday, August 13, 3:45am–4:45

Abstract: In his 1963 PhD thesis, Wilson proposed the first sequential quadratic programming (SQP) method for the solution of constrained nonlinear optimization problems. In the intervening 50 years or so, SQP methods have evolved into a powerful and effective class of methods for a wide range of optimization problems. They are particularly effective for solving a sequence of related problems, such as those arising in mixed-integer nonlinear programming, and the optimization of functions subject to differential equation constraints. Given the scope and utility of nonlinear optimization, it is not surprising that SQP methods are still a subject of active research. We review some recent developments that include: (i) the relationship of SQP methods to other methods, including augmented Lagrangian methods and interior methods; (ii) regularized and stabilized SQP methods; (iii) SQP methods for use in mixed-integer nonlinear programming; and (iv) methods for solving the quadratic programming subproblem.

Asu Ozdaglar

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Asu Ozdaglar received the B.S. degree in electrical engineering from the Middle East Technical University, Ankara, Turkey, in 1996, and the S.M. and the Ph.D. degrees in electrical engineering and computer science from the Massachusetts Institute of Technology, Cambridge, in 1998 and 2003, respectively.

She is currently a professor in the Electrical Engineering and Computer Science Department at the Massachusetts Institute of Technology. She is also a member of the Laboratory for Information and Decision Systems and the Operations Research Center. Her research expertise includes optimization theory, with emphasis on nonlinear programming and convex analysis, game theory, with applications in communication, social, and economic networks, distributed optimization and control, and network analysis with special emphasis on contagious processes, systemic risk and dynamic control.

Professor Ozdaglar is the recipient of a Microsoft fellowship, the MIT Graduate Student Council Teaching award, the NSF Career award, the 2008 Donald P. Eckman award of the American Automatic Control Council, the Class of 1943 Career Development Chair, a 2011 Kavli Fellowship of the National Academy of Sciences, the inaugural Steven and Renee Innovation Fellowship, and the 2014 Spira teaching award. She served on the Board of Governors of the Control System Society in 2010. She has held editorial positions in several journals and is currently the area co-editor for a new area for the journal Operations Research, “Games, Information and Networks”. She is the co-author of the book entitled “Convex Analysis and Optimization” (Athena Scientific, 2003).

Title: Distributed Alternating Direction Method of Multipliers for Multi-agent Optimization
Date: Thursday, August 14, 8:30am–9:30

Abstract: We consider a network of agents solving a global optimization problem, where the objective function is the sum of privately known local convex objective functions and the decision variables are coupled via linear constraints. Recent literature focused on special cases of this formulation and studied their distributed solution through subgradient based methods with $\mathcal{O}(1/\sqrt{k})$ rate of convergence (where k is the iteration number). In this talk, we present distributed Alternating Direction Method of Multipliers (ADMM) based methods for solving this problem. We study both synchronous and asynchronous implementations. We present convergence rate estimates that show that these methods converge at rate $\mathcal{O}(1/k)$ and highlight the dependence of performance on network structure.

Miguel F. Anjos

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Miguel F. Anjos is Full Professor and Canada Research Chair in the Department of Mathematics & Industrial Engineering of Polytechnique Montreal, and is the Founding Director of Polytechnique's Trottier Institute for Energy. He received his degrees from McGill University, Stanford University, and the University of Waterloo. He is Editor-in-Chief of Optimization and Engineering and serves on the editorial boards of Discrete Applied Mathematics, Operations Research Letters, RAIRO-OR, and Surveys in Operations Research and Management Science. He recently completed a 3-year term as Program Director for the SIAM Activity Group on Optimization, and currently serves on the Council of the Mathematical Optimization Society. He is also a member of the Research Review Committee of Mitacs. He received the Méritas Teaching Award from Polytechnique in 2012. He was awarded a Humboldt Research Fellowship for Experienced Researchers in 2009, and the Queen Elizabeth II Diamond Jubilee Medal for significant contributions to mathematical optimization and its industrial applications.

Title: Recent Progress and Current Challenges in Optimization for the Smart Grid
Date: Thursday, August 14, 11:30am–12:30

Abstract: A smart grid is the combination of a traditional power distribution system with two-way communication between suppliers and consumers. This combination is expected to deliver energy savings, cost reductions, and increased reliability and security, but smart grids introduce numerous challenges for the management of the resulting system. These include integrating renewable energy sources such as wind and solar electricity generation, managing bidirectional flows of power, and incorporating demand-response. We will present examples of how optimization is helping to meet these challenges, and we will also discuss some of the directions for future research.

Vahab Mirrokni

Senior Staff Research Scientist
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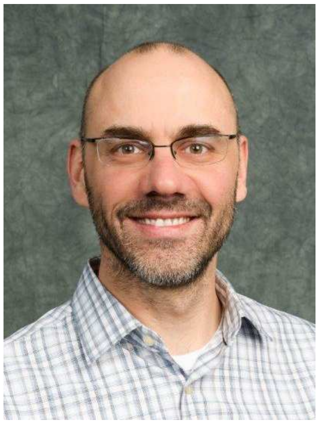
Vahab Mirrokni is a senior staff research scientist at Google Research New York where he leads the algorithms research group at Google NYC. He joined Google after holding research appointments at Microsoft Research, MIT and Amazon.com. He received his PhD from MIT and his B.Sc. from Sharif University. Vahab is a co-winner of a SODA best student paper award and an ACM EC best paper award. Vahab's research interests include algorithms, algorithmic game theory, and large-scale network analysis. At Google, he is mainly working on algorithmic and economic problems related to search and online advertising. Recently he is working on online ad allocation problems, distributed algorithms for large-scale graph mining, and mechanism design for advertising exchanges.

Title: Ad Allocation: Online Problems and Mechanism Design
Date: Thursday, August 14, 5:00pm–6:00

Abstract: Handling advertiser budget and capacity constraints is a central issue in online advertising, resulting in many interesting optimization and game theoretic problems. In this talk, we discuss two aspects of dealing with budget constraints: the online stochastic optimization problems and ad allocation/pricing mechanisms with strategic advertisers.

In the first part, we survey recent results focusing on simultaneous adversarial and stochastic approximations, improved approximations for stochastic variants of the problem, e.g., improved algorithms for online submodular maximization, and finally the multi-objective online optimization. In this regard, we also pose several remaining open problems. More specifically, we present an algorithm that is simultaneously good for adversarial and stochastic arrival models, an algorithm that improves on a $1/5$-approximation for online submodular maximization in random order, and finally an algorithm for online weighted matching that simultaneously optimizes multiple objective functions. In the second part, we discuss the mechanism design problems in the online setting, present the framework of clinching auctions to deal with these constraints, and conclude with open problems in this area.

The talk is based on several recent papers including papers at SODA'12, STOC'12, EC'13, and WINE'13.



ANDREAS WÄCHTER

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Andreas Wächter is an Associate Professor in the Department of Industrial Engineering and Management Sciences at Northwestern University. He obtained his master's degree in Mathematics at the University of Cologne, Germany, in 1997, and this Ph.D. in Chemical Engineering at Carnegie Mellon University in 2002. Before joining Northwestern University in 2011, he was a Research Staff Member in the Department of Mathematical Sciences at IBM Research in Yorktown Heights, NY. His research interests include the design, analysis, implementation and application of numerical algorithms for nonlinear continuous and mixed-integer optimization. He is a recipient of the 2011 Wilkinson Prize for Numerical Software and the 2009 Informs Computing Society Prize for his work on the open-source optimization package Ipopt.

Title: Inexact Methods for Nonlinear Optimization
Date: Friday, August 15, 8:30am–9:30

Abstract: Numerical methods for nonlinear constrained optimization typically require the solution of subproblems, such as linear systems or quadratic optimization problems, to generate the next iterate. For some applications (such as problems involving discretized PDEs in the constraints), obtaining the exact solution of the subproblems is computationally very expensive, while approximate solutions can be computed much faster. To use inexact subproblem solutions in the optimization algorithm, however, care must be taken to ensure that convergence can still be guaranteed, particularly for nonconvex problems. This presentation discusses some "inexact" optimization methods that have been proposed over recent years and that allow the use of approximate subproblem solutions. These frameworks specify generic conditions for the inexact subproblem solutions that do not rely on a particular subproblem solver. The only requirement is that the sequence of inner iterates generated by the subproblem solver converge to the exact solution of the subproblem. A crucial aspect of the subproblem conditions is that they explicitly consider reduction in the merit function instead of only reduction of a linear system residual.

Warren B. Powell

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Warren B. Powell is a professor in the Department of Operations Research and Financial Engineering at Princeton University, where he has taught since 1981. He is the founder and director of the laboratory for Computational Stochastic Optimization and Learning (CASTLE Labs), which spans contributions to models and algorithms in stochastic optimization, with applications to energy systems, transportation systems, and optimal learning in materials science. His work spans different communities in stochastic optimization within operations research and computer science. He is the author of *Approximate Dynamic Programming: Solving the Curses of Dimensionality* (which bridges computer science and operations research) and is a co-author (with Ilya Ryzhov) of *Optimal Learning* (both published by Wiley). He has coauthored 200 refereed publications and is a Fellow of Informs. For more on his work, see www.castlelab.princeton.edu

Title: Bridging the Fields of Stochastic Optimization
Date: Friday, August 15, 11:30am–12:30

Abstract: Mathematical programming has given us a widely used canonical framework for modeling deterministic optimization problems, a property enjoyed by static stochastic optimization problems. However, when we make the transition to sequential stochastic optimization problems, the field fragments into a number of competing communities with names such as stochastic programming, dynamic programming, robust optimization, stochastic search, simulation optimization, and optimal control. Differences between these fields are magnified by notation and terminology, which hide subtle but more important differences in problem characteristics. Complicating matters further is a misunderstanding of basic terms such as dynamic program, policy, and state variable. While deterministic optimization problems are defined by solving for decisions, sequential stochastic optimization problems are characterized by finding *functions* known as policies. I will identify four fundamental classes of policies which unify the competing approaches into a common framework. These ideas will be illustrated using applications drawn from energy, transportation, health and finance.

AIMMS/MOPTA Optimization Modeling Competition 2014

The sixth AIMMS/MOPTA Optimization Modeling Competition is a result of cooperation between AIMMS and the organizers of the MOPTA conference. Teams of two or three graduate students participated and solved a problem related to time-ahead pricing of energy supply. The teams were asked to consider one key decision-making process within the management of the distribution electricity system; namely, how to price the energy for the end consumers. This problem alone has been the subject of very active developments. In particular, teams were asked to focus on one of the key aspects (among many others) that plays a role in deciding the price of energy for end consumers. That is, taking into account the fact that consumers have the ability to change their energy consumption behavior based on the energy price at a given moment in time.

The teams had to form a mathematical model of the problem, implement it in AIMMS, solve it, create a graphical user interface, and write a 15-page report on the project. We are happy that 22 teams from different countries registered and downloaded the problem. In particular, teams from Chile, US, France, India, Colombia, Italy, Portugal, Norway, and Canada participated on the competition. The panel of judges (Alberto Lamadrid and Luis F. Zuluaga from Lehigh University and Peter Nieuwesteeg from AIMMS) selected the following three teams for the final:

Team "Coppta", Universidad de los Andes
Daniel M. Eslava, Jorge A. Huertas, and Andrés F. Pardo
advised by Jaime E. Gonzalez

Team "Gerad 5459", École Polytechnique de Montréal
Elspeth Adams, Mathilde Peyrega
advised by Miguel F. Anjos

Team "ISU-IMSE", Iowa State University
Bokan Chen, Leilei Zhang
advised by Lizhi Wang

The finalist teams will each give 30 minute presentations (20 minute talks + 10 minutes for questions) on their work on Thursday, August 14, starting at 9:45am in the Perella Auditorium. The winning team will be announced at the conference banquet on Thursday evening.

Two other teams have received an honorable mention for their work:

Team "The Good, the Bad and the OPT",
University of Pisa/Scuola Normale Superiore of Pisa
Stefano Massei, Alessandro Neri, Leonardo Gigli
advised by Antonio Frangioni

Team "RensPolymatheIa", Rensselaer Polytechnic Institute
Xin Shen, Jubiao Yang, Biao Mao
advised by John E. Mitchell

We thank all the teams for their participation. We believe that it has been a very positive experience for all parties involved in the process.

Rauch Business Center — Floor Plans

The online version of the program does not contain floor plans.

Wednesday, August 13 — Rauch Business Center

7:30-8:15 – Registration and continental breakfast – Perella Auditorium Lobby

8:15-8:30 – Welcome: Alan J. Snyder, Vice President and Associate Provost for Research and Graduate Studies, Lehigh University – Perella Auditorium

Opening Remarks: Tamás Terlaky, Department Chair, Industrial & Systems Engineering, Lehigh University – Perella Auditorium

8:30-9:30 – Plenary talk – Perella Auditorium. Chair: Luis Zuluaga

Cut-Generating Functions

Gérard Cornuéjols (Carnegie Mellon University)

9:30-9:45 – Coffee break – Perella Auditorium Lobby

9:45-11:15 – Parallel technical sessions

Algorithms for Big Data I **R. Vanderbei** ROOM A	**Semidefinite Programming** **N. Krislock** ROOM B	**Hybrid Optimization** **A. Konak** ROOM C	**Topological Optimization** **N. Vermaak** ROOM D
Optimization for Compressed Sensing: New Insights and Alternatives, **K. Lin**	Approaches for Separating Projection Constraints within a Cutting Plane method, **E. Adams**	Dynamic Facility Layout Problem — A hybrid Approach, **S. Kulturel-Konak**	Reinforced concrete design through stress-dependent topology optimization, **Y. Yang**
Stochastic compositional gradient: optimizing compositions of stochastic functions, **E. Fang**	Sufficient optimality conditions hold for almost all nonlinear semidefinite programs, **W. Gomez**	Minimizing CO2 emissions for a time-dependent, heterogeneous vehicle routing and scheduling problem using dynamic programming and genetic algorithms, **Y. Xiao**	Topology optimization for conducto-convective heat transfers, **G. Marck**
L1 Regularization Via the Parametric Simplex Method, **R. Vanderbei**	BiqCrunch: a semidefinite-based solver for binary quadratic problems, **N. Krislock**	A genetic algorithm to solve defender-attacker type network design problems, **A. Konak**	Topology Optimization and Advanced Manufacturing, **N. Vermaak**

11:15-11:30 – Coffee break – Perella Auditorium Lobby

11:30-12:30 – Plenary talk – Perella Auditorium. Chair: Robert H. Storer

Optimization Problems with Stochastic Order Constraints

Darinka Dentcheva (Stevens Institute of Technology)

12:30-1:30 – Lunch – Rauch Business Center 291/292/293

1:30-3:30 – Parallel technical sessions

Algorithms for Big data II **R. Pasupathy** ROOM A	**Convexification of Nonconvex QPs** **F. Kılınç-Karzan** ROOM B	**Black-Box & Derivative-Free** **R. Regis** ROOM C
Gradient Sliding for Composite Optimization, **G. Lan**	Solving QCQPs, **D. Bienstock**	NOWPAC — A derivative free trust-region method with path-augmented constraints for nonlinear programming, **F. Augustin**
A Parallel Method for Large Scale Convex Regression Problems, **Z. Wang**	Understanding Structure in Conic Mixed Integer Programs: From Minimal Inequalities to Conic Disjunctive Cuts, **F. Kılınç-Karzan**	The use of the q-gradient vector for continuous global optimization problems, **E. J. C. Gouvêa**
Data-driven first-order methods for misspecified convex optimization problems: Global convergence and Rate estimates, **H. Ahmadi**	Disjunctive Cuts for the Second-Order Cone and Its Cross-Sections, **S. Yildiz**	Derivative Free Optimization for partially separable functions, **B. Marteau**
Optimal Adaptive Sampling in Stochastic Recursions, **R. Pasupathy**	A Branch-and-Bound Algorithm for Instrumental Variable Quantile Regression, **G. Xu**	Cellular Material Model Homogenization, **R. Laverty**

3:30-3:45 – Coffee break – Perella Auditorium Lobby. Program continues on next page.

3:45-4:45 – Plenary talk – Perella Auditorium. Chair: Frank Curtis

Sequential Quadratic Programming Methods for Nonlinear Optimization

Philip Gill (University of California, San Diego)

4:45-5:00 – Coffee break – Perella Auditorium Lobby

5:00-7:00 – Parallel technical sessions

Smart Grids I (Energy I) L. Zuluaga — Room A	Mixed Integer Linear Progr. S. Shim — Room B	Path Finding & Routing M. A. Epelman — Room C	Information Theory & Optim. I E. Perevalov — Room D
Wind Aggregation via Risky Power Markets, **Y. Zhao**	Multiobjective optimization for automatic schematic map drawing, **O. Oke**	A Column Generation and Routing Approach to 4π VMAT Radiation Therapy Treatment Planning, **E. Romeijn**	A Markov Decision Process Model for Minimizing Information Leakage through Energy Storage in Smart Metering Systems, **J. Yao**
Chance Constrained Optimization in Electricity Networks with Ramping Constraints, **M. M. Moarefdoost**	Optimal TV Advertising Using a Multi-objective Integer Programming Approach, **V. M. Evangelista**	Network Repair Crew Scheduling and Routing for Emergency Relief Distribution Problem, **I. Dolinskaya**	Distributed estimation in the presence of attacks, **J. Zhang**
Equilibrium Term Structure of Electricity Prices, **M. Troha**	Optimal facility in-network selection for healthcare payers under Reference Pricing, **V. Denoyel-Garnier**	Decomposition methods for multi-period combined network design & routing optimization problem and applications, **D. Papadimitriou**	Demand charge reduction with battery energy storage system (BESS) in electricity network, **F. Chen**
Optimal Internalization of the Cost of Renewable Energy Sources, **A. Lamadrid**	A few strong knapsack facets, **S. Shim**	Finding a roll-minimizing path for a vessel moving in a seaway using the parameter-free Sampled Fictitious Play algorithm, **M. A. Epelman**	Extending information theory to information acquisition processes, **X. Wang**

7:00-9:00 – Student Social – Graduate Student Center – Packer House.

Thursday, August 14 — Rauch Business Center

8:00-8:30 – Continental breakfast – Perella Auditorium Lobby

8:30-9:30 – Plenary talk – Perella Auditorium. Chair: Katya Scheinberg

Distributed Alternating Direction Method of Multipliers for Multi-Agent Optimization

Asu Ozdaglar (Massachusetts Institute of Technology)

9:30-9:45 – Coffee break – Perella Auditorium Lobby

9:45-11:15 – AIMMS /MOPTA Optimization Modeling Competition Final (Winner will be announced at Conference Banquet)

AIMMS/MOPTA Optimization Modeling Competition Final – Perella Auditorium

Chair: Peter Nieuwesteeg

Team “Coppta”, Universidad de los Andes — Daniel M. Eslava, Jorge A. Huertas, and Andrés F. Pardo, advised by Jaime E. Gonzalez

Team “Gerad 5459”, École Polytechnique de Montréal — Elspeth Adams, Mathilde Peyrega, advised by Miguel F. Anjos

Team “ISU-IMSE”, Iowa State University — Bokan Chen, Leilei Zhang, advised by Lizhi Wang

11:15-11:30 – Coffee break – Perella Auditorium Lobby. Program continues on next page.

11:30-12:30 – Plenary talk – Perella Auditorium. Chair: Larry Snyder

Recent Progress & Current Challenges in Optimization for the Smart Grid
Miguel Anjos (Polytechnique Montréal)

12:30-1:30 – Lunch – Rauch Business Center 291/292/293

1:30-3:00 – Parallel technical sessions

Energy II **L. Snyder & M. Anjos** ROOM A	**Convex Relaxations** **H. Dong** ROOM B	**Stochastic Search & ADP** **T. Asamov** ROOM C	**Bilevel Optimization & Risk** **N. A. Uhan** ROOM D
Optimization and Equilibrium Modeling for Renewable Energy: Focus on Wastewater-to-Energy Using a Two-Level Optimization Problem, **S. A. Gabriel**	How Good are Sparse Cutting-Planes?, **S. S. Dey**	Approximation Strategies for Multistage Stochastic Programs, **T. Asamov**	Multi-modal non-linear stochastic bi-level sustainable land use and transportation model, **N. Shahraki**
The Influence of the Panama Canal on Global Gas Trade, **S. Moryadee**	A Discretization Pump for a Class of Mixed-Integer Bilinear Optimization Problems, **D. Papageorgiou**	Knowledge Gradient with Discrete Priors, **S. Chen**	Computing near-optimal Value-at-Risk portfolios using Integer Programming techniques, **O. Babat**
An Equilibrium Model for the US RIN Market, **S. Siddiqui**	Relaxing nonconvex quadratic functions by multiple adaptive diagonal perturbations, **H. Dong**	Optimal Learning with a Local Parametric Belief Model, **B. Cheng**	Dynamic allocations for cooperative games under uncertainty with risk-averse players, **N. A. Uhan**

3:00-3:15 – Coffee break – Perella Auditorium Lobby

3:15-4:45 – Parallel technical sessions

Large-Scale Nonlinear Optim. **F. E. Curtis** ROOM A	**Convex Optimization** **M. Anjos** ROOM B	**Risk-Averse Optimization** **A. Ruszczyński** ROOM C	**Information Theory & Optim. II** **S. Pokutta & Y. Xie** ROOM D
Handling Negative Curvature in Spectral Gradient Methods for Nonlinear Optimization, **W. Guo**	On robust solutions to uncertain linear complementarity problems and their variants, **Y. Xie**	Risk-Averse Markov Control Models, **A. Ruszczyński**	The game of 20 questions with (1) noisy answers or (2) multiple targets: a delight of information theory, probability, control, and computer vision, **B. Jedynak**
A Dynamic Penalty Parameter Updating Strategy For Matrix-Free Sequential Quadratic Optimization Methods, **H. Wang**	Minimizing an indefinite quadratic function subject to a single indefinite quadratic constraint, **M. Salahi**	Time-consistent Approximations: Empirical Results for the Dow Jones Industrial Average, **T. Asamov**	Comparing Post Positions Using the Chi Square Distribution, **R. L. Goodwin**
Large-Scale Sparse Subspace Clustering, **D. Robinson**	A polynomial-time rescaled von Neumann algorithm for linear feasibility problems, **D. Li**	Numerical methods for optimization with multivariate stochastic ordering constraints, **E. Wolfhagen**	Lower Bounds on the Oracle Complexity of Convex Optimization Via Information Theory, **C. Guzmán**

4:45-5:00 – Coffee break – Perella Auditorium Lobby

5:00-6:00 – Plenary talk – Perella Auditorium. Chair: Ted Ralphs

Ad Allocation: Online Problems and Mechanism Design
Vahab Mirrokni (Google Research and New York University)

6:15-7:15 – Cocktail Reception – Siegel Gallery, Iacocca Hall (Mountaintop Campus)

7:15-9:45 – Address by Daniel P. Lopresti, Dean, a.i., P.C. Rossin College of Engineering & Applied Science,
Conference Banquet, and Competition Results – Wood Dining Room, Iacocca Hall

Friday, August 15 — Rauch Business Center

8:00-8:30 – Continental breakfast – Perella Auditorium Lobby

8:30-9:30 – Plenary talk – Perella Auditorium. Chair: Tamás Terlaky

Inexact Methods for Nonlinear Optimization

Andreas Wächter (Northwestern University)

9:30-9:45 – Coffee break – Perella Auditorium Lobby

9:45-11:15 – Parallel technical sessions

Stoch. Optim. in E. (Energy III)
D. Jiang Room A

A Nested Newsvendor Scheduling Policy for Operations Planning in a System with Significant Wind Power Penetration, **G. Gliner**

A Probability Model of Grid Failures using Incomplete Power Outage Information, **L. Al-Kanj**

Optimal Hour-Ahead Bidding in the Real-Time Electricity Market with Battery Storage using Approximate Dynamic Programming, **D. R. Jiang**

Stochastic First Order Methods
Q. Lin Room B

On Data Preconditioning for Regularized Loss Minimization, **T. Yang**

Parallel BCD methods for non-smooth optimization, **M. Razaviyayn**

An Accelerated Randomized Coordinate Descent Method for Strongly Convex Composite Optimization, **Q. Lin**

Expensive Functions
P. I. Frazier Room C

Parallel Bayesian Global Optimization, with Application to Metrics Optimization at Yelp, **J. Wang**

Constrained black-box optimization using radial basis functions within a trust-region framework, **R. G. Regis**

Simulation selection with unknown correlation structures, **I. O. Ryzhov**

Industrial OR Cases
G. S. R. Murthy Room D

Discrete Event Simulation for efficient supply chain management of service parts, **S. Ramaswamy**

Dynamic warehouse management problem for a footwear industry, **A. L. N. Murthy**

Wood Inventory Management in a Pulp Mill, **G. S. R. Murthy**

11:15-11:30 – Coffee break – Perella Auditorium Lobby

11:30-12:30 – Plenary talk – Perella Auditorium. Chair: Boris Defourny

Bridging the Fields of Stochastic Optimization

Warren B. Powell (Princeton University)

12:30-1:30 – Lunch – Rauch Business Center 291/292/293

1:30-3:00 – Parallel technical sessions

Smart Grids II (Energy IV)
L. Zuluaga Room A

Reliability and air emissions impacts of flexible ramp capacity products in the Midcontinent ISO, **D. Patino-Echeverri**

Demand Response in Electricity Markets: Voluntary vs Involuntary Contracts, **R. Lobel**

Graph-Theoretic Algorithm for Nonlinear Power Optimization Problems, **J. Lavaei**

Simulation Optimization
Q. Lin Room B

Bayesian global optimization of expensive functions: exploiting noise with low-dimensional structure, **P. Frazier**

The Knowledge Gradient for Sparse Additive Model, **Y. Li**

A New Stochastic Approximation Algorithm, **M. Chau**

Optim. in Dynamical Systems
A. A. Ahmadi Room C

Robustness of Dynamical Systems with Optimization in Feedback Loop, **M. Roozbehani**

Solving the n-body problem by minimizing the action functional, **R. Vanderbei**

Algorithms and hardness results for stability of polynomial ODEs, **A. A. Ahmadi**

3:00-3:15 – Coffee break – Perella Auditorium Lobby

3:15-4:45 – Parallel technical sessions

Optim. in Machine Learning
M. Takáč Room A

Elementary Estimators for High-dimensional Statistical Models, **P. Ravikumar**

Parallel greedy coordinate descent method for sparse inverse covariance selection, **S. Yektamaram**

Hydra: Distributed Coordinate Descent for Big Data Optimization, **M. Takáč**

Stochastic Dynamic Optim.
Q. Lin Room B

The Benefits of Robustness for Approximate Dynamic Programming, **M. Petrik**

A new optimal stepsize for approximate dynamic programming, **I. O. Ryzhov**

A Budget Allocation Policy for Online Crowdranking, **Q. Lin**

Combinatorial Optimization
F. Vasko Room C

Two Dimensional Load Balancing, **K. Lee**

Fuzzy Data Envelopment Analysis with Common Weights, **C.-F. Hu**

Adapting the Teaching-Learning-Based Optimization Metaheuristic to Combinatorial Optimization, **Y. Lu**

OPTIMIZATION ALGORITHMS FOR BIG DATA PROBLEMS — WED 9:45-11:15

CHAIR: **Robert Vanderbei** (Princeton University) — RM: A

1 – OPTIMIZATION FOR COMPRESSED SENSING: NEW INSIGHTS AND ALTERNATIVES

SPEAKER: **Kevin Lin** (Princeton University, klin1234@gmail.com)
Robert Vanderbei (Princeton University, rvdb@princeton.edu)
Han Liu (Princeton University, hanliu@princeton.edu)
Lie Wang (Massachusetts Institute of Technology, liewang@math.mit.edu)

We present two new approaches to efficiently solve large-scale compressed sensing problems. These two ideas are independent of each other and can therefore be used either separately or together.

For the first approach, we note that the zero vector can be taken as the initial basic (infeasible) solution for the linear programming problem and therefore, if the true signal is very sparse, some variants of the simplex method can be expected to take only a small number of pivots to arrive at a solution. We implemented one such variant and demonstrate a dramatic improvement in computation time on very sparse signals.

The second approach requires a redesigned sensing mechanism in which the vector signal is stacked into a matrix. This allows us to exploit the Kronecker compressed sensing (KCS) mechanism. We show that the Kronecker sensing requires stronger conditions for perfect recovery compared to the original vector problem. However, the Kronecker sensing, modeled correctly, is a much sparser linear optimization problem. Hence, algorithms that benefit from sparse problem representation, such as interior-point methods, can solve the Kronecker sensing problems much faster than the corresponding vector problem. In our numerical studies, we demonstrate a ten-fold improvement in the computation time.

2 – STOCHASTIC COMPOSITIONAL GRADIENT: OPTIMIZING COMPOSITIONS OF STOCHASTIC FUNCTIONS

SPEAKER: **Ethan Fang** (Princeton University, ethanfangxy@gmail.com)
Mengdi Wang (Princeton University, mengdiw@princeton.edu)
Han Liu (Princeton University)

We propose a class of stochastic quasi-gradient methods that solve problems with bi-level uncertainty. The almost sure convergence and sample complexity results are proved.

3 – L1 REGULARIZATION VIA THE PARAMETRIC SIMPLEX METHOD

SPEAKER: **Robert Vanderbei** (Princeton University, rvdb@princeton.edu)

An $\ell 1$ penalty term is often used to coerce sparsity in least-squares problems. The associated weighting parameter requires tuning to get the “right” answer. If the least-squares problem is changed to least-absolute-deviations (LAD), then the problem can be reduced to a linear programming problem that can be solved using the parametric simplex method thereby resolving the tuning question. We will report some comparisons between the least-squares approach and the LAD method.

SEMIDEFINITE PROGRAMMING AND APPLICATIONS — WED 9:45-11:15

CHAIR: **Nathan Krislock** (Northern Illinois University) — RM: B

1 – APPROACHES FOR SEPARATING PROJECTION CONSTRAINTS WITHIN A CUTTING PLANE METHOD

SPEAKER: **Elspeth Adams** (Ecole Polytechnique de Montréal, elspeth.adams@polymtl.ca)
Miguel F. Anjos (Ecole Polytechnique de Montréal)
Franz Rendl (Alpen-Adria-Universität Klagenfurt, Austria)
Angelika Wiegele (Alpen-Adria-Universität Klagenfurt, Austria)

The max-cut problem can be closely approximated using the basic semidefinite relaxation and iteratively refined by adding valid inequalities. We propose a projection polytope as a new way to improve the relaxations and a separation model and related algorithm to identify which of these are valid cuts. Theoretical and computational results will be presented.

2 – SUFFICIENT OPTIMALITY CONDITIONS HOLD FOR ALMOST ALL NONLINEAR SEMIDEFINITE PROGRAMS

SPEAKER: **Walter Gomez** (Universidad de La Frontera, walter.gomez@ufrontera.cl)
Dominik Dorsch (RWTH Aachen University, dorsch@mathc.rwth-aachen.de)
Vladimir Shikhman (Catholic University of Louvain, vladimir.shikhman@uclouvain.be)

We derive a new genericity result for nonlinear semidefinite programming (NLSDP). Namely, almost all linear perturbations of a given NLSDP are shown to be nondegenerate. Here, nondegeneracy for NLSDP refers to the transversality constraint qualification, strict complementarity and second-order sufficient condition. Due to the presence of the second-order sufficient condition, our result is a nontrivial extension of the corresponding results for linear semidefinite programs.

3 – BIQCRUNCH: A SEMIDEFINITE-BASED SOLVER FOR BINARY QUADRATIC PROBLEMS

SPEAKER: **Nathan Krislock** (Northern Illinois University, krislock@math.niu.edu)
Jérôme Malick (CNRS, Laboratoire J. Kunztmann, jerome.malick@inria.fr)
Frédéric Roupin (Université Paris 13, frederic.roupin@lipn.univ-paris13.fr)

BiqCrunch is a branch-and-bound solver for finding exact solutions of any 0-1 quadratic problem, such as Max-Cut, Max-k-cluster, and Max-independent set. The bounds are based on a regularized semidefinite relaxation and are efficiently computable using eigenvalue decomposition and a quasi-Newton optimization method. The resulting semidefinite bounding procedure gives us a competitive branch-and-bound algorithm for solving many binary quadratic problems to optimality.

HYBRID OPTIMIZATION

WED 9:45-11:15

CHAIR: **Abdullah Konak** (Pennsylvania State University)

RM: C

1 – DYNAMIC FACILITY LAYOUT PROBLEM — A HYBRID APPROACH

SPEAKER: **Sadan Kulturel-Konak** (Penn State Berks, sadan@psu.edu)

The Dynamic Facility Layout Problem (DFLP) considers designing a facility in a multi-period planning horizon. The DFLP in the continuous plane is a very challenging nonlinear optimization problem. A hybrid approach using Genetic Algorithm (GA)/Linear Programming (LP) is proposed to solve the DFLP on the continuous plane with unequal area departments. One of the challenges of heuristic approaches to the FLP on the continuous plane is to design a solution representation scheme that provides a consistent arrangement of departments in the facility. In this study, a location/shape representation scheme is used to represent block layouts on the continuous domain. Once the GA sets up relative department positions, actual department locations and shapes are determined by solving an LP problem. The location/shape representation enables the GA to recombine solutions discovered by LP. Promising numerical results are presented for a comprehensive set of test problems from the literature.

2 – MINIMIZING CO2 EMISSIONS FOR A TIME-DEPENDENT, HETEROGENEOUS VEHICLE ROUTING AND SCHEDULING PROBLEM USING DYNAMIC PROGRAMMING AND GENETIC ALGORITHMS

SPEAKER: **Yiyong Xiao** (Penn state Berks, yux18@psu.edu)
Abdullah Konak (Penn state Berks, auk3@psu.edu)

We present a linear mixed integer programming (LMIP) model for the time-dependent heterogeneous vehicles routing and scheduling problem with the objective of minimizing total carbon dioxide emissions (TD-VRSP-CO2). Instead of discrete time intervals, the proposed model utilizes the traveled distances on each arc in each time period as continuous decision variables to determine the traveling schedule of a vehicle. Therefore, the resulting model has far less binary decision variables than traditional discrete-time based models. We propose an exact dynamic programming method to calculate the optimal discrete departure/arriving time for the TD-VRSP-CO2. The dynamic programming method significantly reduces the computational complexity of the TD-VRSP-CO2 when applying existing heuristic algorithms to solve large-sized problems. A genetic algorithm with dynamic programming (GA-DP) is developed for the formulated problem. Computational experiments are carried out to study the efficiency of the proposed hybrid solution approach.

3 – A GENETIC ALGORITHM TO SOLVE DEFENDER-ATTACKER TYPE NETWORK DESIGN PROBLEMS

SPEAKER: **Abdullah Konak** (Penn State Berks, auk3@psu.edu)
Sadan Kulturel-Konak (Penn State Berks, sxk70@psu.edu)
Lawrence V. Snyder (Lehigh University, larry.snyder@lehigh.edu)

This paper presents a genetic algorithm to solve bi-level network design problems formulated based on a defender-attacker type framework. There are two decision makers: a designer and an attacker. The designer's goal is to maximize a performance measure of a network by assigning limited resources to the components of the network, and the attacker tries to interrupt the operation of the network by launching intelligent attacks to those components. Mimicking this process, the proposed genetic algorithm includes two populations (designer and attacker) that evolve independently but in parallel to find robust design decisions under the assumption of worst possible attacks. Convergence properties and the performance of the proposed genetic algorithm are studied using a network relay assignment problem and a competitive facility location problem. In addition, the proposed genetic algorithm is compared with hybrid heuristic algorithms to demonstrate its advantages and disadvantages.

TOPOLOGICAL OPTIMIZATION & ADVANCED MANUFACTURING WED 9:45-11:15

CHAIR: **Natasha Vermaak** (Lehigh University) RM: D

1 – REINFORCED CONCRETE DESIGN THROUGH STRESS-DEPENDENT TOPOLOGY OPTIMIZATION

SPEAKER: **Yang Yang** (Johns Hopkins University, yyang61@jhu.edu)
James K. Guest (Johns Hopkins University, jkguest@jhu.edu)

Strut and tie models (STM) are widely used by designers of reinforced concrete and prestressed concrete structures. Selection of an efficient model, however, becomes a challenging task for complex design domains, such as 3d domains with cutouts. Topology optimization has therefore been promoted as means of automating the development of highly efficient (minimum strain energy) STM. Current drawbacks of such methods are that solutions may complex and fail to properly account for secondary tensile stresses; that is, the case where the major principal stresses are compressive and minor principal stresses are tensile. A hybrid truss-continuum topology optimization scheme was recently developed to overcome these challenges in 2D concrete design. That work is modified and extended herein to three-dimensional domains and mechanics models. The stiffness of the elements are formulated such that truss elements carry only tensile forces and thus represent straight steel rebar, while the continuum elements carry only compressive forces and thus represent the concrete load paths. The latter is achieved using a stress-dependent orthotropic material model. The design goal is then to optimize the STM by minimizing strain energy in the system. Other design considerations, such as constructability, will also be discussed. The algorithm is demonstrated on several benchmark design examples. Results are shown to produce more efficient STM than traditional designs.

2 – TOPOLOGY OPTIMIZATION FOR CONDUCTO-CONVECTIVE HEAT TRANSFERS

SPEAKER: **Gilles Marck** (Pierre and Marie Curie University, gilles.marck@ljll.math.upmc.fr)

Our study focus on the optimal design of thermal devices which are subject to conductive or convective heat transfers. A topology optimization approach is carried out to establish the optimal distribution of both solid and fluid subdomains. On the one hand, a classical objective function aims at minimizing the viscous dissipation occurring through the fluid phase, in order to minimize the power required to set it into motion. On the other hand, an objective relying on the thermal aspects of the problem attempt to maximize the heat transfer. Numerical results show that the solutions reach non-trivial configurations in the frame of heat and mass transfer problems.

3 – TOPOLOGY OPTIMIZATION AND ADVANCED MANUFACTURING

SPEAKER: **Natasha Vermaak** (Lehigh University, vermaak@lehigh.edu)

Techniques for advanced manufacturing such as 3D-printing allow the direct fabrication of architectured and graded materials and structures with variation by region, layer and effectively, point-wise. The integration of manufacturing methods and their associated unique design challenges, with computational methods, is crucial to the support and growth of these advanced technologies. The development of coherent frameworks for multi-material structural topology optimization that combine all of these issues is not yet fully addressed and opportunities for development will be discussed.

ALGORITHMS FOR BIG DATA II

WED 1:30-3:30

CHAIR: **Raghu Pasupathy** (Purdue University)

RM: A

1 – GRADIENT SLIDING FOR COMPOSITE OPTIMIZATION

SPEAKER: **Guanghui Lan** (University of Florida, glan@ise.ufl.edu)

We consider in this paper a class of composite optimization problems whose objective function is given by the summation of a general smooth and nonsmooth component, together with a relatively simple nonsmooth term. We present a new class of first-order methods, namely the gradient sliding algorithms, which can skip the computation of the gradient for the smooth component from time to time. As a consequence, these algorithms require only $\mathcal{O}(1/\sqrt{\epsilon})$ gradient evaluations for the smooth component in order to find an ϵ-solution for the composite problem, while still maintaining the optimal $\mathcal{O}(1/\epsilon^2)$ bound on the total number of subgradient evaluations for the nonsmooth component. We then present a stochastic counterpart for these algorithms and establish similar complexity bounds for solving an important class of stochastic composite optimization problems. Moreover, if the smooth component in the composite function is strongly convex, the developed gradient sliding algorithms can significantly reduce the number of graduate and subgradient evaluations for the smooth and nonsmooth component to $\mathcal{O}(\log(1/\epsilon))$ and $\mathcal{O}(1/\epsilon)$, respectively.

2 – A PARALLEL METHOD FOR LARGE SCALE CONVEX REGRESSION PROBLEMS

SPEAKER: **Zi Wang** (The Pennsylvania State University, zxw121@psu.edu)
Necdet Serhat Aybat (The Pennsylvania State University, nsa10@psu.edu)

Convex regression (CR) problem deals with fitting a convex function to a finite number of observations. It has many applications in various disciplines, such as statistics, economics, operations research, and electrical engineering. Computing the least squares (LS) estimator via solving a quadratic program (QP) is the most common technique to fit a piecewise-linear convex function to the observed data. Since the number of constraints in the QP formulation increases quadratically in N, the number of observed data points, computing the LS estimator is not practical using interior point methods when N is very large. The first-order method described in this talk carefully manages the memory usage through parallelization, and efficiently solves large-scale instances of CR problem with limited memory.

3 – DATA-DRIVEN FIRST-ORDER METHODS FOR MISSPECIFIED CONVEX OPTIMIZATION PROBLEMS: GLOBAL CONVERGENCE AND RATE ESTIMATES

SPEAKER: **Hesamoddin Ahmadi** (Pennsylvania State University, hza108@psu.edu)
Uday V. Shanbhag (Pennsylvania State University, udaybag@engr.psu.edu)

We consider a misspecified optimization problem that requires minimizing of a convex function f(x;q*) in x over a closed and convex set X where q* is an unknown vector of parameters. Suppose q* may be learnt by a parallel learning process that generates a sequence of estimators q_k each of which is an increasingly accurate approximation of q^*. In this context, we examine the development of coupled schemes that generate iterates (x_k,q_k) such that as the iteration index k goes to infinity, then x_k converges to x^*, a minimizer of $f(x;q^*)$ over X and q_k converges to q^*. We make two sets of contributions along this direction. First, we consider the use of gradient methods and proceed to show that such techniques are globally convergent. In addition, such schemes show a quantifiable degradation in the geometric rate of convergence observed for strongly convex optimization problems. However in merely convex regimes, the rate of convergence in function values via averaging is seen to be O(1/K) after K steps; in effect, learning leads to a constant factor degradation but no change on the overall rate. Second, when employing subgradient methods with averaging, we observe that the rate is O(1/sqrt(K)), implying that learning has a constant factor impact. Notably, in such regimes, we also determine the optimal constant stepsize and determine its rate and the impact arising from learning. Numerical studies on a misspecified economic dispatch problem suggest that the schemes hold promise.

4 – OPTIMAL ADAPTIVE SAMPLING IN STOCHASTIC RECURSIONS

SPEAKER: **Raghu Pasupathy** (Purdue University, pasupath@purdue.edu)
Soumyadip Ghosh (IBM Research, ghoshs@us.ibm.com)
Fatemeh Hashemi (Virginia Tech)

We consider the question of adaptive Monte Carlo sampling in general stochastic recursions. Such recursions arise in a wide variety of settings such as stochastic approximation, stochastic trust region methods, and stochastic quasi-Newton methods. Within such settings, we rigorously analyze the behavior of certain adaptive sampling heuristics (based on estimated "signal to noise ratios") that have recently become popular due to observed empirical success. We show that such heuristics are members of a wider class that are efficient in a certain rigorous sense. If time permits, we will illustrate our results using suitable numerics.

CONVEXIFICATION OF NONCONVEX QUADRATIC PROBLEMS — WED 1:30-3:30

CHAIR: **Fatma Kılınç-Karzan** (Carnegie Mellon University) — RM: B

1 – SOLVING QCQPS

SPEAKER: **Daniel Bienstock** (Columbia University, dano@columbia.edu)

QCQPs (or quadratically constrained quadratic programs) are continuous optimization problems that are now the focus of renewed research interest. They are very general (and NP-had) and also arise in many practical applications. In this talk we review some of the current work on this topic that we are engaged in, focusing on solution by approximation through linear and conic convex relaxations.

2 – UNDERSTANDING STRUCTURE IN CONIC MIXED INTEGER PROGRAMS: FROM MINIMAL INEQUALITIES TO CONIC DISJUNCTIVE CUTS

SPEAKER: **Fatma Kılınç-Karzan** (Carnegie Mellon University, fkilinc@andrew.cmu.edu)
Sercan Yildiz (Carnegie Mellon University, syildiz@andrew.cmu.edu)

We study nonlinear mixed integer sets involving a general regular (closed, convex, full dimensional, and pointed) cone K such as the nonnegative orthant, the Lorentz cone or the positive semidefinite cone, and introduce the class of K-minimal valid linear inequalities. Under mild assumptions, we show that these inequalities together with the trivial cone-implied inequalities are sufficient to describe the convex hull. We characterize these inequalities by identifying necessary, and sufficient conditions for an inequality to be K-minimal. This framework and the notion of K-minimality, naturally generalizes the corresponding results for Mixed Integer Linear Programs (MILPs), i.e., our results recover that the minimal inequalities for MILPs are generated by piecewise linear and sublinear functions. However, our study also reveals that such a cut generating function view is not possible for the conic case even when the cone involved is the Lorentz cone.

The structure of valid linear inequalities also generates non-trivial and exciting structural results for conic sets. In particular, we introduce a new technique on deriving closed-form expressions for convex inequalities describing the convex hull of a two-term disjunction applied to the Lorentz cone.

The last part of this talk is joint work with Sercan Yildiz.

3 – DISJUNCTIVE CUTS FOR THE SECOND-ORDER CONE AND ITS CROSS-SECTIONS

SPEAKER: **Sercan Yildiz** (Carnegie Mellon University, syildiz@andrew.cmu.edu)
Fatma Kılınç-Karzan (Carnegie Mellon University, fkilinc@andrew.cmu.edu)
Gérard Cornuéjols (Carnegie Mellon University, gc0v@andrew.cmu.edu)

We study the convex hull of a two-term disjunction applied to the second-order cone and develop a methodology to derive closed-form expressions for convex inequalities that describe the resulting convex hull. Our approach capitalizes on the structure of undominated valid linear inequalities for the disjunction. We use this structure and conic duality to derive a family of convex, possibly nonlinear, valid inequalities that summarize the undominated linear inequalities. We identify and study the cases where these convex inequalities can equivalently be expressed in conic quadratic form and where a single inequality from this family is sufficient to describe the convex hull.

In more recent work, we extend these results to two-term disjunctions on cross-sections of the second-order cone. We show that a single convex inequality is sufficient to characterize the closed convex hull of all two-term disjunctions on ellipsoids and paraboloids, and split disjunctions on all cross-sections of the second-order cone.

4 – A BRANCH-AND-BOUND ALGORITHM FOR INSTRUMENTAL VARIABLE QUANTILE REGRESSION

SPEAKER: **Guanglin Xu** (University of Iowa, guanglin-xu@uiowa.edu)
Samuel Burer (University of Iowa, samuel-burer@uiowa.edu)

We consider a problem arising in statistics called instrumental variable quantile regression (IVQR), and model IVQR as a convex quadratic program with complementarity constraints. Although this type of program is generally NP-hard, we develop a branch-and-bound algorithm to solve it globally. On random, yet realistic, instances of IVQR, we compare our algorithm with two well known solvers and demonstrate that our algorithm solves these instances efficiently and effectively.

BLACK-BOX AND DERIVATIVE-FREE OPTIMIZATION — WED 1:30-3:30

CHAIR: **Rommel Regis** (Saint Joseph's University) — RM: C

1 – NOWPAC — A DERIVATIVE FREE TRUST-REGION METHOD WITH PATH-AUGMENTED CONSTRAINTS FOR NONLINEAR PROGRAMMING

SPEAKER: **Florian Augustin** (Massachusetts Institute of Technology, fmaugust@mit.edu)
Youssef M. Marzouk (Massachusetts Institute of Technology, ymarz@mit.edu)

We present the derivative free trust-region algorithm NOWPAC (Nonlinear Optimization With Path-Augmented Constraints) for computing local solutions to nonlinear constrained optimization problems. The constraints are enforced strictly, guaranteeing feasibility at every intermediate design point. This strategy allows us to establish a proof of convergence of the overall algorithm towards a first order local critical point. To increase the efficiency of the optimization, we introduce an inner-boundary path to support the identification of acceptable trial steps. These trial steps are computed using local surrogate models. In NOWPAC we rely on quadratic minimum Frobenius norm models based on well-poised interpolation points. To compute good interpolation points, we present an approach based on semi-definite programming in homogeneous coordinates. Having ensured good quality of the surrogates, we use their Hessians as "noise indicators" for situations when inexact evaluations of the objective function or the constraints corrupt the convergence of our algorithm. We illustrate these methods with several numerical examples.

2 – THE USE OF THE Q-GRADIENT VECTOR FOR CONTINUOUS GLOBAL OPTIMIZATION PROBLEMS

SPEAKER: **Érica J. Coelho Gouvêa** (National Institute for Space Research, Brazil)
Rommel G. Regis (Saint Joseph's University, rregis@sju.edu)
Aline C. Soterroni (National Institute for Space Research, Brazil, alinecsoterroni@gmail.com)
Fernando M. Ramos (National Institute for Space Research, Brazil, fernando.ramos@inpe.br)

The q-gradient vector is a generalization of the gradient vector based on the q-derivative. We present a q-version of the steepest descent method called the q-G method and a q-version of the Conjugate Gradient method called the q-CG method. Both q-G and q-CG are reduced to their classical versions when q equals 1. The methods are implemented in a way that the search process gradually shifts from global in the beginning to almost local search in the end. Moreover, Gaussian perturbations are used in some iterations to guarantee the convergence of the methods to the global minimum in a probabilistic sense. Finally, we present numerical results comparing q-G and q-CG with their classical versions and also with alternative methods, including an evolutionary algorithm and a direct search method.

3 – DERIVATIVE FREE OPTIMIZATION FOR PARTIALLY SEPARABLE FUNCTIONS

SPEAKER: **Benjamin Marteau** (IFP énergies nouvelles, benjamin.marteau@ifpen.fr)
Laurent Dumas (Université de Versailles Saint-Quentin-en-Yvelines, laurent.dumas@uvsq.fr)
Didier Ding (IFP énergies nouvelles, didier-yu.ding@ifpen.fr)
Delphine Sinoquet (IFP énergies nouvelles, delphine.sinoquet@ifpen.fr)

Minimizing expensive-to-evaluate functions, whose derivative are note easy to compute, is a growing concern in many domains. For example, the history matching problem is a major challenge for the petroleum industry and requires the minimization of a partially separable objective function. To limit as much as possible the number of evaluations of this function, we tried to exploit its particular structure. We will present in this talk a trust region method that greatly reduces the cost of the minimization of partially separable functions.

4 – CELLULAR MATERIAL MODEL HOMOGENIZATION

SPEAKER: **Rich Laverty** (The Boeing Company, richard.r.laverty@boeing.com)

Cellular materials in large vehicle finite element simulations are necessarily approximated with continuum material models to keep computational times reasonable. The number of parameters in the material model can rise essentially without limit, with higher accuracy roughly correlated with higher numbers of parameters. Often, for the higher fidelity material models, there is no direct measurement for the individual material parameters, but they may be determined indirectly from an appropriate experimental measurement. This talk is focused on the determination of the material parameters for a cellular microtruss intended to be used as an energy absorbing structure within a ground combat vehicle. A high strain rate drop test was performed on the microtruss and the acceleration of the dropped mass was recorded. A finite element simulation using a homogenized continuum material undergoing the same experiment was conducted, and the mass' acceleration recorded. The difference between the finite element simulation calculation and the experimental measurement was treated as a "black box" function of the material parameters, and then an optimization was executed with the material parameters as the design variables. Final results are presented and compared with an ideal energy absorbing material.

SMART GRIDS I

WED 5:00-7:00

CHAIR: **Luis Zuluaga** (Lehigh University)

RM: A

1 – WIND AGGREGATION VIA RISKY POWER MARKETS

SPEAKER: **Yue Zhao** (Stanford University, yuez@stanford.edu)
Junjie Qin (Stanford University, jqin@stanford.edu)
Ram Rajagopal (Stanford University, ramr@stanford.edu)
Andrea Goldsmith (Stanford University, andrea@ee.stanford.edu)
H. Vincent Poor (Princeton University, poor@princeton.edu)

Uncertainty and variability of renewable energy generation imposes great challenges on reliable operation of the electricity grid with high renewable penetration. Aggregation of diverse renewable energy sources can effectively reduce their uncertainty and variability. We develop a new market mechanism for renewable energy producers to achieve flexible and distributed aggregation. In this market, we introduce a novel risky (in addition to riskless) power forward contract that allows renewable energy producers to trade uncertain power output, so that their own risks are reduced. We show that the risky power market has a unique competitive equilibrium, characterized in closed form. Moreover, the market equilibrium enjoys a number of efficiency, fairness and stability properties that make the risky power market very appealing.

2 – CHANCE CONSTRAINED OPTIMIZATION IN ELECTRICITY NETWORKS WITH RAMPING CONSTRAINTS

SPEAKER: **M. Mohsen Moarefdoost** (Lehigh University, mom211@lehigh.edu)
Alberto Lamadrid (Lehigh University, ajlamadrid@lehigh.edu)
Luis F. Zuluaga (Lehigh University, luis.zuluaga@lehigh.edu)

The increased introduction of renewable energy sources (RES) such as wind into the electricity networks has made the management and operation of these networks more difficult. The variability in the power output of renewable energy sources requires flexible generation units to ramp up and ramp down more frequently to maintain the power balance and reliability. Moreover, the renewable energy sources are uncertain in nature which adds another complexity to the system. In this paper, we study the generation ramping costs and constraints in the power networks, and examine their effects on the generation and dispatch policies by proposing a ramping cost function that reflects the physical characteristics of the units. Then, we use the chance constrained optimization approach to manage the risk and maintain reliability of the power system. We study the necessary conditions under which the chance constrained model of the system can be reformulated as a suitable deterministic optimization problem for large-scale networks.

3 – EQUILIBRIUM TERM STRUCTURE OF ELECTRICITY PRICES

SPEAKER: **Miha Troha** (University of Oxford, troha@maths.ox.ac.uk)
Raphael Hauser (University of Oxford, hauser@maths.ox.ac.uk)

We propose a term structure power price model that, in contrast to widely accepted no-arbitrage based approaches, accounts for the non-storable nature of power. It belongs to a class of equilibrium game theoretic models with players divided into producers and consumers. Consumers' goal is to maximize a mean-variance utility function subject to satisfying inelastic demand of their own clients (e.g households, businesses etc.) to whom they sell the power on. Producers, who own a portfolio of power plants each defined by a running fuel (e.g. gas, coal, oil...) and physical characteristics (e.g. efficiency, capacity, ramp up/down times, startup costs...), would, similarly, like to maximize a mean-variance utility function consisting of power, fuel, and emission prices subject to production constraints. Our goal is to determine the term structure of the power price at which production matches consumption. In this talk we outline that such a price exists and develop conditions under which it is also unique. Under condition of existence, we propose a tractable quadratic programming formulation for finding the equilibrium term structure of the power price. Numerical results show performance of the algorithm when modeling the whole system of UK power plants.

4 – OPTIMAL INTERNALIZATION OF THE COST OF RENEWABLE ENERGY SOURCES

SPEAKER: **Alberto Lamadrid** (Lehigh University, ajlamadrid@lehigh.edu)
Tim Mount (Cornell University)
Wooyoung Jeon (Korean Institute for Industrial Economics)

The electricity sector provides a platform for a large part of the economic activity in developed countries. Probably because of this, the reliability of the service has been a prime concern, often higher than economic efficiency, as Regional Transmission Organizations (RTO's) and System Operators (SO's) are responsible for assuring the continuous delivery of energy according to mandated reliability standards (NERC, 2013). As most of these economies aim to increase the share of renewable energy generated, and with expected demand increases around 25% (EIA, 2012), the operating reliability of the system is threatened by the variability in the output from these sources (Baldick, 2012). This article suggests a framework to internalize the ramping externalities and study the ef- fect of variable levels of wind penetration Lamadrid, Mount, and Zimmerman (2013). We use a stochastic maximization of the total welfare from the point of view of a social planner, and a network reduction alongside specific placement of RES in connected nodes that may have congestion. The optimization uses CPLEX to find the solution with a Newton Raphson approximation. Our results show that the internalization of costs leads to a maximum on the total welfare that can be achieved, as wind penetration levels increase. The flows of electricity using Kirchhoff's laws show that the income for wind generation owners is reduced, due to the separation occur- ring in the network as congestion builds up, and a number of non linear effects in the interaction between ramping costs and wind penetration levels.

MIXED INTEGER LINEAR PROGRAMMING

WED 5:00-7:00
CHAIR: **Sangho Shim** (Northwestern University) RM: B

1 – MULTIOBJECTIVE OPTIMIZATION FOR AUTOMATIC SCHEMATIC MAP DRAWING

SPEAKER: **Olufolajimi Oke** (Johns Hopkins University, jimi.oke@jhu.edu)
Sauleh Siddiqui (Johns Hopkins University, siddiqui@jhu.edu)

We present an efficient multiobjective mixed binary linear program that automates schematic mapping for network visualization and orientation. Schematic representations use topologically accurate distortion to facilitate access to various classes of networks, including public transit, circuits, organograms, and taxonomies. Automation is desired for optimal designs with minimal cost, and our implementation achieves greater computational efficiency and better user interaction than in previous efforts. We explain our methods using numerical examples, and then apply them to two real-world networks.

2 – OPTIMAL TV ADVERTISING USING A MULTI-OBJECTIVE INTEGER PROGRAMMING APPROACH

SPEAKER: **Vivian M. Evangelista** (St. Joseph's University, vevangel@sju.edu)
Rommel G. Regis (St. Joseph's University, rregis@sju.edu)

One of the issues faced by advertising agencies is generating optimal TV advertising campaigns for multiple brands. The objective is to simultaneously maximize the reach of multiple brands subject to budget constraints, reach and GRP goals, competing brand constraints and others. Previous approaches to solving this problem include a greedy heuristic and a multi-objective genetic algorithm. This paper presents a multi-objective integer programming formulation for this problem. Numerical results will also be presented.

3 – OPTIMAL FACILITY IN-NETWORK SELECTION FOR HEALTHCARE PAYERS UNDER REFERENCE PRICING

SPEAKER: **Victoire Denoyel-Garnier** (ESSEC Business School, victoire.denoyel@essec.edu)
Aurelie Thiele (Lehigh University, aurelie.thiele@lehigh.edu)
Laurent Alfandari (ESSEC Business School, alfandari@essec.edu)

In reference pricing (RP), a payer or insurer determines a maximum paid amount for a procedure, and patients who select a provider charging more pay the difference. Motivated by a recent CalPERS program, we design two MIP optimization models to decide which providers should be subject to it. This research fills the gap of quantitative insights on RP with respect to price and quality. Preliminary results give promising leads on pitfalls and benefits of this policy. We argue that this system has strong potential in terms of costs reduction for payers, quality increase for patients and visibility for high-value providers.

4 – A FEW STRONG KNAPSACK FACETS

SPEAKER: **Sangho Shim** (Northwestern University, shim@kellogg.northwestern.edu)
Sunil Chopra (Northwestern University, s-chopra@kellogg.northwestern.edu)
Wenwei Cao (Georgia Institute of Technology, cww@gatech.edu)

We perform the worst case analysis of the binary facets possibly with coefficients equal to 1/2, which we will call the 1-facets, and other strong facets of the master knapsack problem of order n. Explicit worst case analysis for small orders suggests that the 1-facets are strongest as Shim and Johnson (Math Program 138:273-307, 2013) observed in a shooting experiment, and the next strongest have the multiples of 1/3 or the multiples of 1/4 as their coefficients. We identify the LP-relaxation gaps of the 1-facets. Then, we characterize the 1/3-facets and the 1/4-facets and identify 1/3-facets and 1/4-facets with a large LP-relaxation gap which is largest over the 1/3-facets, where a 1/k-facet is defined to be a knapsack facet with multiples of 1/k as their coefficients which may or may not include coefficients equal to 1/2. The least upper bound of the LP-relaxation gaps of the knapsack facets over all orders is shown to be achieved only among the 1-facets. Upper bounds of the LP-relaxation gaps of the 1/k-facets defined by Araoz, Evans, Gomory and Johnson (Theorem 6.8, Math Program 96:377-408, 2003) decrease as k grows. The upper bounds with k odd are relatively smaller than those with k even. The shooting experiment also suggests such decrease and oscillation of the LP-relaxation gaps of 1/k-facets.

PATH FINDING & ROUTING: APPLICATIONS & ALGORITHMS — WED 5:00-7:00

CHAIR: **Marina A. Epelman** (University of Michigan) — RM: C

1 – A COLUMN GENERATION AND ROUTING APPROACH TO 4π VMAT RADIATION THERAPY TREATMENT PLANNING

SPEAKER: **Edwin Romeijn** (National Science Foundation, eromeijn@nsf.gov)
Troy Long (University of Michigan, troylong@umich.edu)
Thomas Bortfeld (Massachusetts General Hospital and Harvard Medical School, tbortfeld@partners.org)
David Craft (Massachusetts General Hospital and Harvard Medical School, dcraft1@partners.org)
David Papp (Massachusetts General Hospital and Harvard Medical School, Papp.David@mgh.harvard.edu)
Jan Unkelbach (Massachusetts General Hospital and Harvard Medical School, junkelbach@partners.org)

Volumetric Modulated Arc Therapy (VMAT) is rapidly emerging as a method for delivering radiation therapy treatments to cancer patients that is of comparable quality to IMRT but much more efficient. Since VMAT only uses coplanar beam orientations, the next step is to consider non-coplanar orientations as well. This greatly complicates the radiation therapy treatment plan optimization problem by introducing a path finding and routing component. We propose a constructive approach that employs both column generation and routing heuristics.

2 – NETWORK REPAIR CREW SCHEDULING AND ROUTING FOR EMERGENCY RELIEF DISTRIBUTION PROBLEM

SPEAKER: **Irina Dolinskaya** (Northwestern University, dolira@northwestern.edu)
Pablo A. Maya Duque (University of Antioquia, Colombia, Pablo.MayaDuque@ua.ac.be)
Kenneth Sorensen (University of Antwerp, Belgium, kenneth.sorensen@ua.ac.be)

Every year, hundreds of thousands of people are affected by natural disasters. The number of casualties is usually increased by lack of clean water, food, shelter, and adequate medical care during the aftermath. One of the main problems influencing relief distribution is the state of the post-disaster road network. In this paper, we consider the problem of scheduling the emergency repair of a rural road network that has been damaged by the occurrence of a natural disaster. This problem, which we call the Network Repair Crew Scheduling and Routing Problem addresses the scheduling and routing of a repair crew optimizing accessibility to the towns and villages that demand humanitarian relief by repairing roads. We develop both an exact dynamic programming (DP) algorithm and a GRASP metaheuristic to solve the problem and compare the performance of both approaches on small- to medium-scale instances. Our numerical analysis of the solution structure validates the optimization model and provides managerial insights into the problem and its solutions.

3 – DECOMPOSITION METHODS FOR MULTI-PERIOD COMBINED NETWORK DESIGN & ROUTING OPTIMIZATION PROBLEM AND APPLICATIONS

SPEAKER: **Dimitri Papadimitriou** (Bell Labs, dimitri.papadimitriou@alcatel-lucent.com)
Bernard Fortz (Université Libre de Bruxelles, bernard.fortz@ulb.ac.be)

This paper generalizes the conventional Fixed Charge Network Design Problem (FCNDP) over multiple time periods and a routing cost function which takes into account congestion (number of routing paths per edge) and delay (routing path length). With flow aggregation by destination, its resolution on realistic instances becomes intractable with state-of-the-art solvers due to the weak LP bound of the formulation. An extended formulation with flow disaggregation by source-destination pairs increases solution quality and computational time thanks to stronger LP lower bounds though solving the linear relaxation of the problem remains intractable when the network size increases. We investigate an alternative way to overcome these computational limits by projecting the extended formulation to the variables space of the initial formulation. This approach leads to a Benders decomposition method that can be embedded in a branch-and-cut algorithm.

4 – Finding a roll-minimizing path for a vessel moving in a seaway using the parameter-free Sampled Fictitious Play algorithm

SPEAKER: **Marina A. Epelman** (University of Michigan, mepelman@umich.edu)
Irina Dolinskaya (Northwestern University, dolira@northwestern.edu)
Robert L. Smith (University of Michigan, rlsmith@umich.edu)
Esra Sisikoglu (Antalya International University, esras@antalya.edu.tr)

Any vessel moving in a seaway is subjected to the effects of surrounding waves, which impact its motions, especially roll. In this talk, we present a Dynamic Programming (DP) based approach to finding a path between specified origin and destination that minimizes a measure of total roll experienced by the vessel without significantly increasing its travel time. We describe a parameter-free Sampled Fictitious Play algorithm for solving large-scale deterministic DPs, which is very well suited to this application, where accurate evaluation of the cost of each DP transition requires deployment of sophisticated simulation software.

INFORMATION THEORY AND OPTIMIZATION I

WED 5:00-7:00

CHAIR: **Eugene Perevalov** (Lehigh University)

RM: D

1 – A MARKOV DECISION PROCESS MODEL FOR MINIMIZING INFORMATION LEAKAGE THROUGH ENERGY STORAGE IN SMART METERING SYSTEMS

SPEAKER: **Jiyun Yao** (Lehigh University, jiy312@lehigh.edu)
Parv Venkitasubramaniam (Lehigh University, parv.v@lehigh.edu)

In demand response systems with energy electricity storage, it is essential to understand the information leakage through the real time metering. The critical information can be inferred about electricity usage and energy storage level and consequently compromise the user's in-home activity information. In this work, a mathematical framework based on Markov Process model is proposed to study the process of electricity storage control when privacy is a requirement. Modeling information privacy using information theoretic equivocation, the problem is shown to reduce to a POMDP where the rewards are belief dependent and nonlinear.
In particular, inner bounds are presented using a "revealing state" approach, which enables computation of a class of battery control policies that aim to maximize the achievable privacy of in-home demands. Upper bounds are provided using a standard rate-distortion optimization. These bounds are derived for a discrete, where demand and price follow i.i.d uniform distributions. Numerical results show that the our proposed strategy performs quite close to the upper bound of the optimal tradeoff between privacy preserving and cost saving.

2 – DISTRIBUTED ESTIMATION IN THE PRESENCE OF ATTACKS

SPEAKER: **Jiangfan Zhang** (Lehigh University, jiangfanzhang@lehigh.edu)
Rick S. Blum (Lehigh University, rblum@ece.lehigh.edu)

Distributed estimation of an unknown deterministic mean-shift parameter in additive zero-mean noise is studied when using quantized data in the presence of Byzantine attacks. First, we consider the task of identifying and categorizing the attacked sensors into different groups according to distinct attacks. Next, in order to improve the estimation performance, we propose a modified quantization approach to jointly estimate the statistical description of the attacks and the parameter to be estimated after the sensors have been well categorized.

3 – DEMAND CHARGE REDUCTION WITH BATTERY ENERGY STORAGE SYSTEM (BESS) IN ELECTRICITY NETWORK

SPEAKER: **Fang Chen** (Lehigh University, fac210@lehigh.edu)
Lawrence V. Snyder (Lehigh University, larry.snyder@lehigh.edu)

In an electricity network, large power consumers are charged for their peak demand in addition to the energy they consumed. A battery energy storage systems (BESS) may be employed to perform peak shaving tasks. To account for the stochastic feature of the load profile, we first introduce two optimization algorithms. We then introduce a real time planning algorithm, which can adopt load forecast values. Simulation shows that real time algorithm produces good result.

4 – EXTENDING INFORMATION THEORY TO INFORMATION ACQUISITION PROCESSES

SPEAKER: **Xing Wang** (Lehigh University, xiw313@lehigh.edu)
Eugene Perevalov (Lehigh University, eup2@lehigh.edu)

The classical information theory has made great advances in the realm of information transmission. The reason is that it has found a way to accurately describe information quantity. On the other hand, information acquisition and extraction is still performed in an ad hoc problem specific fashion. We attempt to fill this void and to begin developing a general theory of information accuracy and relevance which should allow for a proper treatment of information acquisition processes in a way similar to that the classical information theory allowed for a proper treatment of information transmission.

ENERGY II

THU 1:30-3:00

CHAIR: **Larry Snyder** (Lehigh) & **Miguel Anjos** (Polytechnique Montréal)

RM: A

1 – OPTIMIZATION AND EQUILIBRIUM MODELING FOR RENEWABLE ENERGY: FOCUS ON WASTEWATER-TO-ENERGY USING A TWO-LEVEL OPTIMIZATION PROBLEM

SPEAKER: **Steven A. Gabriel** (University of Maryland, sgabriel@umd.edu)
Chalida U-tapao (King Mongut's Institute of Technology Ladkrabang, Thailand)

In this talk, we present recent results of a two-level optimization problem (MPEC) for energy. In particular, the top-level player is a large wastewater treatment plant that solves a two-stage, stochastic optimization problem to maximize profits at the top level. The first-stage variables at this top level include options for a digester that converts the wastewater to methane and class A biosolids (fertilizer). The second-stage variables for this top-level player include operational considerations. The bottom level of this MPEC are the markets that the wastewater treatment plant interacts with: fertilizer, compressed natural gas for transportation, residential natural gas, and power production. We present the model, solution approaches and representative results.

2 – THE INFLUENCE OF THE PANAMA CANAL ON GLOBAL GAS TRADE

SPEAKER: **Seksun Moryadee** (University of Maryland, smoryade@umd.edu)
Steven A. Gabriel (University of Maryland, stevenagabriel@gmail.com)

An increasing growth of unconventional gas production in the U.S. has gradually turned it into a potential gas exporter. In near future, increasing LNG exports from the U.S. coupled with the capacity of the Panama Canal will change the LNG market. The Panama Canal expansion is the key to the change because the route via this canal reduces the voyage by 7,000 nautical miles to Japan from the Gulf of Mexico. Applying the World Gas Model from the University of Maryland,we investigates the potential effects of varying Panama Canal tolls on the LNG markets via six scenarios of possible Panama Canal tariffs. Results are compared and examined with the focus on prices, LNG flows, and supply displacement. We find a significant LNG volume tradeoff between Asian and European gas markets.

3 – AN EQUILIBRIUM MODEL FOR THE US RIN MARKET

SPEAKER: **Sauleh Siddiqui** (Johns Hopkins University, siddiqui@jhu.edu)
Adam Christensen (Johns Hopkins University, adam.christensen@jhu.edu)

Renewable Identification Numbers (RINs) are used to track the use of biofuels in the US transportation infrastructure and are the primary currency to demonstrate compliance with the mandated biofuel volume requirements. The RIN market and its respective players will be modeled using an equilibrium problem, which will be used to quantify the effects of parallel incentives in the form of tax credits and other policy initiatives.

CONVEX RELAXATIONS FOR NONCONVEX PROBLEMS — THU 1:30-3:00
CHAIR: **Hongbo Dong** (Washington State University) — RM: B

1 – HOW GOOD ARE SPARSE CUTTING-PLANES?

SPEAKER: **Santanu S. Dey** (Georgia Institute of Technology, santanu.dey@isye.gatech.edu)
Marco Molinaro (Georgia Institute of Technology, marco.molinaro@isye.gatech.edu)
Qianyi Wang (Georgia Institute of Technology, qwang62@gatech.edu)

Sparse cutting-planes are often used in mixed-integer programming solvers, since they help in solving linear programs more efficiently. However, how well can we approximate the integer hull by just using sparse cutting-planes? In order to understand this question better, given a polyope P (e.g. the integer hull of a MIP), let P^k be its best approximation using cuts with at most k non-zero coefficients. We present various results on how well P^k approximates P.

2 – A DISCRETIZATION PUMP FOR A CLASS OF MIXED-INTEGER BILINEAR OPTIMIZATION PROBLEMS

SPEAKER: **Dimitri Papageorgiou** (ExxonMobil, dimitri.j.papageorgiou@exxonmobil.com)

Mixed-Integer Linear Programming (MILP) solvers employ an arsenal of primal heuristics (e.g., Rounding, Feasibility Pump, Local Branching, RINS) to quickly generate good feasible solutions to challenging optimization problems. Mixed-Integer Nonlinear Programming (MINLP) solvers, on the other hand, are less mature and can struggle to find feasible solutions. We present a general discretization strategy for a class of mixed-integer bilinear optimization problems that can significantly reduce the time to find good feasible solutions. Although discretization leads to instances with many more variables and constraints, it allows us to exploit the power of MILP solvers to quickly identify good feasible solutions. We believe the approach is quite general and could be incorporated into existing MINLP solvers. Results for a class of challenging multiperiod blending problems that arise in the petrochemical industry are shown to illustrate the effectiveness of the approach.

3 – RELAXING NONCONVEX QUADRATIC FUNCTIONS BY MULTIPLE ADAPTIVE DIAGONAL PERTURBATIONS

SPEAKER: **Hongbo Dong** (Washington State University, hongbo.dong@wsu.edu)

We propose a procedure to generate convex quadratic valid constraints for mixed-integer nonconvex quadratically constrained problems (MIQCP), by considering one nonconvex quadratic constraint and the (separable) variable structure. Our resulting relaxation does not use significantly more variables than the original problem, in contrast to many other relaxations based on lifting. We show that all such valid constraints is equivalent to a Semidefinite Relaxation used by (Buchheim and Wiegele, 2013) in their branch-and-bound code Q-MIST. The corresponding separation problem is a highly structured semidefinite program (SDP) with convex but non-smooth objective. We propose to solve this separation problem with a specialized primal-barrier coordinate minimization algorithm. Computational results show that our approach is very promising and suitable in a branch-and-cut scheme for general MIQCPs.

STOCHASTIC SEARCH & APPROXIMATE DYNAMIC PROGRAMMING THU 1:30-3:00

CHAIR: **Tsvetan Asamov** (Princeton University) RM: C

1 – APPROXIMATION STRATEGIES FOR MULTISTAGE STOCHASTIC PROGRAMS

SPEAKER: **Tsvetan Asamov** (Princeton University, tasamov@princeton.edu)
Warren B. Powell (Princeton University, powell@princeton.edu)

Using the contextual setting of optimizing grid-level energy storage, we study the effect of dimensionality (the number of storage devices) on the performance of different approximation strategies, including regularized stochastic decomposition and piecewise linear, separable approximations. We build on the algorithmic framework of approximate dynamic programming to introduce novel machine learning strategies which overcome the curse of dimensionality inherent in scenario trees. We use the energy storage setting to create families of problems which exhibit different characteristics in terms of dimensionality and structure of the information state.

2 – KNOWLEDGE GRADIENT WITH DISCRETE PRIORS

SPEAKER: **Si Chen** (Princeton University, sichen@princeton.edu)
Kris Reyes (Princeton University, kreyes@princeton.edu)
Warren B. Powell (Princeton University, powell@princeton.edu)

We propose a knowledge-gradient policy based on a small set of discrete priors sampled from a multi-dimensional nonlinear parametric model. At each time step, the policy utilizes the value of information and Bayesian statistics to make decisions. We present an application to solve a Bayesian optimal search program in material science, namely discovering the set of controllable parameters to construct the desired payload delivery system.

3 – OPTIMAL LEARNING WITH A LOCAL PARAMETRIC BELIEF MODEL

SPEAKER: **Bolong Cheng** (Princeton University, bcheng@princeton.edu)
Warren B. Powell (Princeton University, powell@princeton.edu)
Arta Jamshidi (arta@princeton.edu)

We are interested in maximizing smooth functions where observations are noisy and expensive to compute, as might arise in computer simulations or laboratory experimentation. We derive a knowledge gradient policy, which chooses measurements which maximize the expected value of information, while using a locally parametric belief model that uses linear approximations with radial basis functions. The method uses a compact representation of the function which avoids storing the entire history, as is typically required by nonparametric methods. Our technique uses the expected value of a measurement in terms of its ability to improve our estimate of the optimum, capturing correlations in our beliefs about neighboring regions of the function, without posing any assumptions on the global shape of the underlying function a priori. Experimental work suggests that the method adapts to a range of arbitrary, continuous functions, and appears to reliably find the optimal solution. Moreover, the policy is shown to be asymptotically optimal.

Bilevel Optimization & Risk — Thu 1:30-3:00

Chair: **Nelson A. Uhan** (United States Naval Academy) — Rm: D

1 – Multi-modal non-linear stochastic bi-level sustainable land use and transportation model

Speaker: **Narges Shahraki** (Koc university, nshahraki@ku.edu.tr)
Metin Turkay (Koc university, mturkay@ku.edu.tr)

In this research we formulate a bi-level land use and transport model by considering multi-modal and stochastic travel demand. In the lower level, transportation network and land use problem are formulated to maximize travelers utility and in the upper level we consider minimizing carbon monoxide emission. The two-stage model is formulated as a single stage model by considering optimality condition of lower level problem as a set of constraints. We present a solution algorithm based on logic-based outer approximation of bi-objective MINLPs. We analyze the efficiency of the solution algorithm through some examples. In this study, for the first time in open literature a stochastic multi-modal, bi-level optimization model is formulated for land use and transport problem and an efficient solution algorithm is presented to solve the model.

2 – Computing near-optimal Value-at-Risk portfolios using Integer Programming techniques

Speaker: **Onur Babat** (Lehigh University, onur.babat@lehigh.edu)
Luis F. Zuluaga (Lehigh University, luis.zuluaga@lehigh.edu)
Juan C. Vera (Tilburg University, j.c.veralizcano@uvt.nl)

We consider the Value-at-Risk (VaR) portfolio optimization problem, which is an extension of Markowitz's model in which VaR is used instead of variance as the risk measure. The VaR model can be formulated as an integer programming (IP) problem, and the formulation can be solved for small to mid-size instances in a reasonable amount of time. We exploit the IP formulation to develop an efficient algorithm to solve larger scale instances of the VaR model. Relevant numerical experiments will be presented.

3 – Dynamic allocations for cooperative games under uncertainty with risk-averse players

Speaker: **Nelson A. Uhan** (United States Naval Academy, uhan@usna.edu)
Alejandro Toriello (Georgia Institute of Technology, atoriello@isye.gatech.edu)

In situations where uncertain costs are shared over time, static cooperative game-theoretic models and solution concepts like the core may prove inadequate. For example, this holds in multi-period supply chain settings where inventories, capacities and resources must be managed over time in the presence of uncertainty. Motivated by these applications, we consider a class of cooperative games in which the costs of cooperation are uncertain and evolve over time, and the players are risk averse. These games generalize the classic linear production game, and as a result, model a variety of cooperative settings. We study the strong sequential core of these games - the set of allocations that distribute costs as they are incurred and are stable against coalitional defections at any point in time.

ALGORITHMS FOR LARGE-SCALE NONLINEAR OPTIMIZATION THU 3:15-4:45
CHAIR: **Frank E. Curtis** (Lehigh University) RM: A

1 – HANDLING NEGATIVE CURVATURE IN SPECTRAL GRADIENT METHODS FOR NONLINEAR OPTIMIZATION

SPEAKER: **Wei Guo** (Lehigh University, weg411@lehigh.edu)
Frank E. Curtis (Lehigh University, frank.e.curtis@gmail.com)

Gradient-descent methods are proposed for solving unconstrained nonlinear optimization problems. Emphasis is placed on techniques used to compute appropriate step sizes when negative curvature is present. The methods extend the well-known “two-point step size” method of Barzilai and Borwein and a recent limited memory steepest descent method proposed by Fletcher. Global convergence properties of the methods are guaranteed under mild assumptions. Numerical results are presented to illustrate the benefits of the methods in the presence of negative curvature.

2 – A DYNAMIC PENALTY PARAMETER UPDATING STRATEGY FOR MATRIX-FREE SEQUENTIAL QUADRATIC OPTIMIZATION METHODS

SPEAKER: **Hao Wang** (Lehigh University, haw309@gmail.com)
James V. Burke
Frank E. Curtis
Jiashan Wang

This talk focuses on the issue of updating the penalty parameter within a penalty Sequential Quadratic Optimization (SQO) algorithm for solving nonlinear optimization problems. In contemporary penalty SQO methods, the common strategy is to update the penalty parameter after a subproblem (or a sequence of them) has been solved. This may lead to inefficiency if the parameter is slow to adapt to the problem scaling or structure. By contrast, we propose an approach to update a penalty parameter during the optimization process for each subproblem, where the goal is to produce a search direction that simultaneously predicts progress towards feasibility and optimality. We prove that our approach yields reasonable (i.e., not excessively small) values of the penalty parameter and illustrate the behavior of our approach via numerical experiments.

3 – LARGE-SCALE SPARSE SUBSPACE CLUSTERING

SPEAKER: **Daniel Robinson** (Johns Hopkins University, daniel.p.robinson@gmail.com)

In certain applications, such as face clustering and image segmentation, one obtains a large amount of data that lies in the union of low dimensional subspaces. This leads to the very challenging learning problem of determining the number of subspaces, their dimensions, a basis for each space, and the membership of the data to the various subspaces. During this talk I first give an introduction to a highly successful method called Sparse Subspace Clustering (SSC), which has excellent performance on data of size 10,000. Second, I discuss two scalable optimization algorithms based on SSC that is appropriate when the data size is in the millions.

CONVEX OPTIMIZATION — THU 3:15-4:45

CHAIR: **Miguel Anjos** (Polytechnique Montréal) — RM: B

1 – ON ROBUST SOLUTIONS TO UNCERTAIN LINEAR COMPLEMENTARITY PROBLEMS AND THEIR VARIANTS

SPEAKER: **Yue Xie** (Pennsylvania State University, xieyue1990@gmail.com)
Uday V. Shanbhag (Pennsylvania State University, udaybag@psu.edu)

Variational inequality and complementarity problems have found utility in modeling a range of optimization and equilibrium problems arising in engineering, economics, and the sciences. In what we believe is amongst the very first efforts to comprehensively address such problems in an uncertain but distribution-free environment, we present an avenue for obtaining robust solutions to uncertain linear complementarity problems. We show that robust solutions to such a class of problems can be tractably obtained through the solution of a single convex or nonconvex program. Furthermore, a branch and bound method is presented for obtaining global solutions to such nonconvex programs. Preliminary numerics on uncertain traffic equilibrium suggest that such avenues hold promise.

2 – MINIMIZING AN INDEFINITE QUADRATIC FUNCTION SUBJECT TO A SINGLE INDEFINITE QUADRATIC CONSTRAINT

SPEAKER: **Maziar Salahi** (University of Guilan, salahim@guilan.ac.ir)
Saaed Fallahi (University of Guilan)
Tamás Terlaky (Lehigh University, terlaky@lehigh.edu)

In this talk we consider the problem of minimizing an indefinite quadratic function subject to a single indefinite quadratic constraint. A key difficulty with this problem is its nonconvexity. Using Lagrange duality, we show that under a mild assumption, this problem can be solved by solving a linearly constrained convex univariate minimization problem. Our preliminary numerical experiments on several randomly generated test problems show that, the new approach is much faster in finding the global optimal solution than the known semidefinite relaxation approach, especially when solving large scale problems.

3 – A POLYNOMIAL-TIME RESCALED VON NEUMANN ALGORITHM FOR LINEAR FEASIBILITY PROBLEMS

SPEAKER: **Dan Li** (Lehigh University, dal207@lehigh.edu)
Kees Roos (Delft University of Technology, c.roos@tudelft.nl)
Tamás Terlaky (Lehigh University, terlaky@lehigh.edu)

We propose a rescaled von Neumann algorithm with complexity $\mathcal{O}(n^5 \text{size}(A))$. This is the first polynomial-time variant of the von Neumann algorithm. It is based on Chubanov's so called Basic Procedure and applies its outcome as a rescaling evidence to repeatedly rescale the linear system. Some numerical experiments are presented as well. We also improve the performance of Chubanov's method.

RISK-AVERSE OPTIMIZATION
THU 3:15-4:45

CHAIR: **Andrzej Ruszczyński** (Rutgers University)
RM: C

1 – RISK-AVERSE MARKOV CONTROL MODELS

SPEAKER: **Andrzej Ruszczyński** (Rutgers University, rusz@business.rutgers.edu)

We consider Markov decision processes with dynamic measures of risk. We derive a specific structure of a Markov risk measure and use it to develop dynamic programming equations in finite and infinite time. We propose methods for solving these equations and illustrate their operation of several examples.

2 – TIME-CONSISTENT APPROXIMATIONS: EMPIRICAL RESULTS FOR THE DOW JONES INDUSTRIAL AVERAGE

SPEAKER: **Tsvetan Asamov** (Princeton University, tasamov@princeton.edu)

We use dynamic time-consistent formulations to approximate problems having a single coherent risk measure applied to the aggregated costs over all time periods. The dual representation of coherent risk measures is used to create a time-consistent cutting plane algorithm. Additionally, we also develop methods for the construction of universal time-consistent upper bounds. The performance of the techniques is tested using monthly return data for the components of the Dow Jones Industrial Average.

3 – NUMERICAL METHODS FOR OPTIMIZATION WITH MULTIVARIATE STOCHASTIC ORDERING CONSTRAINTS

SPEAKER: **Eli Wolfhagen** (Stevens Institute of Technology, ewolfhag@stevens.edu)

This talk will provide a review of the extent methods for solving optimization problems with multivariate stochastic ordering constraints, both for static and two-stage problems. We will present the results of numerical testing to compare the methods with respect to computational speed and number of iterations.

INFORMATION THEORY AND OPTIMIZATION II

THU 3:15-4:45

CHAIR: **Sebastian Pokutta** & **Yao Xie** (Georgia Tech)

RM: D

1 – THE GAME OF 20 QUESTIONS WITH (1) NOISY ANSWERS OR (2) MULTIPLE TARGETS: A DELIGHT OF INFORMATION THEORY, PROBABILITY, CONTROL, AND COMPUTER VISION

SPEAKER: **Bruno Jedynak** (Johns Hopkins University, bruno.jedynak@jhu.edu)

We will explore various instances of the game of 20 questions with special interest in the situations where (1) the responses are noisy and (2) there are multiple targets. We will discuss adaptive as well as non-adaptive policies. We will study performance and optimality for an information theoretic cost function. Application in fast face detection, micro-surgical tool tracking, and human vision will be briefly presented.

2 – COMPARING POST POSITIONS USING THE CHI SQUARE DISTRIBUTION

SPEAKER: **Roger L. Goodwin** (rgoodwin@gpo.gov)

In horse racing, at the start of a race, horses line-up in starting gates. The rack track assigns horses and their jockeys their starting gates in advance of a race. We examine the published data from a racetrack to determine if a starting gate is preferred over another. We compare the number of wins across the post positions for sprint races and long distance races using two chi-square distributions. Given the post positions and the number of wins for a given race track, it can be determined that the inner-most and outer-most track positions tend to be preferred over the inner track positions.

3 – LOWER BOUNDS ON THE ORACLE COMPLEXITY OF CONVEX OPTIMIZATION VIA INFORMATION THEORY

SPEAKER: **Cristóbal Guzmán** (Georgia Tech, cguzman@gatech.edu)
Sebastian Pokutta (Georgia Tech)
Gabor Braun

We extend the notion of black box oracle complexity in optimization to the distributional setting, as the worst average running time of algorithms against a distribution of instances. In this model, the distribution of instances is part of the input to the algorithm, so they can potentially accelerate their running time. However, we show that for nonsmooth convex optimization distributional lower bounds coincide to worst-case complexity up to a constant factor; we can further extend these lower bounds to prove high running time with high probability and for bounded error algorithms. Interestingly, we subsume all classical lower bounds by a reduction from a simple string-guessing problem, which can be analyzed by information-theoretic tools.

STOCHASTIC OPTIMIZATION IN ENERGY

FRI 9:45-11:15

CHAIR: **Daniel Jiang** (Princeton University)

RM: A

1 – A NESTED NEWSVENDOR SCHEDULING POLICY FOR OPERATIONS PLANNING IN A SYSTEM WITH SIGNIFICANT WIND POWER PENETRATION

SPEAKER: **Genna Gliner** (Princeton University, genna@princeton.edu)
Warren B. Powell (Princeton University, powell@princeton.edu)

In recent years, wind has established a large presence in the worldwide power generation portfolio and the amount of wind power capacity continues to grow. Large-scale adoption of wind power generation presents various integration challenges because it is highly intermittent and unpredictable. Due to these challenges, wind power generation cannot be scheduled and dispatched in the classical sense and there is a need to investigate alternatives and improvements to the current unit commitment policies in order to take full advantage of the generation capabilities. To address the challenge of uncertain wind forecasts, we propose the addition of intra-day markets and formulate the unit commitment problem as a lagged nested newsvendor model in the presence of rolling wind forecasts. We show how the model can be used to produce an analytical solution to the energy commitment problem in the presence of wind and evaluate the potential benefits of intra-day markets in managing wind power uncertainty.

2 – A PROBABILITY MODEL OF GRID FAILURES USING INCOMPLETE POWER OUTAGE INFORMATION

SPEAKER: **Lina Al-Kanj** (Princeton University, lalkanj@princeton.edu)
Warren B. Powell (Princeton University, powell@princeton.edu)

We consider the problem of estimating the likelihood of an outage occurring at different points of the distribution grid, using only the configuration of the grid and the pattern of calls from customers that they have lost power. These calls occur at a very low rate (approximately 1 percent), and when an outage occurs, it triggers circuit breakers that cut power to a much larger part of a distribution circuit. We develop a method for computing the probability of outages using Bayes' theorem, taking into account the configuration of the grid. We propose a method for handling the combinatorial growth of events when there may be more than one outage, and demonstrate the behavior using a real circuit.

3 – OPTIMAL HOUR-AHEAD BIDDING IN THE REAL-TIME ELECTRICITY MARKET WITH BATTERY STORAGE USING APPROXIMATE DYNAMIC PROGRAMMING

SPEAKER: **Daniel R. Jiang** (Princeton University, drjiang@princeton.edu)
Warren B. Powell (Princeton University, powell@princeton.edu)

There is growing interest in the use of grid-level storage to smooth variations in supply that are likely to arise with increased use of wind and solar energy. Battery arbitrage, the process of buying, storing, and selling electricity to exploit variations in electricity spot prices, is becoming an important way of paying for expensive investments into grid level storage. Independent system operators such as the NYISO (New York Independent System Operator) require that battery storage operators place bids into an hour-ahead market (although settlements may occur in increments as small as 5 minutes, which is considered near "real-time"). The operator has to place these bids without knowing the energy level in the battery at the beginning of the hour, while simultaneously accounting for the value of left-over energy at the end of the hour. The problem is formulated using the dynamic programming framework. We describe and employ a convergent approximate dynamic programming (ADP) algorithm that exploits monotonicity of the value functions to find a profitable bidding policy. Benchmarking results show that the ADP algorithm can find near-optimal policies using significantly less computation than traditional backward dynamic programming.

STOCHASTIC FIRST ORDER METHODS — FRI 9:45-11:15

CHAIR: **Qihang Lin** (University of Iowa) — RM: B

1 – ON DATA PRECONDITIONING FOR REGULARIZED LOSS MINIMIZATION

SPEAKER: **Tianbao Yang** (University of Iowa, yangtia1@gmail.com)
Rong Jin (Michigan State University, rongjin@cse.msu.edu)
Shenghuo Zhu (NEC Labs America, zsh@nec-labs.com)

In this work, we study data preconditioning, a well-known and long-existing technique, for boosting the convergence of first-order methods for regularized loss minimization. It is well understood that the condition number of the problem, i.e., the ratio of the Lipschitz constant to the strong convexity modulus, has a harsh effect on the convergence of the first-order optimization methods. Therefore, minimizing a small regularized loss for achieving good generalization performance, yielding an ill conditioned problem, becomes the bottleneck for big data problems. We provide a theory on data preconditioning for regularized loss minimization. In particular, our analysis exhibits an appropriate data preconditioner and characterizes the conditions on the loss function and on the data under which data precon- ditioning can reduce the condition number and therefore boost the convergence for minimizing the regularized loss. To make the data preconditioning practically useful, we endeavor to employ and analyze a random sampling approach to efficiently compute the preconditioned data. The preliminary experiments validate our theory.

2 – PARALLEL BCD METHODS FOR NON-SMOOTH OPTIMIZATION

SPEAKER: **Meisam Razaviyayn** (University of Minnesota, razav002@umn.edu)
Mingyi Hong (University of Minnesota)
Zhi-Quan Luo (University of Minnesota)
Jong-Shi Pang (University of Southern California)

Consider the problem of minimizing the sum of a smooth (possibly non-convex) and a convex (possibly nonsmooth) function involving a large number of variables. A popular approach to solve this problem is the block coordinate descent (BCD) method whereby at each iteration only one variable block is updated while the remaining variables are held fixed. With the recent advances in the developments of the multi-core parallel processing technology, it is desirable to parallelize the BCD method by allowing multiple blocks to be updated simultaneously at each iteration of the algorithm. In this work, we propose an inexact parallel BCD approach where at each iteration, a subset of the variables is updated in parallel by minimizing convex approximations of the original objective function. We investigate the convergence of this parallel BCD method for both randomized and cyclic variable selection rules. We analyze the asymptotic and non-asymptotic convergence behavior of the algorithm for both convex and non-convex objective functions. The numerical experiments suggest that for a special case of Lasso minimization problem, the cyclic block selection rule can outperform the randomized rule.

3 – AN ACCELERATED RANDOMIZED COORDINATE DESCENT METHOD FOR STRONGLY CONVEX COMPOSITE OPTIMIZATION

SPEAKER: **Qihang Lin** (University of Iowa, qihang-lin@uiowa.edu)
Lin Xiao (Microsoft Research)
Zhaosong Lu (SimonFraserUniversity)

We propose an accelerated randomized block-coordinate descent method for minimizing the sum of a smooth convex function and a block-separable convex function. The algorithm is developed based on the technique of randomized estimate sequence. Compared to existing coordinate descent methods, our method guarantees a linear convergence rate when the problem is strongly convex and its complexity has a better dependence on the condition number of the problem.

LEARNING AND OPTIMIZATION OF EXPENSIVE FUNCTIONS — FRI 9:45-11:15

CHAIR: **Peter I. Frazier** (Cornell University) — RM: C

1 – PARALLEL BAYESIAN GLOBAL OPTIMIZATION, WITH APPLICATION TO METRICS OPTIMIZATION AT YELP

SPEAKER: **Jialei Wang** (Cornell University, jw865@cornell.edu)
Scott Clark (Yelp Inc., sclark@yelp.com)
Eric Liu (Yelp Inc., eliu@yelp.com)

We consider parallel global optimization of expensive-to-evaluate functions, and propose an efficient method based on stochastic approximation for implementing a conceptual Bayesian optimization algorithm proposed by Ginsbourger et al. (2010). We also introduce an open-source software implementation of this algorithm, called Metrics Optimization Engine, developed in collaboration with engineers at Yelp, Inc. and used internally at Yelp to optimize prediction models and performance metrics.

2 – CONSTRAINED BLACK-BOX OPTIMIZATION USING RADIAL BASIS FUNCTIONS WITHIN A TRUST-REGION FRAMEWORK

SPEAKER: **Rommel G. Regis** (Saint Joseph's University, rregis@sju.edu)
Stefan M. Wild (Argonne National Laboratory, wild@mcs.anl.gov)

This talk presents CONORBIT, which is a derivative-free algorithm for constrained black-box optimization where the objective and constraint functions are computationally expensive. CONORBIT employs a trust-region framework that uses interpolating radial basis function (RBF) models for the objective and constraint functions and is an extension of the ORBIT algorithm (Wild, Regis and Shoemaker 2008). It uses a small margin for the RBF model constraints to facilitate the generation of feasible iterates and extensive numerical tests confirm that such a margin is helpful in improving performance. CONORBIT is compared with alternatives on 39 test problems with up to 30 decision variables and with up to 38 inequality constraints. It is also applied to a chemical process optimization problem and to a large-scale automotive application with 124 decision variables and 68 black-box inequality constraints. Numerical results show that CONORBIT performs better than a direct search method, a sequential penalty derivative-free method, and an RBF heuristic on the test problems and on the automotive application.

3 – SIMULATION SELECTION WITH UNKNOWN CORRELATION STRUCTURES

SPEAKER: **Ilya O. Ryzhov** (University of Maryland, iryzhov@rhsmith.umd.edu)
Huashuai Qu (University of Maryland, huashuai@math.umd.edu)
Michael C. Fu (University of Maryland, mfu@rhsmith.umd.edu)

We create the first computationally tractable Bayesian statistical model for learning unknown correlation structures in fully sequential simulation selection. Correlations represent similarities or differences between various design alternatives, and can be exploited to extract much more information from each individual simulation. However, in most applications, the correlation structure is unknown, thus creating the additional challenge of simultaneously learning unknown mean performance values and unknown correlations. Based on our new statistical model, we derive a Bayesian procedure that allocates simulations based on the value of information, thus anticipating future changes to our beliefs about the correlations. Our approach outperforms existing methods for known correlation structures in numerical experiments, including one motivated by the problem of optimal wind farm placement, where real data are used to calibrate the simulation model.

INDUSTRIAL OR APPLICATIONS: LIVE CASE STUDIES — FRI 9:45-11:15

CHAIR: **Gudimella S. R. Murthy** (Indian Statistical Institute) — RM: D

1 – DISCRETE EVENT SIMULATION FOR EFFICIENT SUPPLY CHAIN MANAGEMENT OF SERVICE PARTS

SPEAKER: **Sridhar Ramaswamy** (Caterpillar Inc., ramaswamy_sridhar@cat.com)

This talk presents a case study of planning supply chain network for aftermarket parts by a leading construction equipment manufacturer to meet demand across its global network. The problem of volatile demand, high-value slow moving parts, and meeting targeted service levels is addressed through Discrete-Event simulation modelling. A heuristic solution is provided that helped the company improve their supply chain efficiency.

2 – DYNAMIC WAREHOUSE MANAGEMENT PROBLEM FOR A FOOTWEAR INDUSTRY

SPEAKER: **Addepalli L. N. Murthy** (Indian Statistical Institute, simhaaln@rediffmail.com)
Gudimella S. R. Murthy (Indian Statistical Institute, murthygsr@gmail.com)
Katta G. Murty (University of Michigan, murty@umich.edu)

A practical scheme to handle the dynamic storage and retrieval procedure of cuboidal boxes for footwear industry is presented. The efficacy of the scheme is compared with a procedure using nonlinear formulation in vogue and other optimal solutions.

3 – WOOD INVENTORY MANAGEMENT IN A PULP MILL

SPEAKER: **Gudimella S. R. Murthy** (Indian Statistical Institute, murthygsr@gmail.com)
Katta G. Murty (University of Michigan, katta_murty@umich.edu)
Addepalli L. N. Murthy (Indian Statistical Institute, simhaaln@rediffmail.com)

Wood procurement, its inventory and production planning in pulp mills is a complex problem as it involves shelf life, weight losses, furnish and feed constraints. This study presents a live case study of this problem in a leading paper manufacturing company in India for which a decision support system is developed.

SMART GRIDS II

FRI 1:30-3:00

CHAIR: **Luis Zuluaga** (Lehigh University)

RM: A

1 – RELIABILITY AND AIR EMISSIONS IMPACTS OF FLEXIBLE RAMP CAPACITY PRODUCTS IN THE MIDCONTINENT ISO

SPEAKER: **Dalia Patino-Echeverri** (Duke University, dalia.patino@duke.edu)
Adam Cornelius (Duke University, adam.cornelius@duke.edu)

We explore the economic, environmental, and reliability impacts of MISO's proposed Ramp Capability Products. We simulate system's operations using a baseline unit-commitment/economic dispatch model — representing current MISO practices —, and a ramp capability model including the proposed flexi-ramp products. Comparison of air emissions, electricity prices and reliability metrics show the impact of different attributes of the test system including the level of wind power penetration, its variability and forecast error, and the baseline ramp capability of conventional generating units.

2 – DEMAND RESPONSE IN ELECTRICITY MARKETS: VOLUNTARY VS INVOLUNTARY CONTRACTS

SPEAKER: **Ruben Lobel** (University of Pennsylvania, rlobel@wharton.upenn.edu)
Kaitlin Daniels (University of Pennsylvania, kaitd@wharton.upenn.edu)

Electricity markets today suffer from a disconnect between market pricing and end consumption. To mitigate this problem, demand response firms provide incentives for consumers to reduce consumption during peak demand events. The foregone consumption is sold as virtual supply on the electricity market. We explore two curtailment contract types: involuntary and voluntary. The involuntary contract requires a set curtailment from enrolled consumers, whereas the voluntary contract allows curtailment to vary with the consumer's opportunity cost. In this paper we study the optimal choice of contract type first from firm's point of view, and then from a social planner's perspective. We find that the firm's contract choice is primarily driven by the sensitivity of market price to changes in consumption and the distribution of the consumer's opportunity cost. While the firm's choice is not always welfare maximizing, we find that it does maximize curtailment and so can be viewed as consistent with the environmentally optimal choice. Finally we demonstrate these phenomena using a case study from a curtailment service provider, EnerNOC, and data from the PJM electricity market.

3 – GRAPH-THEORETIC ALGORITHM FOR NONLINEAR POWER OPTIMIZATION PROBLEMS

SPEAKER: **Javad Lavaei** (Columbia University, lavaei@ee.columbia.edu)
Ramtin Madani (Columbia University, ramtin_madani@yahoo.com)
Somayeh Sojoudi (New York University, Somayeh.Sojoudi@nyumc.org)
Ghazal Fazelnia (Columbia University, ghazal.fazelnia@gmail.com)
Abdulrahman Kalbat (Columbia University, ak3369@columbia.edu)

In this talk, we study a general mixed-integer nonlinear optimization problem using a semidefinite programming (SDP) relaxation. The existence of a rank-1 matrix solution to the SDP relaxation enables the recovery of a global solution of the original problem. We propose a graph-theoretic technique to sparsify the optimization problem of interest such that its SDP relaxation will have a guaranteed low-rank solution. We also discuss the implications of this technique for multiple power problems. For instance, we show that the Polish system is so sparse that the SDP relaxation of every security-constrained unit-commitment optimal power flow problem defined over this network has a matrix solution with rank at most 26, which would reduce to 3 after applying our sparsification method. We then propose a penalization technique to find a near-global solution to the original optimization problem by enforce the low-rank SDP matrix to become rank 1. We also generalize our result to the optimal distributed control of a power network where the system is subject to both algebraic and dynamic constraints.

STOCHASTIC AND SIMULATION OPTIMIZATION — FRI 1:30-3:00

CHAIR: **Qihang Lin** (University of Iowa) — RM: B

1 – BAYESIAN GLOBAL OPTIMIZATION OF EXPENSIVE FUNCTIONS: EXPLOITING NOISE WITH LOW-DIMENSIONAL STRUCTURE

SPEAKER: **Peter Frazier** (Cornell University, pf98@cornell.edu)
Jing Xie (American Express, jx66@cornell.edu)
Alison Marsden (University of California, San Diego, amarsden@eng.ucsd.edu)
Sethuraman Sankaran (University of California, San Diego, sesankaran@eng.ucsd.edu)
Abhay Bangalore Ramachandra (University of California, San Diego, abbangal@ucsd.edu)

In many applications of simulation optimization, most of the variability in the output measure of interest is determined by a small number of random exogenous inputs. Motivated by an application to the design of cardiovascular bypass grafts using a computationally-expensive physics-based stochastic simulator, we provide a new Bayesian global optimization method that exploits this low-dimensional structure to improve performance.

2 – THE KNOWLEDGE GRADIENT FOR SPARSE ADDITIVE MODEL

SPEAKER: **Yan Li** (Princeton University, yanli@princeton.edu)
Han Liu (Princeton University, hanliu@princeton.edu)
Warren B. Powell (Princeton University, powell@princeton.edu)

This work considers a Bayesian ranking and selection problem with underlying sparse belief functions. We first derive a knowledge gradient policy for sparse linear model with group Lasso penalty. Particularly, this algorithm can be generalized to the nonparametric additive model and functional ANOVA model through B-spline basis expansion. Empirical studies on both synthetic data and real applications show that this algorithm can efficiently do optimal learning and model selection simultaneously.

3 – A NEW STOCHASTIC APPROXIMATION ALGORITHM

SPEAKER: **Marie Chau** (University of Maryland, mchau@math.umd.edu)
Michael C. Fu (University of Maryland, mfu@isr.umd.edu)
Huashuai Qu (University of Maryland, huashuai@math.umd.edu)

We introduce Secant-Tangents AveRaged (STAR) Stochastic Approximation (SA), a new SA algorithm that estimates the gradient using a hybrid estimator, which is a convex combination of a symmetric finite difference and an average of two direct gradient estimators. For the deterministic weight sequence that minimizes the variance of the STAR gradient, we prove that for quadratic functions, the mean squared error (MSE) of the STAR-SA algorithm using this weight sequence is strictly less than that of the classical SA methods of Robbins-Monro (RM) and Kiefer-Wolfowitz (KW). We also prove convergence of the STAR-SA algorithm for general concave functions. Furthermore, we illustrate its effectiveness through numerical experiments by comparing the MSE of the STAR-SA algorithm against RM and KW for simple quadratic functions with various steepness and noise levels.

Optimization in Dynamical Systems
Fri 1:30-3:00

Chair: **Amir Ali Ahmadi** (IBM Watson Research Center)
Rm: C

1 – Robustness of Dynamical Systems with Optimization in Feedback Loop

Speaker: **Mardavij Roozbehani** (Massachusetts Institute of Technology, mardavij@mit.edu)

Dynamical systems with optimization in feedback loop arise in various contexts including but not limited to power networks, transportation networks, economic application modeled as dynamic games, and iterative optimization algorithms. The evolution of the state in such systems is often best described by a system of implicit equations, as the explicit solution to the underlying optimization problem may be difficult, if not impossible, to characterize. Motivated by these applications, in this talk we first show how certain Lyapunov analysis techniques can be extended to analysis of such systems. We then present a new framework based on a properly defined notion of stochastic contraction for analysis of stability and robustness properties of dynamical systems in implicit form. Time permitting, we will discuss some applications in more detail.

2 – Solving the n-body problem by minimizing the action functional

Speaker: **Robert Vanderbei** (Princeton University, rvdb@princeton.edu)

Recently, some surprisingly-elegant, stable periodic solutions to the 4-body problem were discovered by finding local minima to the so-called action functional. In this talk, I will explain how optimization can be used to find solutions to the n-body problem and I will review some of the new discoveries.

3 – Algorithms and hardness results for stability of polynomial ODEs

Speaker: **Amir Ali Ahmadi** (IBM Research, a_a_a@mit.edu)

Numerous dynamical systems in science and engineering are modeled by polynomial differential equations: dynamics of population growth in ecology, prices and business cycles in economics, chemical reactions in cell biology, spread of epidemics in network science, and motion of a wide range of electromechanical systems in control and robotics are but few examples. A fundamental question in all of these areas is that of determining stability of equilibrium points.

In this talk, we give an overview of our recent work on this problem which studies it from an algorithmic perspective. On the negative side, we establish complexity theoretic lower bounds on the difficulty of this problem. On the positive side, we present algorithms based on semidefinite, second order cone, and linear programming that automatically search for certificates of stability. Success and limitations of these algorithms are also discussed both in theory and practice.

OPTIMIZATION IN MACHINE LEARNING FRI 3:15-4:45

CHAIR: **Martin Takáč** (Lehigh University) RM: A

1 – ELEMENTARY ESTIMATORS FOR HIGH-DIMENSIONAL STATISTICAL MODELS

SPEAKER: **Pradeep Ravikumar** (University of Texas at Austin, pradeep.ravikumar@gmail.com)
Aurelie Lozano (IBM Research)

We consider the problem of learning high-dimensional statistical models, a class of problems that includes the learning of Gaussian as well as discrete graphical models. This class of problems has attracted considerable attention over the last decade, with state of the art statistical estimators based on solving regularized convex programs. Scaling these typically non-smooth convex programs to very large-scale problems is thus an ongoing and rich area of research. Here, we attempt to address this scaling issue at the source, by asking whether one can build simpler possibly closed-form estimators, that yet come with statistical guarantees that are nonetheless comparable to regularized likelihood estimators. Surprisingly, we answer this question in the affirmative. We provide empirical corroboration of its statistical and computational performance on simulated data.

2 – PARALLEL GREEDY COORDINATE DESCENT METHOD FOR SPARSE INVERSE COVARIANCE SELECTION

SPEAKER: **Seyedalireza Yektamaram** (Lehigh University, sey212@lehigh.edu)
Katya Scheinberg (Lehigh University, katyas@lehigh.edu)

In this study, we propose a parallel version of SINCO method for sparse inverse covariance selection problem. SINCO is a greedy coordinate descent method which finds non-zero pattern of the inverse covariance matrix of normally distributed random variables. Non-zero pattern of this matrix manifests conditional dependency of corresponding pairs of random variables. SINCO is a sequential algorithm which updates one coordinate at each iteration, such that the objective function improvement if the largest over all coordinates. It consists of two general phases, first phase is to find the best coordinate and second phase is to update the corresponding coordinate and update the covariance matrix accordingly. Each phase can be performed in parallel and in theory near linear speedup is possible. We present a parallel version of the algorithm using distributed memory system known as Message Passing Interface (MPI). Numerical experiments show good speed-up which allows us to solve larger problems. We will discuss extensions of this method to block-coordinate setting for further speedup.

3 – HYDRA: DISTRIBUTED COORDINATE DESCENT FOR BIG DATA OPTIMIZATION

SPEAKER: **Martin Takáč** (Lehigh University, Takac.MT@gmail.com)
Peter Richtarik (The University of Edinburgh, Peter.Richtarik@ed.ac.uk)

Hydra: HYbriD cooRdinAte descent method for solving loss minimization problems with big data. We initially partition the coordinates and assign each partition to a different node of a cluster. At every iteration, each node picks a random subset of the coordinates from those it owns, independently from the other computers, and in parallel computes and applies updates to the selected coordinates based on a simple closed-form formula. We give bounds on the number of iterations sufficient to approximately solve the problem with high probability, and show how it depends on the data and on the partitioning. We perform numerical experiments with a LASSO instance described by a 3TB matrix.

STOCHASTIC DYNAMIC OPTIMIZATION — FRI 3:15-4:45

CHAIR: **Qihang Lin** (University of Iowa) — RM: B

1 – THE BENEFITS OF ROBUSTNESS FOR APPROXIMATE DYNAMIC PROGRAMMING

SPEAKER: **Marek Petrik** (IBM T.J. Watson Research Center, mpetrik@us.ibm.com)

We describe how to use robust Markov decision processes for value function approximation with state aggregation. The robustness is introduced to reduce the sensitivity to the approximation error of sub-optimal policies in comparison with methods such as fitted value iteration. This results in reducing the bounds on the γ-discounted infinite horizon performance loss by a factor of 1/(1 - γ) while preserving polynomial-time computational complexity. Our experimental results show that using the robust representation can significantly improve the solution quality with minimal additional computational cost.

2 – A NEW OPTIMAL STEPSIZE FOR APPROXIMATE DYNAMIC PROGRAMMING

SPEAKER: **Ilya O. Ryzhov** (University of Maryland, iryzhov@rhsmith.umd.edu)
Peter Frazier (Cornell University, pf98@cornell.edu)
Warren B. Powell (Princeton University, powell@princeton.edu)

Approximate dynamic programming (ADP) has proven itself in a wide range of applications spanning large-scale transportation problems, health care, revenue management, and energy systems. The design of effective ADP algorithms has many dimensions, but one crucial factor is the stepsize rule used to update a value function approximation. Many operations research applications are computationally intensive, and it is important to obtain good results quickly. Furthermore, the most popular stepsize formulas use tunable parameters and can produce very poor results if tuned improperly. We derive a new stepsize rule that optimizes the prediction error in order to improve the short-term performance of an ADP algorithm. With only one, relatively insensitive tunable parameter, the new rule adapts to the level of noise in the problem and produces faster convergence in numerical experiments.

3 – A BUDGET ALLOCATION POLICY FOR ONLINE CROWDRANKING

SPEAKER: **Qihang Lin** (University of Iowa, qihang-lin@uiowa.edu)

We propose an accelerated randomized block-coordinate descent method for minimizing the sum of a smooth convex function and a block-separable convex function. The algorithm is developed based on the technique of randomized estimate sequence. Compared to existing coordinate descent methods, our method guarantees a linear convergence rate when the problem is strongly convex and its complexity has a better dependence on the condition number of the problem.

COMBINATORIAL OPTIMIZATION — FRI 3:15-4:45

CHAIR: **Francis Vasko** (Kutztown University) — RM: C

1 – TWO DIMENSIONAL LOAD BALANCING

SPEAKER: **Kangbok Lee** (York College, The City University of New York, klee5@york.cuny.edu)
Joseph Y-T. Leung (New Jersey Institute of Technology, leung@cis.njit.edu)
Michael L. Pinedo (New York University, mpinedo@stern.nyu.edu)

We consider a bi-criteria parallel machine scheduling problem in which the first objective is the minimization of the makespan of the schedule and the second objective is the minimization of the maximum machine cost. Since the problem is strongly NP-hard, we propose a fast heuristic and derive its worst-case performance bound.

2 – FUZZY DATA ENVELOPMENT ANALYSIS WITH COMMON WEIGHTS

SPEAKER: **Cheng-Feng Hu** (National Chiayi University, chu1@isu.edu.tw)
Fung-Bao Liu (I-Shou University, fliu@isu.edu.tw)
Cheng-Kai Hu (Kao Yuan University, t80147@cc.kyu.edu.tw)

This work studies the data envelopment analysis (DEA) with common weights in a fuzzy environment. Applying the basic principle of compromise of the technique for order preference by similarity ideal solution (TOPSIS), the k-objective fuzzy DEA program can be reduced into an auxiliary bi-objective fuzzy decision-making problem. Moreover, following the “tolerance approach”, the solution of the resulting auxiliary bi-objective fuzzy optimization problem can be obtained by solving a min-max problem. An algorithm of finding the compromise solution for the fuzzy DEA program is provided. The implementation issue on the algorithm is also included. Since the efficiency measures are expressed in different degrees of confidence rather than crisp values, more information is provided for management, which makes the proposed DEA program more powerful for practical applications.

3 – ADAPTING THE TEACHING-LEARNING-BASED OPTIMIZATION METAHEURISTIC TO COMBINATORIAL OPTIMIZATION

SPEAKER: **Yun Lu** (Kutztown University, lu@kutztown.edu)
Francis Vasko (Kutztown University, vasko@kutztown.edu)
Kenneth Zyma (Kutztown University, kzyma650@live.kutztown.edu)

A new metaheuristic based on the relationship between teachers and learners has recently been proposed by Rao, Savsani and Vakharia (2011). This metaheuristic is designed to solve continuous nonlinear optimization problems. It has been shown to be an efficient and effective approach for solving various structural and mechanical design problems. It is of particular interest because it is a population-based metaheuristic that requires no parameter fine-tuning other than determining the size of the population and convergence criteria. In this paper, we adapt this metaheuristic, designed for continuous problems, to solve two combinatorial optimization problems: the weighted set covering problem and the multichoice multidimensional knapsack problem. Empirical results demonstrate the competitiveness of this approach both in terms of solution quality and execution time. The advantage to this approach is its relative simplicity.

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