MOPTA 2015

Modeling and Optimization: Theory and Applications

http://coral.ie.lehigh.edu/~mopta

20-22 July '15

Lehigh University
Bethlehem, PA, USA

Program and Abstracts

■ A very warm Welcome to MOPTA 2015

The Modeling and Optimization: Theory and Applications (MOPTA) conference is 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 consists 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 that 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 2015 is hosted by the Department of Industrial and Systems Engineering at Lehigh University.

■ Directions

The conference will take place at:
Lehigh University
Iacocca Hall, 111 Research Drive
Mountaintop Campus
Bethlehem, PA 18015
US

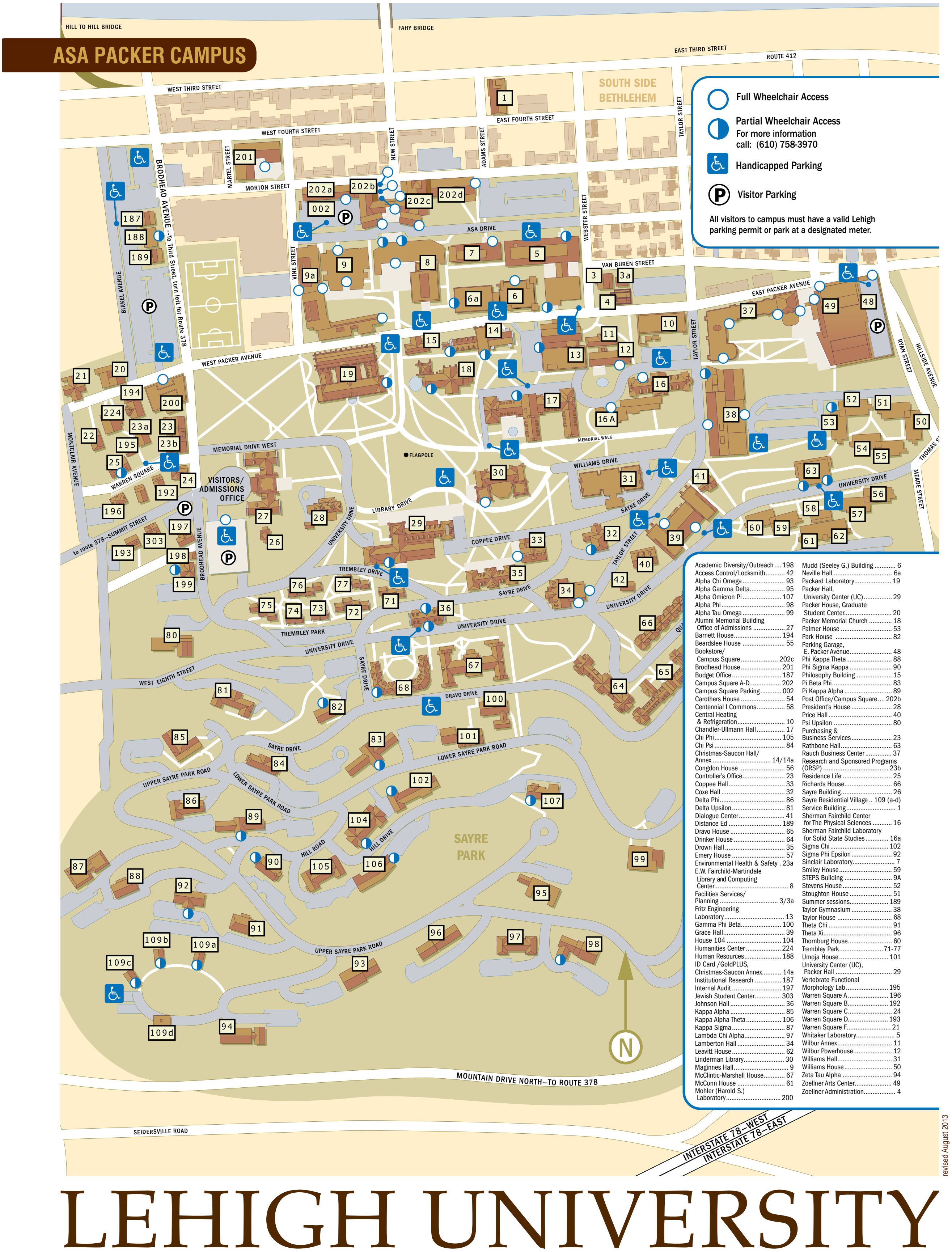
MOPTA Shuttle Service

Day	Locations	Time
Monday	Comfort Suites to Iacocca Hall	7:15 a.m. – 9:00 a.m.
	Iacocca Hall to Comfort Suites	6:15 p.m. – 7:15 p.m.
Tuesday	Comfort Suites to Iacocca Hall	7:15 a.m. – 9:00 a.m.
	Iacocca Hall to Comfort Suites	8:45 p.m. – 9:30 p.m.
Wednesday	Comfort Suites to Iacocca Hall	7:15 a.m. – 9:00 a.m.
	Iacocca Hall to Comfort Suites	3:00 p.m. – 3:45 p.m.

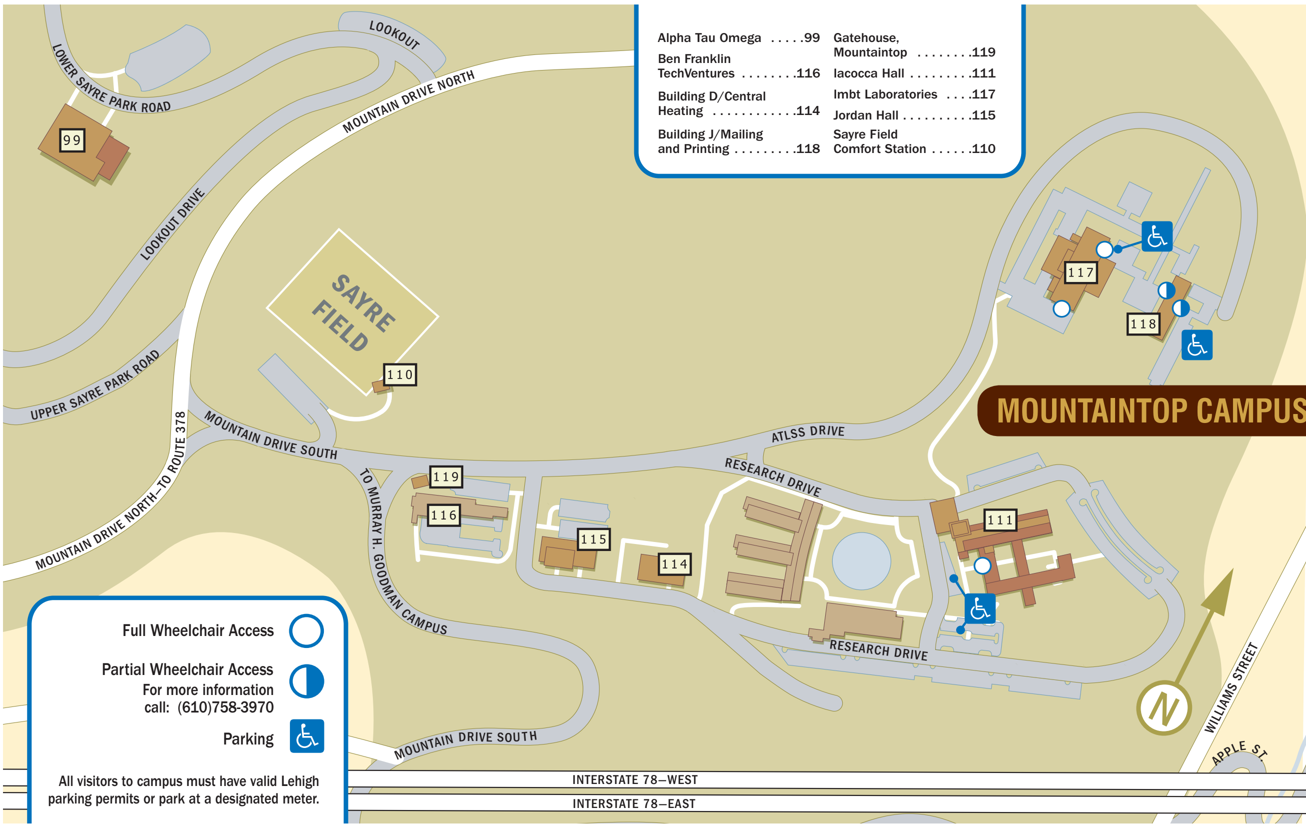
Individual transportation

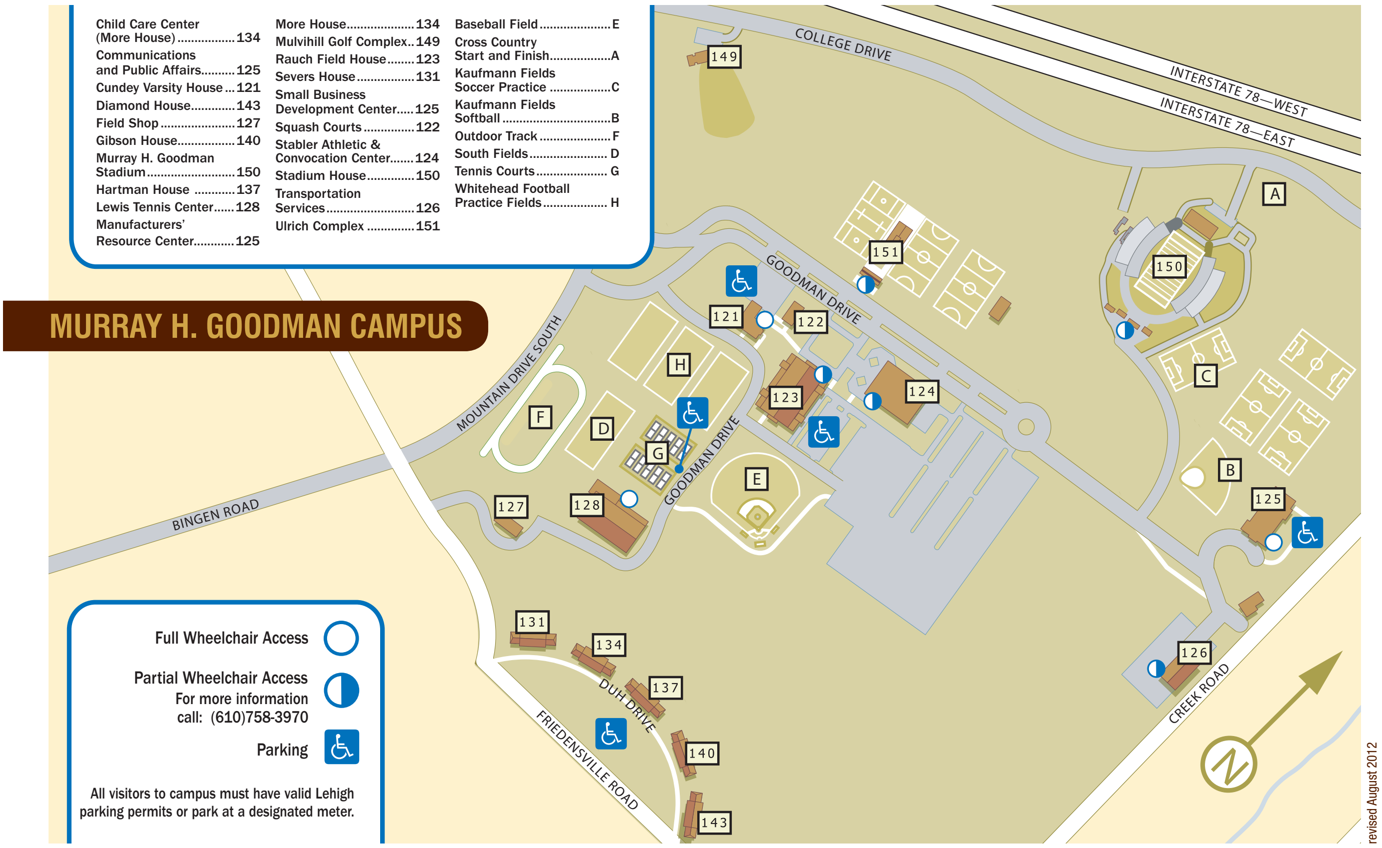
If participants are not planning on taking the shuttle from Comfort Suites to Iaccoca Hall, they may drive separately. Participants that plan to drive to Iacocca Hall should park in the guest lot on the Mountaintop campus to avoid parking fees during business hours.
Graduate students attending the Graduate Student Social – Please know that Packer House (see ASA Packer Campus map - Building 20), where the social is located, is within walking distance of Comfort Suites.
If you need to leave during the conference, please see the registration desk for information about taxis and car services.

■ Maps


ASA PACKER CAMPUS
SOUTH SIDE BETHLEHEM
HILL TO HILL BRIDGE
FAHY BRIDGE
EAST THIRD STREET
ROUTE 412
WEST THIRD STREET
EAST FOURTH STREET
WEST FOURTH STREET
MORTON STREET
ASA DRIVE
VAN BUREN STREET
EAST PACKER AVENUE
WEST PACKER AVENUE
MEMORIAL DRIVE WEST
MEMORIAL WALK
WILLIAMS DRIVE
UNIVERSITY DRIVE
LIBRARY DRIVE
COPPEE DRIVE
TREMBLEY DRIVE
TREMBLEY PARK
SAYRE DRIVE
DRAVO DRIVE
LOWER SAYRE PARK ROAD
UPPER SAYRE PARK ROAD
HILL DRIVE
WEST EIGHTH STREET
WARREN SQUARE
to route 378–SUMMIT STREET
MONTCLAIR AVENUE
BIRKEL AVENUE
BRODHEAD AVENUE
BRODHEAD AVENUE –To Third Street, turn left for Route 378
VISITORS/ ADMISSIONS OFFICE
FLAGPOLE
SAYRE PARK
MOUNTAIN DRIVE NORTH–TO ROUTE 378
SEIDERSVILLE ROAD
INTERSTATE 78–WEST
INTERSTATE 78–EAST
TAYLOR STREET
MEADE STREET
RYAN STREET
HILLSIDE AVENUE
Full Wheelchair Access
Partial Wheelchair Access
For more information
call: (610) 758-3970
Handicapped Parking
Visitor Parking
All visitors to campus must have a valid Lehigh parking permit or park at a designated meter.
Academic Diversity/Outreach 198
Access Control/Locksmith 42
Alpha Chi Omega 93
Alpha Gamma Delta 95
Alpha Omicron Pi 107
Alpha Phi 98
Alpha Tau Omega 99
Alumni Memorial Building Office of Admissions 27
Barnett House 194
Beardslee House 55
Bookstore/ Campus Square 202c
Brodhead House 201
Budget Office 187
Campus Square A-D 202
Campus Square Parking 002
Carothers House 54
Centennial I Commons 58
Central Heating & Refrigeration 10
Chandler-Ullmann Hall 17
Chi Phi 105
Chi Psi 84
Christmas-Saucon Hall/ Annex 14/14a
Congdon House 56
Controller's Office 23
Coppee Hall 33
Coxe Hall 32
Delta Phi 86
Delta Upsilon 81
Dialogue Center 41
Distance Ed 189
Dravo House 65
Drinker House 64
Drown Hall 35
Emery House 57
Environmental Health & Safety . 23a
E.W. Fairchild-Martindale Library and Computing Center 8
Facilities Services/ Planning 3/3a
Fritz Engineering Laboratory 13
Gamma Phi Beta 100
Grace Hall 39
House 104 104
Humanities Center 224
Human Resources 188
ID Card /GoldPLUS, Christmas-Saucon Annex 14a
Institutional Research 187
Internal Audit 197
Jewish Student Center 303
Johnson Hall 36
Kappa Alpha 85
Kappa Alpha Theta 106
Kappa Sigma 87
Lambda Chi Alpha 97
Lamberton Hall 34
Leavitt House 62
Linderman Library 30
Maginnes Hall 9
McClintic-Marshall House 67
McConn House 61
Mohler (Harold S.) Laboratory 200
Mudd (Seeley G.) Building 6
Neville Hall 6a
Packard Laboratory 19
Packer Hall, University Center (UC) 29
Packer House, Graduate Student Center 20
Packer Memorial Church 18
Palmer House 53
Park House 82
Parking Garage, E. Packer Avenue 48
Phi Kappa Theta 88
Phi Sigma Kappa 90
Philosophy Building 15
Pi Beta Phi 83
Pi Kappa Alpha 89
Post Office/Campus Square 202b
President's House 28
Price Hall 40
Psi Upsilon 80
Purchasing & Business Services 23
Rathbone Hall 63
Rauch Business Center 37
Research and Sponsored Programs (ORSP) 23b
Residence Life 25
Richards House 66
Sayre Building 26
Sayre Residential Village .. 109 (a-d)
Service Building 1
Sherman Fairchild Center for The Physical Sciences 16
Sherman Fairchild Laboratory for Solid State Studies 16a
Sigma Chi 102
Sigma Phi Epsilon 92
Sinclair Laboratory 7
Smiley House 59
STEPS Building 9A
Stevens House 52
Stoughton House 51
Summer sessions 189
Taylor Gymnasium 38
Taylor House 68
Theta Chi 91
Theta Xi 96
Thornburg House 60
Trembley Park 71-77
Umoja House 101
University Center (UC), Packer Hall 29
Vertebrate Functional Morphology Lab 195
Warren Square A 196
Warren Square B 192
Warren Square C 24
Warren Square D 193
Warren Square F 21
Whitaker Laboratory 5
Wilbur Annex 11
Wilbur Powerhouse 12
Williams Hall 31
Williams House 50
Zeta Tau Alpha 94
Zoellner Arts Center 49
Zoellner Administration 4
revised August 2013
N
LEHIGH UNIVERSITY

LEHIGH UNIVERSITY® CAMPUS MAPS





■ Plenary Talks

Monday 08:30–09:30. Ravi Mazumdar

A little bit of randomization can drastically improve queueing performance in systems with a large number of servers

University of Waterloo

mazum@ece.uwaterloo.ca

Randomization in routing problems was popularized in the 1990's by Turner (Cambridge), Vvedenskaya and Dobrushin (Moscow), and by Mitzenmacher (Berkeley) who coined the term the *Power of Two* rule. This rule states that the benefits of the Join the Shortest Queue (JSQ), that is known to be optimal for minimizing the average waiting time in a system with many queues, can be achieved by randomly picking two queues uniformly and routing to the shorter queue.
These problems are re-emerging in the context of cloud resource systems where latency is an important issue. All the prior work only addressed the case of identical servers while practical systems can have heterogeneous servers. While this makes the problem much more difficult it also throws up the issue of stability and therefore we need to devise more robust and appropriate routing strategies. Only recently have we begun to make progress on analyzing such models. In the talk we will begin with an overview of the classical results and then address the modelling and analysis of heterogeneous systems where we will show that depending on the information available differing strategies can be adopted.
The talk will focus on the mathematical aspects of such models that exploits size in the number of servers and combines mean field and propagation of chaos.
Joint work with Arpan Mukhopadhyay and A. Karthik .

Speaker Biography. The speaker was educated at the Indian Institute of Technology, Bombay (B.Tech, 1977), Imperial College, London (MSc, DIC, 1978) and obtained his PhD under A. V. Balakrishnan at UCLA in 1983.
He is currently a University Research Chair Professor in the Dept. of ECE at the University of Waterloo, Ont., Canada where he has been since September 2004. Prior to this he was Professor of ECE at Purdue University, West Lafayette, USA. Since 2012 he is a D.J. Gandhi Distinguished Visiting Professor at the Indian Institute of Technology, Bombay, India. He is a Fellow of the IEEE and the Royal Statistical Society. He is a recipient of the INFOCOM 2006 Best Paper Award and was runner-up for the Best Paper Award at INFOCOM 1998.
His research interests are in modeling, control, and performance analysis of both wireline and wireless networks, and in applied probability and stochastic analysis with applications to queueing, filtering, and optimization.

Monday 11:30–12:30. Alper Atamtürk

Conic Integer Optimization

University of California-Berkeley

atamturk@berkeley.edu

In the last 25 years we have experienced significant advances in conic optimization. Polynomial interior point algorithms that have earlier been developed for linear optimization have been extended to second-order cone optimization and semi-definite optimization. The availability of efficient algorithms for convex conic optimization spurred many novel optimization and control applications in diverse areas ranging from medical imaging to statistical learning, from finance to truss design. However, the advances in convex conic optimization and linear integer optimization have until recently not translated into major improvements in conic integer optimization, i.e., conic optimization problems with integer variables. In this talk we will review the recent progress in conic integer optimization. We will discuss cuts, lifting methods, and conic reformulations for improving computations for general as well as special structured problems and connections to submodular optimization for the 0-1 case. We will present applications of conic integer optimization in probabilistic optimization, portfolio optimization, location/inventory optimization with risk pooling.

Speaker Biography. Alper Atamturk is a Professor of Industrial Engineering and Operations Research at the University of California - Berkeley. He received his Ph.D. from the Georgia Institute of Technology in 1998 with a major in Operations Research and minor in Computer Science. His current research interests are in discrete optimization and optimization under uncertainty with applications to energy, finance and operations interface, cancer therapy, and defense. He serves on the editorial boards of Discrete Optimization, Journal of Risk, Mathematical Programming C, Networks, and Operations Research. He served on the organizing committees of INFORMS, IPCO, MIP and few others. He served as vice chair-integer programming of the INFORMS Optimization Society during 2008-2009. Dr. Atamturk is a US Department of Defense National Security Fellow.

Monday 15:15–16:15. Tong Zhang

Stochastic Optimization Techniques for Big Data Machine Learning

Baidu's Big Data Lab; Rutgers University

tongzhang0@gmail.com

Many modern big-data machine learning problems encountered in the internet industry involve optimization problems so large that traditional methods are difficult to handle. The complex issues in these large scale applications have stimulated fast development of novel optimization techniques in recent years. I will present an overview of progresses made by the machine learning community to handle these large scale optimization problems, as well as challenges and directions.

Speaker Biography. Dr. Tong Zhang is currently directing Baidu's Big Data Lab, and is a professor at Rutgers University. Previously he has worked at IBM T.J. Watson Research Center in Yorktown Heights, New York, and Yahoo Research in New York city. He is a fellow of American Statistical Association, and has been in the editorial boards of leading machine learning journals and program committees of top machine learning conferences. Tong Zhang received a B.A. in mathematics and computer science from Cornell University and a Ph.D. in Computer Science from Stanford University.

Tuesday 08:30–09:30. Eugene A. Feinberg

Berge's Maximum Theorem for Noncompact Decision Sets and Its Applications

Stony Brook University

Eugene.Feinberg@stonybrook.edu

For an upper semi-continuous set-valued mapping from one topological space to another one and for a lower semi-continuous function defined on the product of these spaces, Berge's theorem states lower semi-continuity of the minimum of this function taken over the image sets. If the set-valued mapping and the function are continuous, Berge's maximum theorem states continuity of the minimum and upper semi-continuity of the solution multifunction. The image sets can be interpreted as action or decision sets, and these two theorems play important roles in mathematical programming, game theory, control theory, and Markov decision processes.
A major limitation of Berge's theorem and Berge's maximum theorem is that action sets are assumed to be compact. In this talk we describe generalizations of Berge's theorem and Berge maximum theorem to problems with possibly noncomact decision sets and discuss applications to Markov decision processes and inventory control.

Speaker Biography. Dr. Eugene A. Feinberg received his Ph.D. in Mathematics (Probability and Statistics) from Vilnius University, Lithuania, in 1979. Between 1976 and 1988 he held research and faculty positions in the Department of Applied Mathematics at Moscow State University of Railway Transportation, Russia. After holding a one-year visiting faculty position at Yale University in 1988-89, he joined Stony Brook University. He has spent two one-semester sabbatical leaves at MIT.
His research interests include stochastic models of operations research, Markov decision processes, and industrial applications of Operations Research and Statistics. Since 1999, he has been working on electric energy applications. He has published more than 150 papers and edited the Handbook on Markov Decision Processes. His research is partially supported by the National Science Foundation (NSF), Department of Energy (DOE), Office of Naval Research (ONR), New York Office of Science, Technology and Academic Research (NYSTAR), New York State Energy Research and Development Authority (NYSERDA), and industry. He is a member of several editorial boards including Mathematics of Operations Research, Operations Research Letters, and Applied Mathematics Letters.
Dr. Feinberg has been awarded an Honorary Doctorate from the Institute of Applied System Analysis, National Technical University of Ukraine. He is a Fellow of INFORMS, elected in 2011 "for his fundamental contributions to the theory and practice of operations research in the areas of Markov decision processes and dynamic programming". He is a recipient of the 2012 IEEE Charles Hirsh Award "for developing and implementing on Long Island, electric load forecasting methods and smart grid technologies", and the 2012 IBM Faculty Award.

Tuesday 15:15–16:15. Amir Beck

Primal and dual variables decomposition methods in convex optimization

Technion – Israel Institute of Technology
beckamir314@gmail.com

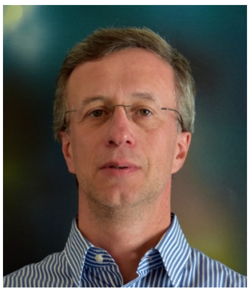
We consider the rates of convergence of several decomposition methods, which are based on either exact block minimization or on the block proximal gradient operator. We will then discuss the model of minimizing a strongly convex function and a term comprising the sum of extended real-valued convex functions (atoms). We derive several dual-based variables decomposition methods that take into account only one of the atoms and analyze their rate of convergence through a simple primal-dual formula. Finally, the effectiveness of the methods are illustrated through image denoising problems.

Speaker Biography. Amir Beck is an Associate Professor in the Department of Industrial Engineering at The TechnionâĂŤIsrael Institute of Technology. He has published numerous papers, has given invited lectures at international conferences, and was awarded the Salomon Simon Mani Award for Excellence in Teaching and the Henry Taub Research Prize. He is on the editorial board of Mathematics of Operations Research, Operations Research, and Journal of Optimization Theory and Applications. His research interests are in continuous optimization, including theory, algorithmic analysis, and applications.

Wednesday 08:30–09:30. Luis Nunes Vicente

Probabilistic Descent and Subspace Decomposition for Nonlinear Optimization

University of Coimbra, Portugal
lnv@mat.uc.pt



Direct-search methods are a class of popular derivative-free algorithms characterized by evaluating the objective function using a step size and a number of (polling) directions. When applied to the minimization of smooth functions, the polling directions are typically taken from positive spanning sets which in turn must have at least $n+1$ vectors in an n-dimensional variable space. In addition, to ensure the global convergence of these algorithms, the positive spanning sets used throughout the iterations must be uniformly non-degenerate in the sense of having a positive (cosine) measure bounded away from zero.

However, recent numerical results indicated that randomly generating the polling directions without imposing the positive spanning property can improve the performance of these methods, especially when the number of directions is chosen considerably less than $n+1$.

In this talk, we analyze direct-search algorithms when the polling directions are probabilistic descent, meaning that with a certain probability at least one of them is of descent type. Such a framework enjoys almost-sure global convergence. More interestingly, we will show a global decaying rate of $1/\sqrt{k}$ for the gradient size, with overwhelmingly high probability, matching the corresponding rate for the deterministic versions of the gradient method or of direct search. Our analysis helps to understand numerical behavior and the choice of the number of polling directions.

We will also sketch a subspace decomposition approach for nonlinear optimization, both of deterministic and probabilistic types, using motivation and deriving results similarly as in the directional case.

This is joint work with M. Dodangeh, R. Garmanjani, S. Gratton, C. Royer, and Z. Zhang.

Speaker Biography. Luis Nunes Vicente is a Professor of Mathematics at the University of Coimbra, Portugal. He obtained his PhD from Rice University, TX in 1996 under a Fulbright scholarship and was among the three finalists of the 94-96 A. W. Tucker Prize of the Mathematical Optimization Society.

He held visiting positions at the IBM T.J. Watson Research Center and the IMA/University of Minnesota in 2002/2003 and at the Courant Institute of Mathematical Sciences/NYU and the UniversitÃľ Paul Verlaine of Metz in 2009/2010. He has been visiting Chercheur SÃľnior of the Fondation de CoopÃľration Sciences et Technologies pour l'AÃľronautique et l'Espace (RÃľseau ThÃľmatique de Recherche AvancÃľe) at CERFACS and Institut National Polytechnique, Toulouse, during 2010-2015.

His research interests include the development and analysis of numerical methods for large-scale nonlinear programming, sparse optimization, PDE constrained optimization problems, and derivative-free optimization problems, and applications in computational sciences, engineering, and finance. His research has been supported by the European Union, the European Space Agency, the Portuguese Foundation for Science and Technology (FCT), and the Portuguese Agency for Innovation (AdI).

L. N. Vicente is a co-author of the book Introduction to Derivative-Free Optimization, MPS-SIAM Series on Optimization, SIAM, Philadelphia, 2009.

He is a member of several editorial boards including SIAM Journal on Optimization, EURO Journal on Computational Optimization, and Optimization Methods and Software. He is currently Editor-in-Chief of Portugaliae Mathematica, the Portuguese Mathematical research journal published by the European Mathematical Society.

He has given a number of plenary lectures in reputed society/serial conferences (13th French-German Conf. Optim., VII Brazilian Workshop on Continuous Optim., 8th EUROPT, ICCOPT III, JournÃl'es de l'Optimisation - MontrÃl'al, 5th Sino-Japanese Optim. Meeting, 43rd Annual Conf. of Italian OR Society, 3rd EUCCO, 26th IFIP TC 7 / 2013, JournÃl'es Annuelles 2014 CNRS Optimisation).
He has participated in several boards, councils, and prize committees (various Mathematical Optimization Society committees, various SIAM Activity Group on Optimization committees, Direction of UT Austin | Portugal Program, CIM-Portugal Scientific Council).

Wednesday 11:30–12:30. Mirjam Dür

Copositive programming: a framework for quadratic and combinatorial optimization

University of Trier
duer@uni-trier.de

A copositive optimization problem is a problem in matrix variables with a constraint which requires that the matrix be in the copositive cone. This means that its quadratic form takes nonnegative values over the nonnegative orthant. Many combinatorial problems like for example the maximum clique problem can be equivalently formulated as a copositive problem. Burer (2009) showed that also any nonconvex quadratic problem with linear constraints and binary variables can be reformulated as such a copositive problem. This is remarkable, since by this approach, a nonconvex problem is reformulated equivalently as a convex problem. The complexity of the original problem is entirely shifted into the cone constraint. We review recent progress in this copositive approach, concerning both theoretical results and numerical progress.

Speaker Biography. Mirjam Dür was born in Vienna, Austria, where she received a M.Sc. degree in Mathematics from the University of Vienna in 1996. She received a PhD in applied mathematics from University of Trier (Germany) in 1999. After that, she worked as an assistant professor at Vienna University of Economics and Business Administration, as a junior professor at TU Darmstadt, Germany, and as an Universitair Docent at the University of Groningen, The Netherlands. Since October 2011, she is a full professor of Nonlinear Optimization in Trier.
She is a member of the editorial boards of Mathematical Methods of Operations Research, Journal of Global Optimization, and Optimization Methods and Software. In 2010, she was awarded a VICI-grant by the Dutch Organisation for Scientific Research (NWO), and in 2012 a GIF Research grant by the German-Israeli Foundation for Scientific Research and Development.

■ AIMMS/MOPTA Optimization Modeling Competition 2015

The seventh 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 the management of a portfolio of projects. The teams were asked to consider one key decision-making process; namely, the selection and scheduling of projects over a three year horizon. In particular, teams were asked to focus on one of the key aspects (among many others) that plays a role in making a portfolio robust to uncertainties, namely, taking into account the riskiness of each project in terms of success, cost and duration; the dependencies among projects; and the existence of alternatives such as acquiring a company or pursuing a research and development effort.
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 18 teams from different countries registered and downloaded the problem, in particular, teams from US, China, The Netherlands, Portugal, Egypt, and New Zealand. The panel of judges (Boris Defourny and Luis F. Zuluaga from Lehigh University and Peter Nieuwesteeg from AIMMS) selected the following two teams for the final:

Team "DOM", University of Twente
Victor Reijnders, Martijn Schoot Uiterkamp, Mike Visser
advised by Bodo Manthey

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

The finalist teams will each give 30 minute presentations (20 minute talks + 10 minutes for questions) on their work on Tuesday, July 21, starting at 11:30am. The winning team will be announced at the conference banquet on Tuesday evening.
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.

■ Instructions

For Speakers

- We ask all speakers to be familiar with the time and the location of their stream and talk, as specified in the conference booklet.
- Speakers should arrive at the location of their stream and talk 10 minutes prior to the scheduled start time of the session.
- Upon arrival you will be met by the chair of the session. Please introduce yourself and, if applicable, provide the chair with a copy of your presentation to upload onto the seminar room computer.
- Talks are strictly 25 minutes long plus 5 minutes for questions and answers. Anyone going over this time will be asked to stop by the chair.
- To aid you with the timing of your presentation, the chair will show the 'time remaining' cards when you have 5 minutes and then 1 minute remaining for your presentation.

For Chairs

- Please arrive at the appropriate seminar room 10 minutes before the start of the stream you will be chairing. You should familiarise yourself with the equipment and ensure there are no obvious problems which would prevent the stream from running to schedule.
- In the event of a problem you should immediately seek the help of a local conference organiser.
- Delegates presenting in the stream should also be present in the seminar room 10 minutes before the start of the stream. You should introduce yourself to the speakers. They will provide you with electronic copies of their presentations to be loaded onto the seminar room computer.
- Uploading presentations: When you arrive at the seminar room you should login to the seminar room computer using the username and password issued to you at registration. You should then upload each speaker's presentation onto the desk top ready for the stream to begin.
- Your main role will be to ensure that the stream runs to time. The speaker has 25 minutes for presentation followed by 5 minutes of questions and answers. Each talk is followed by a 5 minute break for the comfort of the audience and to allow for movement between streams.
- If a speaker fails to show for their talk, advise the audience to attend a talk in an alternative seminar room. Please, do not move the next talk forward.
- Before each speaker presents, you should introduce them and remind the audience that all interruptions and questions are to be reserved until the scheduled 5 minute question and answer session following each presentation.
- Should a speaker overrun, you must politely but firmly stop their presentation and move on to the question and answer section of the time slot.
- After each talk, thank the speaker, encourage applause, and open the floor to questions.

■ Conference Sponsors

■ MOPTA 2015 Committee

Tamas Terlaky
Department chair

Alexander Stolyar
Conference Chair

Martin Takac
Conference Chair

Katya Scheinberg

Frank E. Curtis
SIAM Representative

Boris Defourny

Ted K. Ralphs

Lawrence V. Snyder

Eugene Perevalov

Robert H. Storer

Aurélie C. Thiele

Luis F. Zuluaga

PROGRAM

	B013	B131	Governor's Suite	Wood Dining Room
	Monday, 20th July 2015			
07:30 – 08:15	Registration and Breakfast			
08:15 – 08:30	Wellcome (Wood Dining Room)			
08:30 – 09:30	Plenary talk: Ravi Mazumdar (Wood Dining Room)			
09:30 – 09:45	Coffee Break			
09:45 – 11:15	Inverse imaging problem	Robust Optimization	Large-scale distributed conv. Opt. I	Energy Markets and Trading
11:15 – 11:30	Coffee Break			
11:30 – 12:30	Plenary talk: Alper Atamtürk (Wood Dining Room)			
12:30 – 13:30	Lunch			
13:30 – 15:00	Stochastic models of resource allocation	Nonconvex and Sequential Optimization	Large-Scale Optimization	Energy Storage
15:00 – 15:15	Coffee Break			
15:15 – 16:15	Plenary talk: Tong Zhang (Wood Dining Room)			
16:15 – 16:30	Coffee Break			
16:30 – 18:00	Healthcare	Learning	Large-scale distributed conv. Opt. II	Demand-Side Management in Power Sys.
19:00 – 21:00	Graduate Student Social – Packer House, 217 West Packer Avenue, Bethlehem			
	Tuesday, 21st July 2015			
08:00 – 08:30	Registration and breakfast			
08:30 – 09:30	Plenary talk: Eugene A. Feinberg (Wood Dining Room)			
09:30 – 09:45	Coffee Break			
09:45 – 11:15	Operational Research	Optimization	Large-Scale Optimization and Applications	
11:15 – 11:30	Coffee Break			
11:30 – 12:30	Modeling Competition (Wood Dining Room)			
12:30 – 13:30	Lunch			
13:30 – 15:00		Optimization	Large scale optimization in ML	Electric Power Generation
15:00 – 15:15	Coffee Break			
15:15 – 16:15	Plenary talk: Amir Beck (Wood Dining Room)			
16:15 – 16:30	Coffee Break			
16:30 – 18:00	Conic optimization	Applications	Large-Scale Optimization	Energy Systems
18:00 – 19:00	Cocktail Reception (Wood Dining Room Foyer)			
19:00 – 21:00	Banquet (Wood Dining Room)			
	Wednesday, 22nd July 2015			
08:00 – 08:30	Registration and Breakfast			
08:30 – 09:30	Plenary talk: Luis Nunes Vicente (Wood Dining Room)			
09:30 – 09:45	Coffee Break			
09:45 – 11:15			Nonlinear Optimization Algorithms	Derivative free optimization
11:15 – 11:30	Coffee Break			
11:30 – 12:30	Plenary talk: Mirjam Dür (Wood Dining Room)			
12:30 – 13:30	Lunch			
13:30 – 15:00			Optimization	Resource allocation models
15:00 – 15:15	Coffee Break			

Registration and all breaks and lunches will be held at the entrance to the Wood Dining Room.

07:30–08:15 **Registration and breakfast**

08:15–08:30 **Welcome** (Wood Dining Room)

08:30–09:30 **Plenary talk** (Wood Dining Room) *Chair: Tamas Terlaky*

- **A little bit of randomization can drastically improve queueing performance in systems with a large number of servers** *Ravi Mazumdar*

09:30–09:45 **Coffee Break**

09:45–11:15 **Inverse imaging problem** (B013) *Chair: Baasansuren Jadamba*

1. **A computational framework for the elastography inverse problem of tumor identification** *Akhtar Khan*
2. **Inverse Problems and Multiobjective Approximation** *Christiane Tammer*
3. **Equation error approach for elasticity imaging inverse problem** *Baasansuren Jadamba*

09:45–11:15 **Robust Optimization** (B131) *Chair: Amir Ali Ahmadi; Robert J. Vanderbei*

1. **Resource Allocation under Coherent Distortion Risk Measures** *Chaithanya Bandi*
2. **Finding Stable Periodic Solutions to the n-Body Problem via Robust Optimization** *Robert Vanderbei*
3. **Robust to Dynamics Optimization** *Amir Ali Ahmadi*

09:45–11:15 **Large-scale distributed convex optimization I** (Governor's Suite) *Chair: Madeleine Udell*

1. **Multiagent Distributed Optimization: Convergence Rate of ADMM** *Ali Makhdoumi*
2. **On Stochastic Gradient Methods** *Angelia Nedich*
3. **A Fast Distributed Algorithm for Sparse Semidefinite Programs** *Javad Lavaei*

09:45–11:15 **Energy Markets and Trading** (Wood Dining Room) *Chair: Larry Snyder; Miguel F. Anjos*

1. **Policy Analysis of Global Wood Chips Trade Using Spatial Equilibrium Model** *Wei Jiang*
2. **Fundamental limits on optimizing for resistive power losses in synchronous power networks** *Milad Siami*
3. **An Oil Market Model for the United States** *Olufolajimi Oke*

11:15–11:30 **Coffee Break**

11:30–12:30 **Plenary talk** (Wood Dining Room) *Chair: Ted K. Ralphs*

- **Conic Integer Optimization** *Alper Atamtürk*

12:30–13:30 **Lunch**

13:30–15:00 **Stochastic models of resource allocation** (B013) *Chair: Alexander Stolyar*

1. **LP-Based Component Allocation Policies for Inventory Control in Assemble-to-Order Manufacturing** *Qiong Wang*
2. **Ergodic control of multiclass multi-pool parallel server systems in the Halfin-Whitt regime** *Guodong Pang*
3. **Pull-based load distribution in large-scale heterogeneous service systems** *Alexander Stolyar*

13:30–15:00 **Nonconvex and Sequential Optimization** (B131) *Chair: Amir Ali Ahmadi; Robert J. Vanderbei*

1. **Optimal Learning of Demand Response for the Nested Lagged Commitment Problem** *Nana Aboagye*
2. **DC Decomposition of Nonconvex Polynomials with Algebraic Techniques** *Georgina Hall*
3. **Approximate Dynamic Programming for Risk-Averse Markov Decision Processes using Dynamic Quantile-Based Risk Measures** *Daniel Jiang*

13:30–15:00 **Large-Scale Optimization** (Governor's Suite) *Chair: Martin Takac*

1. **CoCoA - Communication Efficient Distributed Coordinate Ascent** *Martin Jaggi*
2. **Simultaneous Model Selection and Learning through Parameter-free Stochastic Gradient Descent** *Francesco Orabona*
3. **Stochastic Dual Newton Ascent for Empirical Risk Minimization** *Martin Takac*

13:30–15:00 **Energy Storage** (Wood Dining Room) *Chair: Larry Snyder; Miguel F. Anjos*

1. **Co-optimizing Battery Storage for Energy Arbitrage and Frequency Regulation** *Bolong Cheng*
2. **A new optimization model for techno-economic studies in the case of hybrid energy** *Abdelghani Bouras*

15:00–15:15 **Coffee Break**

15:15–16:15 **Plenary talk** (Wood Dining Room) *Chair: Boris Defourny*

- **Stochastic Optimization Techniques for Big Data Machine Learning** *Tong Zhang*

16:15–16:30 **Coffee Break**

16:30–18:00 **Healthcare** (B013) *Chair: David Papp*

1. **Optimization models for cancer treatment using arc therapy** *David Papp*
2. **A Sample-gradient-based Algorithm for Multiple-OR and PACU Surgery Scheduling** *Miao Bai*

16:30–18:00 **Learning** (B131) *Chair: Yingfei Wang*

1. **The Knowledge Gradient with Logistic Belief Models for Binary Classification** *Yingfei Wang*
2. **The Knowledge Gradient Policy With Regularized Trees** *Yan Li*
3. **Multi-armed bandit problems, models and algorithms** *Michael Katehakis*

16:30–18:00 **Large-scale distributed convex optimization II** (Governor's Suite) *Chair: Madeleine Udell*

1. **Adding vs. Averaging in Distributed Primal-Dual Optimization** *Virginia Smith*
2. **Revisiting distributed sparse-direct solvers for Interior Point Methods and generalized least squares problems** *Jack Poulson*
3. **Balancing systems and optimization concerns for strong scaling** *Alex Poms*

16:30–18:00 **Demand-Side Management in Power Systems** (Wood Dining Room) *Chair: Larry Snyder; Miguel F. Anjos*

1. **Electric Power Distribution System Operations in the Smart Grid Environment** *Kankar Bhattacharya*
2. **mixed integer models to optimize demand side bidding in conjenction with interruptible load reserve** *Golbon Zakeri*
3. **Bilateral Contract Optimization In Power Markets** *Francois Gilbert*

19:00–21:00 **Graduate Student Social - Packer House, 217 West Packer Avenue, Bethlehem**

08:00–08:30 **Registration and breakfast**

08:30–09:30 **Plenary talk** (Wood Dining Room) *Chair: Alexander Stolyar*

- **Berge's Maximum Theorem for Noncompact Decision Sets and Its Applications** *Eugene A. Feinberg*

09:30–09:45 **Coffee Break**

09:45–11:15 **Operational Research** (B013) *Chair: Andy Zhang*

1. **Equilibrium problems for the sum of two multivalued mappings** *Gabor Kassay*
2. **Stochastic Dynamic Portfolio Liquidation with Adaptive Price Impact** *Andy Zhang*
3. **An Improved Two-Stage Optimization-Based Framework for Unequal-Areas Facility Layout** *Miguel F. Anjos*

09:45–11:15 **Optimization** (B131) *Chair: Francis Vasko*

1. **Teacher Training Enhances the Teaching-Learning-Based Optimization Metaheuristic when used to Solve Multiple-Choice Multidimensional Knapsack Problems** *Francis Vasko, Yun Lu*
2. **Semilocal methods for solving variational inclusions** *Alain Pietrus*
3. **Distributed Stochastic Variance Reduced Gradient Methods** *Qihang Lin*

09:45–11:15 **Large-Scale Optimization and Applications** (Governor's Suite) *Chair: Daniel Robinson*

1. **Primal-Dual Active-Set (PDAS) Algorithms for Isotonic Regression and Trend Filtering** *Zheng Han*
2. **Handling Nonconvexity and Nonsmoothness in Algorithms for Nonlinear Optimization** *Frank E. Curtis*
3. **Flexible Coordinate Descent** *Rachael Tappenden*

11:15–11:30 **Coffee Break**

11:30–12:30 **Plenary talk** (Wood Dining Room) *Chair: Luis F. Zuluaga*

- **AIMMS/MOPTA Optimization Modeling Competition Final** *Peter Nieuwesteeg*

12:30–13:30 **Lunch**

13:30–15:00 **Optimization** (B131) *Chair: Dimitri Papadimitriou*

1. **Variants of the von Neumann algorithm** *Negar Soheili*
2. **Multi-source multi-commodity capacitated facility location problem (cFLP) with uncertain demands** *Dimitri Papadimitriou*

13:30–15:00 **Large scale optimization in Machine Learning** (Governor's Suite) *Chair: Katya Scheinberg*

1. **An Asynchronous Distributed Proximal Method for Composite Convex Optimization** *Zi Wang*
2. **Efficient Hierarchical Multi-Label Learning** *Xiaocheng Tang*
3. **Derivative free optimization for hyperparameter tuning in large scale machine learning problems** *Katya Scheinberg*

13:30–15:00 **Electric Power Generation** (Wood Dining Room) *Chair: Larry Snyder; Miguel F. Anjos*

1. **Unit Commitment - Complementarity, new thoughts** *Bala Venkatesh*
2. **Parallel Computing of Stochastic Programs with Application to Energy System Capacity Expansion** *Run Chen*
3. **Dynamic robust optimization approaches to lot sizing** *Stefano Coniglio*

15:00–15:15 **Coffee Break**

15:15–16:15 **Plenary talk** (Wood Dining Room) *Chair: Martin Takac*

- **Primal and dual variables decomposition methods in convex optimization** *Amir Beck*

16:15–16:30 **Coffee Break**

16:30–18:00 **Conic optimization** (B013) *Chair: Jiming Peng*

1. **A primal-dual interior-point method for hyperbolicity cone optimisation** *Tor Myklebust*
2. **"Cone-Free" Infeasible-Start Primal-Dual Methods** *Mehdi Karimi*
3. **New global algorithm for non-convex quadratic optimization** *Jiming Peng*

16:30–18:00 **Applications** (B131) *Chair: Reza Arastoo*

1. **Robust Joint Collaborative Beamforming and Linear Estimator Design for Wireless Sensor Networks** *Jiang Zhu*
2. **Application of Particle Swarm Optimization on Network Design of Closed-loop Supply Chains** *Wu-Hsun Chung*

3. **Output Feedback Controller Sparsification via Mixed $\mathcal{H}_2/\mathcal{H}_\infty$ Approximation** *Reza Arastoo*

16:30–18:00 **Large-Scale Optimization** (Governor's Suite) *Chair: Martin Takac*

1. **Linear Convergence of the Randomized Feasible Descent Method Under the Weak Strong Convexity Assumption** *Chenxin Ma*
2. **A problem generator and performance of methods for big data optimization** *Kimon Fountoulakis*
3. **Mini-Batch Semi-Stochastic Gradient Descent in the Proximal Setting** *Jie Liu*

16:30–18:00 **Energy Systems** (Wood Dining Room) *Chair: Boris Defourny*

1. **Multistage Power Generation Capacity Expansion Models with Different Risk Measures** *Shu Tu*
2. **Optimal Maintenance Scheduling of an Ocean Wave Farm** *Parth Pradhan*
3. **Stochastic Optimal Control of Grid-Level Storage** *Yuhai Hu*

18:00–19:00 **Cocktail Reception**

19:00–21:00 **Banquet**

08:00–08:30 **Registration and breakfast**

08:30–09:30 **Plenary talk** (Wood Dining Room) *Chair: Katya Scheinberg*

- **Probabilistic Descent and Subspace Decomposition for Nonlinear Optimization** *Luis Nunes Vicente*

09:30–09:45 **Coffee Break**

09:45–11:15 **Nonlinear Optimization Algorithms** (Governor's Suite) *Chair: Frank Curtis*

1. **A Trust Region Algorithm with a Worst-Case Iteration Complexity of $O(\epsilon^{3/2})$ for Nonconvex Optimization** *Mohammadreza Samadi*
2. **A nonmonotone filter SQP method: local convergence and numerical results** *Yueling Loh*
3. **A Primal-Dual Predictor-Corrector Interior-Point Algorithm for NLP** *Daniel P. Robinson*

09:45–11:15 **Derivative free optimization** (Wood Dining Room) *Chair: Rommel Regis*

1. **Derivative-Free Optimization of Expensive Noisy Functions using Stratified Bayesian Optimization** *Saul Toscano-Palmerin*
2. **Positive Bases and their Applications to Derivative-Free Optimization** *Rommel Regis*

11:15–11:30 **Coffee Break**

11:30–12:30 **Plenary talk** (Wood Dining Room) *Chair: Frank E. Curtis*

- **Copositive programming: a framework for quadratic and combinatorial optimization** *Mirjam Dür*

12:30–13:30 **Lunch**

13:30–15:00 **Optimization** (Governor's Suite) *Chair: Jason Hicken*

1. **Evaluate the Range of Functions via A New Directed Balanced Interval Arithmetic for Global Interval optimization** *Sijie Liu*
2. **A New Globally Convergent Incremental Newton Method** *Mert Gurbuzbalaban*
3. **Stochastic Arnoldi's Method for PDE-constrained Optimization of Chaotic Systems** *Jason Hicken*

13:30–15:00 **Resource allocation models** (Wood Dining Room) *Chair: Walter Gomez*

1. **Analysis of distributive policies in artisanal fishery using multiobjective optimization** *Walter Gomez*
2. **A Heterogeneous Reliable Location Model with Risk Pooling under Supply Disruptions** *Ying Zhang*
3. **Order Acceptance and Parallel Machine Scheduling with Earliness-Tardiness Penalities** *Gen-Han Wu*

15:00–15:15 **Coffee Break**

ABSTRACTS

■ Inverse imaging problem

Room: **B013** (09:45 - 11:15) Chair: *Baasansuren Jadamba*

1. A computational framework for the elastography inverse problem of tumor identification

Akhtar Khan[1,*]

[1]Rochester Institute of Technology; *aaksma@rit.edu;

This talk will focus on various optimization formulations for solving the nonlinear inverse problem of identifying cancerous tumors in the human body. Detailed numerical examples will be given.

2. Inverse Problems and Multiobjective Approximation

Christiane Tammer[1,*]

[1]Martin Luther University Halle-Wittenberg;
*christiane.tammer@mathematik.uni-halle.de;

Methods of multiobjective approximation theory are helpful in the study of inverse problems. We use these methods in order to generate approximate solutions of inverse problems. In the talk we present necessary optimality conditions for solutions of multiobjective approximation problems. These optimality conditions are applied for deriving adaptive solution procedures.

3. Equation error approach for elasticity imaging inverse problem

Baasansuren Jadamba[1,*]

[1]Rochester Institute of Technology; *bxjsma@rit.edu;

An equation error approach for the inverse problem is studied in an optimization framework. Existence results for the proposed approach and numerical results for smooth and discontinuous coefficients are given.

■ Robust Optimization

Room: **B131** (09:45 - 11:15) Chair: *Amir Ali Ahmadi*

1. Resource Allocation under Coherent Distortion Risk Measures

Chaithanya Bandi[1,*], *Paat Rusmevichientong*[2]

[1]Northwestern University;
*c-bandi@kellogg.northwestern.edu;[2]Marshall School of Business, USC;

In this paper, we consider high dimensional resource allocation problems faced by a decision maker with a sophisticated risk attitude. We model the risk attitude of the decision maker using a fairly general risk measure known as a coherent distorted risk measure (CDRM) which encompasses many popular risk measures such as spectral risk measures and law-invariant coherent risk measures. The main goal of the paper was to address the problem of tractability escpecially given the large scale nature of the applications we are targetting, and the real time needs of the solution approach. We were able to obtain explicit closed form solution for the CVaR objective function, where we were able to solve for all values of simultaneously, thus giving the decision maker an exact understanding of the sensitivity of the optimal allocation to the risk attitude. We then extended this approach to present an algorithm that computes explicitly the solution for an arbitrary functionally coherent risk measure objective function in O(log n) time, where n is the number of projects. This is in contrast to the complexity of the traditional linear programming formulation which has O(n) variables and constraints. Furthermore, we leverage these closed form characterizations to extend our approach to novel pricing mechanisms introduced recently in some of the application domains.

2. Finding Stable Periodic Solutions to the n-Body Problem via Robust Optimization

Robert Vanderbei[1,*]

[1]Princeton University; *rvdb@princeton.edu;

It is rather easy to use nonconvex nonlinear optimization techniques to find periodic solutions to the n-body problem in celestial mechanics. But, the vast majority of the solutions found are dynamically unstable. In this talk, I will discuss how one can adapt ideas from robust optimization to coerce the optimization toward local solutions that are in fact stable. Some preliminary results will be shown.

3. Robust to Dynamics Optimization

Amir Ali Ahmadi[1,*], *Oktay Gunluk*[2]

[1]Princeton University; *a_a_a@princeton.edu;[2]IBM Research;

We introduce a new type of robust optimization problems that we call ”robust to dynamics optimization” (RDO). The input to an RDO problem is twofold: (i) a mathematical program (e.g., an LP, SDP, IP), and (ii) a dynamical system (e.g., a linear, nonlinear, discrete, or continuous dynamics). The objective is to maximize over the set of initial conditions that forever remain feasible under the dynamics. We initiate an algorithmic study of RDO and demonstrate tractability of some important cases.

■ Large-scale distributed convex optimization I

Room: **Governor's Suite** (09:45 - 11:15) Chair: *Madeleine Udell*

1. Multiagent Distributed Optimization: Convergence Rate of ADMM

Ali Makhdoumi[1,*], *Asu Ozdaglar*[1]

[1]MIT; *makhdoum@mit.edu;

We propose a distributed algorithm based on Alternating Direction Method of Multipliers (ADMM) to minimize the sum of locally known convex functions. This optimization problem captures many applications in distributed machine learning and statistical estimation. We propose a fully distributed broadcast-based Alternating Direction Method of Multipliers (ADMM), in which each agent broadcasts the outcome of his local processing to all his neighbors. We first show that when the functions are convex, then an ϵ-optimal solution can be computed with $O(\frac{1}{\epsilon})$ iterations. We also provide a novel analysis that shows if the functions are strongly convex and have Lipschitz gradients, then an ϵ-optimal solution can be computed with $O(\sqrt{\kappa_f}\log(\frac{1}{\epsilon}))$ iterations, where κ_f is the condition number of the problem. This iteration complexity for distributed ADMM matches the best known iteration complexity for centralized ADMM. Our analysis also highlights the effect of network structure on the convergence rate.

2. On Stochastic Gradient Methods

Angelia Nedich[1,*], *Chandramani Singh*[2], *R. Srikant*[3]

[1]UIUC; *angelia@illinois.edu;[2]Indian Institute of Science, Bangalore India;[3]University of Illinois, Urbana-Champaign, USA;

We study stochastic gradient projection algorithms based on randomized partial updates of the objective function. When partial updates are performed in the decision variables, these algorithms generalize random coordinate descent methods. We analyze these algorithms with and without assuming strong convexity of the objective function. We explore whether this algorithms can exhibit similar rates of convergence as their full gradient based deterministic counterparts.

3. A Fast Distributed Algorithm for Sparse Semidefinite Programs

Javad Lavaei[1,*], *Abdulrahman Kalbat*[2], *Ramtin Madani*[2]

[1]University of California, Berkeley; *lavaei@berkeley.edu;[2]Columbia University;

In this talk, we develop a fast, parallelizable algorithm for an arbitrary decomposable semidefinite program (SDP). To formulate a decomposable SDP, we consider a multiagent canonical form represented by a graph, where each agent (node) is in charge of computing its corresponding positive semidefinite matrix subject to local equality and inequality constraints as well as overlapping (consistency) constraints with regards to the agent's neighbors. Based on the alternating direction method of multipliers, we design a numerical algorithm, which has a guaranteed convergence under very mild assumptions. Each iteration of this algorithm has a simple closed-form solution, consisting of matrix multiplications and eigenvalue decompositions performed by individual agents as well as information exchanges between neighboring agents. The cheap iterations of the proposed algorithm enable solving real-world large-scale conic optimization problems. We will demonstrate the proposed algorithm on large-scale power optimization problems.

■ Energy Markets and Trading

Room: **Wood Dining Room** (09:45 - 11:15) Chair: *Miguel F. Anjos*

1. Policy Analysis of Global Wood Chips Trade Using Spatial Equilibrium Model

Wei Jiang[1,*], *Sauleh Siddiqui*[1]

[1]Johns Hopkins University; *wjiang1990@gmail.com;

Wood chips can be used for paper manufacturing and renewable fuel nowadays. The demand of wood chips from countries such as China and European keeps increasing for the past 10 years. United States of America (USA) is a major exporter of wood chips worldwide. USA's total wood chips export could be limited by EPA's regulation. We want to build a spatial equilibrium model to analyze the effect of this policy scenario on global trade of wood chips. Specifically, we want to explore whether tropical countries with lots of forest like Brazil would increase their export of wood chips. If exports from these countries increased, then the carbon emission there would increase as well.

2. Fundamental limits on optimizing for resistive power losses in synchronous power networks

Milad Siami[1,*], *Milad Siami*[1], *Nader Motee*[1]

[1]Lehigh University; *mis311@lehigh.edu;

In this work we consider a network of synchronous generators and investigate network design strategies to optimize its global performance. One viable performance measure is the total resistive power losses due to returning the power network to synchrony or maintaining its synchrony in the presence of external stochastic disturbances. Our optimal control problem is to design a graph topology for a power network that yields minimal power losses. In the first step, we develop a graph-theoretic methodology to reformulate the problem and relate structural specifications of the underlying graphs of the network to its performance measure. In our approach, rather than trying to solve for a graph topology that yields minimal total resistive power losses, we explicitly quantify fundamental limits on the minimum achievable values for the total resistive power loss. For each transmission line in the network we define its quality based on the ratio of its conductance to its susceptance. Under the assumption that all line qualities are identical, we show the total power loss does not depend on the topology of the power network. Moreover, for the nonidentical case we show that if the coupling graph has specific properties then the total resistive power loss is independent of the network topology but depends on the number of generators. In particular, we show that in a network of synchronous generators its total resistive power loss is more dependent on a network's size and the quality of its transmission lines than its topology. At the end, we will address and discuss open problems related to this subject.

3. An Oil Market Model for the United States

Olufolajimi Oke[1,*], *Daniel Huppmann*[1], *Max Marshall*[1], *Ricky Poulton*[1], *Sauleh Siddiqui*[1]

[1]Johns Hopkins University; *ooke1@jhu.edu;

The United States' crude oil industry, in adapting to the recent uptick in production, has been constrained by inadequate refining and transportation infrastructure and a decades-old export ban. A significant consequence of these limitations is the surge in crude-by-rail shipments, which has been of great environmental concern. We adapt Huppmann and Egging's energy system and resource market equilibrium model (MultiMod) to the current U.S. crude oil market and its interaction with Canada and the rest of the world. The mathematical framework of our model is a dynamic Generalized Nash Equilibrium derived from individual players' profit maximization problems. Currently included in the model are 13 production nodes and 25 refinery nodes that account for over 95% of the U.S. market and 99% of the global market in crude oil and are connected by 269 rail, pipeline and shipping arcs. With this model, we will be able to analyze the transportation of crude oil and explore scenarios to understand and recommend solutions for safe movement across the country, as well as gauge the economic impact of new regulations and policy interventions.

■ Stochastic models of resource allocation

Room: **B013** (13:30 - 15:00) Chair: *Alexander Stolyar*

1. LP-Based Component Allocation Policies for Inventory Control in Assemble-to-Order Manufacturing

Qiong Wang[1,*]

[1]University of Illinois; *qwang04@illinois.edu;

In Assemble-to-Order (ATO) systems, multiple components are used to build many products with different values. Components are either ordered from outside vendors who require positive lead times (in case of ATO inventory systems) or produced internally under capacity constraints (ATO production/inventory systems). Demand arrive according to some stochastic processes, so do component replenishments. Because of the randomness of these two processes, component shortage is inevitable under any reasonable ordering or production decision. This gives rise to the problem of optimally allocating components to minimize the average backlog and inventory holding costs over time. We use an LP model to develop allocation policies. Inputs of the LP are updated dynamically based on the current state of the ATO system. The corresponding updated optimal solution is applied to determine which products should be assembled at the current moment. We show that our policies are justified by a well-established asymptotic optimality criterion.

2. Ergodic control of multiclass multi-pool parallel server systems in the Halfin-Whitt regime

Guodong Pang[1,*], *Ari Arapostathis*[2]

[1]Penn State University; *gup3@engr.psu.edu;[2]University of Texas at Austin;

We study the scheduling and routing control of Markovian multiclass multi-pool networks under the long-run average (ergodic) cost criteria in the Halfin-Whitt regime. Two formulations are considered: (i) both queueing and idleness costs are minimized, and (ii) the queueing cost is minimized while a constraint is imposed upon the idleness of all server pools. We consider the admissible controls in the class of preemptive control policies. We develop a new framework to study the associated unconstrained and constrained ergodic diffusion controls. We first develop a leaf elimination algorithm and obtain an explicit representation of the drift for the controlled diffusions. We characterize the optimal solutions of the constrained and unconstrained problems via the associated HJB equations. We prove the asymptotic optimality results: the values for the ergodic control problems of the networks are shown to converge to those of the associated ergodic diffusion control problems in both formulations. A spatial truncation technique to approximate the optimal solutions of ergodic diffusion controls play a key role in proving the asymptotic optimality.

3. Pull-based load distribution in large-scale heterogeneous service systems

Alexander Stolyar[1,*]

[1]Lehigh University; *stolyar@lehigh.edu;

We consider a heterogeneous service system, consisting of several (different) large server pools, and study an asymptotic regime in which the customer arrival rate and pool sizes scale to infinity simultaneously. We introduce a 'pull-based' scheme (called PULL), for routing arriving customers to servers and prove that, under subcritical load, both waiting times and blocking probabilities asymptotically vanish. In particular, the performance of PULL is vastly superior to that of the celebrtated 'power-of-d-choices' (JSQ(d)) routing algorithm.

■ Nonconvex and Sequential Optimization

Room: **B131** (13:30 - 15:00) Chair: *Robert J. Vanderbei*

1. Optimal Learning of Demand Response for the Nested Lagged Commitment Problem

Nana Aboagye[1,*], *Warren B. Powell*

[1]Princeton University;
*aboagye@exchange.Princeton.EDU;

We address the problem of making lagged commitments to resources in order to maximize revenue over time while sequentially making decisions. The motivating application is hotel resource management and a separate dimension involves learning how the market will respond to price. For this, we assume we have a prior on the price-response relationship (demand function), and introduce the possibility of experimenting with prices to learn this relationship. We consider two cases: where demand is unknown but static and where demand is unknown and dynamic. We use the optimization algorithm called the Knowledge gradient to learn the optimal demand function.

2. DC Decomposition of Nonconvex Polynomials with Algebraic Techniques

Georgina Hall[1,*], *Amir Ali Ahmadi*[1], *Amirali Ahmadi*[1]

[1]Princeton University; *gh4@princeton.edu;

The concave-convex procedure is a majorization-minimization algorithm for difference of convex (DC) optimization, where the constraints and the objective function are given as the difference of two convex functions. Although several important problems (e.g., in machine learning) already appear in DC form, such a decomposition is not always available. We consider this decomposition question for polynomial optimization. We introduce LP, SOCP, and SDP based algorithms for finding optimal DC decompositions by appealing to the algebraic concepts of "DSOS-Convex, SDSOS-Convex, and SOS-Convex" polynomials. We also study structural properties of these polynomials and answer existence questions about polynomial DC decompositions.

3. Approximate Dynamic Programming for Risk-Averse Markov Decision Processes using Dynamic Quantile-Based Risk Measures

Daniel Jiang[1,*]

[1]Princeton University; *drjiang@princeton.edu;

We consider a finite-horizon Markov decision process (MDP) for which the objective at each stage is to minimize a quantile-based risk measure of the sequence of future costs (we call the overall objective a dynamic quantile-based risk measure). In particular, we consider optimizing dynamic risk measures constructed using one–step risk measures that are a convex combination of the expectation and either the quantile (i.e., value at risk or VaR) or the conditional value at risk (CVaR). Although there is considerable theoretical development of risk-averse MDPs in the literature, the computational challenges have not been explored as thoroughly. We propose simulation-based approximate dynamic programming (ADP) algorithms, modeled after Q-learning, to solve the risk-averse sequential decision problem. The algorithms converge almost surely and for any time horizon, enjoy a O(1/n) convergence rate. We also present numerical results by applying the algorithms in the context of an application related to the energy market.

■ Large-Scale Optimization

Room: **Governor's Suite** (13:30 - 15:00) Chair: *Martin Takac*

1. CoCoA - Communication Efficient Distributed Coordinate Ascent

Martin Jaggi[1,*], *Virginia Smith*[2], *Martin Takac*[3], *Jonathan Terhorst*[2], *Sanjay Krishnan*[2], *Thomas Hofmann*[1], *Michael I. Jordan*[2]

[1]ETH Zurich; *jaggi@inf.ethz.ch;[2]UC Berkeley;[3]Lehigh University;

Communication remains the most significant bottleneck in the performance of distributed optimization algorithms for large-scale machine learning. We propose a communication-efficient framework, COCOA, that uses local computation in a primal-dual setting to dramatically reduce the amount of necessary communication. We provide a strong convergence rate analysis for this class of algorithms, as well as experiments on real-world distributed datasets with implementations in Spark. In the later presentation in the afternoon, Virginia Smith will talk about extensions of COCOA.

2. Simultaneous Model Selection and Learning through Parameter-free Stochastic Gradient Descent

Francesco Orabona[1,*]

[1]Yahoo Labs; *francesco@orabona.com;

Stochastic gradient descent algorithms for training linear and kernel predictors are gaining more and more importance, thanks to their scalability. While various methods have been proposed to speed up their convergence, the issue of the model selection phase has often been ignored in the literature. In fact, in theoretical works most of the time unrealistic assumptions are made, for example, on the prior knowledge of the norm of the optimal solution. Hence, costly validation methods remain the only viable approach in practical applications. In this talk, I show how a family of kernel-based stochastic gradient descent algorithms can perform model selection while training, with no parameters to tune, nor any form of cross-validation, and only one pass over the data. Optimal rates of convergence will be shown under standard smoothness assumptions on the target function, as well as empirical results.

3. Stochastic Dual Newton Ascent for Empirical Risk Minimization

Martin Takac[1,*], *Zheng Qu*[2], *Peter Richtarik*[2], *Olivier Fercoq*[3]

[1]Lehigh University; *takac.mt@gmail.com;[2]The University of Edinburgh;[3]Telecom Paris-Tech, France;

We propose a new algorithm for minimizing regularized empirical loss: Stochastic Dual Newton Ascent (SDNA). Our method is dual in nature: in each iteration we update a random subset of the dual variables. However, unlike existing methods such as stochastic dual coordinate ascent, SDNA is capable of utilizing all curvature information contained in the examples, which leads to striking improvements in both theory and practice - sometimes by orders of magnitude. In the special case when an L2-regularizer is used in the primal, the dual problem is a concave quadratic maximization problem plus a separable term. In this regime, SDNA in each step solves a proximal subproblem involving a random principal submatrix of the Hessian of the quadratic function; whence the name of the method. If, in addition, the loss functions are quadratic, our method can be interpreted as a novel variant of the recently introduced Iterative Hessian Sketch.

■ Energy Storage

Room: **Wood Dining Room** (13:30 - 15:00) Chair: *Miguel F. Anjos*

1. Co-optimizing Battery Storage for Energy Arbitrage and Frequency Regulation

Bolong Cheng[1,*]

[1]Princeton University; *bcheng@princeton.edu;

We are interested in optimizing the use of battery storage for multiple applications, in particular energy shifting, energy arbitrage and frequency regulation. The nature of this problem requires the battery to make charging and dis- charging decisions at different time scales while accounting for the stochastic information such as load demand, electricity prices, and regulation signals. Solving the problem for even a single-day operation would be computation- ally inefficient due to the large state space and time steps. We propose a dynamic programming approach that takes advantage of the nested structure of the problem by solving smaller sub-problems of different sizes.

2. A new optimization model for techno-economic studies in the case of hybrid energy

Abdelghani Bouras[1,*], *Nabila Cherfi*[2]

[1]Industrial Engineering Dept, King Saud University; *bouras@ksu.edu.sa;[2]University of Sciences and Technology Houari Boumediene;

The paper considers a decision problem for small electrification projects using hybrid sources. We suggest a mathematical model that provides an optimal sizing of equipment and the best allocation of resources in opposition to existing methods with feasible alternatives. In order to get the lowest cost and to fulfill the demand during peak hours, we determine the way to switch between the energy sources, the amount of energy to store, and the type/size of equipment to face variation in electricity demand and change in weather. A sensitivity analysis is provided to support decision makers.

■ Healthcare

Room: **B013** (16:30 - 18:00) Chair: *David Papp*

1. Optimization models for cancer treatment using arc therapy

David Papp[1,*], *Thomas Bortfeld*[2], *Jan Unkelbach*[2]

[1]North Carolina State University, Department of Mathematics; *dpapp@ncsu.edu;[2]Department of Radiation Oncology, Massachusetts General Hospital;

During radiotherapy, cancer patients are irradiated with beams of ionizing radiation that kill both cancerous and healthy cells. Treatment, therefore, has to be carefully designed in order to deliver the prescribed radiation dose to the tumor while sparing critical organs and healthy tissue from damage.

Arc therapy is a specific type of radiotherapy treatment, during which patients are irradiated using a beam whose shape and intensity can be continuously varied as the radiation source revolves around the patient in a circle. With the latest treatment machines, the radiation source can also follow more complex trajectories.

The optimization of these treatments is highly challenging; natural formulations of these problems are both large-scale and non-convex optimization models even if the beam trajectory is fixed. The talk will present an approach to decompose the problem so that it can be solved approximately by solving only small non-convex and large convex optimization problems. Time permitting, extensions to multicriteria optimization of these plans may also be discussed.

2. A Sample-gradient-based Algorithm for Multiple-OR and PACU Surgery Scheduling

Miao Bai[1,*], *R. H. Storer*[1], *G. L. Tonkay*[1]

[1]Lehigh University; *mib411@lehigh.edu;

We address a multiple-OR surgery scheduling problem constrained by shared PACU capacity within the block-booking framework. Given the surgery sequence, a Discrete Event Dynamic System-based stochastic optimization model is formulated in order to minimize the cost incurred by patient waiting time, surgeon idle time, OR blocking time, OR overtime and PACU overtime. A sample-gradient-based algorithm is proposed to solve the sample average approximation of our formulation.

■ Learning

Room: **B131** (16:30 - 18:00) Chair: *Yingfei Wang*

1. The Knowledge Gradient with Logistic Belief Models for Binary Classification

Yingfei Wang[1,*], *Warren Powell*[1]

[1]Princeton University; *yingfei@cs.princeton.edu;

We consider sequential decision making problems for binary classification scenario in which the learner takes an active role in repeatedly selecting samples from the action pool and receives the binary label of the selected alternatives. Our problem is motivated by applications where observations are time consuming and/or expensive, resulting in small samples. The goal is to identify the best alternative with the highest response. We use Bayesian logistic regression to predict the response of each alternative. By formulating the problem as a Markov decision process, we develop a knowledge-gradient type policy to guide the experiment by maximizing the expected value of information of labeling each alternative and provide a finite-time analysis on the estimated error. Experiments on benchmark UCI datasets demonstrate the effectiveness of the proposed method.

2. The Knowledge Gradient Policy With Regularized Trees

Yan Li[1,*], *Han Liu*[1], *Warren B. Powell*[1]

[1]Princeton University; *yanli@princeton.edu;

We propose a sequential learning policy for noisy discrete global optimization and ranking and selection problems with a tree regularization framework. Besides selecting the best alternative before the finite budget is exhausted, we also aim to learn the important features and the low order interaction terms. We derive a knowledge gradient policy for binary decision trees. This policy myopically optimizes the expected increment in the value of sampling information in each time period. It can naturally deal with categorical and numerical variables, missing values, different scales between variables, interactions and nonlinearities. Experimental work shows that the method is scalable to high dimensions and efficiently learns the underlying low dimensional structures.

3. Multi-armed bandit problems, models and algorithms

Michael Katehakis[1,*], *Wesley Cowan*[1]

[1]Rutgers University; *mnk@rutgers.edu;

This talk will provide a survey and some recent advances for multi-armed bandit (MAB) models.
In its basic form a MAB problem involves sampling sequentially from a finite number of $N \geq 2$ populations or 'bandits', where each population i is specified by a sequence of random variables $\{X_k^i\}_{k\geq 1}$, X_k^i representing the reward received the k^{th} time population i is sampled. For each i, the $\{X_k^i\}_{k\geq 1}$ are taken to be i.i.d. random variables with unknown finite mean.
In recent work, under mild regularity conditions, we construct two simple policies that achieve a measure of regret of order $O(g(n))$ almost surely as $n \to \infty$, for any slowly increasing function g. In our constructions, the function g effectively controls the 'exploration' of the classical 'exploration/exploitation' tradeoff.
When additional parametric assumptions can be made, one can construct policies that are asymptotically optimal in the sense of achieving the lower bound on the logarithmic rate of increase of the regret of Burnetas and Katehakis (1996). We present such asymptotically optimal policies for the cases in which $\{X_k^i\}$ are: a) are Normal with unknown means μ_i and unknown variances σ_i^2, and b) Uniform with unknown supports $[a_i, b_i]$.

■ Large-scale distributed convex optimization II

Room: **Governor's Suite** (16:30 - 18:00) Chair: *Madeleine Udell*

1. Adding vs. Averaging in Distributed Primal-Dual Optimization

Virginia Smith[1,*], *Chenxin Ma*[2], *Martin Jaggi*[3], *Michael I. Jordan*[4], *Peter Richtarik*[5], *Martin Takac*[2]

[1]Berkeley; *vsmith@berkeley.edu;[2]Lehigh University;[3]ETH Zurich;[4]UC Berkeley;[5]University of Edinburgh;

Distributed optimization algorithms for large-scale machine learning suffer from a communication bottleneck. Reducing communication makes the efficient aggregation of partial work from different machines more challenging. In this paper we present a novel generalization of the recent communication efficient primal-dual coordinate ascent framework (CoCoA). Our framework, CoCoA+, allows for additive combination of local updates to the global parameters at each iteration, whereas previous schemes only allowed conservative averaging. We give stronger (primal-dual) convergence rate guarantees for both CoCoA as well as our new variants, and generalize the theory for both methods to also cover non-smooth convex loss functions. We provide an extensive experimental comparison on several real-world distributed datasets, showing markedly improved performance, especially when scaling up the number of machines.

2. Revisiting distributed sparse-direct solvers for Interior Point Methods and generalized least squares problems

Jack Poulson[1,*]

[1]Stanford; *poulson@stanford.edu;

Despite the current surge in academic and commercial interest in first-order methods for optimization, research on sparse-direct techniques for distributed second-order methods and (generalized) least squares solvers has received comparatively little attention. This talk will discuss the high-level details associated with the efficient, scalable solution of sparse, indefinite KKT systems, such as the choice of regularization and how to refine the inexact solution of the regularized system towards the true solution of the original system.
An example of a small, sparse matrix with a condition number of less than 15 which breaks many state-of-the-art codes will be presented and an argument will be made for preconditioning a Flexible GMRES(k) solver for the original quasi-semidefinite KKT system with the (quad-precision) iteratively-refined solution of the a-priori regularized system's Cholesky-like sparse-direct factorization. Furthermore, the recent open-source implementation of this approach within Elemental will be discussed, as well as its immediate extension towards

Equality-constrained Least Squares, General Linear Models, and general (nonsymmetric) sparse-direct solvers. Plans for future algorithmic and architectural generalizations will also be discussed.

3. Balancing systems and optimization concerns for strong scaling

Alex Poms[1,*], *Christopher Fougner*[2], *Saman Ashkiani*[1], *Stephen Boyd*[2], *John D. Owens*[1]

[1]UC Davis; [*]abpoms@ucdavis.edu;[2]Stanford;

We extend a convex optimization solver for graph form problems to exhibit strong and weak scaling across multiple nodes with multiple GPUs per node. This is achieved by leveraging block splitting to divide an optimization problem into smaller, per-iteration independent problems that can be computed in parallel. We investigate the critical point where the benefits of splitting the optimization problem to improve parallelism is outweighed by the increase in number of iterations required for convergence and balanced with the costs of communication. This critical point is further extended by our hybrid implementation that leverages both distributed linear algebra and distributed optimization. We also show how one can reformulate classic problems such as Linear Programming to "balance" the sub problems to achieve better convergence of the overall problem.

■ Demand-Side Management in Power Systems

Room: **Wood Dining Room** (16:30 - 18:00) Chair: *Miguel F. Anjos*

1. Electric Power Distribution System Operations in the Smart Grid Environment

Kankar Bhattacharya[1,*]

[1]Department of Electrical & Computer Engineering, University of Waterloo, Waterloo, Ontario, CANADA;
[*]kankar@uwaterloo.ca;

This presentation will dwell upon electric power distribution system operations in the smart grid environment. An overview of smart distribution systems will be presented and the new issues and challenges to local distribution companies (LDCs) will be brought out. A mathematical modeling framework for the analysis of Plug-in Electric Vehicle (PEV) charging in unbalanced, residential, distribution systems will be discussed. Also, in the same context, mathematical models for generic price-responsive and controllable loads will be developed. Thereafter, a load model, for a load controllable by the LDC, i.e., one which can be scheduled through remote signals, demand response programs or customer-end home energy management systems, will be discussed. Finally, the impact of PEV loads- both uncontrolled charging and smart charging, uncontrolled price-responsive loads, and the LDC controllable loads, on distribution system operations will be examined.

2. mixed integer models to optimize demand side bidding in conjenction with interruptible load reserve

Golbon Zakeri[1,*]

[1]University of Auckland; [*]g.zakeri@auckland.ac.nz;

In a number of electricity markets demand side bids are not only allowed but encouraged for the proper functioning of the market. We will provide a model that determines an optimal demand side bid for a large price responsive consumer of electricity, over a single period of trading in an electricity market. In fact our model co-optimizes this demand side bid in conjunction with the interruptible load reserve offer that the same large consumer of electricity can provide.

3. Bilateral Contract Optimization In Power Markets

Francois Gilbert[1,*], *Miguel Anjos*[2], *Patrice Marcotte*[3], *Gilles Savard*[2]

[1]Argonne National Laboratory;
[*]francois.gilbert.fg@gmail.com;[2]GERAD and Polytechnique Montreal;[3]University of Montreal;

We consider an energy broker linking its customers and the power grid through a two-sided portfolio of bilateral contracts. The contracts cover a number of actions taken by the customers on request within specified periods. Managing this portfolio raises a number of modelling and computational issues due to the aggregation of disparate resources. We propose an innovative algorithmic framework that models short-term decisions factoring in long-term information obtained from a separate model.

■ Operational Research

Room: **B013** (09:45 - 11:15) Chair: *Andy Zhang*

1. Equilibrium problems for the sum of two multivalued mappings

Gabor Kassay[1,*], *Mihaela Miholca*[1]

[1]Babes-Bolyai University; *kassay@math.ubbcluj.ro;

The equilibrium problem appeared as a natural extension of both scalar and vector optimization problems and served later as a unified approach of many other important problems like saddlepoint (minimax) problems, variational inequalities, Nash equilibria problems, complementarity problems, fixed point problems, etc. Apart from its theoretical interest, important problems arising from economics, mechanics, electricity and other practical sciences motivate the study of an equilibrium problem. In this talk we study vector equilibrium problems for the sum of two multivalued bifunctions. The assumptions are required separately on each of these bifunctions. Sufficient conditions for the existence of solutions of such problems are shown in a general setting. The results unify, improve and extend some well-known existence theorems from the literature.

2. Stochastic Dynamic Portfolio Liquidation with Adaptive Price Impact

Andy Zhang[1,*], *Somayeh Moazeni*

[1]Stevens Institute of Technology; *azhang4@stevens.edu;

We study optimal portfolio execution problem for time dependent stochastic price impact models. We find closed-form solutions for the stochastic dynamic programming formulation and develop a method for simultaneous execution and learning. Finally we revisit the notion of dynamic arbitrage in this setting.

3. An Improved Two-Stage Optimization-Based Framework for Unequal-Areas Facility Layout

Miguel F. Anjos[1,*], *Manuel V.C. Vieira*[2]

[1]Polytechnique Montreal, Canada; *miguel-f.anjos@polymtl.ca;[2]Universidade Nova de Lisboa;

The facility layout problem seeks the optimal arrangement of non-overlapping departments with unequal areas within a facility. We present an improved framework combining two mathematical optimization models. The first model is a nonlinear approximation that establishes the relative position of the departments, and the second model is an exact convex optimization formulation of the problem that determines the final layout. Aspect ratio constraints are taken into account by both models. Our preliminary results show that the proposed framework is computationally efficient and consistently produces competitive, and often improved, layouts for instances from the literature as well as for new large-scale instances with up to 100 departments.

■ Optimization

Room: **B131** (09:45 - 11:15) Chair: *Francis Vasko*

1. Teacher Training Enhances the Teaching-Learning-Based Optimization Metaheuristic when used to Solve Multiple-Choice Multidimensional Knapsack Problems

Francis Vasko, Yun Lu [1,*], *Yun Lu*[1]

[1]Kutztown University; *vasko@kutztown.edu;

A new metaheuristic, the Teaching-Learning-Based Optimization (TLBO) metaheuristic, based on the relationship between teachers and learners has recently been proposed by Rao, Savsani and Vakharia (2011) for solving continuous nonlinear optimization problems. It is of particular interest because it is a population-based metaheuristic that can easily be adapted to solve combinatorial optimization problems and requires no parameter fine-tuning other than determining the size of the population and convergence criteria. In this paper, we enhance the performance of the TLBO method by introducing "teacher training" before the teaching phase of TLBO. That is, before the teaching phase of TLBO, we perform a local neighborhood search on the best solution (the teacher) in the current population. The effectiveness of teacher training (TT) in terms of both solution quality and convergence rate will be demonstrated by using this approach (TT-TLBO) to solve a large (393) number of problem instances from the literature for the important (NP-Hard) multiple-choice multidimensional knapsack problem (MMKP). Furthermore, we will demonstrate that TLBO outperforms the best published solution approaches for the MMKP.

2. Semilocal methods for solving variational inclusions

Alain Pietrus[1,*]

[1]University of Antilles; *apietrus@univ-ag.fr;

In the last decades, several iterative methods have been presented to solve variational inclusions. Most of them use the concept of metric regularity and the convergence obtained is local. In these cases it is not easy to make numerical experiments. The aim of this talk is to introduce various semilocal methods for solving some variational inclusions. The main tool used for these methods is the concept of convex process introduced by Rockafellar (1967) and clearly formalized by Robinson (1972). When the single part of the inclusion is semismooth, the Clarke Jacobian allows to obtain a semismooth Newton method with superlinear convergence. At the end of the talk some numerical methods are given to illustrate the convergence.

3. Distributed Stochastic Variance Reduced Gradient Methods

Qihang Lin[1,*], *Tengyu Ma*[2], *Jason Li*[3]

[1]The University of Iowa; *qihang-lin@uiowa.edu;[2]Princeton University;[3]Stanford University;

We study the problem of minimizing the average of N convex functions using m machines with each machine being able to access n = N/m functions. We design a distributed stochastic variance reduced gradient (DSVRG) algorithm which, when the condition number of problem is less than the size of data in each machine, simultaneously achieves the optimal parallel runtime and rounds of communication among all first-order methods up to constant factors. It also outperforms existing distributed algorithms in these metrics when n is relatively large. For the regime when n is relatively small, we propose a distributed accelerated SVRG algorithm which further reduces the runtime.

■ Large-Scale Optimization and Applications

Room: **Governor's Suite** (09:45 - 11:15) Chair: *Daniel Robinson*

1. Primal-Dual Active-Set (PDAS) Algorithms for Isotonic Regression and Trend Filtering

Zheng Han[1,*], *Frank E. Curtis*[2]

[1]Lehigh; *zhh210@lehigh.edu;[2]Lehigh University;

Isotonic regression (IR) is a non-parametric calibration method widely used in supervised learning. For solving large-scale problems, we propose a primal-dual active-set (PDAS) algorithm which, in contrast to the state-of-the-art Pool Adjacent Violators (PAV) algorithm, is easily warm-started and can be parallelized easily. Like PAV, we prove that our PDAS algorithm for IR is convergent and has a work complexity of O(n), but is practically faster. This fact is illustrated by numerical experiments. Furthermore, we provide PDAS algorithm variants for solving related trend-filtering problems and provide the results of numerical experiments with and without safeguarding strategies to ensure convergence.

2. Handling Nonconvexity and Nonsmoothness in Algorithms for Nonlinear Optimization

Frank E. Curtis[1,*], *Wei Guo*[1]

[1]Lehigh University; *frank.e.curtis@gmail.com;

We discuss the design of numerical methods for solving nonlinear optimization problems. Emphasis is placed on the design of methods for solving problems that may be nonconvex and even nonsmooth. Our algorithms are motivated by practical performance, but also possess strong global convergence guarantees on problems satisfying relatively weak assumptions.

3. Flexible Coordinate Descent

Rachael Tappenden[1,*], *Kimon Fountoulakis*

[1]Johns Hopkins University;
*rachael.e.h.tappenden@gmail.com ;

In this talk I will present a novel randomized block coordinate descent method for the minimization of a convex composite objective function. The method uses (approximate) partial second-order (curvature) information, so that the algorithm performance is more robust when applied to highly nonseparable or ill conditioned problems. We call the method Flexible Coordinate Descent (FCD). At each iteration of FCD, a block of coordinates is sampled randomly, a quadratic model is formed about that block and the model is minimized approximately/inexactly to determine the search direction. An inexpensive line search is then employed to ensure a monotonic decrease in the objective function and acceptance of large step sizes. I present preliminary numerical results to demonstrate the practical performance of the method.

■ Optimization

Room: **B131** (13:30 - 15:00) Chair: *Dimitri Papadimitriou*

1. Variants of the von Neumann algorithm

Negar Soheili[1,*], *Javier Pena*[2], *Daniel Rodriguez*[2]

[1]University of Illinois at Chicago; *nazad@uic.edu;[2]Carnegie Mellon University;

The von Neumann algorithm is a simple greedy algorithm to determine whether the origin belongs to a polytope generated by a finite set of points. The algorithm's rate of convergence depends on the radius of the largest ball around the origin contained in the polytope. We propose some variants of the von Neumann algorithm that retain the algorithm's simplicity while achieving faster convergence rate.

2. Multi-source multi-commodity capacitated facility location problem (cFLP) with uncertain demands

Dimitri Papadimitriou[1,*]

[1]Alcatel-Lucent Bell;
*dimitri.papadimitriou@alcatel-lucent.com;

Given a set of potential facilities F (with individual opening cost f_j and finite capacity s_j), a set of clients C with variable demands, and a distance metric d(i,j) defined between client i and facility j, the capacitated Facility Location Problem (cFLP) consists in selecting a subset S of facilities to open and assigning demands to open facilities that minimize the sum of the facility opening cost, the supplying cost and the connection cost (total distance between every client and the facility it is connected to). This problem shares many similarities with the one consisting in minimizing the cost for opening a set of servers or replicas for storing a set of digital objects (data) and connecting clients to facility locations so as to satisfy their demands. The multi-source dimension of the problem translates the situation where the same data object may be available simultaneously at different facility locations. When data objects of different types are available simultaneously at multiple facility locations, the problem shares the characteristics of a multi-product or multi-commodity model.
On the other hand, due to the inherent variability of client demands resulting from many exogenous dependencies, the input data to the problem is subject to uncertainty. To take this uncertainty into account as part of the problem formulation, we extend the set induced robust optimization method (where the uncertain data are assumed to be varying in a given uncertainty set U) to find solutions which remain valid even if the input data (the spatio-temporal properties of client demands) changes. The dynamics of client demands may indeed lead to consider the replication of data objects at multiple facility locations depending on the capacity allocation and sharing model together with their associated constraints; therefore, client demands can be possibly assigned to locations other than the closest facility.
In this paper, we propose and compare different robust formulations (depending on the properties of the uncertainty sets) together with resolution methods of the multi-source multi-commodity capacitated facility location problem adapted for replicas placement and data replication. Results of numerical experiments performed on representative settings and running scenarios are reported and analyzed.

■ Large scale optimization in Machine Learning

Room: **Governor's Suite** (13:30 - 15:00) Chair: *Katya Scheinberg*

1. An Asynchronous Distributed Proximal Method for Composite Convex Optimization

Zi Wang[1,*], *Necdet S. Aybat*[1], *Garud Iyengar*[2]

[1]Penn State University; *zxw121@psu.edu;[2]Columbia Univeristy;

We propose an asynchronous distributed first-order augmented Lagrangian (DFAL) algorithm to minimize sum of composite convex functions, where each term is a private function belonging to one node, and only nodes connected by an edge can directly communicate. This model abstracts various applications in machine-learning. We show that any limit point of iterates is optimal; and for any p>0 and eps>0, an eps-optimal and eps-feasible solution can be computed with probability at least 1-p within O(1/eps log(1/p)) communications in total. We demonstrate the efficiency of DFAL on large scale sparse-group LASSO problems.

2. Efficient Hierarchical Multi-Label Learning

Xiaocheng Tang[1,*], *Vladan Radosavljevic*[2], *Nemanja Djuric*[2], *Mihajlo Grbovic*[2], *Katya Scheinberg*[1]

[1]Lehigh University; *xiaocheng.t@gmail.com;[2]Yahoo Labs;

Hierarchical Multi-label Learning (HML) has found applications in ad targeting or document classification where labels are organized in a connected (tree) structure. Existing approaches, however, do not adequately address the keys of HML: 1) how to exploit the hierarchy structure during training; and 2) how to preserve the same structure during prediction. Here we propose a novel, efficient two-stage HML model that directly addresses both of these problems, and we demonstrate HML on large-scale real-world data sets from document classification, as well as ad targeting domains that involves two million users' daily activities. The results indicate that the proposed approach outperforms traditional multi-label learning models on both tasks.

3. Derivative free optimization for hyperparameter tuning in large scale machine learning problems

Katya Scheinberg[1,*]

[1]Lehigh University; *kas410@lehigh.edu;

We will describe one particular application of hyperparameter tuning in large scale classification which involves black-box optimization. The function under optimization is stochastic in nature and we will relate our recent theoretical results for applying DFO to stochastic function to derive an efficient algorithm for this problem. Some preliminary computational results will be given.

■ Electric Power Generation

Room: **Wood Dining Room** (13:30 - 15:00) Chair: *Miguel F. Anjos*

1. Unit Commitment - Complementarity, new thoughts

Bala Venkatesh[1,*], *Steven Craig*

[1]Ryerson University; *bala@ryerson.ca;

A need exists to optimally dispatch power generation to meet per-hour requirements on the power grid. This is a well-documented and well-established problem commonly known as Unit Commitment (UC). It is typically formulated as a Mixed Integer Linear Program (MILP), which utilizes modern advancements in solver intelligence to produce a solution with speed and accuracy. This paper introduces the Theory of Complementarity to the optimization in order to remove the inherent integer restrictions of a typical MILP, resulting in a continuous solution space rather than a discontinuous space. An optimization problem will be formulated to demonstrate a proof of concept of the complementarity theory as used in UC. A small subset of constraints will be used and the results will be compared against those from an MILP optimization, for 10- and 26-generator configurations. Similar trends in generator status and total cost are noted. Index TermsâĂŤ-Complementarity, power engineering, power systems, power demand, unit commitment.

2. Parallel Computing of Stochastic Programs with Application to Energy System Capacity Expansion

Run Chen[1,*]

[1]School of Industrial Engineering, Purdue University; *chen885@purdue.edu;

Power grids' planning and operations exhibit extreme multiscale in the time dimension, ranging from hourly unit commitment dispatch to decades of investment decisions. The linkage between decisions of different time scales usually is simple. Once the linkage is relaxed, the problem can be separated into multiple problems with each representing a single time scale. This presents a natural idea of using an augmented Lagrangian multiplier (ALM) method to design parallel algorithms, which can be embedded into the well-known progressive hedging (PH) algorithm, which itself is amenable for parallel computing. We will show convergence of the embedded algorithm for convex problems and present preliminary numerical results.

3. Dynamic robust optimization approaches to lot sizing

Stefano Coniglio[1,*], *A. M.C.A. Koster, N. Spiekermann, L. Taccari*

[1]RWTH Aachen University; *stefano.coniglio@gmail.com;

We address a lot sizing problem stemming from a fuel-to-heat&power cogeneration application in which the production demand (of heat) is assumed to be uncertain. We will discuss different two-stage robust optimization formulations for the problem which involve different types of recourse actions. More specifically, we will focus on the case with a fully adaptive storage (containing fully adaptive second stage storage variables), as well as on that with affinely adaptive production levels (which involves first stage affinely adaptive production variables). For the latter, we will also address the nonanticipavity issues that arise when a two-stage robust production plan has to be realized over time, time step by time step, as the uncertain demand is revealed. We will then propose integer programming formulations to tackle the problem and valid inequalities to tighten the bounds they produce, also addressing the challenges that arise when a nonlinear fuel-to-heat&power transfer curve is employed.

■ Conic optimization

Room: **B013** (16:30 - 18:00) Chair: *Jiming Peng*

1. A primal-dual interior-point method for hyperbolicity cone optimisation

Tor Myklebust[1,*], *Levent Tuncel*

[1]University of Waterloo; *tmyklebu@csclub.uwaterloo.ca;

Symmetric primal-dual algorithms are among the successful algorithms for solving symmetric cone optimisation problems. This talk discusses a primal-dual interior point method for general convex programming that is primal-dual symmetric and has good worst-case complexity. Hyperbolicity cones are a strictly larger class of cones than the symmetric cones. Every hyperbolicity cone has a natural barrier for which a certain "long-step Hessian estimation property" holds—but which does not necessarily hold for its dual. The algorithm in this talk can make use of this structure whenever it is present.

2. "Cone-Free" Infeasible-Start Primal-Dual Methods

Mehdi Karimi[1,*], *Levent Tuncel*

[1]University of Waterloo; *m7karimi@uwaterloo.ca;

We develop an infeasible-start primal-dual algorithm for convex optimization problems. Our approach is "cone-free" in the sense that we directly apply our techniques to the given "good" formulation without necessarily reformulating it in a conic form, however, our approach can also be applied to conic optimization problems. After defining our primal-dual central path, we introduce a long-step path following algorithm and prove that it solves the problem in polynomial time; returns an optimal solution if it exists, otherwise detects infeasibility or unboundedness. We introduce our Matlab-based code that solves a large class of problems including LP, SOCP, SDP, QCQP, Geometric programming, and Entropy programming among others.

3. New global algorithm for non-convex quadratic optimization

Jiming Peng[1,*]

[1]University of Houston; * jopeng@Central.UH.EDU;

How to locate a globally optimal solution to non-convex quadratic optimization problem has been a long-standing challenge in optimization community. Moreover, even finding a local optimal solution in quadratic optimization has been proved to be NP-hard.
In this talk, we introduce a new design paradigm to develop effective algorithms for linearly constrained non-convex quadratic optimization. The new algorithm integrates several simple ideas in optimization such as Lagrangian method, convex relaxation, linear approximation and line search to find a global optimal solution within a prespecified tolerance. The global convergence of the algorithm and its complexity will be estimated and numerical results for problems with a few negative eigenvalues will be reported.

■ Applications

Room: **B131** (16:30 - 18:00) Chair: *Reza Arastoo*

1. Robust Joint Collaborative Beamforming and Linear Estimator Design for Wireless Sensor Networks

Jiang Zhu[1,*], *Rick S. Blum*[2]

[1]Tsinghua University, Now I am visiting Lehigh University.; *jiz614@lehigh.edu;[2]Electrical and Computer Engineering Department, Lehigh University;

The problem of distributed complex scalar parameter estimation in wireless sensor networks (WSNs) under bounded channel uncertainty and individual power constraints is studied. By restricting the estimator at the fusion center to be linear, we wish to find both the optimal beamformer and linear estimator for the worst-case channel in the mean square error (MSE) sense. Although this problem is nonconvex due to the bilinear terms, we find that by re-parameterization and semidefinite relaxation (SDR), the original optimization problem can be relaxed to become a semidefinite programming (SDP) problem. Interestingly, we find that the relaxation is tight and the global optimal solution can be found. Finally, numerical simulations are conducted to evaluate the performance of the robust estimator. It is demonstrated that the robust estimator is better than the so called plug-in estimator in the worst-case MSE sense, where the plug-in estimator assumes that the true channel is the nominal channel and then uses this to find the optimal beamformer and linear estimator.

2. Application of Particle Swarm Optimization on Network Design of Closed-loop Supply Chains

Wu-Hsun Chung[1,*], *Chyh-Ming Lai*[2], *Wei-Chang Yeh*[2]

[1]Dept. of Transportation Science, National Taiwan Ocean University; *wxc218@email.ntou.edu.tw;[2]Dept. of Industrial Engineering and Engineering Management, National Tsing Hua University, Taiwan;

Due to the increasing post-sale activities in supply chains (e.g., repair, recycling, and reuse), the network design of closed-loop supply chains (CLSC) draws close attention. The locations of various facilities in CLSC play a key role in the efficiency of CLSCs. Most relevant works studied various discrete facility location problems searching the facility location in a finite space. Instead, the paper focused on a continuous multi-facility location problem in a CLSC so that more unexplored facility locations in an infinite space can be searched. The multi-facility location problem in the paper included various facilities for forward and reverse logistics in a CLSC network, such as demand points (DPs), collection points (CPs), factories distribution centers, and collection centers. Given DPs, CPs, and factories, a method was proposed to locate these distribution centers and collection centers for simultaneously coordinating forward and reverse logistics to minimize total cost in the CLSC network. The method adopted a population-based stochastic approach, Particle Swarm Optimization (PSO), to iteratively optimize the CLSC network until the low-cost locations of the distribution centers and collection centers were found. The research showed that the PSO-based method could effectively locate the facilities supporting forward and reverse logistics in a CLSC network and avoided the drawbacks in discrete facility location problems searching broader continuous space for the better facility locations.

3. Output Feedback Controller Sparsification via Mixed $\mathcal{H}_2/\mathcal{H}_\infty$ Approximation

Reza Arastoo[1,*], *Reza Arastoo*[1], *Mirsaleh Bahavarnia*[1], *Mayuresh V. Kothare*[1], *Nader Motee*[1]

[1]Lehigh University; *rea308@lehigh.edu;

In this work, we develop a sparsity-promoting algorithm to improve sparsity pattern of a given power network (modeled by a linearized version of the swing equations for synchronous power network) by solving a regularized governing optimal control problem for power grid. We formulate an optimization program based on H_p approximations capable of synthesizing a structured sparse static controller gain for which the overall closed-loop system exhibits empirical frequency characteristics resembling that of the system controlled with a pre-designed centralized controller. Our methodology provides guarantees for the control signal generated by the sparse controller to stay in the vicinity of the centralized control input. Furthermore, we show that our optimization problem can be equivalently reformulated into a rank constrained problem for which we propose to use a version of Alternating Direction Method of Multipliers (ADMM) as a computationally efficient algorithm to sub-optimally solve it. We will illustrate the effectiveness of our proposed method by testing it on a class of synchronous power network models.

■ Large-Scale Optimization

Room: **Governor's Suite** (16:30 - 18:00) Chair: *Martin Takac*

1. Linear Convergence of the Randomized Feasible Descent Method Under the Weak Strong Convexity Assumption

Chenxin Ma[1,*], *Rachael Tappenden*[2], *Martin Takac*[1]

[1]Lehigh University; *chm514@lehigh.edu;[2]Johns Hopkins University;

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

2. A problem generator and performance of methods for big data optimization

Kimon Fountoulakis[1,*]

[1]ICSI, University of Berkeley;
*K.Fountoulakis@sms.ed.ac.uk;

We present an instance generator for l1-regularized least squares problems. The generator allows to control the properties of the input data matrix and the optimal solution of the problem. For example, the sparsity of the input data matrix, its spectral decomposition, the sparsity of the optimal solution and its norm. The generator has very low memory requirements and scales well with the dimensions of the problem. We believe that the flexibility of the proposed generator will cover the need for generation of various good test problems.
Using the proposed generator we study the performance of first- and second-order optimization methods as the conditioning of the problem changes and the dimensions of the problem increase up to one trillion.

3. Mini-Batch Semi-Stochastic Gradient Descent in the Proximal Setting

Jie Liu[1,*], *Jakub Konecny*[2], *Peter Richtarik*[2], *Martin Takac*[1]

[1]Lehigh University; *jild13@lehigh.edu;[2]The University of Edinburgh;

We propose mS2GD: a method incorporating a mini-batching scheme for improving the theoretical complexity and practical performance of semi-stochastic gradient descent (S2GD). We consider the problem of minimizing a strongly convex function represented as the sum of an average of a large number of smooth convex functions, and a simple nonsmooth convex regularizer. Our method first performs a deterministic step (computation of the gradient of the objective function at the starting point), followed by a large number of stochastic steps. The process is repeated a few times with the last iterate becoming the new starting point. The novelty of our method is in introduction of mini-batching into the computation of stochastic steps. In each step, instead of choosing a single function, we sample b functions, compute their gradients, and compute the direction based on this. We analyze the complexity of the method and show that it benefits from two speedup effects. First, we prove that as long as b is below a certain threshold, we can reach any predefined accuracy with less overall work than without mini-batching. Second, our mini-batching scheme admits a simple parallel implementation, and hence is suitable for further acceleration by parallelization.

■ Energy Systems

Room: **Wood Dining Room** (16:30 - 18:00) Chair: *Boris Defourny*

1. Multistage Power Generation Capacity Expansion Models with Different Risk Measures

Shu Tu[1,*]

[1]Lehigh University; *sht213@lehigh.edu;

We investigate different stochastic optimization formulations for the multistage power generation capacity expansion problem. In particular, we focus on risk measures whose parameters can be calibrated from market data.

2. Optimal Maintenance Scheduling of an Ocean Wave Farm

Parth Pradhan[1,*], *Shalinee Kishore*[1], *Boris Defourny*[1]

[1]Lehigh University; *pap212@lehigh.edu;

Out of several challenges that the Wave Energy conversion is facing in its development, one is to come up with a maintenance strategy that can help reduce the overall cost of electricity from ocean waves. In a situation where wave energy converters deployed in real harsh ocean environment are prone to failures and where frequent maintenance cost is considered very expensive, a static maintenance may not be the best strategy. In this work, we propose a dynamic wave farm maintenance scheduling policy that maximizes the revenue from the extracted wave power. We discuss the monotonic nature of the optimal policy and give a detailed analysis of its structure using Barycentric co-ordinate system. The effects of ocean weather conditions on the optimal policy are also analyzed briefly.

3. Stochastic Optimal Control of Grid-Level Storage

Yuhai Hu[1,*], *Boris Defourny*[1]

[1]Lehigh University; *yuh212@lehigh.edu;

We consider a stochastic control problem for the operations of a battery connected to the power grid. We study the sensitivity of the valuation of the battery on different assumptions we make regarding the price process and the physical characteristics of the battery.

■ Nonlinear Optimization Algorithms

Room: **Governor's Suite** (09:45 - 11:15) Chair: *Frank Curtis*

1. A Trust Region Algorithm with a Worst-Case Iteration Complexity of $O(\epsilon^{3/2})$ for Nonconvex Optimization

Mohammadreza Samadi[1,*], *Frank E. Curtis*[1], *Daniel P. Robinson*[2]

[1]Lehigh University; [*]mos213@lehigh.edu;[2]Johns Hopkins University;

We present a trust region method for unconstrained nonconvex optimization that, in the worst-case, is able to drive the norm of the gradient of the objective below a prescribed threshold $\epsilon \geq 0$ after at most $O(\epsilon^{-3/2})$ iterations. Our work is inspired by the recently proposed Adaptive Regularisation framework using Cubics (i.e., the ARC algorithm), which attains the same worst-case complexity bound. Our algorithm is modeled after a traditional trust region algorithm, but employs modified step acceptance criteria and a novel trust region updating mechanism that allows it to achieve this desirable property. Importantly, our method also maintains standard global and fast local convergence guarantees. Numerical results are presented.

2. A nonmonotone filter SQP method: local convergence and numerical results

Yueling Loh[1,*]

[1]Johns Hopkins University; [*]yueling.loh@jhu.edu;

We present a nonmonotone variant of a filter SQP algorithm for nonlinear optimization that avoids the restoration phase. Like the monotone version of this algorithm, the search direction is computed using the same procedure during every iteration from subproblems that are always feasible and computationally tractable. This variant inherits the previously established global convergence property, and we will now establish local superlinear convergence of the iterates, as well as provide the results of numerical experiments. The numerical tests validate our method and highlight an interesting numerical trade-off between accepting more (on average lower quality) steps versus fewer (on average higher quality) steps.

3. A Primal-Dual Predictor-Corrector Interior-Point Algorithm for NLP

Daniel P. Robinson[1,*], *Philip Gill*[2], *Vyacheslav Kungurtsev*[3]

[1]Johns Hopkins University; [*]daniel.p.robinson@gmail.com;[2]UCSD;[3]Czech Technical University in Prague;

I present a new primal-dual penalty-barrier merit function that may be used to develop optimization algorithms. The merit function uses shifts to both equality and inequality constraints, which allow for the development of algorithms that do not require any of the associated parameters to converge to zero; this is important from a practical perspective. I proceed to show one way in which the new merit function may be used by describing a new predictor-correction interior-point algorithm for solving general nonlinear optimization problems. Preliminary numerical experiments will be provided.

■ Derivative free optimization

Room: **Wood Dining Room** (09:45 - 11:15) Chair: *Rommel Regis*

1. Derivative-Free Optimization of Expensive Noisy Functions using Stratified Bayesian Optimization

Saul Toscano-Palmerin[1,*], *Peter Frazier*[1]

[1]Cornell University; [*]st684@cornell.edu;

We consider simulation optimization, and derivative-free optimization of noisy expensive functions, when most of the randomness in the objective is produced by a few influential scalar random inputs. We present a new Bayesian global optimization algorithm, called Stratified Bayesian Optimization (SBO), which uses this strong dependence to improve performance. Our algorithm borrows classical ideas from derivative-free optimization, including Gaussian process metamodels and value of information analysis, but is also similar in spirit to stratification, a classical technique from simulation, which uses strong dependence on a categorical representation of the random input to reduce variance.

2. Positive Bases and their Applications to Derivative-Free Optimization

Rommel Regis[1,*]

[1]Saint Joseph's University, Department of Mathematics; [*]rregis@sju.edu;

This talk begins with a review of the main properties positive bases and then it presents some theoretical results that have not been previously mentioned in the literature. It also presents some numerical algorithms that involve positive bases, positive spanning sets and positively independent sets. Finally, this talk discusses the applications of positive bases in the design of derivative-free optimization algorithms.

■ Optimization

Room: **Governor's Suite** (13:30 - 15:00) Chair: *Jason Hicken*

1. Evaluate the Range of Functions via A New Directed Balanced Interval Arithmetic for Global Interval optimization

Sijie Liu[1,*]

[1]University of Alabama; [*]sliu28@crimson.ua.edu;

The main advantage of interval method for solving the global optimization problem is because of its strong capacity of providing rigorous bounds in the presence of round of errors. But the overestimation and low efficiency are major drawbacks in conventional interval computations. The dependency is a major obstacle to the application of interval arithmetic if a variable occurs several times in a function and treating them independently in the standard interval arithmetic, it might lead to an unwanted expanded result. Though, this is not always true with more complicated functions. Here we developed a new directed balanced (inner and outer) interval arithmetic redefining an interval as a term of several parameters that tracking the original sources interval, monotonicity of every operation rather than one interval with interval arithmetic. In this case, this method can get a more exact inclusion function result comparing the standard interval arithmetic and inner arithmetic. And we propose a forward-and-backward propagation algorithm to calculate the inclusion function value. And comparing results shows this can be used for reducing errors of the approximations for the function value and finding a better result for the global optimization problem.

2. A New Globally Convergent Incremental Newton Method

Mert Gurbuzbalaban[1,], Asuman Ozdaglar, Pablo Parrilo*

[1]MIT; *mertg@mit.edu;

We develop and analyze a new globally convergent incremental Newton method for minimizing the sum of strongly convex functions, motivated by machine learning problems over large data sets and distributed optimization over networks. We discuss its convergence rate and prove its linear convergence under some assumptions.

3. Stochastic Arnoldi's Method for PDE-constrained Optimization of Chaotic Systems

Jason Hicken[1,], Anthony Ashley[1]*

[1]Rensselaer Polytechnic Institute; *hickej2@rpi.edu;

Many engineering systems are governed by chaotic dynamics. In general, a PDE-constrained design optimization of these systems must contend with 1) large primal-space dimensions 2) expensive function evaluations and 3) noisy data. Together, these three characteristics challenge existing optimization algorithms. To address this challenge, we present a generalization of Arnoldi's method for linear systems that we call Stochastic Arnoldi's Method (SAM). We show that SAM is effective at optimizing large-dimensional convex optimization problems in the presence of noise. In addition, we describe a variation of SAM that handles biased noise in the gradient evaluations, an issue that arises when using regularized adjoints for chaotic differential equations.

■ Resource allocation models

Room: **Wood Dining Room** (13:30 - 15:00) Chair: *Walter Gomez*

1. Analysis of distributive policies in artisanal fishery using multiobjective optimization

Walter Gomez[1,], Jara, Miguel[2], Dresdner, Jorge[2]*

[1]Universidad de La Frontera; *walter.gomez@ufrontera.cl;[2]Universidad de ConcepciÃşn, Chile;

This research analyzes the effects that a redistributive fishing quota policy applied could have on the profits and employment related to the artisanal fishery activity. We use a multi-objective model and data from the common sardine and anchovies fishery in Southern Chile. With the multiobjective model we can identify a better allocation effort for the artisanal fishery organizations and estimate the trade-offs between three main objectives: profits, employment and equity.

2. A Heterogeneous Reliable Location Model with Risk Pooling under Supply Disruptions

Ying Zhang[1,], Larry Snyder[2]*

[1]Tsinghua University, Lehigh University; *yiz814@lehigh.edu;[2]Lehigh University;

This paper investigates a facility location model that considers the disruptions of facilities and the cost savings from the inventory risk-pooling effect and economies of scale. Facilities may have heterogenous disruption probabilities. When a facility fails, its customers may be reassigned to other surviving ones to hedge against lost-sales costs. We first develop both an exact and an approximate expression for the nonlinear inventory cost, and then formulate the problem as a nonlinear integer programming model. The objective is to minimize the expected total cost across all possible facility failure scenarios. To solve this problem, we design two methods, an exact approach using special ordered sets of type two (SOS2) and a heuristic based on Lagrangian relaxation. We test the model and algorithms on data sets with up to 150 nodes. Computational results show that the proposed algorithms can solve the problem efficiently in reasonable time. Managerial insights on the optimal facility deployment, customer assignments and inventory control strategies are also drawn.

3. Order Acceptance and Parallel Machine Scheduling with Earliness-Tardiness Penalities

Gen-Han Wu[1,], Shih-Yu Chou[2]*

[1]National Dong Hwa University, Hualien, Taiwan; *genhanwu@mail.ndhu.edu.tw;[2]BenQ Materials Corp., Tainan, Taiwan;

In the make-to-order environment, manufacturing companies often receive a number of order requests in a short time. Due to the limited production capacities, the orders' profits, the due dates and the resources consumed need to be deliberately evaluated in order to decide which orders should be accepted, schedule in the suitable machines, and maximize the profit. We consider the earliness-tardiness penalty costs and focus on the problem of order acceptance and parallel machine scheduling in a make-to-order manufacturing environment. Hence, the goal of this study is to select the suitable orders, arrange the orders sequence in different machines, decide the best production time, and maximize the profit.

Normally, this type of the problem can be handled into two subproblems— the sequencing problem and the timing problem. The sequencing problem is to decide the accepted orders' sequence in different machines. In the timing problem, the production times of the orders are adjusted and arranged in a given orders' sequence in order to maximize the profit. The optimal timing algorithms are normally the polynomial-time algorithms and are categorized as three classes. The first calss OTA1 are based on the concept of the cluster. The jobs are separated into the clusters, and then the production times are shifted by the different clusters. The second class OTA2, based on the same unit earliness penalty and unit tardiness penalty, is that the jobs' times are arranged one by one. We need to examine if the current job is assigned to the same block of the previous job and then adjust the production time of the whole block. The third class OTA3 is similar to the second class. The main difference is that the production time of the whole block is directly moved to the time with the minimum cost. The earliness-tardiness single machine scheduling problem is a NP-hard problem. This study is an extent from single machine to parallel machines. The optimal approaches can only solve the small-sized problems but the large-sized problems need to be solved by the metaheuristics.

We assume that the processing time, the sequence-dependent setup time, the due date, the revenue, earliness penalty weight, and tardiness penalty weight of each order are known. A mathematical model for earliness-tardiness order acceptance and identical parallel machine scheduling problem is formulated to maximize the total profit. In the development of the algorithms, five particle swarm optimization algorithms, embedded with the structure of variable neighborhood search, are introduced and the production sequence of the orders is determined. In the following, Three optimal timing algorithms, OTA1 3, are used to obtain the optimal production times of the orders in a fixed production sequence.

In the particle swarm optimization design of sequencing problem, this study adopts the numerical encoding. Each particle represents a solution. Each solution has two types of sequences including order sequence and machine sequence which indicates the assigned machine of the order. Moreover, these two types of sequence values can be transformed into the production sequence of the orders in each machine. The basic updated formula of particle location and velocity is performed. Each particle moves its velocity, direction, and location to the fittest solution based on itself velocity, the locations of this particle's best solution and all particles' best solution. Additionally, variable neighborhood search is embedded into the particle swarm optimization algorithm in order to intensify the capability of the particle swarm optimization algorithm. Variable neighborhood search normally select the best solution from the neighborhood to update the solution but too much search time is consumed. Hence, the rule of first improvement is utilized. Only one neighbor solution is evaluated in each time. If this evaluated neighbor solution is better than current solution, current solution will be updated. Four neighborhoods, including order insertion, machine revised, order swap, and machine swap are designed.

Different sizes of problems are tested to validate the effect of the proposed algorithms. The CPU is i7-3770CPU@3.40GHz and the computer memory is 12GB. The Software, Microsoft Visual Studio 2008 is used to compile the programming and CPLEX v12.5 is executed to obtain the optimal solution for the small-sized problems. We find out that PSOVNS4-OTA2 is better if earliness penalty weight is equal to tardiness penalty weight. If earliness penalty weight is not equal to tardiness penalty weight, PSOVNS4-OTA1 is better. In the end, we tested different ranges of due dates in order to check if it will affect the computing time. We find that it takes more time to solve the problem in the wide range of due dates. In the future, the due windows and the release time of the orders may be considered. Identical parallel machines can also be extended to unrelated parallel machines.

Key words: parallel machine, earliness-tardiness scheduling, particle swarm optimization, variable neighborhood search, optimal timing algorithm, order acceptance

Register