linear equations in nearly-linear time. The main tools used in these algorithms are sparse approximations of graphs and approximations of graphs by low-stretch spanning trees. The ability to quickly solve such systems of equations has led to the asymptotically fastest algorithms for computing maximum flows and minimum cost flows. The techniques used in the Laplacian equation solvers have been used to design the fastest algorithms for approximating maximum flows. We will provide an introduction to these recent developments.

Friday, 10:20am - 11:50am

■ FB01

01- Grand 1

Complementarity/Variational Inequality VII

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Stephan Dempe, TU Bergakademie Freiberg, Freiberg, 09596, Germany, dempe@tu-freiberg.de

1 - Using Mathematical Programming with Equilibrium Constraints for Parameter Identification in Contact

Ying Lu, PhD, Rensselaer Polytechnic Institute, 2408 21st Street, Apt. 6, Troy, NY, 12180, United States of America, rosebudflyaway@gmail.com, Jeff Trinkle

A common model of contact dynamics used in robotics takes the form of complementarity problem. When comparing the behaviors of multibody contact of dynamics simulation, with real physical experiment data, in order to verify the reliability and robustness of simulation methods, we have to identify the unmeasurable system parameters such as frictional coefficients. We introduce an optimization approach to solve this problem. The objective function is the sum of squared errors at each time step and the constraints are a set of complementarity conditions defining the simulation model. The result is a challenging MPEC problem. We study the performance of several derivative-free optimization methods in solving this problem.

2 - Solution Algorithm for Bilevel Optimization Problems

Stephan Dempe, TU Bergakademie Freiberg, Freiberg, 09596, Germany, dempe@tu-freiberg.de

Bilevel optimization problems are problems of minimizing an objective function subject to the graph of a second parametric optimization problem. This problem is transformed using the optimal value function of the lower level problem. The reason for this is explained. To solve it, the optimal value function is approximated from above. Realization of the resulting algorithm is explained if the lower level problem is fully convex. Convergence to a global respectively local solution is shown.

3 - Equivalent Convex Problems in the Pre-Dual Space

Michael Rotkowitz, University of Maryland, Dept. of ECE, A.V. Williams Bldg., The University of Maryland, College Park, MD, 20742, United States of America, mcrotk@umd.edu

Given a constrained convex optimization problem, we discuss the formulation and solution of equivalent problems in the pre-dual space. This is intended for problems where the dual of the constraint space cannot be easily classified or is not well-understood, but the pre-dual space can be classified. Our main motivation is constrained control problems in the Hardy space H-infinity; the space of functions of bounded variation is another space of this nature.

■ FB02

02- Grand 2

Recent Advances in Copositive Programming

Cluster: Conic Programming

Invited Session

Chair: Roland Hildebrand, Weierstrass Institute, Mohrenstrasse 39, Berlin, 10117, Germany, roland.hildebrand@wias-berlin.de

1 - Scaling Relationship between the Copositive Cone and Parrilo's First Level Approximation

Peter Dickinson, University of Twente, P.O. Box 217, Enschede, 7500 AE, Netherlands, p.j.c.dickinson@utwente.nl, Mirjam Dür, Luuk Gijben, Roland Hildebrand

Winner of the 2013 OPTL Best Paper Award. In this talk we consider Parillo's inner approximations of the copositive cone. For orders greater than four we show that, in contrast to the copositive cone, Parillo's approximations are not invariant under scalings, and thus are not equal to the copositive cone. This opens up scalings as a new line of research for considering how to improve inner approximations of the copositive cone.

2 - On Completely Positive Modeling of Quadratic Problems

Duy-Van Nguyen, Trier University, Department of Mathematics, Trier, 54286, Germany, nguyen@uni-trier.de, Mirjam Dür

Copositive programming deals with linear optimization problems over the copositive cone and its dual, the completely positive cone. The motivation to study this type of problem is that many nonlinear quadratic problems (even with binary constraints) can be cast in this framework. In order to have strong duality in conic optimization, strict feasibility of the problems is required. Strict feasibility is also advantagous in numerical solution approaches, for example when inner approximations of the copositive cone are used. We show that not all of the known completely positive formulations of quadratic and combinatorial problems are strictly feasible and discuss conditions which ensure this property.

3 - Representations of the Interior of the Completely Positive Cone

Patrick Groetzner, University of Trier, Department of Mathematics, Trier, 54286, Germany, groetzner@uni-trier.de, Mirjam Dür

Many combinatorial and nonlinear problems can be reformulated as convex problems using the copositive and the completely positive cone. Therefore it is of interest, whether a matrix is in the interior of one of these cones. There are some characterizations for the interior of the completely positive cone, which just provide sufficient but not necessary conditions. The main goal of this talk is to extend these known characterizations using certain orthogonal transformations.

■ FB03

03- Grand 3

Algorithms for Combinatorial Optimization Problems

Cluster: Combinatorial Optimization

Invited Session

Chair: Asaf Levin, The Technion, Faculty of IE&M, The Technion, The Technion City, Haifa, Israel, levinas@ie.technion.ac.il

1 - Models for the k-Metric Dimension

Leah Epstein, University of Haifa, Mount Carmel, Haifa, Israel, lea@math.haifa.ac.il, Ron Adar

For an undirected graph, a vertex x separates vertices u and v\neq u, if their distances to x are distinct. For a parameter k, a subset of vertices L is a feasible landmark set, if for every two vertices, there are at least k vertices in L, each separating them. We study a generalization of the classic problem (where k=1) for k>1, and analyze two models. In AP, k separations are needed for every pair of distinct vertices of V, while in NL, such separations are needed only for pairs of vertices in V\L. We focus on the weighted version, where the goal it to find a minimum cost solution, and design algorithms for several graph classes. We demonstrate the differences between the two new models, and between the cases k=1 and k>1.

2 - A Polynomial-Time Approximation Scheme for the Airplane Refueling Problem

Danny Segev, University of Haifa, Department of Statistics, Haifa, 31905, Israel, segev.danny@gmail.com, Iftah Gamzu

We propose a polynomial-time approximation scheme for the airplane refueling problem, which was introduced by the physicists George Gamow and Marvin Stern in their classical book "Puzzle-Math" (1958). Sticking to the original story behind this problem, suppose we have to deliver a bomb in some distant point of the globe, the distance being much greater than the range of any individual airplane at our disposal. Thus, the only feasible option to carry out this mission is to better utilize our fleet via mid-air refueling. Starting with several airplanes that can refuel one another, and gradually drop out of the flight until the single plane carrying the bomb reaches the target, how would you plan the refueling policy?

3 - Improved Approximation Algorithms for Discounted Reward TSP

Asaf Levin, The Technion, Faculty of IE&M, The Technion, The Technion City, Haifa, Israel, levinas@ie.technion.ac.il, Boaz Farbstein

The Discounted Reward TSP is defined as follows. The input is a graph G=(V,E) where each node v has an initial prize pi(v) and this prize deteriorates exponentially. Therefore, the prize collected from node v is pi(v) times lambda^t, where lambda is the deterioration rate and t is the total distance until the first time v was visited. The objective is to find a path that maximizes the total prize collected from the nodes of G. We present two different algorithms for Discounted Reward TSP, each improving the previously best known approximation ratio of 0.1481-delta shown by Blum et al. (SICOMP'07). Our better algorithm is a (0.1929-delta)-approximation algorithm.

■ FB04

04- Grand 4

Semidefinite Programming for Polynomial and Tensor Optimization

Cluster: Conic Programming

Invited Session

Chair: João Gouveia, University of Coimbra, Apartado 3008 EC Santa Cruz, Coimbra, 3001-501, Portugal, jgouveia@mat.uc.pt

Co-Chair: Hamza Fawzi, Massachusetts Institute of Technology, Cambridge MA 02139, hfawzi@mit.edu

Co-Chair: James Saunderson, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-D572, Cambridge, MA, 02139, United States of America, jamess@mit.edu

1 - Sparse Sum-of-Squares Certificates on Finite Abelian Groups

James Saunderson, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-D572, Cambridge, MA, 02139, United States of America, jamess@mit.edu, Hamza Fawzi, Pablo Parrilo

We consider functions on finite abelian groups that are non-negative and also sparse in the Fourier basis. We investigate when such functions are sums of squares of functions with a small common Fourier support. We give a combinatorial condition for this based on finding chordal covers (with additional symmetry properties) of a graph that encodes the group and sparsity pattern of interest. These techniques allow us to resolve a conjecture of Laurent about non-negative quadratic functions on the hypercube, and to prove that a certain family of trigonometric cyclic polytopes (indexed by dimension) have significantly smaller SDP descriptions than LP descriptions.

2 - Polynomial Optimization on Algebraic Curves

Mauricio Velasco, Universidad de los Andes, Cra 1 N∫ 18A- 12, Bogota, Colombia, mvelasco@uniandes.edu.co, Greg Blekherman, Gregory Smith

In this talk we describe new asymptotically sharp upper bounds for the degrees of sums of squares multipliers for nonnegative forms on algebraic curves. These bounds give exact polynomial optimization algorithms on curves via their semidefinite programming relaxations.

3 - Semidefinite Relaxations for Tensor Learning

Parikshit Shah, Yahoo! Research Lab, Yahoo! Research Lab, San Jose, CA, United States of America, pshah@discovery.wisc.edu, Gongguo Tang

Tensors provide powerful yet flexible approaches for modeling multi-dimensional data. Important machine learning tasks such as multi-task learning, collaborative filtering, topic modeling, and mixture learning can be modeled naturally via tensors. While tensors are undoubtedly useful, they are also notoriously difficult to work with since basic computational building blocks such as tensor decomposition and tensor rank are intractable. In this talk, I will present some recent work that establishes new, principled, convex optimization based approaches for tensor decomposition and tensor completion.

■ FB05

05- Kings Garden 1

Large Scale Optimization and Preconditioning

Cluster: Nonlinear Programming

Invited Session

Chair: Giovanni Fasano, Assistant Professor, University Ca'Foscari of Venice, Department of Management, S.Giobbe, Cannaregio 873, Venice, VE, 30121, Italy, fasano@unive.it

1 - A General Class of Conjugate Gradient Methods

Mehiddin Al-Baali, Dr., Sultan Qaboos University, Dept. of Mathematics and Statistics, P.O. Box 36, Muscat, 123, Oman, albaali@squ.edu.om

A new class of conjugate gradient methods for large-scale unconstrained optimization will be considered. The class contains most of the well known and recently proposed conjugate gradient methods with standard approximate line search frameworks. A new strategy for enforcing the sufficient descent and global convergence properties of the class will be analysed. Numerical results will be described to illustrate the behaviour of certain members of the class of methods and their modifications (in particular those of the Fletcher-Reeves and Polak-RibiËre). It will be shown that introducing a simple technique to the conjugate gradient methods will improve the performance of the methods substantially.

2 - A Spectral Projected Gradient-Based Method for Image Segmentation

Daniela di Serafino, Prof., Department of Mathematics and Physics, Second University of Naples, viale A. Lincoln, 5, Caserta, I-81100, Italy, daniela.diserafino@unina2.it, Laura Antonelli, Valentina De Simone

We investigate the application of a nonmonotone projected gradient method to a region-based variational model for image segmentation. We consider a "discretize-then-optimize" approach and solve the resulting nonlinear optimization problem by an alternating minimization procedure that exploits the spectral projected gradient method by Birgin, MartÌnez and Raydan. We provide a convergence analysis and perform numerical experiments on several images to evaluate the effectiveness of this procedure. Computational results show that our approach is competitive with a very efficient solver based on the Split Bregman method.

3 - Evolution Strategies for Stochastic Optimization Problems

Soualmi Nacer, CERFACS, 42 Avenue Gaspard Coriolis, Toulouse, 31057, France, soualmi@cerfacs.fr, Luis Nunes Vicente, Serge Gratton

Evolution Strategies (ES) are known to handle well noise and uncertainty in function evaluations. This is due to the fact the points for evaluation are generated randomly within an ensemble or population. However, their greediness in function evaluations is a major limitation in real applications, in particular for higher dimensions. We adapt existing ES for problems where the objective function is formulated stochastically, and where, in addition, the level of noise in function values can be adjustable by varying the computational complexity. We will show that taking the most accurate values can be particularly inappropriate in some instances. Our approach is validated by theoretical and numerical results.

■ FB06

06- Kings Garden 2

Cutting Plane Approaches for Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Ricardo Fukasawa, Associate Professor, University of Waterloo, 200 University Ave West, Waterloo, On, N2L3G1, Canada, rfukasawa@uwaterloo.ca

1 - The Master Equality Polyhedron: Two-Slope Facets and Separation Algorithm

Cathy Wang, University of Waterloo, 619 Wild Ginger Ave. J55, Waterloo, ON, N2V2X1, Canada, cathy.wang@uwaterloo.ca, Ricardo Fukasawa

This talk presents our findings about the Master Equality Polyhedron (MEP), an extension of Gomory's Master Group Polyhedron. We prove a theorem analogous to Gomory and Johnson's two-slope theorem for the case of the MEP. We then show how such theorem can lead to facet defining inequalities for MEPs or extreme inequalities for an extension of the infinite group model. We finally study certain coefficient-restricted inequalities for the MEP and how to separate them.

2 - Single-Row Corner Relaxation with Integral Variables

Alinson Xavier, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L3G1, Canada, axavier@uwaterloo.ca

We study the facial structure of the single-row corner relaxation where the integrality of one or more non-basic variables is preserved. This relaxation can be used to generate cutting planes for general mixed-integer problems. First, we rewrite this set as a constrained two-row corner relaxation, and prove that all its facets arise from a finite number of maximal S-free splits and wedges. Then, we describe an algorithm for enumerating all these facet-defining sets and provide an upper bound on their split rank. Finally, we run computational experiments to compare their strength against MIR cuts.

3 - On Maximal S-Free Sets with the Covering Property

Joseph Paat, Johns Hopkins University, Whitehead Hall, 3400 N. Charles St, Baltimore, MD, 21218, United States of America, jpaat1@jhu.edu, Amitabh Basu

Current algorithms for solving mixed integer programs use cutting planes to approximate the solution set. A collection of these cutting planes can be generated by objects called S-free sets. Certain S-free sets exhibit the 'covering property', a tiling-like feature that yields computational tools for creating cutting planes. In this talk, we discuss these ideas, in addition to methods of constructing S-free sets with the covering property.

■ FB07

07- Kings Garden 3

Computation of Economic Equilibrium

Cluster: Variational Analysis

Invited Session

Chair: Vladimir Shikhman, Catholic University of Louvain (UCL), Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, vladimir.shikhman@uclouvain.be

1 - An Effective Approach to the Determination of Equilibria for Incomplete Asset Markets

Chuangyin Dang, Professor, City University of Hong Kong, Dept. of SEEM, 83 Tat Chee Avenue, Kowloon, Hong Kong - PRC, mecdang@cityu.edu.hk

The difficulty for computing equilibrium of incomplete asset markets arises from the loss of full rank of the asset return matrix. To overcome this difficulty, we formulate the markets as a two-player game consisting of a price player and a consumption player. By introducing an extra variable to incorporate barrier terms into utility functions for both players, we obtain a two-player barrier game that deforms continuously from a trivial game to the original game while the asset return matrix varies from a full-rank trivial one to the original one. The equilibrium conditions of the barrier game yield a smooth path that starts from the unique equilibrium of the trivial game and ends at an equilibrium for the incomplete asset markets.

2 - Algorithm of Price Adjustment for Market Equilibrium

Vladimir Shikhman, Catholic University of Louvain (UCL), Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, vladimir.shikhman@uclouvain.be, Yurii Nesterov

We suggest an algorithm for price adjustment towards a partial market equilibrium. Its convergence properties are crucially based on Convex Analysis. Our price adjustment corresponds to a subgradient scheme for minimizing a special nonsmooth convex function. This function is the total excessive revenue of the market's participants, and its minimizers are equilibrium prices. As the main result, the algorithm of price adjustment is shown to converge to equilibrium prices. Additionally, a market equilibrium clears on average during the price adjustment process. Moreover, an efficient rate of convergence is obtained.

■ FB08

08- Kings Garden 4

Information and Sparse Optimization

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Deanna Needell, Claremont McKenna College, 850 Columbia Ave, Claremont, CA, 91711, dneedell@cmc.edu

1 - Convergence Theory for Subspace Estimation from Undersampled Data

Laura Balzano, University of Michigan, 1301 Beal Ave, Ann Arbor, MI, 48109, United States of America, girasole@umich.edu

Non-convex problem formulations in matrix factorization sometimes lead to faster algorithms empirically, yet we are only recently beginning to understand general convergence theory for these problems. In this talk we will discuss algorithms and theory for solving non-convex formulations of subspace estimation and union of subspaces estimation problems. We consider the context where data are undersampled, where SVD methods for subspace estimation do not directly apply. SVD methods may be applied by generalizing the notion of projections to the case where data are undersampled. This leads to a tradeoff between convergence rate and undersampling rate. We demonstrate our methods on data in computer vision and network topology identification.

2 - Constrained Adaptive Sensing

Deanna Needell, Claremont McKenna College, 850 Columbia Ave, Claremont, CA, 91711, dneedell@cmc.edu

Suppose that we wish to estimate a vector from a small number of noisy linear measurements. When the vector is sparse, one can obtain a significantly more accurate estimate by adaptively selecting the samples based on the previous measurements. In this talk we consider the case where we wish to realize the benefits of adaptivity but where the samples are subject to physical constraints. We demonstrate both the limitations and advantages of adaptive sensing in this constrained setting.

3 - Practical Quantization and Encoding of Compressed Sensing Measurements: Exponential Accuracy

Rayan Saab, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA, 92093, United States of America, rsaab@ucsd.edu

In the era of digital computation, data acquisition consists of a series of steps. A sampling or measurement process is typically followed by quantization, or digitization. In turn, quantization is often followed by encoding, or compression, to efficiently represent the quantized data. In this talk, we propose quantization and encoding schemes for compressed sensing, along with associated reconstruction algorithms based on convex optimization. Our methods, which also work in the extreme case of 1-bit quantization, yield near-optimal approximation accuracy as a function of the bit-rate while preserving the stability and robustness properties of standard compressed sensing schemes. Joint work with Rongrong Wang and Ozgur Yilmaz.

■ FB09

09- Kings Garden 5

Topics in Robust Optimization III

Cluster: Robust Optimization

Invited Session

Chair: Angelos Georghiou, ETH Zurich, Physikstrasse 3, ETL K 12, Zurich, 8037, Switzerland, angelosg@control.ee.ethz.ch

1 - Robust Optimization of Trusses under Dynamic Loads via Nonlinear Semidefinite Programming

Anja Kuttich, TU Darmstadt, Dolivostr. 15, Darmstadt, 64293, Germany, kuttich@mathematik.tu-darmstadt.de, Stefan Ulbrich

We consider the problem of truss topology design with respect to uncertainty in time-dependent loads via robust optimization. To evaluate the stability and stiffness of truss structures we use the mean square displacement as a suitable objective function, which allows for an efficient calculation of a worst-case scenario. We use the H-infinity norm of the transfer-function for the worst-case objective function and the Bounded-Real Lemma to obtain a nonlinear semidefinite programming problem. We present numerical results.

2 - Robust Perfect Matching Problem

Viktor Bindewald, Technische Universitaet Dortmund, Fakultaet fuer Mathematik, Vogelpothsweg 87, Mathematik, TU Dortmund, Dortmund, 44227, Germany, viktor.bindewald@math.tu-dortmund.de, Dennis Michaels, David Adjiashvili

We study theoretical and algorithmically applicable properties of the following structural robust combinatorial problem. Given a graph G=(V,E) and subsets of E, each constituting a scenario in which the specified edges fail and are removed from G. The objective is to find a minimum cardinality edge set containing a perfect matching for every scenario. We focus on bipartite graphs with two single failing edges and the setting where every edge can fail.

3 - Multistage Adaptive Mixed-Integer Optimization

Angelos Georghiou, ETH Zurich, Physikstrasse 3, ETL K 12, Zurich, 8037, Switzerland, angelosg@control.ee.ethz.ch, Dimitris Bertsimas

In recent years, decision rules have been established as the preferred solution method for addressing the computationally demanding, multistage adaptive optimization problems. Despite their success, existing decision rules (a) are typically constrained by their a priori design and (b) do not incorporate in their modelling adaptive binary decisions. In this talk, we present a methodology for the near optimal design of continuous and binary decision rules using mixed-integer optimization.

■ FB10

10- Kings Terrace

Optimization with Nonlinear Risk Measures

Cluster: Finance and Economics

Invited Session

Chair: Alexander Vinel, The University of Iowa, 3131 Seamans Center for the Engineering, and Sciences, Iowa City, IA, 52242, United States of America, alexander-vinel@uiowa.edu

1 - Certainty Equivalent Measures of Risk

Alexander Vinel, The University of Iowa, 3131 Seamans Center for the Engineering, and Sciences, Iowa City, IA, 52242, United States of America, alexander-vinel@uiowa.edu, Pavlo Krokhmal

We study a framework for constructing coherent and convex measures of risk which is inspired by infimal convolution operator, and prove that the proposed approach constitutes a new general representation of these classes. We then discuss how this scheme may be eeffectively employed to obtain a class of certainty equivalent measures of risk that can directly incorporate decision maker's preferences as expressed by utility functions. This approach is consequently employed to introduce a new family of measures, the log-exponential convex measures of risk. Conducted numerical experiments show that this family can be a useful tool when modeling risk-averse decision preferences under heavy-tailed distributions of uncertainties.

2 - A Scenario Decomposition Algorithm for Stochastic Programming Problems with a Class of Downside Risk

Maciej Rysz, NRC - AFRL, 1350 N. Poquito Road, Shalimar, FL, United States of America, mwrysz@yahoo.com, Pavlo Krokhmal, Eduardo Pasiliao, Alexander Vinel

We present an efficient scenario decomposition algorithm for solving large-scale convex stochastic programming problems that involve a particular class of downside risk measures. The considered risk functionals encompass coherent and convex measures of risk that can be represented as an infimal convolution of a convex certainty equivalent. The resulting structure of the feasible set is then exploited via iterative solving of relaxed problems, and it is shown that the number of iterations is bounded by a parameter that depends on the problem size. The computational performance of the developed scenario decomposition method is illustrated on portfolio optimization problems involving two families of nonlinear measures of risk.

3 - Risk-Averse Strategic Planning of HVDC Renewable Energy Grids

Bo Sun, University of Iowa, 4219 Seamans Center, Iowa City, IA, 52242, United States of America, bo-sun-1@uiowa.edu, Yong Chen, Pavlo Krokhmal

We consider the problem of risk-averse strategic planning of high-voltage direct current (HVDC) grids. HVDC transmission systems offer significant advantages comparing to the traditional AC transmissions. We discuss the problem of long-term (strategic) planning of HVDC grids that incorporate sources of renewable energy, such as large-scale wind farms. Risks of power shortages are controlled using nonlinear higher-moment coherent risk (HMCR) measures. Solution methods for the resulting mixed-integer programming problems and computational case studies are presented.

■ FB11

11- Brigade

Models of Traffic and Traffic Equilibrium

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Sebastien Blandin, IBM Resarch, IBM Singapore, 9 Changi Business Park Ce, The IBM Place, Singapore, 486048, Singapore, sblandin@sg.ibm.com

1 - Fast Optimal Traffic Control for Incidents

Laura Wynter, IBM Research, IBM Singapore, 9 Changi Business Park, Singapore, Singapore, lwynter@sg.ibm.com, Saif Jabari, Sebastien Blandin, Charles Brett

The convergence of ubiquitous sensing has permitted more computationally efficient methods for traffic control on road networks so as to operate in real-time in a live environment. In this work, we present a new fast decomposition method for network optimization problems, with application to real-time traffic control and in particular for traffic control re-optimization during incident conditions. Our approach is based on an observation that the nonlinear programming formulation can be recast in a much simpler form, leading to an order of magnitude improvement.

2 - Tolled User Equilibria of Macroscopic Traffic Flow Models in the Context of Prospect Theory

Sebastien Blandin, IBM Resarch, IBM Singapore, 9 Changi Business Park Ce, The IBM Place, Singapore, 486048, Singapore, sblandin@sg.ibm.com, Thomas Palomares

In this work, we consider the problem of modeling choice in a network game with preferences that follows the axioms of prospect theory, and when the underlying behavioral model is a scalar partial differential equation. The choice function includes convex-concave response to the stimulus. Under natural assumptions, we extend existing results based on monotonic cost functions, and prove the existence of a "maximal" Nash equilibrium (definition introduced in this work) under any response scheme, and we exhibit necessary and sufficient conditions for its uniqueness. Numerical results are also presented.

3 - Optimal Base Stations Location and Configuration for Cellular

Shokri Selim, Professor, King Fahd University of Petroleum & Mineral, Department of systems engineering, King Fahd University of Petroleum & Mine, Dhahran, 31261, Saudi Arabia, selim@kfupm.edu.sa, Mansour Aldajani, Yasser Almoghathawi

We study the problem of base stations location and configuration. Antenna configuration includes number of antennas installed at the base station, the azimuth of each base station, tilt, height, and transmitted power for each antenna for cellular mobile networks. An integer program. The objective of the model is to minimize the cost of the network. The model guarantees that each demand point is covered. A demand point represents a cluster of uniformly distributed multiple users. In addition, the signal-to- noise ratio at each demand point is set at a given threshold value. To illustrate the capability of the formulated IP model, we use a discretized map of some area with demand points. The IP model is solved using a commercial software.

■ FB13

13- Rivers

Some Applications Based on Cone Programming

Cluster: Conic Programming

Invited Session

Chair: Yu Xia, Assistant Professor, Lakehead University, 955 Oliver Rd., Thunder Bay, ON, P7B 5E1, Canada, yxia@lakeheadu.ca

1 - Appointment Scheduling with Unpunctuality

Zhichao Zheng, Singapore Management University, Lee Kong Chian School of Business, 50 Stamford Road, Singapore, 178899, Singapore, danielzheng@smu.edu.sg, Chung Piaw Teo, Qingxia Kong, Chung-Yee Lee

Typical healthcare appointment scheduling problems assume that patients arrive punctually according to assigned appointment time, which is rarely true in practice, especially in outpatient clinics. We study the design of healthcare appointment system when patient arrivals deviate from the scheduled appointment time by a random amount. We use a network flow model to capture the dynamics of the system and develop a copositive optimization model to solve the appointment scheduling problem. Our analysis using clinical data suggests it is important to account for patient unpunctuality in the design of appointment policies.

2 - Object Oriented Geometric Programming in Python

Edward Burnell, Graduate Student Researcher, MIT, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, eburn@mit.edu, Warren Hoburg

We present GPkit, an open source modeling package for geometric programming (GP), written in Python. GPkit gives users the ability to quickly construct GP models for a wide range of engineering applications. Features include monomial and posynomial substitutions, unit checking and conversions, interactive explorations, sweeps over Pareto-optimal design spaces, and support of reusable object-oriented GP models.

3 - Second-Order Cone Programming for P-Spline Simulation Metamodeling

Yu Xia, Assistant Professor, Lakehead University, 955 Oliver Rd., Thunder Bay, ON, P7B 5E1, Canada, yxia@lakeheadu.ca, Farid Alizadeh

This paper approximates simulation models by B-splines with a penalty on high-order finite differences of the coefficients of adjacent B-splines. The penalty prevents overfitting. The simulation output is assumed to be nonnegative. The nonnegative spline simulation metamodel is casted as a second-order cone programming problem, which can be solved efficiently by modern optimization techniques. The method is implemented in MATLAB.

■ FB14

14- Traders

Game Theory

Cluster: Game Theory

Invited Session

Chair: Gomatam Ravindran, Associate Professor, Indian Statistical Institute, 110, Nelson Manickam Road, Chennai, Chennai, 600029, India, ravi@isichennai.res.in

1 - "And the Winners are..." – Impartial Selection of More than One

Antje Bjelde, TU Berlin, Str. des 17. Juni 136, Berlin, 10623, Germany, bjelde@math.tu-berlin.de, Max Klimm, Felix Fischer

We study the problem of selecting k agents based on nominations made within their group. A selection mechanism is called impartial if no agent can alter its own probability of being selected by changing its nominations. We are interested in approximating the number of nominations the selected agents received and present tight results for deterministic respectively universally impartial mechanisms for the case k=2. For general k, lower and upper bounds on the performance of any impartial mechanism are given.

2 - Cooperative Games on Intersecting Families

Ayumi Igarashi, University of Oxford, Wolfson Building, Parks Road, Oxford, United Kingdom, ayumi.igarashi@cs.ox.ac.uk, Yoshitsugu Yamamoto

Recent years have seen a growing interest in cooperative games on subfamilies. By defining a game on a subfamily of subsets of players that satisfy certain axioms, it has become possible to grasp proposed solution concepts from a more general view. One of the issues in this line of research, however, is that the standard definition of supermodular games is no longer applicable to such general situations. In this paper, we introduce the relaxed notion of supermodularity for games on subfamilies, called quasi-supermodularity, and show that the class of intersecting families is a maximal class to preserve supermodularity for the extended games. We also investigate the properties of game theoretic solutions for these games.

3 - On the Game Theoretic Value of a Linear Transformation on a Self-Dual Cone

Gomatam Ravindran, Associate Professor, Indian Statistical Institute, 110, Nelson Manickam Road, Chennai, Chennai, 600029, India, ravi@isichennai.res.in, Muddappa Seetharama Gowda

We present generalisation of the concept of a value of (zero-sum) matrix game. Given a finite dimensional real inner product space V with a self dual cone K, an element e in the interior of K, and a linear transformation L, we define the value of L as the minimax value v(L) by := max min (L(x), y)= min max(L(x), y) (x and y each vary over K with (x,e)=1 and (y,e)=1. We extend some classical results of Kaplansky and Raghavan. In addition for a Z-transformation (which is a generalisation of Z - matrix), we relate the value with various properties such as positive stable property, the S-property etc. We apply these results to find the values of the L_A and and S_A on the cone of nXn real positive semidefinite matrices.

■ FB15

15- Chartiers

Global Optimization: Algorithms and Applications

Cluster: Global Optimization

Invited Session

Chair: Hong Seo Ryoo, Professor, Korea University, 145 Anam-Ro, Seoungbuk-Gu, Seoul, 136-713, Korea, Republic of, hsryoo@korea.ac.kr

1 - Box Clustering and Logical Analysis of Data

Paolo Serafini, Prof., University of Udine, Dipartimento di Matematica e Informatica, Via delle Scienze 206, Udine, UD, 33100, Italy, paolo.serafini@uniud.it, Giuseppe Lancia, Franca Rinaldi

We address the problem of classifying data via box clustering. The data are in general integer-valued vectors. In the particular case they are binary vectors, like in Logical Analysis of Data, boxes can be identified with strings of 0's, 1's and wild cards which can take either the value 0 or the value 1. The classification calls for covering the positive data, while not hitting any negative data, with a set of boxes that is at the same time of minimal cardinality and of maximum redundancy. The mathematical programming model to solve the problem is based on column generation. The resulting branch-and-price scheme requires special branching techniques in order to increase the efficiency of the branch-and-bound tree search.

2 - Optimization via Clustering in Machine Learning

Young Woong Park, Northwestern University, 2145 Sheridan Rd, Evanston, IL, United States of America, ywpark@u.northwestern.edu, Diego Klabjan

We propose a clustering-based iterative algorithm to solve certain optimization problems, where we start the algorithm by aggregating the original data, solving the problem on aggregated data, and then in subsequent steps gradually disaggregate the aggregated data. We apply the algorithm to common machine learning problems such as the least absolute deviation regression, support vector machine, and semi-supervised support vector machine. We derive model-specific data aggregation and disaggregation procedures. We also show optimality, convergence, and the optimality gap of the approximated solution.
A computational study is provided.

3 - A Rectified LAD for Numerical Data

Cui Guo, Associate Professor, Shantou University, 243 Da Xue Road, Shantou, China, cguo@stu.edu.cn, Hong Seo Ryoo

LAD presents some limitations when analyzing numerical data, owing to a difference in structural properties of originally 0-1 data and binarized 0-1 data. This paper illustrates these limitations and develops a way to rectify the general LAD framework to more accurately analyze numerical data.

■ FB16

16- Sterlings 1

Advances in Stochastic Dynamic Programming

Cluster: Stochastic Optimization

Invited Session

Chair: David Brown, Duke University, 100 Fuqua Drive, Durham, NC, 27708, United States of America, dbbrown@duke.edu

1 - Decomposable Markov Decision Processes: A Fluid Optimization Approach

Velibor Misic, Operations Research Center, Massachusetts Institute of Technology, 77 Massachusetts Avenue, E40-149, Cambridge, MA, 02139, United States of America, vvmisic@mit.edu, Dimitris Bertsimas

Decomposable MDPs are problems where the system and its dynamics can be decomposed along multiple components. We propose a fluid optimization approach for such problems that achieves tractability by exploiting decomposability. We show that this approach achieves strong performance in restless bandit problems, optimal stopping problems and network revenue management.

2 - Tax-Aware Dynamic Asset Allocation

Martin Haugh, Associate Professor, Columbia University, 500 West 120th Street, Room 332, New York, NY, 10027, United States of America, mh2078@columbia.edu, Chun Wang, Garud Iyengar

We consider dynamic asset allocation problems where the investor is required to pay capital gains taxes on her investment gains. This is a very challenging problem because the tax to be paid whenever a security is sold depends on the tax basis, i.e. the price(s) at which the security was originally purchased. This feature results in high-dimensional and path-dependent problems which cannot be solved exactly except in the case of very stylized problems with just one or two securities and relatively few time periods. We develop several sub-optimal trading policies for these problems and use duality techniques based on information relaxations to assess their performances.

3 - Information Relaxation Bounds for Infinite Horizon Markov Decision Processes

David Brown, Duke University, 100 Fuqua Drive, Durham, NC, 27708, United States of America, dbbrown@duke.edu, Martin Haugh

We study infinite horizon MDPs with discounted costs and develop a general approach for calculating performance bounds using information relaxations. We discuss ways to make the approach computationally manageable on problems with large state spaces and study the quality of the resulting bounds: the approach provably improves upon bounds from "Bellman feasible" approximate value functions. We apply the approach to the problem of dynamic service allocation in a multiclass queue. In our examples, we find the information relaxation lower bounds are relatively easy to calculate and are very close to the upper bounds obtained from simple heuristic policies.

■ FB17

17- Sterlings 2

Multi-Stage and Multi-Level Optimization for Treatment Decisions in Healthcare Applications

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Marina Epelman, University of Michigan, Industrial and Operations Engineering, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, mepelman@umich.edu

1 - Biomarker-Based Two-Stage Stochastic Optimization Treatment Planning Models in Radiation Therapy

Marina Epelman, University of Michigan, Industrial and Operations Engineering, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, mepelman@umich.edu, Troy Long, Victor Wu, Edwin Romeijn, Martha Matuszak

Intensity Modulated Radiation Therapy is a common cancer treatment technique that uses external beams of radiation to deliver non-homogeneous intensity patterns to a patient from multiple stationary locations. Treatment planners optimize a physician's treatment planning goals while satisfying the constraints of the treatment modality using information obtained pre-treatment. Increasingly, biomarker data obtained during treatment is shown to provide patient-specific information on response to radiation and predisposition to radiation-induced side effects. We explore two-stage stochastic optimization models for adaptive treatment planning to improve patient outcomes, with examples from lung and liver cancer cases.

2 - Copayment Restructuring for a Heterogeneous Patient Population

Gregg Schell, University of Michigan, 1205 Beal Ave, Ann Arbor, MI, 48109, United States of America, schellg@umich.edu, Mariel Lavieri

Operations research has contributed heavily to the derivation of optimal treatment guidelines for chronic disease. However, this research has assumed that patients will follow the optimal guidelines. Targeted incentives have the potential to improve patient adherence to the guidelines. To determine the optimal allocation of incentives across a heterogeneous patient population, we formulate a bilevel optimization problem with constraints on resource availability as well as maximum inequity.

3 - Optimal Learning of Dose-Response from a Cohort

Jakob Kotas, University of Washington, Box 353925, Seattle, WA, 98195, United States of America, jkotas@uw.edu, Archis Ghate

We present a stochastic dynamic programming (DP) framework for learning a dose-response parameter while optimally dosing a cohort of patients. Solution of Bellman's equations for this problem is computationally intractable, so we explore two approximation methods: certainty equivalent control (CEC) and semi-stochastic CEC. Under natural assumptions on the underlying functions, we prove properties of these approximate methods, including convexity, separation of the problem across patients, and monotonicity and stationarity of the optimal dosing policy. Numerical results using data from a clinical trial on rheumatoid arthritis will be discussed.

■ FB18

18- Sterlings 3

Nonlinear Programming

Cluster: Nonlinear Programming

Invited Session

Chair: James Hungerford, Experienced Researcher, MINO Initial Training Network, M.A.I.O.R., 512 Via San Donato, Lucca, LU, Italy, jamesthungerford@gmail.com

1 - A Strongly Polynomial Simplex Method for Totally Unimodular LP

Shinji Mizuno, Professor, Tokyo Institute of Technology, 2-12-1-W9-58 Oo-Okayama, Meguro, Tokyo, Japan, mizuno.s.ab@m.titech.ac.jp

We combine results of Kitahara and Mizuno for the number of distinct solutions generated by the simplex method and Tardos's strongly polynomial algorithm. We propose an algorithm for solving a standard form LP problem. The algorithm solves polynomial number of auxiliary LP problems by the simplex method with Dantzig's rule. It is shown that the total number of distinct basic solutions generated by the algorithm is polynomially bounded in the number of constraints, the number of variables, and the maximum determinant of submatrices of a coefficient matrix.

2 - The Continuous Quadratic Knapsack Problem

James Hungerford, Experienced Researcher, MINO Initial Training Network, M.A.I.O.R., 512 Via San Donato, Lucca, LU, Italy, jamesthungerford@gmail.com, William Hager, Tim Davis

The continuous quadratic knapsack problem (CQK) is to minimize a separable convex quadratic function subject to a box constraint and a knapsack constraint. The CQK arises as a subproblem in many areas of optimization, including network flows, graph partitioning, and quadratic resource allocation. Most algorithms assume the objective function is strictly convex and are based on finding a root of the derivative of the dual function, a piecewise linear function with 2n breakpoints. In this talk, we survey the available methods for solving the CQK, and show how one of these methods, known as the variable fixing method, can be extended to the case where the objective function is non-strictly convex. Numerical results are presented.

■ FB19

19- Ft. Pitt

Multiunit Auctions

Cluster: Game Theory

Invited Session

Chair: Mariann OllarPostdoctoral Research , Associate 160 McNeil Building, 3718 Locust Walk, Philadelphia, PA, 19104, United States of America, omariannwisc@gmail.com

1 - Simple Auctions with Simple Strategies

Jamie Morgenstern, Postdoctoral Researcher, University of Pennsylvania, 337 Roup Ave, Pittsburgh, Pe, 152321011, United States of America, jamiemmt@cs.cmu.edu, Nikhil R. Devanur, Seth Matthew Weinberg, Vasilis Syrgkanis

We introduce single-bid auctions as a new format for combinatorial auctions. In single-bid auctions, each bidder submits a single real-valued bid for the right to buy items at a fixed price. In this auction format, bidders can implement no-regret learning strategies for single-bid auctions in polynomial time. Price of anarchy bounds for correlated equilibria concepts in single-bid auctions therefore have more bite than their counterparts for auctions and equilibria for which learning is not known to be computationally tractable. To this end, we show that for any subadditive valuations the social welfare at equilibrium is an O(log m)-approximation to the optimal social welfare, where m is the number of items.

2 - Pay-as-Bid: Selling Divisible Goods to Uninformed Bidders

Kyle Woodward, UCLA, Economics Department, Los Angeles, United States of America, kwoodward@ucla.edu, Marek Pycia

Pay-as-bid is the most popular auction format for selling treasury securities. We prove the uniqueness of pure-strategy Bayesian-Nash equilibria in pay-as-bid auctions where symmetrically-informed bidders face uncertain supply, and we establish a tight sufficient condition for the existence of this equilibrium. Equilibrium bids have a convenient separable representation: the bid for any unit is a weighted average of marginal values for larger quantities. We leverage our representation of bids to show that when maximizing revenue, selecting supply is more effective than selecting a reserve price. With optimal supply and reserve price, the pay-as-bid auction is revenue-equivalent to the uniform-price auction.

3 - Privacy-Preserving Market Design

Mariann Ollar, Postdoctoral Research Associate, University of Pennsylvania, 160 McNeil Building, 3718 Locust Walk, Philadelphia, PA, 19104, United States of America, ollar@sas.upenn.edu, Ji Hee Yoon, Marzena Rostek

Privacy is a concern in auctions and exchanges. We formulate a market design problem restricting to uniform-price market clearing to study the joint design of feedbacks (Observables); contingent bids (Contingent Variables) and the timing of market clearings. A design preserves privacy if the observable outcomes are not sufficient to recover the participants' private information before the relevant bidding stage. In a quadratic Gaussian Double Auction environment, we show that this minimal privacy requirement is generically necessary for exchange. Yet, there need not be a trade-off between privacy and welfare in that privacy-preserving designs with rich set of conditionals can be efficient.

■ FB20

20- Smithfield

Randomized, Distributed, and Primal-Dual Methods I

Cluster: Nonsmooth Optimization

Invited Session

Chair: Peter Richtarik, Professor, University of Edinburgh, Peter Guthrie Tait Road, EH9 3FD, Edinburgh, EH9 3FD, United Kingdom, peter.richtarik@ed.ac.uk

1 - Constrained Convex Minimization via Model-Based Excessive Gap

Volkan Cevher, Laboratory for Information and Inference Systems (LIONS), EPFL, Switzerland, EPFL STI IEL LIONS, ELE 233 (B,timent ELE) Station 11, Lausanne, 1015, Switzerland, volkan.cevher@epfl.ch, Quoc Tran-Dinh

We introduce a model-based excessive gap technique to analyze first-order primal-dual methods for constrained convex minimization. As a result, we construct new primal-dual methods with optimal convergence rates on the objective residual and the primal feasibility gap of their iterates separately. Through a dual smoothing and prox-function selection strategy, our framework subsumes the augmented Lagrangian, and alternating methods as special cases, where our rates apply.

2 - Stochastic Dual Newton Ascent for Empirical Risk Minimization

Peter Richtarik, Professor, University of Edinburgh, Peter Guthrie Tait Road, EH9 3FD, Edinburgh, EH9 3FD, United Kingdom, peter.richtarik@ed.ac.uk, Zheng Qu, Martin Takac, Olivier Fercoq

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 more or all of curvature information contained in the examples, which leads to striking improvements in both theory and practice - sometimes by orders of magnitude. In the case of ridge regression, our method can be interpreted as a novel variant of the recently introduced Iterative Hessian Sketch.

3 - Communication-Efficient Distributed Optimization of Self-Concordant Empirical Loss

Lin Xiao, Microsoft Research, Machine Learning Groups, Redmond, WA, 98052, United States of America, Lin.Xiao@microsoft.com, Yuchen Zhang

We propose a communication-efficient distributed algorithm for large-scale empirical risk minimization in machine learning. The algorithm is based on an inexact damped Newton method, where the Newton steps are computed by a distributed preconditioned conjugate gradient method. We analyze its iteration complexity and communication efficiency for minimizing self-concordant empirical loss functions. In a standard setting for supervised learning where the problem condition number grows with the total sample size, the required number of communication rounds of our algorithm does not increase with the sample size, but only grows slowly with the number of machines in the distributed system.

■ FB21

21-Birmingham

MINLPs in Gas Network Optimization

Cluster: Optimization in Energy Systems

Invited Session

Chair: Alexander Martin, FAU Erlangen-Nürnberg, Department Mathematik, Cauerstr 11, Erlangen, Germany, alexander.martin@math.uni-erlangen.de

1 - Legal Physics: Modelling Contracts on Gas Networks – The KWP Tool

Thorsten Koch, Prof. Dr., ZIB / TU Berlin, Takustr. 7, Berlin, 14195, Germany, koch@zib.de

Germany decided to end nuclear power and conduct an energy turnaround. While renewables shell account for the majority of the electricity, the plan calls for gas power station to absorb peak loads. Due to the unbundling of gas transport and gas trading by the EU, the transport system operators are now required to reliably provide large amounts of gas to the newly build power stations on very short notice. Extending the network costs about 1 Mio €per km. The new KWP contract allows coping with this situation much more efficiently on a pure legal basis. But it also means you need a robust solution to a large-scale stochastic mixed-integer non-linear optimization problem every day. We will try to describe the problem and possible solutions.

2 - Technical Capacities of Gas Networks and their Impact on Market Design

Lars Schewe, Friedrich-Alexander-Universitaet Erlangen-Nürnberg (FAU), Cauerstrafle 11, 91058 Erlangen, Germany, Lars.Schewe@math.uni-erlangen.de

Under the current European entry-exit system for trading of gas network capacities, so-called technical capacities (i.e. the capacities that can be transported by the network) are at the heart of the capacity market. We show that the computation of technical capacities in a gas network under current regulations can be posed as a multi-stage mixed-integer nonlinear optimization problem. We discuss the hardness of the problem and propose an approximation approach. Furthermore, the impact of these results on the current design of the capacity market.

3 - Solving Power-Constrained Gas Transport Problems using an MIP-based Alternating Direction Method

Martin Schmidt, Friedrich-Alexander-Universitaet Erlangen-Nürnberg, Cauerstrafle 11, Erlangen, 91058, Germany, mar.schmidt@fau.de, Lars Schewe, Antonio Morsi, Bjoern Geifller

We present an algorithm for problems from gas transport. Due to nonconvex physics as well as discrete controllability of active devices, these problems lead to hard nonconvex MINLPs. Our method is based on MIP techniques using piecewise linear relaxations of the nonlinearities and a tailored alternating direction method. In addition to most other publications in the field of gas transport optimization, we do not only consider pressure and flow as main physical quantities but further incorporate heat power supplies and demands as well as a mixing model for different gas qualities. We demonstrate the capabilities of our method by numerical results on the largest instances that were ever reported in the literature for this problem class.

■ FB22

22- Heinz

Polynomial Root Minimization, Accelerating Projection Algorithms, and Self-Contracted Curves

Cluster: Variational Analysis

Invited Session

Chair: C.H. Jeffrey Pang, Assistant Professor, National University of Singapore, Mathematics, Blk S17, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, matpchj@nus.edu.sg

1 - Accelerating Projection Algorithms: Greediness and Nonconvexity

C.H. Jeffrey Pang, Assistant Professor, National University of Singapore, Mathematics, Blk S17, 10 Lower Kent Ridge Road, Singapore, 119076, Singapore, matpchj@nus.edu.sg

The feasibility problem (i.e., finding a point in the intersection of several convex/nonconvex sets) is typically solved by the method of alternating projections. If the sets were convex, we can project onto to these sets to obtain supporting halfspaces, and then project onto the intersection of these halfspaces using standard methods in quadratic programming to accelerate convergence. This strategy can give multiple-term superlinear convergence for convex problems. We show how to design “greedy” algorithms that have such superlinear convergence, and show how to extend the algorithm for nonconvex super-regular sets in the sense of Lewis-Luke-Malick.

2 - Self-Contracted Curves and Applications

Aris Daniilidis, Profesor Titular, Universidad de Chile, Departamento de Ingenerìa Matematica, Blanco Encalada 2120, piso 5, oficina 523, Santiago, Chile, arisd@dim.uchile.cl

The notion of self-contracted curve is tightly related to convexity. Given a convex function, self-contracted curves appear naturally as solutions (orbits) of its corresponding (sub)gradient dynamical system, or as polygonal curves determined by the proximal algorithm under any choice of parameters. In this talk, we discuss asymptotic properties of such curves in Euclidean spaces and their applications.

3 - Polynomial Root Radius Optimization with Affine Constraints

Julia Eaton, Assistant Professor, University of Washington Tacoma, Interdisciplinary Arts and Sciences, Campus Box 358436, 1900 Commerce Street, Tacoma, WA, 98402, United States of America, jreaton@uw.edu, Sara Grundel, Mert Gurbuzbalaban, Michael L. Overton

The root radius of a polynomial is the maximum of the moduli of its roots (zeros). We consider the following optimization problem: minimize the root radius over monic polynomials of degree n, with either real or complex coefficients, subject to k consistent affine constraints on the coefficients. We show that there always exists an optimal polynomial with at most $k-1$ inactive roots, that is, whose moduli are strictly less than the optimal root radius. We illustrate our results using some examples arising in feedback control.

■ FB23

23- Allegheny

The Lovasz Local Lemma

Cluster: Combinatorial Optimization

Invited Session

Chair: Nicholas Harvey, University of British Columbia, ICICS/CS Building, 2366 Main Mall, Vancouver, BC, V6T 1Z4, Canada, nickhar@cs.ubc.ca

1 - An Algorithmic Proof of the Lopsided Lovasz Local

Nicholas Harvey, University of British Columbia, ICICS/CS Building, 2366 Main Mall, Vancouver, BC, V6T 1Z4, Canada, nickhar@cs.ubc.ca, Jan Vondrak

The breakthrough results of Moser and Tardos give algorithmic forms of the Lovasz Local Lemma when the probability space is defined by independent variables. We give a new algorithmic form of the local lemma for more general probability spaces, assuming only a "resampling oracle" for each event. We show that the existence of resampling oracles is equivalent to a positive association property similar to the assumptions of the "lopsided local lemma". In particular, efficient resampling oracles can be designed for the known application scenarios of the lopsided local lemma (random permutations, matchings, spanning trees). We present several new algorithmic results in these scenarios.

2 - Finding Global Optima by Randomized Local Search

Fotis Iliopoulos, UC Berkeley, EECS, Berkeley, CA, 95129, United States of America, fotis.iliopoulos@berkeley.edu, Dimitris Achlioptas

At the heart of every local search procedure is a directed graph on candidate solutions (states) such that every unsatisfying state has at least one outgoing arc. In randomized local search the hope is that a random walk on the graph reaches a satisfying state (sink) quickly. We give a general algorithmic local lemma by establishing a sufficient condition for this to be true. Our work is inspired by Moser's entropic method proof of the Lov\'{a}sz Local Lemma (LLL) for satisfiability and completely bypasses the Probabilistic Method formulation of the LLL. In particular, our method allows both the search space and the optimality conditions to be entirely amorphous, enabling the analysis of far more sophisticated algorithms than the LLL. Similarly to Moser's argument, the key point is that algorithmic progress is measured in terms of entropy rather than in terms of energy (number of violated constraints) so that termination can be established even under the proliferation of local optima. The talk assumes no familiarity with the LLL or the Probabilistic Method.

■ FB24

24- Benedum

Lifting and Mixed-Integer Quadratic Programming

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Emiliano Traversi, University of Paris 13, 99 Avenue Jean-Baptiste Clément, Villetaneuse, France, emiliano.traversi@gmail.com

1 - Approximated Perspective Relaxations: A Project & Lift Approach

Fabio Furini, LAMSADE - Universite' Paris Dauphine, Place du Maréchal de Lattre de Tassigny, Paris, France, fabio.furini@dauphine.fr, Antonio Frangioni, Claudio Gentile

The Perspective Reformulation (PR) of a Mixed-Integer NonLinear Program with semi-continuous variables is obtained by replacing each term in the (separable) objective function with its convex envelope. Solving the corresponding Perspective Relaxation requires appropriate techniques. While the AP2R bound can be weaker than that of the PR, this approach can be applied in many more cases and allows direct use of off-the-shelf MINLP software; this is shown to be competitive with previously proposed approaches in many applications.

2 - QPLIB, a library of Quadratic Programming Instances

Emiliano Traversi, University of Paris 13, 99 Avenue Jean-Baptiste Clément, Villetaneuse, France, emiliano.traversi@gmail.com, Fabio Furini

In this work we present a library of Quadratic Programming Instances (QPLIB). Quadratic programming problems have received an increasing amount of attention in recent years, both from theoretical and practical points of view. This category of problems is particularly important, since quadratic programs model many real-world classes of problems. The QPLIB balances instances from real-world applications and academic problems, obtained after a call for instances using a variety of means of communication. The QPLIB aims at being used as reference for the community and the practitioner involved in QP.

■ FB25

25- Board Room

Models and Algorithms for Commitment and Dispatch

Cluster: Optimization in Energy Systems

Invited Session

Chair: Uday Shanbhag, Pennsylvania State University, 353 Leonhard Building, University Park, PA, 16802, United States of America, udaybag@psu.edu

1 - Deriving Utility Functions from Revealed Preference Data

Daniel Ralph, University of Cambridge, Judge Business School, Cambridge, United Kingdom, d.ralph@jbs.cam.ac.uk, Jean-Pierre Crouzeix, Andrew Eberhard

Some decades ago, Afriat showed that a finite sample of revealed preference data that satisfy some standard economic axioms, such as the Generalised Axiom of Revealed Preference, can be used to construct a concave utility function that is consistent with the data. We ask what happens when the sample is infinite, which takes us out of the realm of convex analysis into quasiconvex and pseudoconvex analysis. This relates to a problem of integration which is to recover a pseudoconvex function from the normal cones to its level sets. We focus on existence of solutions to these problems.

2 - A Scalable Primal-Dual Method for the Two-Stage Stochastic Unit Commitment Problem

Farzad Yousefian, Pennsylvania State University, 224 Leonhard Building, University Park, PA, 16802, United States of America, szy5@psu.edu, Uday Shanbhag

We consider a two-stage unit commitment scheduling problem capturing the uncertainties in demand and availability with nonlinear costs. The resulting mathematical model is a possibly large-scale stochastic mixed integer nonlinear program; unfortunately, commercial packages, e.g. CPLEX struggle to accommodate nonlinearity and uncertainty in a scalable fashion. We develop a scalable primal-dual method for obtaining KKT points of smoothed counterparts. Preliminary simulation results are presented.

3 - Multi-Stage Generation and Transmission Co-Planning under Uncertainty

Benjamin Hobbs, Johns Hopkins University, 3400 N Charles Street, Baltimore, MD, 21211, United States of America, bhobbs@jhu.edu, Pearl Donohoo-Vallet

Transmission planning commonly follows a deterministic approach. This deterministically-derived plan is then tested for performance under various scenarios. This work instead explicitly plans transmission under uncertainty and includes multiple stages to allow for recourse decisions. We also model the interaction between new transmission and generation facilities by co-planning both transmission and generation simultaneously.

■ FB26

26- Forbes Room

Optimization in Big Data

Cluster: Stochastic Optimization

Invited Session

Chair: Diego Klabjan, Professor, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States of America, d-klabjan@northwestern.edu

1 - Large-scale Optimization With Mapreduce and Spark

Alexandros Nathan, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States of America, anathan@u.northwestern.edu, Diego Klabjan

In the age of Big Data, the need to train massive statistical models is ever-increasing. Parallel computing is arguably the most efficient way to train such models. In this work we compare three data-parallel and MapReduce-friendly optimization algorithms, namely the iterative parameter averaging method (IPA), the alternating direction method of multipliers (ADMM) and the progressive hedging method (PH). We conduct numerical experiments in MapReduce and Spark on problems that arise in machine learning, and we study the trade-offs between time and solution quality.

2 - A Method for Solving the Stochastic Fleet Assignment Problem using MapReduce and Parallelization

Mingyang Di, Northwestern University, 2145 Sheridan Road, C210, Evanston, IL, 60208, United States of America, mingyangdi2012@u.northwestern.edu, Diego Klabjan

We propose a two-stage stochastic fleet assignment model (FAM) and solve the model through a noble MapReduce-based progressive hedging approach. The developed algorithm could dramatically reduce the overall running time, thus bringing the model even closer to a point of integration into a practice-oriented support system.

3 - Mining Of Disease Trends And Treatment Outcome

Eva Lee, Georgia Institute of Technology, eva.lee@isye.gatech.edu

This work is joint with Care Coordination Institute in South Caroline. We will discuss the use of 2.7 million patient data from over 400+ providers for studying disease trends and treatment outcome. In this talk, we will focus on chronic disease management and practice variance and outcome prediction across the multiple practices. Optimization and machine learning advances will be discussed.

■ FB27

27- Duquesne Room

The Geometry of Linear Optimization

Cluster: Combinatorial Optimization

Invited Session

Chair: Jesus De Loera, Professor, University of California, Dept. of Mathematics, Davis, CA, 95616, United States of America, deloera@math.ucdavis.edu

1 - Special Polynomial Cases of Colorful Linear Programming

Frédéric Meunier, Professor, Ecole des Ponts ParisTech, 6 et 8, av. Blaise Pascal, Marne-la-Vallèe, 77455, France, frederic.meunier@enpc.fr, Wolfgang Mulzer, Pauline Sarrabezolles, Yannik Stein

Consider a linear program with pairwise disjoint feasible bases B_1,...,B_r. There exists a feasible basis B whose intersections with the B_i's have sizes of arbitrary ratios (colorful CarathÈodory theorem). Whether such a basis B can be computed in polynomial time is an open question. We present polynomial cases, e.g. the case when r=2 or cases provided by applications of the colorful CarathÈodory theorem to graph theory, and show that they become NP-complete as soon as feasibility of the B_i's is no longer required.

2 - Diameters of Polyhedra and Simplicial Complexes

Francisco Santos, Professor, University of Cantabria, Santander, Spain, francisco.santos@unican.es

The Hirsch conjecture stated that graphs of d-polyhedra with n facets have diameter at most n-d. Although it has been disproved (Klee-Walkup 1967, Santos 2012), no polynomial upper bound is known for the diameters that were conjectured linear and no polyhedron violating the bound by more than 25% is known. In this talk we review recent approaches to the question, some in the world of polyhedra and some generalizing it to simplicial complexes. In particular, we show that the maximum diameter of pure simplicial complexes is in the order of n^d, we sketch the proof of Hirsch's bound for flag polyhedra by Adiprasito and Benedetti, and we summarize the ideas in the polymath 3 project, a collective effort trying to prove an upper bound of nd.

3 - Covering Grid Points with Subspaces

Tamon Stephen, Simon Fraser University, Department of Mathematics, 250-13450 102nd Ave., Surrey, BC, V3T 0A3, Canada, tamon@sfu.ca

We consider a problem of covering (perhaps modulo 2) a box of grid points with axis-aligned affine subspaces. The objective is to do this so that each co-ordinate hyperplane containing grid points contains a subspace from the cover, and to minimize the number of elements in the cover. This problem arises in connection with the colourful simplicial depth problem.

■ FB28

28- Liberty Room

Combinatorial Optimization in Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Erick Moreno-Centeno, Texas A&M University, 3131 TAMU, College Station, TX, United States of America, emc@tamu.edu

1 - Optimal Design of Switched Ethernet Networks Implementing the Multiple Spanning Tree Protocol

Martim Joyce-Moniz, Université Libre de Bruxelles - Graphes et Optimisation Mathématique, Boulevard du Triomphe CP 210/01, Bruxelles, 1050, Belgium, martim.moniz@ulb.ac.be, Bernard Fortz, Luis Neves Gouveia

We propose and compare different MIP formulations to the Traffic Engineering problem of finding optimal designs for switched Ethernet networks implementing the IEEE Multiple Spanning Tree Protocol. This problem consists in designing networks with multiple VLANs, such that each one is defined by a spanning tree that meets the required traffic demand. Additionally, all the VLANs must jointly verify the bandwidth capacity of the network. Meanwhile the worst-case link utilization (ratio between link's load and capacity) is minimized. Moreover, we propose a binary search algorithm, that produces near-optimal solutions, by solving a sequence of sub-problems, that can be seen as a capacitated, multiple spanning tree versions of the OCSTP (Hu,74).

2 - Network Simplex Applied to the Harder Minimal Steiner Tree Problem

Badri Toppur, Associate Professor, Rajalakshmi School of Business, Kuthambakkam Post, Chennai, India, badri.toppur@rsb.edu.in

We have described a scheme for a divide-and-conquer heuristic for the minimal Steiner tree problem in the Euclidean plane and in space. Inserting the best bridge between two optimal Steiner trees often does not give the best topology for the combined tree. The topology selection sub-problem can be solved by the application of network simplex. This is achieved by placing unit demands on the nodes of one sub-tree, and unit supplies on the nodes of the other sub-tree. The network simplex is performed, on the complete graph of the two sub-trees. One can repeat iterations of the network simplex, and the algorithm for optimizing a fixed topology, until there is no change in the topology and no change in the coordinates of the Steiner points.

■ FB29

29- Commonwealth 1

New Developments on QCQPs and MINLPs I

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Daniel Bienstock, 500 W 120th St, New York, NY, 10027, United States of America, dano@columbia.edu

1 - Computational Approaches to Mixed Integer Second Order Cone Optimization (MISOCO)

Aykut Bulut, PhD Candidate, Lehigh University, 200 W Packer Avenue, Bethlehem, PA, 18015, United States of America, aykut@lehigh.edu, Ted Ralphs

It is well-known that the feasible region of a MISOCO problem can be approximated by a polyhedron. We present a solver implementing a cutting plane algorithm for solving second order conic optimization (SOCO) problems based on such linear approximations. In this algorithm, we iteratively solve linear optimization problem (LP) relaxations of the original MISOCO problem, strengthened by generating linear cuts from the conic constraints. We discuss computational performance of this approach on conic benchmark library (CBLIB 2014) problems.

2 - Max Clique Cuts for Standard Quadratic Programs

Jonas Schweiger, CPLEX Optimization, IBM Italy, Via Martin Luther King 38/2, Bologna, BO, 40132, Italy, jonas.schweiger@it.ibm.com, Pierre Bonami, Andrea Tramontani, Andrea Lodi

The theorem of Motzkin-Strauss establishes a connection between the clique number of a graph and a Standard Quadratic Program (SQP), i.e. the optimization of a quadratic objective over the standard simplex. We use this result to derive cutting planes on the linearization variables of SQPs and provide computational results to show the efficiency. The cuts can be generalized for QCQP and also to quadratic problems with a weighted upper bound on the original variables.

3 - Zero-Half Cuts for Solving Nonconvex Quadratic Programs with Box Constraints

Jeff Linderoth, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53711, United States of America, linderoth@wisc.edu, Oktay Gunluk, Pierre Bonami

Inequalities valid for the Boolean Quadric Polytope are also valid for nonconvex quadratic programs with box constraints. We demonstrate the utility of using zero-half Chvatal Gomory cuts in a solver for nonconvex quadratic programs.

■ FB30

30- Commonwealth 2

Approximation and Online Algorithms XIII

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Bruce Shepherd, Prof, McGill University, 805 Sherbrooke St West, Montreal, QC, H3A2K6, Canada, bruce.shepherd@mcgill.ca

1 - Excluded Grid Theorem: Improved and Simplified

Julia Chuzhoy, Toyota Technological Institute at Chicago, 6045 S. Kenwood Ave, Chicago, Il, 60637, United States of America, cjulia@ttic.edu, Chandra Chekuri

One of the key results in Robertson and Seymour's seminal work on graph minors is the Excluded Grid Theorem. The theorem states that for every fixed-size grid H, every graph whose treewidth is large enough, contains H as a minor. This theorem has found many applications in graph theory and algorithms. Let f(k) denote the largest value, such that every graph of treewidth k contains a grid minor of size f(k). Until recently, the best known bound on f(k) was sub-logarithmic in k. In this talk we will survey new results and techniques that establish polynomial bounds on f(k).

2 - Approximation Algorithms for All-or-Nothing Flow and Disjoint Paths

Chandra Chekuri, Professor, University of Illinois, 201 N. Goodwin Ave, Urbana, IL, 61801, United States of America, chekuri@illinois.edu

Given an undirected graph G and k source-sink pairs we consider the problem of maximizing the number of pairs that can be routed. A set of pairs S is routable if there is a feasible multiflow in G that routes one unit of flow for each pair in S. If the flow is allowed to be fractional we have the all-or-nothing flow problem. If the flow is required to be integral we obtain the disjoint paths problem. In this talk we will report on some recent work with Julia Chuzhoy that addresses the node-capacitated setting. In particular, we obtain a poly-logarithmic approximation for the all-or-nothing flow problem that guarantees a half-integral flow for the routed pairs.

3 - Capacitated Confluent Flows

Bruce Shepherd, Professor, McGill University, 805 Sherbrooke St West, Montreal, QC, H3A2K6, Canada, bruce.shepherd@mcgill.ca, Adrian Vetta

The single-sink confluent flow problem has a factor-3 approximation to the maximum throughput objective in the uniform node capacity setting. We discuss several roadblocks to extending this result to the case where nodes have general capacities. For the maximum single-sink capacitated confluent flow problem (directed or undirected), we show a poly-logarithmic hardness result in the case where capacities satisfy the no-bottleneck-assumption (NBA), and polynomial hardness for general instances. This former result stands in contrast to single-sink unsplittable flows which admit O(1) approximations in the NBA setting.

Friday, 1:10pm - 2:40pm

■ FC01

01- Grand 1

Complementarity/Variational Inequality VIII

Cluster: Complementarity/Variational Inequality/Related Problems

Invited Session

Chair: Stephen M. Robinson, University of Wisconsin - Madison, WI, smrobins@wisc.edu

1 - The Equilibrium Structure of Complementarity Problems

Shu Lu, Assistant Professor, University of North Carolina at Chapel Hill, 355 Hanes Hall, Cb#3260, UNC-Chapel Hill, Chapel Hill, NC, 27599, United States of America, shulu@email.unc.edu

We treat complementarity problems as Nash equilibrium problems by considering each component as a player. From such a viewpoint we analyze the structure of complementarity problems with a focus on properties such as solution existence and uniqueness.

2 - A Game-Theoretic Approach to Computation Offloading in Mobile Cloud Computing

Francisco Facchinei, University of Rome La Sapienza, Via Ariosto 25, Rome, 00185, Italy, facchinei@diag.uniroma1.it, Valeria Cardellini, Vittoria De Nitto Persone, Vincenzo Grassi, Francesco Lo Presti, Veronica Piccialli, Valerio Di Valerio

We consider a three-tier architecture for mobile and pervasive computing scenarios, consisting of a local tier of mobile nodes, a middle tier (cloudlets) of nearby computing nodes characterized by a limited amount of resources, and a remote tier of distant cloud servers, with practically infinite resources. We consider a usage scenario with no central authority and where mobile users behave non cooperatively. We define a model to capture the users behavior and formulate the problem as a generalized Nash equilibrium problem and show existence of an equilibrium. We present a distributed algorithm for the computation of an equilibrium and illustrate its behavior and the characteristics of the achieved equilibria.

3 - Linear Algebra and Affine Variational Inequalities

Stephen M. Robinson, University of Wisconsin - Madison, WI, smrobins@wisc.edu

Key portions of linear algebra deal with linear transformations of vector spaces, whereas key portions of the theory of affine variational inequalities (AVI) deal with linear transformations of more complex structures: the graphs of normal-cone operators of polyhedral convex sets. In this talk we will examine some of the similarities between these and discuss how they can help Students to understand the structure and behavior of AVI.

■ FC02

02- Grand 2

Optimization Problems with Moments and Polynomials II

Cluster: Conic Programming

Invited Session

Chair: Jiawang Nie, Associate Professor, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA, 92093, United States of America, njw@math.ucsd.edu

Co-Chair: Jean Lasserre, Laboratory for Analysis and Architecture of Systems, lasserre@laas.fr

1 - First-Order Methods for General Hyperbolic Programming

James Renegar, Cornell University, Rhodes Hall, Ithaca, NY, United States of America, renegar@cornell.edu

We show any hyperbolic program can easily be recast as a convex optimization problem in which the only constraints are linear equations, and the objective function is Lipschitz continuous with constant 1. Consequently, virtually any subgradient method can be applied to solving the recast problem. When a particular well-known subgradient method is employed, we show the number of iterations is (almost) optimal. Furthermore, we show the objective function is naturally smoothed, allowing accelerated gradient methods to be employed, resulting in the desired iteration counts for solving general hyperbolic programs, including all forms of linear programs, second-order cone programs and semidefinite programs.

2 - Matrix Relaxation of the LMI Domination Problem and Bounding its Error

J. William Helton, UC San Diego, Gillman Dr, La Jolla, CA, United States of America, helton@math.ucsd.edu

While determining if all solutions to a given LMI are solutions to another given LMI is an NP hard problem, a natural relaxation of this is to use matrix variables in the LMIs, thereby obtaining a relaxed problem which can be solved with an LMI. The talk describes a systematic approach to bounding the error of such relaxations. For the classic cube inclusion problem we obtain explicitly the (sharp) bound andnew probability results. With Igor Klep, Scott McCullough.

3 - Deciding Convexity of Symmetric Polynomials and Positivity of Multisymmetric Polynomials

Cordian Riener, cordian.riener@gmail.com, Paul Goerlach, Tillmann Weisser

The question how to certify non-negativity of a polynomial function lies at the foundation of polynomial optimisation. We present results of this question in the context of multisymmetric polynomials. In this setting we generalise a characterisation of non-negative symmetric polynomials. As a direct corollary result we are able to derive that in the case of (multi-)symmetric polynomials of a fixed degree testing for convexity can be done in a time which is polynomial in the number of variables. This is in sharp contrast to the general case, where it is known that testing for convexity is NP-hard already in the case of quartic polynomials.

■ FC03

03- Grand 3

Extended Formulations

Cluster: Combinatorial Optimization

Invited Session

Chair: Thomas Rothvoss, University of Washington, Seattle, WA, United States of America, rothvoss@uw.edu

1 - Subgraph Polytopes, Spanning Tree Polytopes and Independence Polytopes of Count Matroids

Stefan Weltge, Otto von Guericke University Magdeburg, weltge@ovgu.de, Volker Kaibel, Matthias Walter, Michele Conforti

Given a graph, we study the non-empty subgraph polytope, which is the convex hull of incidence vectors of pairs (F,S) where S is a non-empty subset of nodes and F is a set of edges with both endnodes in S. We show that the non-empty subgraph polytope and the spanning tree polytope have roughly the same extension complexity, and on the way give a complete linear description of the former. We further show how the non-empty subgraph polytope can be used to obtain polynomial size extended formulations for independence polytopes of count matroids, generalizing results by Iwata et al. on sparsity matroids. As a consequence, the extension complexities of these polytopes yield lower bounds on the extension complexity of the spanning tree polytope.

2 - Inapproximability of Combinatorial Problems via Small LPs and SDPs

Sebastian Pokutta, Georgia Institute of Technology, Ferst Dr., Atlanta, GA, United States of America, sebastian.pokutta@me.com, Gabor Braun, Daniel Zink

We provide a framework for studying the size of LPs and SDPs of combinatorial optimization problems without encoding them first as linear programs or semidefinite programs. As a result we can define the first consistent reduction mechanism that degrades approximation factors in a controlled fashion and which, at the same time, is compatible with approximate linear and semidefinite programming formulations. As a consequence we can establish strong linear programming inapproximability for LPs (and SDPs) with a polynomial number of constraints for a host of problems. Combining our framework with a recent result of Lee, Raghavendra, and Steurer we can also obtain inapproximability results for SDPs.

3 - No Small Linear Program Approximates Vertex Cover within a Factor 2 – epsilon

Abbas Bazzi, PhD Student, EPFL, Building INJ (INJ110), Station 14, Lausanne, 1015, Switzerland, abbas.bazzi@epfl.ch, Sebastian Pokutta, Samuel Fiorini, Ola Svensson

The vertex cover problem is one of the most important and intensively studied combinatorial optimization problems. Khot and Regev proved that the problem is NP-hard to approximate within a factor 2-epsilon, assuming the Unique Games Conjecture (UGC). Without resorting to the UGC, the best inapproximability result for the problem is due to Dinur and Safra: vertex cover is NP-hard to approximate within a factor 1.3606. We prove that every LP relaxation that approximates vertex cover within a factor of 2-epsilon has super-polynomially many inequalities. As a direct consequence of our methods, we also establish that LP relaxations that approximate the independent set problem within any constant factor have super-polynomially many inequalities.

■ FC04

04- Grand 4

Multi-Objective Optimization in Industry

Cluster: Multi-Objective Optimization

Invited Session

Chair: Nelson HeinProf., Universidade Regional de Blumenau, Rua Antonio da Veiga, 140, Blumenau, SC, 89012-900, Brazil, hein@furb.br

1 - Vector Games to Accounting Evaluation of Brazilian Companies by using Financial Indicators

Adriana Kroenke, Prof., Universidade Regional de Blumenau, Rua Antonio da Veiga, 140, Blumenau, SC, 89012-900, Brazil, akroenke@furb.br, Nelson Hein, Volmir Eugẽnio Wilhelm

The investor aims at strategically organizing their alternatives, which are read as being companies in which to invest or to be evaluated. Nature is composed by economic and financial ratios. From these indicators it was possible to establish the accounting positioning within its sector, taken here as being their competitors. The general objective was to evaluate the accounting positioning of steel and metallurgy companies listed on the BM&FBovespa by using Vector Games.

2 - VIKOR Method to Input Purchase in Brazilian Textile Industry

Nelson Hein, Prof., Universidade Regional de Blumenau, Rua Antonio da Veiga, 140, Blumenau, SC, 89012-900, Brazil, hein@furb.br, Leandro Keunecke, Adriana Kroenke

Technical specifications, delivery time and price are criteria involved in the analysis of inputs purchase in an organization. This research applied the Vikor method as a tool to support multi-criteria decision when purchasing inputs in a Brazilian textile company, in order to better meet quality and price parameters. The study considered the stable and unstable relativity of information in determining the weights of the criteria, obtained by entropy.

3 - A New Exact Method and Matheuristics for Bi-Objective 0/1 ILPs: Application to FTTx-Network Design

Markus Sinnl, ISOR, University of Vienna, Oskar-Morgenstern-Platz 1, Vienna, 1090, Austria, markus.sinnl@univie.ac.at, Ivana Ljubic, Markus Leitner, Axel Werner

We introduce a new exact iterative method and matheuristics for bi-objective 0/1 ILPs. The new exact method, adaptive search in objective space, is a combination of the epsilon-constraint method and the binary search in objective space. The matheuristics are boundary induced neighborhood search and directional local branching. Computational experiments are performed on real-world instances from telecommunication network design, which proved to be very difficult for traditional approaches.

■ FC05

05- Kings Garden 1

Stochastic Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Shiqian Ma, Assistant Professor, Department of Systems Engineering and Engineering Management, The Chinese University of Hong Kong, William M.W.Mong Engineering Building, Shatin, N.T., Hong Kong - PRC, sqma@se.cuhk.edu.hk

1 - A Gradient Aggregation Method for Large-Scale Learning

Jorge Nocedal, Northwestern University, Room M326, Technological Institute, 2145 Sheridan Road, Evanston, IL, United States of America, j-nocedal@northwestern.edu

We present a variance reduction (or gradient aggregation) method for very large machine learning problems where one pass over the data suffices to give good testing error. We describe the convergence properties of the algorithm and present numerical results on problems arising in machine learning.

2 - Convergence of Stochastic Quasi-Newton Methods

Alejandro Ribeiro, University of Pennsylvania, 200 South 33rd Street, Philadelphia, PA, 19104, United States of America, aribeiro@seas.upenn.edu, Aryan Mokhtari

The solution of stochastic optimization problems with stochastic gradient descent algorithms (SGD) is widespread, but SGD methods are slow to converge. This has motivated the use of stochastic quasi-Newton methods that utilize stochastic gradients as both, descent directions and ingredients of a curvature estimation methodology. This paper considers two methods: (i) RES, a regularized stochastic version of the BFGS method (ii) oLBFGS a stochastic limited memory version of BFGS. We show that both of these methods converge to optimal arguments under hypotheses of strong convexity and decreasing stepsizes. We further establish O(1/t) convergence rates in expectation and present numerical evaluations to showcase the advantages relative to SGD.

3 - Stochastic Quasi-Newton Methods for Nonconvex Stochastic Optimization

Xiao Wang, University of Chinese Academy of Sciences, No. 19A, Yuquan Road, Beijing, China, wangxiao@ucas.ac.cn, Wei Liu, Shiqian Ma

We study stochastic quasi-Newton methods for nonconvex stochastic optimization. We assume that only stochastic gradient is available. Firstly, we propose a framework of stochastic quasi-Newton methods which extend classic methods working in deterministic settings to stochastic settings, and prove the almost sure convergence. Secondly, we propose a framework for a class of randomized stochastic quasi-Newton methods, where the iteration number is random. The complexity of such methods is analyzed. Thirdly, we present two specific methods that fall into this framework, namely stochastic damped-BFGS method and stochastic cyclic Barzilai-Borwein method. Finally, we report numerical results to demonstrate the efficiency of the proposed methods.

■ FC06

06- Kings Garden 2

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Aleksandr Kazachkov, PhD Student, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, akazachk@cmu.edu

1 - Applications of Bilevel Programming to Cutting Plane Generation

Stefano Coniglio, PhD, RWTH Aachen University, Lehrstuhl 2 für Mathematik, Pontdriesch 14-16, Aachen, 52062, Germany, coniglio@math2.rwth-aachen.de, Stefano Gualandi, Martin Tieves

We address the generation of "template-free" inequalities which, except for their validity, do not have a predetermined combinatorial structure. After highlighting the bilevel nature of their separation problem, we illustrate ways to tackle it, with an application to the separation of rank inequalities for the stable set problem. We then consider the problem of generating k cuts which jointly maximize the bound improvement. We show how to turn the corresponding bilevel generation problem into a single level one, with an application to the generation of stable set inequalities for the max clique problem and of cover inequalities for the 0-1 knapsack problem.

2 - Partial Hyperplane Activation for Generalized Intersection Cuts

Aleksandr Kazachkov, PhD Student, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, akazachk@cmu.edu, Egon Balas, Francois Margot, Selvaprabu Nadarajah

Generalized intersection cuts offer a non-recursive paradigm for cut generation in mixed-integer linear programs using a linear program formulated from a set of intersection points. The existing method to generate intersection points requires repeatedly intersecting (activating) hyperplanes with a polyhedron, which may create exponentially many points. We introduce and numerically evaluate a partial hyperplane activation procedure that yields a polynomial-sized point collection in polynomial time. We also characterize theoretical properties of these collections.

3 - A Multi-Level Approach to Semidefinite Integer Programs on Graphs

Fu Lin, Postdoctoral Appointee, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL, 60439, United States of America, fulin@mcs.anl.gov, Zichao Di, Sven Leyffer

Semidefinite programs with integer variables subject to linear constraints arise in many engineering applications. Modern applications involving large graphs are beyond the capability of existing SDP-based branch-and-bound solvers. We consider a multi-level approach that solves a sequence of coarsened problems on smaller graphs. With a careful design of interpolation schemes, we show that coarse-level solutions are guaranteed to be feasible for the fine-level problems. This feature enables a multi-level branch-and-bound framework for semidefinite integer programs.

■ FC07

07- Kings Garden 3

PDE-Constrained Imaging and Shape Optimization

Cluster: PDE-Constrained Optimization and Multi-Level/Multi-Grid Methods

Invited Session

Chair: Mazlinda Ibrahim, University of Liverpool, 608,, Monument Buildings, Liverpool, L3 5PH, United Kingdom, mazlinda@liv.ac.uk

1 - Shape Optimization of the Boussinesq Equations via a Characteristics P1/P1 FE Discretization

Michael Fischer, TU Darmstadt, Dolivostrasse 15, Darmstadt, Germany, mfischer@mathematik.tu-darmstadt.de, Stefan Ulbrich

In this talk we consider the perturbation of identity method for shape optimization based on the works of Murat and Simon, to solve shape optimization problems governed by the Boussinesq equations. After an introduction to the control problem on PDE level we introduce the stabilized characteristics P1/P1 finite element method as a discretization concept for the Boussinesq equations. Furthermore, we investigate the sensitivity of the discrete operator describing the stabilized characteristics FE method with respect to the control and state variables in a suitable function space setting.

2 - Multigrid-Base Optimization Approach for Tomographic Inversion from Multiple Data Modalities

Zichao Di, Postdoctoral Appointee, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL, 60439, United States of America, wendydi@mcs.anl.gov, Stefan Wild, Sven Leyffer

Fluorescence tomographic reconstruction can be used to reveal the internal elemental composition of a sample while transmission tomography can be used to obtain the spatial distribution of the absorption coefficient inside the sample. In this work, we integrate both modalities and formulate an optimization approach to simultaneously reconstruct the composition and absorption effect in the sample. By using multigrid¨-based optimization framework (MG/OPT), significant speedup and improvement of accuracy has shown for several examples.

3 - A Decomposition Model Combining Parametric and Non-Parametric Image Registration

Mazlinda Ibrahim, University of Liverpool, 608, Monument Buildings, Liverpool, L3 5PH, United Kingdom, mazlinda@liv.ac.uk, Ke Chen

Image registration aims to find a reasonable transformation so that the template image becomes similar to the so-called given reference image. Through such transformation, information from these images can be compared or combined. There exist many image registration models and the models can be divided into either parametric or non-parametric categories. In this talk, I shall introduce a novel image registration model called a decomposition model where it combines parametric and non-parametric models. We choose one cubic B-splines and a linear curvature model for parametric and non-parametric part respectively.

■ FC08

08- Kings Garden 4

Algebraic Methods in Conic Optimization

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Amir Ali Ahmadi, Princeton University, a_a_a@princeton.edu

1 - Generic Sensitivity Analysis for Semi-Algebraic Optimization

Adrian Lewis, Professor, Cornell University, School of ORIE, Ithaca, NY, 14853, United States of America, adrian.lewis@cornell.edu, Dmitriy Drusvyatskiy, Alexander Ioffe

Concrete optimization is often semi-algebraic, definable using only polynomial inequalities. The first-order optimality conditions involve a set-valued operator on n-dimensional space whose graph is everywhere n-dimensional (or "thin"). Semi-algebraic monotone operators also have thin graphs, by Minty's theorem. A Sard-type theorem holds for semi-algebraic operators with thin graphs, ensuring good sensitivity behavior for generic data. In particular, optimizers of semi-algebraic problems typically lie on an "active manifold" (identified by popular algorithms), and satisfy strict complementarity and the second-order sufficient conditions.

2 - Fast Binary Embeddings

Constantine Caramanis, University of Texas-Austin, Austin, TX, United States of America, constantine@utexas.edu

Binary embedding is a nonlinear dimension reduction methodology where high dimensional data are embedded into the Hamming cube while preserving the structure of the original space. Specifically, for an arbitrary set of N distinct points on the p-dimensional sphere, our goal is to encode each point using m-dimensional binary strings such that we can reconstruct their geodesic distance up to δ-uniform distortion. Existing binary embedding algorithms either lack theoretical guarantees or suffer from running time $O(mp)$. We make three contributions: (1) we establish a lower bound that shows any binary embedding oblivious to the set of points requires $m = \Omega(\log{N}/\delta^2)$ bits and a similar lower bound for non-oblivious embeddings into Hamming distance; (2) we propose a novel fast binary embedding algorithm with provably optimal bit complexity m = O(\log{N}/\delta^2}) and near linear running time O(p \log p) whenever $\log N \ll \delta \sqrt{p}$, with a slightly worse running time for larger \log N; (3) we also provide an analytic result about embedding a general set of points on the sphere, with even infinite size. Our theoretical findings are supported through experiments on both synthetic and real data sets.

3 - Relative Entropy Relaxations for Signomial Optimization

Venkat Chandrasekaran, Caltech, 1200 E. California Blvd, MC 305-16, Pasadena, CA, 91125, United States of America, venkatc@caltech.edu, Parikshit Shah

Due to its favorable analytical properties, the relative entropy function plays a prominent role in a variety of contexts in information theory and in statistics. In this talk, we discuss some of the beneficial computational properties of this function by describing a class of relative-entropy-based convex relaxations for obtaining bounds on signomials programs (SPs), which arise commonly in many problems domains. SPs are non-convex in general, and families of NP-hard problems can be reduced to SPs. The central idea underlying our approach is a connection between the relative entropy function and efficient proofs of nonnegativity via the arithmetic-geometric-mean inequality.

■ FC09

09- Kings Garden 5

Alternating Methods and Generalized Proximal Point Algorithms

Cluster: Nonsmooth Optimization

Invited Session

Chair: Maryam Yashtini, Dr., Georgia Institute of Technology, School of Mathematics, Atlanta, GA, 30332, United States of America, myashtini3@math.gatech.edu

1 - Iteration Complexity Analysis of Block Coordinate Descent Methods

Xiangfeng Wang, Dr., East China Normal University, 3663# North Zhongshan Road, Science Building A1614, Shanghai, China, xfwang.nju@gmail.com, Mingyi Hong, Zhi-Quan Luo, Meisam Razaviyayn

We provide a unified iteration complexity analysis for a family of general block coordinate descent (BCD) methods, covering popular methods such as the block coordinate gradient descent (BCGD) and the block coordinate proximal gradient(BCPG), under various different coordinate update rules. Moreover, we show that for a special class of algorithm called the block coordinate minimization (BCM) where each block is minimized exactly, the sublinear rate can be achieved either when certain per-block strong convexity assumption is met, or when the smooth function satisfies some additional assumptions.

2 - On the Linear Convergence Rate of a Generalized Proximal Point Algorithm

Min Tao, Dr., Nanjing University, HanKou Road No. 22, Nanjing, China, taom@nju.edu.cn, Xiaoming Yuan

The proximal point algorithm (PPA) has been well studied in the literature. Its linear convergence rate has been studied by Rockafellar in 1976 under certain condition. We consider a generalized PPA in the generic setting of finding a zero point of a maximal monotone operator, and show that the condition proposed by Rockafellar can also sufficiently ensure the linear convergence rate for this generalized PPA. Both the exact and inexact versions of this generalized PPA are discussed.

3 - Fast Alternating Minimization Algorithms for Convex and Nonconvex Inverse Problems and Applications

Maryam Yashtini, Dr., Georgia Institute of Technology, School of Mathematics, Atlanta, GA, 30332, United States of America, myashtini3@math.gatech.edu

In the first part, I will introduce a fast alternating direction approximate Newton method for solving total variation regularized inverse problems. The proposed algorithm is designed to handle applications where the matrix in the fidelity term is a large dense, ill conditioned. Numerical results are provided using test problems from parallel magnetic resonance imaging. In the second part, I will focus on the Euler's Elastica-based model. The associated Euler-Lagrange equation of this model is fourth order hence minimization of energy functionals becomes very complex. I will introduce some algorithms to solve this problem much more efficiently. Comparisons are made with some state of art algorithms on image inpainting and denoising.

■ FC10

10- Kings Terrace

Semidefinite Programming and Portfolio Management

Cluster: Finance and Economics

Invited Session

Chair: Koichi Fujii, NTT DATA Mathematical Systems Inc., 1F Shinanomachi Rengakan, 35, Shinanomac, Shinjuku-ku, Tokyo 160-0016, JAPAN, Tokyo, Japan, fujii_kouichi@msi.co.jp

1 - Two SDP-Based Algorithms for the Long-Short Portfolios

Koichi Fujii, NTT DATA Mathematical Systems Inc., 1F Shinanomachi Rengakan, 35, Shinanomac, Shinjuku-ku, Tokyo 160-0016, JAPAN, Tokyo, Japan, fujii_kouichi@msi.co.jp, Kouhei Harada, Takahito Tanabe

We present two SDP-based algorithms for the optimal long-short portfolios, which are known to be difficult MIQPs. One is a modified Lagrangian relaxation in which we impose semidefinite constraints on Lagrangian dual problems. The other is a randomized algorithm which utilizes SDP relaxations in the same way as Goemans-Williamson MAX CUT approximation algorithm. Computational results show the significant improvements in proving the optimality or finding good feasible solutions compared with LP-based branch-and-bound algorithm.

■ FC11

11- Brigade

Process Flexibility Network Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Vineet Goyal, Columbia University, 500W 120th St, New York, NY, United States of America, vgoyal@ieor.columbia.edu

1 - Optimal Sparse Designs for Process Flexibility via Probabilistic Expanders

Yuan Zhou, MIT, Department of Mathematics, MIT, Cambridge, MA, 02140, United States of America, yuanzhou@mit.edu, Jiawei Zhang, Xi Chen

We study the problem of how to design a sparse flexible process structure in a balanced and symmetrical production system to match supply with random demand more effectively. Our goal is to provide a sparsest design to achieve (1-e)-optimality relative to the fully flexible system. In a system with n plants and n products, Chou et al. proved that there exists a graph expander with O(n/e) arcs to achieve (1-e)-optimality for every demand realization. In this paper, we introduce a new concept called probabilistic graph expanders. We prove that a probabilistic expander with O(n ln(1/e)) arcs guarantees (1-e)-optimality with high probability (w.h.p.). We also show any structure needs O(n ln(1/e)) arcs to achieve (1-e)-optimality w.h.p.

2 - Distribution-Free Analyses of Process Flexibility Design

Tianhu Deng, Assistant Professor, Tsinghua University, Shunde Building 607, Tsinghua University, Beijing, 100084, China, deng13@mail.tsinghua.edu.cn, Max Zuojun Shen

For a process flexibility design model, we do not assume full knowledge of demand joint distribution and instead investigate four distribution-free models: (1) marginal moment model, (2) marginal distribution model, (3) cross moment model, and (4) marginal moment model with independence. For the first three models, we provide efficient solution methods based on second order cone programming, stochastic bounds and completely positive cone programming, respectively. For the fourth model, we show that three-point distributions are the worst-case discrete distributions.

3 - Sparse Process Flexibility Designs: Is Long Chain Really Optimal?

Antoine Desir, Columbia University, 601 W 113th Street, Apt 3J, New York, NY, 10025, United States of America, ad2918@columbia.edu, Jiawei Zhang, Yehua Wei, Vineet Goyal

Sparse process flexibility and long chain has become an important concept in design flexible manufacturing systems since the seminal paper of Jordan and Graves (1995). In this presentation, we study the performance of long chain in comparison to all designs with at most 2n edges over n supply and n demand nodes. We show that, surprisingly, long chain is not optimal in this class of networks even for i.i.d. demand distributions. This is quite surprising and contrary to the intuition that a connected design performs better than a disconnected one for symmetric distributions. We then show that the long chain is optimal if we compare it to connected designs with at most 2n edges for exchangeable demand distributions.

■ FC13

13- Rivers

Modeling Languages and Libraries in Optimization

Cluster: Constraint Programming

Invited Session

Chair: Laurent Michel, Associate Professor, University of Connecticut, 371 Fairfield Rd, Storrs, CT, 06269, United States of America, ldm@engr.uconn.edu

1 - Automated Modelling in Constraint Programming with Essence and Conjure

Ozgur Akgun, University of St Andrews, School of Computer Science, St Andrews, United Kingdom, ozgur.akgun@st-andrews.ac.uk

Constraint Programming (CP) offers an efficient means of solving a variety of combinatorial problems. A well-recognised bottleneck in the application of CP is the formulation of an effective (or even correct) CP model. This can lead to very poor solving efficiency or incorrect solutions. Our approach to this challenge is to allow users to describe problems in the specification language Essence without having to make low level modelling decisions. Then, our automated modelling tool Conjure automatically produces concrete CP models, including class-level symmetry breaking constraints. Since it is possible to generate several alternative models for a problem specification, Conjure uses heuristics and model racing to find an effective model.

2 - The Objective-CP Modeling and Optimization Platform

Laurent Michel, Associate Professor, University of Connecticut, 371 Fairfield Rd, Storrs, CT, 06269, United States of America, ldm@engr.uconn.edu, Pascal Van Hentenryck

Constraint Programming promotes an approach to combinatorial optimization that separates the declarative modeling of the problem from the creation of search procedures. This separation of concerns lends considerable flexibility and opens the door to an environment where a single high-level declarative model can be used with multiple solvers to produce technology specific programs as well as increasingly complex hybrid solvers. This talk investigates Objective-CP, an optimization platform that embraces this principle and delivers a compelling environment in which one can author complex optimization programs.

3 - An XML Schema for Matrix and Cone Programming

Horand Gassmann, Dalhousie University, Rowe School of Business, Halifax, NS, Canada, Horand.Gassmann@Dal.Ca, Imre Polik, Kipp Martin, Jun Ma

Cone programming and matrix programming are relatively new areas of mathematical optimization that have received attention in recent years due to their applicability in solving stochastic programs as well as mixed integer programs. Solver implementations exist, but benchmarking is hampered because there are few accepted input formats in which to communicate instances to the solvers. This talk presents efforts to facilitate the formulation of matrix and cone programming problems within the OSiL framework, a unified representation format for a large variety of mathematical optimization problem instances. OSiL is part of the OS project, an open source COIN-OR project. A prototype interface to the CSDP solver is also described.

■ FC14

14- Traders

Price of Anarchy II

Cluster: Game Theory

Invited Session

Chair: Vasilis Syrgkanis, Post-doc Researcher, 641 Avenue of the Americas, NY, United States of America, bsyrganis@gmail.com

1 - Efficiency, Pricing, and the Walrasian Mechanism

Brendan Lucier, Researcher, Microsoft Research, One Memorial Drive, Cambridge, MA, United States of America, brlucier@microsoft.com

Central results in economics guarantee efficient equilibria in markets, but a common assumption is that agents honestly report their demands. In practice agents can benefit by reducing demand, leading to inefficiency. But how inefficient can these outcomes be? We study the Walrasian Mechanism: collect reported demands, then find clearing prices in the reported market. We show that every equilibrium yields a constant fraction of the optimal welfare, in a variety of settings without complements. I will also discuss a related approach: post fixed prices based on distributions over preferences, leading to sequential price-taking behavior. This approach can be used to design simple, truthful mechanisms in Bayesian settings.

2 - Valuation Compressions in VCG-Based Combinatorial Auctions

Paul Duetting, London School of Economics, Houghton Street, London, WC2A 2AE, United Kingdom, P.D.Duetting@lse.ac.uk, Martin Starnberger, Monika Henzinger

The focus of classic mechanism design has been on truthful direct-revelation mechanisms. In the context of combinatorial auctions the truthful direct-revelation mechanism that maximizes social welfare is the VCG mechanism. For many valuation spaces computing the allocation and payments of the VCG mechanism, however, is a computationally hard problem. We prove upper and lower bounds on the welfare loss that results from restricting the bids to a subspace of the valuation space for which the VCG outcome can be computed efficiently. All our bounds apply to equilibrium concepts that can be computed in polynomial time as well as to learning outcomes. Our bounds show that the welfare loss increases with expressiveness.

3 - Price Competition in Online Markets

Renato Paes Leme, Researcher, Google Research, 111 8th Ave, New York, NY, 10011-5201, United States of America, renatoppl@google.com, Moshe Babaioff, Noam Nisan

We consider a single buyer with a combinatorial preference that would like to purchase related products and services from different vendors, where each vendor supplies exactly one product. We study the game that is induced on the vendors, where a vendor's strategy is the price that he asks for his product. This model generalizes both Bertrand competition and Nash bargaining and captures a wide variety of complex scenarios. We show existence of Nash equilibrium and give conditions for uniqueness. We also discuss the efficiency of equilibria.

■ FC15

15- Chartiers

Routing and Facility Location

Cluster: Combinatorial Optimization

Invited Session

Chair: Andreas Bley, Heinrich-Plett-Str. 40, Kassel, Germany, abley@mathematik.uni-kassel.de

1 - A Compact MIP for Aggregation and Multicast Trees under Flexible Routing and Function Placement

Matthias Rost, TU Berlin, Marchstrafle 23, MAR 4-4, Berlin, Germany, mrost@inet.tu-berlin.de, Stefan Schmid

With the advent of Software-Defined Networking and Network Functions Virtualization, the selective and flexible placement of functionality has recently gained importance. We introduce the Constrained Virtual Steiner Arboresence Problem that captures spanning multicast and aggregation trees where installing multicast (duplication of flows) or aggregation (merging of flows) functionality comes at a certain price and needs to be traded off with bandwidth usage costs. We discuss the relation to classic optimization problems and present our main result: a single-commodity flow Mixed-Integer Program that relies on a novel flow decomposition scheme. We also derive linear heuristics and show the benefits in a computational study.

2 - A Constant-Factor Local Search Approximation for Two-Stage Facility Location Problems

Felix J. L. Willamowski, Chair of Operations Research, RWTH Aachen, Kackertstrasse 7, Aachen, 52072, Germany, willamowski@or.rwth-aachen.de, Andreas Bley

We present a constant-factor local search approximation algorithm for the metric two-stage uncapacitated facility location problem and a variation of this, where the demands of the clients are served via trees. Additionally, we show that a general mutable metric does not allow constant approximation factors and that the introduced algorithm permits a more general mutable metric in contrast to previous algorithms, which only allow scenario-dependend inflation factors.

■ FC16

16- Sterlings 1

Stochastic Optimization

Cluster: Stochastic Optimization

Invited Session

Chair: Milena Brand„o, Federal University of Uberl,ndia, 20 Street, Tupa, Ituiutaba, 38304-402, Brazil, milena@pontal.ufu.br

1 - Coupled Bisection for Root Ordering

Stephen Pallone, Cornell University, 290 Rhodes Hall, Cornell University, Ithaca, NY, 14853, United States of America, snp32@cornell.edu, Peter Frazier, Shane Henderson

We consider the problem of solving multiple “coupled” root-finding problems at once, in that we can evaluate every function at the same point simultaneously. Using a dynamic programming formulation, we show that a sequential bisection algorithm is a close-to-optimal method for finding a ranking with respect to the zeros of these functions. We show the ranking can be found in linear time, prove an asymptotic approximation guarantee of 1.44, and conjecture that this policy is near-optimal.

2 - Semi-proximal Mirror Prox for Nonsmooth Composite Minimization

Niao He, Georgia Institute of Technology, 765 Ferst Drive, Atlanta, United States of America, nhe6@gatech.edu, Zaid Harchaoui

We introduce a new first-order algorithm to solve composite minimization with objective given by non-smooth convex loss and norm regularization terms. The proposed algorithm, called Semi-Proximal Mirror-Prox , leverages the Fenchel-type representation of one part of the objective while handling the other part of the objective via linear minimization over the domain. The algorithm stands in contrast with more classical proximal gradient algorithms with smoothing, which require the computation of proximal operators and can therefore be impractical for high-dimensional problems. The algorithm exhibits optimal complexity bounds and promising experimental performance in comparison to competing methods.

■ FC17

17- Sterlings 2

Optimization Problems in the Evolution of Cancer

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Kevin Leder, Assistant Professor, University of Minnesota, 111 Church St, Minneapolis, MN, 55455, lede0024@umn.edu

1 - Treatment of Chronic Myeloid Leukemia with Multiple Targeted Therapies

Qie He, Assistant Professor, University of Minnesota, 111 Church St, Minneapolis, MN, 55455, qhe@umn.edu, Kevin Leder, Jasmine Foo, Junfeng Zhu

In the past fifteen years several targeted therapies have been developed to treat Chronic Myeloid Leukemia (CML). These new drugs have greatly improved the prognosis of newly diagnosed patients. However, many patients eventually develop CML that is resistant to therapy. We develop a mathematical model for the evolution of normal cells and CML cells that are sensitive and resistant to the therapy, and derive the optimal combination of treatment strategies under a variety of toxicity constraints. This problem can be modeled as a mixed integer program with ODE constraints. We obtain good solutions of this model by solving an approximate mixed integer linear program, and compare our solution with the strategy used in common practices.

2 - Robust Optimization of Dose Schedules in Radiotherapy

Hamidreza Badri, Graduate Student, University of Minnesota, 111 Church St, Minneapolis, MN, 55455, United States of America, badri019@umn.edu, Kevin Leder

A major difficulty of choosing an optimal radiation schedule is the uncertainty of model parameters due to geometric and patient specific uncertainties. This paper proposes a method for determining the optimal fractionation schedule in the Linear Quadratic model with multiple normal tissue toxicity constraints in the presence of uncertainties with unknown and known underlying distributions. We proved that our problem can be solved efficiently via a decision variable transformation and then iterating standard optimization algorithms. We performed substantial numerical experiments for head-and-neck tumors with six normal tissue constraints to reveal the effects of parameter uncertainty on the structure of optimal schedules.

3 - Minimizing the Risk of Cancer: Tissue Architecture and Cellular Replication Limits

Ignacio Rodriguez-Brenes, Post-doctoral Scholar, University of California Irvine, 340 Rowland Hall, University of Irvine, Irvine, CA, 92697, United States of America, ignacio.rodriguezbrenes@uci.edu, Natalia Komarova, Dominik Wodarz

Normal somatic cells are capable of only a limited number of divisions, which limits cell proliferation and the onset of tumors. Cancer cells find ways to circumvent this obstacle, typically by expressing telomerase. Hence, it is important to understand how a tissue’s architecture affects the replicative capacity of a cell population. We discuss how several characteristics of cell lineages affect the replication capacity of dividing cells. We describe an optimal tissue architecture that minimizes the replication capacity of cells and thus the risk of cancer. Some of the features that define an optimal tissue architecture have been documented in various tissues, suggesting that they may have evolved as a cancer-protecting mechanism.

■ FC18

18- Sterlings 3

Numerical Methods for Structured Nonlinear Programs II

Cluster: Nonlinear Programming

Invited Session

Chair: Christian Kirches, Junior Research Group Leader, TU Braunschweig / Heidelberg University, Im Neuenheimer Feld 368, Heidelberg, 69120, Germany, christian.kirches@iwr.uni-heidelberg.de

1 - Augmented Lagrangian Based Algorithm for Distributed Optimal Control

Boris Houska, Shanghai Tech University, 319 Yueyang Road, Shanghai, China, borish@shanghaitech.edu.cn, Janick Frasch, Moritz Diehl

This talk is about distributed derivative based algorithms for solving optimization problems with separable and potentially non-convex objectives as well as coupled affine constraints, a structure that is present in optimal control problems with long horizons. We propose a parallelizable method that borrows concepts from the field of sequential quadratic programming and augmented Lagrangian algorithms. In contrast to existing decomposition methods, such as the alternating direction method of multipliers, the proposed algorithm is applicable to non-convex optimization problems and can achieve a superlinear convergence rate. We present applications from the field of optimal control.

2 - Distributed IPM for Robust Model Predictive Control

Jens Hübner, Leibniz Universitaet Hannover, Welfengarten 1, Hannover, 30167, Germany, huebner@ifam.uni-hannover.de, Martin Schmidt, Marc C. Steinbach

We address MPC for dynamic processes given by ODEs with stochastic disturbances. Explicit modeling of the disturbances leads to nonlinear MSPs that we treat by an IPM framework. We solve the huge-scale KKT systems with a structure-exploiting direct method incorporating problem-tailored inertia corrections that avoid re-factorizations of the entire KKT matrix. We use internal numerical differentiation to evaluate first-order derivatives of the ODE solutions and generate second-order derivatives by a structured quasi-Newton approach based on partially separable Lagrangians. The algorithm is completely distributed based on a depth-first distribution of the tree that causes few communication overhead. Numerical results will be presented.

3 - A Dual Newton Strategy for Convex QP in Model Predictive Control

Sebastian Sager, Prof. Dr., Otto-von-Guericke Universitaet Magdeburg, Universitaetsplatz 2, Magdeburg, 39106, Germany, sager@ovgu.de, Janick Frasch, Moritz Diehl

QPs that arise from dynamic optimization problems typically exhibit a very particular structure. We propose a dual Newton strategy that exploits the block-bandedness similarly to an interior-point method and features warmstarting capabilities of active-set methods. We give implementation details and a convergence proof. A numerical study based on the open-source implementation qpDUNES shows that the algorithm outperforms both well-established general purpose QP solvers as well as state-of-the-art tailored control QP solvers significantly on the considered benchmark problems.

■ FC19

19- Ft. Pitt

Derivative-Free and Simulation-Based Optimization

Cluster: Derivative-Free and Simulation-Based Optimization

Invited Session

Chair: John Eason, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, jeason@andrew.cmu.edu

1 - Parameter Calibration of High Dimensional Computationally Expensive Multimodal Models

Yilun Wang, University of Electronic Science and Technology of China, No.2006, Xiyuan Ave, West Hi-Tech Zone, Chengdu, 611731, China, yw397@cornell.edu

We have been further extending our proposed framework called ``SOARS", i.e. Statistical and Optimization Analysis for parameter calibrating of computationally expensive prediction models, based on Response Surfaces. The extension aims to achieve better performance for high dimensional problems, i.e., the main difficulty is the ``high dimensionality and small evaluations". Our work is to develop new efficient adaptive learning (also called sample selection or optimal experimental design) for better sparse approximation of the underlying relatively high dimensional computationally expensive black box function. Numerical experiments show the outstanding performance of our extensions.

2 - Surrogate Management for Mixed-Integer Derivative-Free Optimization for Industrial Applications

Anne-Sophie Crélot, University of Namur, Rempart de la Vierge 8, Namur, 5000, Belgium, ascr@math.unamur.be, Charlotte Beauthier, Dominique Orban, Caroline Sainvitu, Annick Sartenaer

We propose a surrogate management framework (SMF) for NOMAD, an implementation of the mesh-adaptive direct-search method, in the context of costly black-box mixed-integer industrial problems and aerodynamic applications. The SMF builds upon tools from Minamo, the surrogate-assisted evolutionary algorithm developed at Cenaero. We compare several surrogate strategies for mixed-integer derivative-free optimization and formulate recommendations based on our experience.

3 - Trust Region Methods for Optimization with Reduced Models Embedded in Chemical Process Flowsheets

John Eason, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States of America, jeason@andrew.cmu.edu, Lorenz Biegler

For advanced simulation models in chemical process optimization, we propose reduced-model trust region methods with desired convergence properties. In particular, we handle equality constraints that link complex simulation models in a flowsheet, which cause difficulties with established trust region methods with reduced models. Here we develop new filter-based trust region methods and compare against straightforward penalty function formulations. We also sketch convergence properties and demonstrate advantages of the filter-based approach on several chemical process applications.

■ FC20

20- Smithfield

Optimization Aspects of Energy Efficient Mobility

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Armin Fügenschuh, Helmut Schmidt University / University of the Federal Armed Forces Hamburg, Holstenhofweg 85, Hamburg, 22043, Germany, fuegenschuh@hsu-hh.de

1 - Integrated Freight Train Composition and Scheduling under Energy Efficiency Aspects

Frederik Fiand, Technical University Braunschweig, Pockelsstr. 14, Braunschweig, 38106, Germany, f.fiand@tu-braunschweig.de, Uwe Zimmermann

Given a set of shipment requests and predefined freight train schedules that allow some local time shifts, our goal is to find optimal transportation plans. Here it is the main objective to minimize the energy consumption under consideration of several business rules like demand satisfaction, capacity constraints and release and due dates. The requirements result in a highly complex large scale problem based on tremendous time expanded networks. We develop a solution approach that combines a tailor made preprocessing with large scale Mixed Integer Programming techniques and provide first promising results. The corresponding project "e-motion" is funded by the German Federal Ministry of Education and Research (BMBF).

2 - Integrating Peak Loads into Energy Sensitive Operational Train Timetabling

Anja Haehle, Chemnitz University of Technology, Reichenhainer Strasse 39, Chemnitz, 09126, Germany, anja.haehle@mathematik.tu-chemnitz.de, Christoph Helmberg

Given passenger and freight trains with time windows and prespecified routes in a coarsened track network, operational train timetabling asks for feasible schedules of these trains that observe the time windows as well as station capacities and headway times. We present a model and an algorithmic framework for including energy information in scheduling the trains. Considering — on top of total energy consumption — peak loads at an early stage in the planning process only make sense, if later perturbations in departure times do not render the results useless. We discuss robust variants to cope with such uncertainties. For first steps into this direction we present computational results on real world instances of Deutsche Bahn.

3 - The Route Planning Problem for Airplanes

Nam Dung Hoang, Zuse Institute Berlin, Takustrasse 7, Berlin, 14195, Germany, hoang@zib.de, Marco Blanco, Ralf Borndoerfer, Thomas Schlechte

The goal of the air traffic service route planning problem for airplanes is to compute a feasible minimum-cost 4D-trajectory between two airports in a network for an aircraft and its starting amount of fuel. The total cost is the sum of fuel cost, overflight cost, and possibly time cost. Weather forecasts, aircraft properties as well as security and operative constraints regulating air traffic have to be considered. From the mathematical perspective it is a shortest path problem with complex constraints and dynamic edge costs on a large graph. In this talk we present a discrete-continuous approach for the problem. Due to the requirement of real world aviation operations our algorithm need to deliver a good solution within a few minutes.

■ FC21

21-Birmingham

Stochastic Aspects of Energy Management II

Cluster: Optimization in Energy Systems

Invited Session

Chair: Wim van Ackooij, EDF R&D, 1 Avenue du Général de Gaulle, Clamart, 92141, France, wim.van.ackooij@gmail.com

1 - Hydrothermal Unit Commitment Subject to Uncertain Demand and Water Inflows

Erlon Finardi, UFSC, EEL - CTC - UFSC - Caixa Postal 476, Florianopolis, 88040-900, Brazil, erlon.finardi@ufsc.br, Murilo Reolon Scuzziato, Antonio Frangioni

We study stochastic Unit Commitment problems where uncertainty concerns water availability in reservoirs and demand (weather conditions), as in the highly hydro-dependent Brazilian system. We compare different decomposition schemes (space and scenario approaches) for these large-scale mixed-binary linear programming problem in terms of quality of produced lower bound, quality of the solutions provided by Lagrangian heuristics, and running time. Tuning of the algorithmic parameters of the employed nonsmooth optimization solver is also discussed.

2 - Scenario Decomposition of Stochastic Unit Commitment Problems

Tim Schulze, The University of Edinburgh, Mathematics, JCMB 5620, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom, t.schulze-2@sms.ed.ac.uk, Kenneth McKinnon

In recent years the expansion of renewable energy supplies has triggered an increased interest in stochastic optimization models for generation unit commitment. Solving this problem directly is computationally intractable for large instances. In this talk we describe a stabilised scenario decomposition algorithm and report test results with a central scheduling model of the British power system. We evaluate stochastic vs. deterministic rolling horizon scheduling over a period of one year and discuss the added value of stochastic planning.

3 - Optimization of Booked Capacity in Gas Transport Networks using Nonlinear Probabilistic Constraints

Holger Heitsch, Dr., Weierstrass Institute, Mohrenstrasse 39, Berlin, 10117, Germany, holger.heitsch@wias-berlin.de, Rene Henrion

We present an approach to deal with booked capacity optimization of gas transport networks under uncertainty, where we make use of probabilistic constraints representing a major model of stochastic optimization. One approach for solving such models consists in applying nonlinear programming methods. Therefore, approximations for values and gradients of probability functions must be provided. We introduce a sampling scheme based on the spheric-radial decomposition of Gaussian random vectors to simultaneously compute both values and gradients of corresponding probability functions. A theoretical concept for simple gas networks including one single cycle and numerical experiences are presented that demonstrate the efficiency of our approach.

■ FC22

22- Heinz

Advances in Integer Programming X

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Andrea Lodi, University of Bologna, Viale Risorgimento 2, Bologna, Italy, andrea.lodi@unibo.it

Co-Chair: Robert Weismantel, Eidgenoessische Technische Hochschule Zuerich (ETHZ), Institute for Operations Research, IFOR, Department Mathematik, HG G 21.5, Raemistrasse 101, Zuerich, 8092, Switzerland, robert.weismantel@ifor.math.ethz.ch

1 - Primal Cuts in the Integral Simplex using Decomposition

Samuel Rosat, GERAD Research Center, 3000, ch. de la Cote Sainte Catherine, Montréal, QC, H3T2A7, Canada, samuel.rosat@gerad.ca, François Soumis, Andrea Lodi, Issmail Elhallaoui

We propose a primal algorithm for the Set Partitioning Problem based on the Integral Simplex Using Decomposition of Zaghrouti et al. (2014). We present the algorithm in a pure primal form, and show that cutting planes can be transferred to the subproblem. We prove that these cutting planes always exist and that they are primal cuts. We propose efficient separation procedures for primal clique and odd-cycle cuts, and prove that their search space can be restricted to a small subset of the variables. Numerical results demonstrate the effectiveness of adding cutting planes to the algorithm; tests are performed on set partitioning problems from aircrew and bus-driver scheduling instances up to 1,600 constraints and 570,000 variables.

2 - Influence of the Normalization Constraint in the Integral Simplex using Decomposition

François Soumis, Polytechnique Montrèal, 3000, ch. de la Cote Sainte Catherine, Montreal, QC, Canada, Francois.Soumis@gerad.ca, Issmail Elhallaoui, Samuel Rosat, Driss Chakour

For the set partitioning problem, there exists a decreasing sequence of integer extreme points that leads to the optimum, such that each solution is adjacent to the previous one. Several algorithms aim to determine that sequence; one example is the integral simplex using decomposition (ISUD) of Zaghrouti et al. (2014). In ISUD, the next solution is often obtained by solving a linear program without using any branching strategy. We study the influence of the normalization-weight vector of this linear program on the integrality of the next solution. We propose new normalization constraints that encourage integral solutions. Numerical tests on scheduling instances (with up to 500,000 variables) demonstrate the potential of our approach.

3 - Column Generation Combining Three Stabilization Methods and Impact on Generalized Assignment

Ruslan Sadykov, Inria Bordeaux - Sud-Ouest, 200 avenue de la Vieille Tour, Talence, 33405, France, Ruslan.Sadykov@inria.fr, Artur Alves Pessoa, Eduardo Uchoa, François Vanderbeck

To accelerate convergence of column generation, we combine dual price smoothing, directional smoothing, and piecewise linear penalty functions. Our parameter self-adjusting scheme is a key ingredient, reducing parameters to just one constant that requires tuning. This combined stabilization scheme performs significantly better than the individual stabilizations on the GAP set covering formulation. Beyond 400 jobs, instances could not be solved with existing individually stabilized column generation approaches due to severe convergence issues. Our approach can tackle instances with up to 80 machines and 1600 jobs. Combining it with a diversified diving heuristic, we improve published primal bounds for all open literature instances.

■ FC23

23- Allegheny

Matching and Assignment

Cluster: Combinatorial Optimization

Invited Session

Chair: Konstantinos Kaparis, Lancaster Univeristy, Department of Management Science, Lancaster University, Lancaster, LA1 4YX, United Kingdom, K.Kaparis@lancaster.ac.uk

1 - Perfect f-Matchings and f-Factors in Hypergraphs

Isabel Beckenbach, Zuse Institute Berlin, Takustr. 7, Berlin, 14195, Germany, beckenbach@zib.de, Ralf Borndörfer, Robert Scheidweiler

Conforti, Cornuéjols, Kapoor, and Vuökovic generalized Hall's condition for the existence of a perfect matching in a bipartite graph to balanced hypergraphs. We show how this result can be used to derive a condition for the existence of a perfect f-matching and an f-factor in a unimodular hypergraph. We discuss how these conditions generalize the known ones in bipartite graphs. Furthermore, we give a condition for the existence of a perfect f-matching in a uniform, balanced hypergraph.

2 - A Minimal Polyhedral Description of Stable b-matching

Pavlos Eirinakis, Athens University of Economics and Business, Department of Management Science & Techn, Patission 76, Athens, 10434, Greece, peir@aueb.gr, Dimitrios Magos, Ioannis Mourtos

The theory of matroid-kernel polyhedra provides a linear description of stable b-matching (MM). We revisit this description to establish the dimension, minimal equation system and facets of the MM polytope. This minimal representation is significantly sparser than the existing one and linear to the size of the problem. It carries over to stable admissions (SA), for which we also establish the facial correspondence of the linear description based on matroid-kernels to the one based on combs. Besides bringing a closure to the polyhedral study of MM and SA, these results are of practical importance in variants involving additional constraints, e.g., couples in residency schemes, where problem specific combinatorial algorithms become useless.

■ FC24

24- Benedum

New Developments on QCQPs and MINLPs II

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Daniel Bienstock, 500 W 120th St, New York, NY, 10027, United States of America, dano@columbia.edu

1 - Graph-Theoretic Convexification of Polynomial Optimization Problems: Theory and Applications

Javad Lavaei, Assistant Professor, Columbia University, New York, New York, United States of America, lavaei@ee.columbia.edu, Ramtin Madani, Somayeh Sojoudi, Abdulrahman Kalbat, Morteza Ashraphijuo

The objective of this talk is to find a near-global solution of an arbitrary real or complex polynomial optimization problem. Using a semidefinite programming (SDP) relaxation, we aim to address several problems: How does structure affect the complexity of an optimization problem? How does sparsity help? How to design a penalized convex relaxation to find a near-global solution whenever the customary SDP relaxation fails? How to design an efficient numerical algorithm to solve a large-scale conic optimization problem? Our approach relies on the notions of OS-vertex sequence and treewidth in graph theory, matrix completion, and low-rank optimization, among others.

2 - Extended Formulations for Quadratic Mixed Integer Programming

Juan Pablo Vielma, MIT, 100 Main Street, E62-561, Cambridge, MA, 02142, United States of America, jvielma@mit.edu

An extended formulation for Mixed Integer Programming (MIP) is a formulation that uses a number of auxiliary variables in addition to the original or natural variables of a MIP. Extended formulations for linear MIP have been extensively used to construct small, but strong formulations for a wide range of problems. In this talk we consider the use of extended formulations in quadratic MIP to improve the performance of LP-based branch-and-bound algorithms.

3 - Convexification Tools for Non-Convex Quadratic Programs

Fatma Kilinc-Karzan, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, fkilinc@andrew.cmu.edu, Nam Ho-Nguyen, Sam Burer

We study structured non-convex sets defined by the intersection of a second-order cone (SOC) representable constraint, a single homogeneous non-convex quadratic and an affine hyperplane. We derive simple, computable convex relaxations given by a new SOC representable constraint, and show that our relaxations precisely describe the corresponding convex hull under easy to check conditions. Our results imply that the classical trust region subproblem (TRS) can be solved by only relying on SOC optimization. We develop an efficient first-order method to solve the resulting SOC problems associated with TRS, and establish its rate of convergence. This method involves only matrix-vector products at each iteration and thus scales up very well.

■ FC25

25- Board Room

Optimization in Energy Systems II

Cluster: Optimization in Energy Systems

Invited Session

Chair: Victor Zavala, Computational Mathematician, Argonne National Laboratory, 9700 South Cass Ave, Argonne, IL, 60439, United States of America, vzavala@mcs.anl.gov

1 - A Data-Driven Bidding Model for a Cluster of Price-Responsive Consumers of Electricity

Juan Miguel Morales Gonzalez, Associate Professor, Technical University of Denmark, Matematiktorvet, Building 303b, 008, Kgs. Lyngby, 2800, Denmark, jmmgo@dtu.dk, Javier Saez-Gallego, Marco Zugno

We deal with the market bidding problem of a cluster of price-responsive consumers of electricity. We develop an inverse optimization method that uses price-consumption data to estimate the complex market bid that best captures the price-response of the cluster. A complex market bid is defined here as a series of utility functions plus some physical constraints on demand such as maximum pick-up and drop-off rates. The proposed modeling approach also leverages information on exogenous factors that may influence the consumption behavior of the cluster, such as outside temperature, calendar effects, etc. We test the proposed methodology for a particular application: forecasting the power consumption of a small aggregation of households.

2 - Moment-based Relaxations of the Optimal Power Flow Problem

Daniel Molzahn, Dow Postdoctoral Fellow, University of Michigan, 1301 Beal Avenue, Room 4234A, Ann Arbor, MI, 48109, United States of America, dan.molzahn@gmail.com, Ian Hiskens

Optimal power flow (OPF) is the key problem in operating electric power systems. A hierarchy of convex “moment” relaxations globally solves many non-convex OPF problems for which existing relaxations fail. Comparing the feasible spaces of the low-order relaxations illustrates the capabilities of the moment relaxations. Exploiting sparsity and selectively applying the higher-order relaxation enables global solution of larger problems.

3 - A Structure-Oriented Approach to Nonlinear Optimization of Energy Systems

Nai-Yuan Chiang, Argonne National Laboratory, 9700 South Cass Avenue, Lemont, IL, United States of America, nychiang@mcs.anl.gov, Cosmin Petra, Victor Zavala

We present a structure-oriented approach for nonlinear programs arising in power grid, buildings, and natural gas infrastructures. The approach can be used when inertia information is unavailable or unreliable and is thus suitable for tailored linear algebra implementations. We present a global convergence proof and numerical evidence that the approach is as robust as modern NLP packages and can tackle large stochastic programs.

■ FC27

27- Duquesne Room

Discrepancy Theory and its Applications

Cluster: Combinatorial Optimization

Invited Session

Chair: Daniel Dadush, CWI, Science Park, Amsterdam, Netherlands, dndadush@gmail.com

1 - Geometric Discrepancy and Packings

Esther Ezra, Assistant Professor, Georgia Tech, School of Mathematics, Georgia Tech, 686 Cherry Street, Atlanta, GA, 30332-0160, United States of America, esther@cims.nyu.edu

Discrepancy theory has been developed into a diverse and fascinating field, with numerous closely related areas. In this talk, I will survey several classic results in combinatorial and geometric discrepancy and then present discrepancy bounds for set systems of bounded ``primal shatter dimension”, with the property that these bounds are sensitive to the actual set sizes. These bounds are nearly-optimal. Such set systems are abstract, but they can be realized by simply-shaped regions, as halfspaces and balls in d-dimensions. Our analysis exploits the so-called “entropy method” and the technique of “partial coloring”, combined with the existence of small “packings”.

2 - Differential Privacy and Discrepancy Theory

Aleksandar Nikolov, Postdoc, Microsoft Research Redmond, Microsoft Research, Redmond, United States of America, a.t.nikolov@gmail.com

Differential privacy is a rigorous definition of what it means for a data analysis algorithm to preserve the privacy of the information of individuals. Recently, fascinating connections have been discovered between differential privacy and statistics, machine learning, convex geometry, and discrepancy theory, among others. In this talk we will describe this last connection and show how it allowed us to gain a nearly complete understanding of the amount of error that is necessary and sufficient to achieve differential privacy for any given set of counting queries.

3 - Constructive Discrepancy Minimization: Vector Coloring and Equivalence Relations

Daniel Dadush, CWI, Science Park, Amsterdam, Netherlands, dndadush@gmail.com, Aleksandar Nikolov

Given an n x n matrix A, the discrepancy minimization problem is to find a -1/1 coloring x minimizing the infinity norm of Ax. The Komlos conjecture is that if A has bounded column norms then there exists a coloring of constant discrepancy. We show that this conjecture holds for a natural SDP relaxation of discrepancy, together with a simple algorithm to construct an SDP solution. Additionally, we show an equivalence of a seminal result of Banaszczyk (proving Komlos up O(sqrt(log n))) with the existence distributions on x such that Ax is subgaussian.

■ FC28

28- Liberty Room

Vulnerability Analysis and Design of Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Neng Fan, Assistant Professor, University of Arizona, 1127 E. James E. Rogers Way Room 111, Tucson, AZ, 85721, United States of America, nfan@email.arizona.edu

1 - Diameter-Constrained Network Design Problems with Connectivity Requirements

Elham Sadeghi, Graduate Research Assistant, University of Arizona, United States of America, sadeghi@email.arizona.edu, Neng Fan

A connected graph is said to be k-vertex connected if the resulted graph after removal of fewer than k vertices is still connected. Also, a connected graph is called l-edge connected if the resulted graph after removal fewer than l edges,is still connected. The diameter d of a graph is the greatest distance between any pair of vertices. We combine the edge and vertex connectivity requirements with diameter constraint, by proposing integer programming models and designing algorithms, to design a minimum-cost network such that the resulted graph, after removal of at most k vertices and/or l edges, has diameter d.

2 - Integer Programming Approaches for Vulnerability Analysis of Interdependent Networks

Andres Garrido, Universidad de La Frontera, Antonio Varas 1195, Temuco, IX, Chile, amgarrido.ortiz@gmail.com, Neng Fan

In this talk, we analyze the vulnerability of interdependent networks by identify a set of nodes in power grid, whose removal results high impacts by the cascading failures in the interdependent communication network and itself. We propose an approach by integer programming to identify a set of nodes such that the the size of the largest connected component in the resulted network after cascading failures is minimized. Knowing the behavior of these networks can help to be more prepared before attacks and failures that may affect the power network supply and functionality.

■ FC29

29- Commonwealth 1

Mixed-Integer Nonlinear Programming

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Elmor Peterson, Retired, Systems Science Research and Consulting, 3717 Williamsborough Court, Raleigh, NC, 27609, United States of America, elmor.peterson@gmail.com

1 - Mixed-Integer Linearly-Constrained Convex Programming MILCCP Reduced to Unconstrained Convex Programming UCP

Elmor Peterson, Retired, Systems Science Research and Consulting, 3717 Williamsborough Court, Raleigh, NC, 27609, United States of America, elmor.peterson@gmail.com

A relaxation (without the integer constraints) is easily transformed (in a new way) into an equivalent convex "GGP problem" whose corresponding "Conjugate GGP Dual" is unconstrained and hence can be solved with any UCP algorithm — after which any cutting plane resulting from the easily-computed GGP primal-optimal solution readily produces a "GGP Dual Update" that is also unconstrained — and hence solvable without (relatively inefficient) branching, bounding, or cold re-starting. During each such iteration, vector parallel-processing can be directly used (without pre-processing) to solve some extra-large-scale or multi-scale problems (in LP, MILP, LCCP or MILCCP) that were previously unsolvable in real time. Finally, some related stochastic MILCCP problems can also be solved by this GGP methodology.

2 - A Global DC Programming Algorithm for Solving Mixed-01 Nonlinear Program

Yi-Shuai Niu, Professor, Shanghai Jiao Tong University, 800 Dong Chuan Rd., Shanghai, 200240, China, niuyishuai@sjtu.edu.cn

We propose a new hybrid method based on DC (Difference of convex functions) programming algorithm (DCA) combining with Branch-and-Bound (B&B), DC/SDP relaxation technique and DC-Cut for globally solving mixed-01 nonlinear program. We will firstly reformulate a mixed-01 nonlinear program as a DC program via continuous representation techniques and penalization techniques. Then we consider in B&B, an efficient local optimization algorithm DCA is proposed for searching upper bound. The DC/SDP relaxation will be constructed for lower bound estimation. And the DC-Cutting plane helps to cut off local minimizers, thus reduce the feasible set and accelerate the convergence of B&B. Some preliminary numerical results of our method will be reported.

■ FC30

30- Commonwealth 2

Approximation and Online Algorithms

Cluster: Approximation and Online Algorithms

Invited Session

Chair: Ankur Kulkarni, Assistant Professor, Indian Institute of Technology Bombay, Powai, Mumbai, India, kulkarni.ankur@iitb.ac.in

1 - Efficient Approximation Schemes for Lot-Sizing in Continuous Time

Mathieu Van Vyve, Universitè catholique de Louvain, Voie du Roman Pays 34, Louvain-La-Neuve, 1348, Belgium, mathieu.vanvyve@uclouvain.be, Claudio Telha

We consider a continuous-time variant of the classical Economic Lot-Sizing (ELS) problem. In this model, the setup cost is a continuous function with lower bound Kmin > 0, the demand and holding costs are integrable functions of time and the replenishment decisions are not restricted to be multiples of a base period. This problem generalizes both the ELS and EOQ models. Assuming a one-dimensional optimization oracle, we describe approximation schemes that are polynomial in 1/eps and a variant of the size of the output.

2 - Exact and Approximation Algorithms for Weighted Matroid Intersection

Naonori Kakimura, University of Tokyo, 3-8-1 Komaba Meguro-ku, Tokyo, 153-8902, Japan, kakimura@global.c.u-tokyo.ac.jp, Chien-Chung Huang, Naoyuki Kamiyama

We give exact and approximation algorithms for the weighted matroid intersection problems. The core of our algorithms is a decomposition technique: we decompose the weighted version of the problem into a set of unweighted problems. The advantage of this approach is that we can then exploit fast unweighted matroid intersection algorithms as a black box. To be precise, we can find an exact solution via solving W unweighted problems, where W is the largest weight. Furthermore, we can find a (1-epsilon)-approximate solution via solving O(1/epsilon * log r) unweighted problems, where r is the smallest rank of the given two matroids. Our algorithms are simple and flexible: they can be adapted to specific matroid intersection problems.

Friday, 2:45pm - 4:15pm

■ FD01

01- Grand 1

Cutting Planes for Mixed-Integer Programs

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Oktay Gunluk, IBM Research, 1101 Kitchawan Road, Yorktown Heights, NY, United States of America, gunluk@us.ibm.com

1 - Cutting Planes from Extended LP Formulations

Sanjeeb Dash, IBM Research, 1101 Kitchawan Road, Yorktown Heights, United States of America, sanjeebd@us.ibm.com, Oktay Gunluk, Merve Bodur

We study "extended LP formulations" of mixed-integer programs (MIP) that give the original LP relaxation when projected down to the original space and show that split cuts applied to such formulations can be more effective than split cuts applied to the original formulation. For any 0-1 MIP with n integer variables, we give an extended LP formulation in 2n variables that has integral split closure. For general MIPs, we show that extended LP formulations may not give any additional strength over the original problem with respect to split cuts. We also study extended LP formulations of structured problems such as the stable set problem and the 2-row continuous group relaxation.

2 - On On-Off Polytopes

Laurence Wolsey, Emeritus Professor, CORE,University of Louvain, Voie du Roman Pays 34, Louvain-la-Neuve, 1348, Belgium, laurence.wolsey@uclouvain.be, Maurice Queyranne

The problem arising in production planning and unit commitment of switching a machine on/off with time-dependent minimum/maximum bounds on the length of the on/off periods, limits on the number of start-ups and the possibility of cold/hot starts is considered. Introducing new integer variables, the basic problem is formulated as a network dual problem providing among others simple integrality proofs, valid inequalities (alternating and others) and separation algorithms.

3 - Cut-Generating Functions for Integer Variables

Gerard Cornuejols, Carnegie Mellon Univ., Tepper School of Business, Pittsburgh, PA, United States of America, gc0v@andrew.cmu.edu, Sercan Yildiz

For an integer linear program, Gomory's corner relaxation is obtained by ignoring the nonnegativity of the basic variables in a tableau formulation. In the present study, we do not relax these nonnegativity constraints. We generalize a classical result of Gomory and Johnson characterizing minimal cut-generating functions in terms of subadditivity, symmetry, and periodicity. Our result is based on a new concept, the notion of generalized symmetry condition. We also extend to our setting the 2-slope theorem of Gomory and Johnson for extreme cut-generating functions.

■ FD02

02- Grand 2

Convex Optimization Algorithms

Cluster: Conic Programming

Invited Session

Chair: Osman Guler, Professor, UMBC, 1000 Hilltop Circle, Baltimore, MD, 21250, United States of America, guler@umbc.edu

1 - Network Flow Problems with Convex Conic Constraints

Farid Alizadeh, Professor, Rutgers University, MSIS Department, 100 Rockefellar, Room 5142, Piscataway, NJ, 08854, United States of America, alizadeh@rci.rutgers.edu, Mohammad Ranjbar, Deniz Seyed Eskandani, Marta Cavaleiro

We consider network flow problems where arc capacities, costs, and node demand/supply are represented by vectors restricted to be in a proper cone K. For example, in time-varying problems, these parameters may be required to be coefficients of nonnegative polynomial functions of time. We examine challenges for extending familiar combinatorial algorithms such as augmenting path methods, or simplex (primal, dual, or primal-dual) algorithms to conic network flow problems. We also examine classical results such as the max-flow-min-cut theorem in the conic context.

2 - First-order Methods for Convex Programming and Monotone Operators

Osman Guler, Professor, UMBC, 1000 Hilltop Circle, Baltimore, MD, 21250, United States of America, guler@umbc.edu

Currently, there is considerable interest and demand for first-order algorithms that can effectively deal with large applications coming from machine learning and others. In this talk, we investigate acceleration schemes for such algorithms in the framework of convex optimization and monotone operator theory. We will consider a variety of tools to construct such methods, including continuous dynamical systems (odes), splitting, and duality.

■ FD03

03- Grand 3

Rectangle Packing in Chip Design

Cluster: Combinatorial Optimization

Invited Session

Chair: Stefan Hougardy, University of Bonn, Research Institute for Discrete Mathematics, Lennestr. 2, Bonn, 53113, Germany, hougardy@or.uni-bonn.de

1 - Optimal Ratios for Soft Packings of Rectangles

Ulrich Brenner, University of Bonn, Research Institute for Discrete Mathematics, Lennestr. 2, Bonn, 53113, Germany, brenner@or.uni-bonn.de

We consider the problem of packing a set of rectangles of total size 1 into a square A. The sizes of the single rectangles are given while we may choose their aspect ratios from a given interval [1,g]. As a main result, we will show that there is always a feasible solution if A has size at least max(4g/(4g-1), 2/g). This result generalizes an older theorem that showed that for g=1 a size of 2 for A is sufficient. Moreover, we will prove that this bound is tight.

2 - The Cut Rectangle Problem

Pascal Cremer, PhD Candidate, University of Bonn, Research Institute for Discrete Mathematics, Lennestr. 2, Bonn, 53113, Germany, cremer@or.uni-bonn.de

The Cut Rectangle Problem is to find n rectangles that all have the same width and must have some minimum height. In addition, the rectangles must fulfill certain requirements on their absolute and relative positions, for example, they are not allowed to overlap. The goal is then to maximize the total area of these rectangles. This problem appears as a subproblem in the fabrication of modern semiconductors with double patterning techniques. We present different versions of the Cut Rectangle Problem and prove the NP-hardness for some of them, while we present polynomial time algorithms for the others.

3 - BonnPlan: Floorplanning with Flexible Aspect Ratios

Jannik Silvanus, University of Bonn, Research Institute for Discrete Mathematics, Lennestr. 2, Bonn, 53113, Germany, silvanus@or.uni-bonn.de, Jan Schneider

In VLSI design, chips are often constructed hierarchically to both simplify the task and improve the solution quality. This is done by creating a floorplan that divides the chip into rectangular blocks and distributing cells to these blocks. The blocks can be designed independently and are later put together according to the floorplan. We present an algorithm that both computes a partition of the netlist into clusters and generates a floorplan with rectangular blocks for these clusters based on a flat placement of the netlist. The algorithm supports flexible aspect ratios for these blocks and uses a linear programming formulation to simultaneously optimize aspect ratios and positions of blocks.

■ FD04

04- Grand 4

Convex Relaxations and Applications in Statistical Learning

Cluster: Conic Programming

Invited Session

Chair: Alexandre d'Aspremont, 23 av d'Italie, Paris, France, aspremon@ens.fr

1 - Tightness of Convex Relaxations for Certain Inverse Problems on Graphs

Afonso Bandeira, Graduate Student, Princeton University, Program in Applied and Computational Mat, Fine Hall 2nd floor, Washington Rd, Princeton, NJ, 08544, United States of America, afonsobandeira@gmail.com

Many maximum likelihood estimation problems are known to be intractable in the worst case. A common approach is to consider convex relaxations of the maximum likelihood estimator, and relaxations based on semidefinite programming are among the most popular. We will focus our attention on a certain class of graph-based inverse problems.

2 - Semidefinite Relaxations for Angular Synchronization are Often Tight

Nicolas Boumal, Postdoctoral Researcher, Inria & ENS, 23 Avenue d'Italie, Paris, 75013, France, nicolasboumal@gmail.com, Amit Singer, Afonso Bandeira

We consider the problem of estimating phases (points on a circle) from noisy, pairwise, relative phase measurements. Assuming Gaussian noise, the maximum likelihood estimator (MLE) is the solution of a hard, nonconvex quadratically constrained quadratic program. The latter can be relaxed into a semidefinite program (SDP) by lifting (dropping a rank 1 constraint). Remarkably, this SDP turns out to be tight (i.e., it reveals the true MLE in polynomial time) with high probability, even in the face of large noise. We provide a proof of this statement in a preprint: http://arxiv.org/abs/1411.3272. Come see the talk for a quick tour and intuition!

3 - Decomposition Methods for Sparse Matrix Nearness Problems

Yifan Sun, University of California, Los Angeles, 420 Westwood Plaza, Los Angeles, CA, United States of America, ysun01@ucla.edu, Lieven Vandenberghe

We present decomposition methods for computing Euclidean projections on three types of sparse matrix cones with given sparsity patterns: sparse positive semidefinite matrices, and sparse matrices with a positive semidefinite or Euclidean distance completion. The methods combine clique decomposition results for chordal graphs with applications of first-order methods for convex optimization. They include the dual projected gradient method, the dual block coordinate ascent method (or Dykstra's method), and the Douglas-Rachford splitting method. A key feature of the methods is that they only require a series of projections on small dense matrix cones. We compare these methods on a set of test problems, with matrix sizes up to 100,000.

■ FD05

05- Kings Garden 1

Algorithms for Nonlinear Optimization Problems in Machine Learning

Cluster: Nonlinear Programming

Invited Session

Chair: Figen Oztoprak, Assistant Professor, Istanbul Bilgi University, Santral Istanbul, Eyup, Istanbul, Turkey, figen.topkaya@bilgi.edu.tr

1 - A Distributed Incremental Quasi-Newton Algorithm for Large-Scale Matrix Factorization

S. Ilker Birbil, Sabanci University, Orhanli-Tuzla, Istanbul, Turkey, sibirbil@sabanciuniv.edu, Umut Simsekli, Hazal Koptagel, A. Taylan Cemgil, Figen Oztoprak

We propose a distributed incremental quasi-Newton method for solving matrix factorization problems. The proposed method does not require convexity neither does it involve any randomness. We first present the algorithm and then discuss its convergence behavior. We also observe that our discussion, in fact, applies to a quite generic algorithm. This observation is significant as some other convergent algorithms along the same lines may be devised in the future. Finally, we conduct a comprehensive computational study indicating that the proposed algorithm performs very well for solving large-scale matrix factorization problems.

2 - Local Linear Convergence of ISTA and FISTA on the LASSO Problem

Shaozhe Tao, University of Minnesota, 111 Church Street SE, Minneapolis, MN, 55455, United States of America, taoxx120@umn.edu, Daniel Boley, Shuzhong Zhang

We establish local linear convergence bounds for the ISTA and FISTA iterations on the model LASSO problem. We show that FISTA can be viewed as an accelerated ISTA process. Using a spectral analysis, we show that, when close enough to the solution, both iterations converge linearly, but FISTA slows down compared to ISTA, making it advantageous to switch to ISTA toward the end of the iteration processs. We illustrate the results with some synthetic numerical examples.

3 - On Existing Theory Adapted for Recent Algorithms

Figen Oztoprak, Assistant Professor, Istanbul Bilgi University, Santral Istanbul, Eyup, Istanbul, Turkey, figen.topkaya@bilgi.edu.tr

We present some theoretical results regarding three recent algorithms that we have proposed for certain non-smooth and stochastic optimization problems motivated by machine learning applications. The main point of the talk is that all the results that we present do adapt or use existing theory developed for different problems at different contexts; in particular, from linear complementarity, semismooth-Newton, and matrix convergence literature.

■ FD06

06- Kings Garden 2

Integer and Mixed-Integer Programming

Cluster: Integer and Mixed-Integer Programming

Invited Session

Chair: Luigi De Giovanni, Dipartimento di Matematica, Padova, 35121, Italy, luigi.degiovanni@unipd.it

1 - Disjunctive Cuts for Large Formulations

Stefan Ropke, Danmarks Tekniske Universitet, Produktionstorvet, building 426, Kgs. Lyngby, 2800, Denmark, ropke@dtu.dk

This talk presents a computational experiment where disjunctive cuts are generated from formulations with a large number of constraints, implicitly represented using separation oracles. The disjunctive cuts themselves are found by solving a cut finding LP using column generation. Results in terms of lower bounds on the Dantzig, Fulkerson and Johnson model for the asymmetric and symmetric TSP, as well as for the capacitated vehicle routing problem (CVRP) are presented. Some preliminary results showing the effect of using the disjunctive cuts inside a branch-and-cut algorithm for the CVRP are reported as well.

2 - New Facets for the Consecutive Ones Polytope

Luigi De Giovanni, Universita di Padova, Dipartimento di Matematica, via Trieste, 63, Padova, 35121, Italy, luigi@math.unipd.it, Laura Brentegani, Mattia Festa

A 0/1 matrix has the Consecutive-Ones Property if a permutation of its columns makes the ones consecutive in every row. In many applications, one has to find an optimal matrix with this property, and literature proposes Integer Linear Programming formulations based on Tucker (1972) characterization and on classes of facet defining inequalities (Oswald and Reinelt, 2004). We propose a graph-based method to derive new classes of facets and we embed them in a branch-and-cut algorithm.

3 - Communicating with External Heuristic Solvers to Improve the Performance of MIP Solvers

Shunji Umetani, Osaka University, 2-1 Yamadaoka, Suita, Osaka, Japan, umetani@ist.osaka-u.ac.jp, Yuji Shinano

The progress of internal primal heuristics of MIP solvers has much improved their performance in recent years. However, external heuristic solvers still achieve better primal bounds than MIP solvers for many combinatorial optimization problems. We develop a parallel extension of MIP solvers that communicate with external heuristic solvers to improve their performance.

■ FD07

07- Kings Garden 3

Combinatorial Optimization and Networks

Cluster: Telecommunications and Networks

Invited Session

Chair: Warren Adams, Professor, Clemson University, Clemson, SC, 29634, United States of America, wadams@clemson.edu

1 - Solvable Instances of the Quadratic Assignment Problem via the Reformulation-Linearization Technique

Warren Adams, Professor, Clemson University, Clemson, SC, 29634, United States of America, wadams@clemson.edu, Lucas Waddell

Due to the difficulty associated with solving the NP-hard quadratic assignment problem (QAP), a research direction has been to identify objective function structures that allow polynomial solvability. Accordingly, a QAP instance has been defined in the literature to be “linearizable” if it can be rewritten as a linear assignment problem that preserves the objective value at all feasible points. We show that every linearizable instance of the QAP can be characterized in terms of the continuous relaxation of the level-1 reformulation-linearization technique (RLT) form, and that this program will have a binary optimal extreme point that solves the QAP for every such instance. As a consequence, we identify the dimension of the level-1 RLT form.

2 - A Risk-Averse Multistage Generalized Network Flow Model for Water Allocation

Guzin Bayraksan, Associate Professor, Ohio State University, 1971 Neil Ave., Columbus, OH, 43210, United States of America, bayraksan.1@osu.edu

We formulate a water allocation problem by risk-averse multistage programming, which has the advantage of controlling high-risk severe water shortage events. We consider five decompositions of the resulting risk-averse model in order to solve it via the nested L-shaped method. We introduce separate approximations of the mean and the risk measure and also investigate the effectiveness of multiple cuts. In numerical experiments we (1) present a comparative computational study of the risk-averse nested L-shaped variants and (2) analyze the risk-averse approach to the water allocation problem.

3 - A Branch-and-Cut Method for Solving the Bilevel Clique Interdiction Problem

Tim Becker, Rice University, 1330 Old Spanish Trail, Apt 4305, Houston, TX, United States of America, tjbecker04@gmail.com

I introduce an algorithm to solve the current formulation of the bilevel clique interdiction problem. The problem defines a defender who attempts to minimize the number of cliques removed by an attacker. The algorithm presented in this talk uses a branch and cut approach to solve the proposed problem and give preliminary results. This algorithm is expected to be usable on any social network, thereby improving the study of many network problems including terrorist cells or marketing strategies.

■ FD08

08- Kings Garden 4

Structured Optimization in High Dimensional Inference

Cluster: Sparse Optimization and Applications

Invited Session

Chair: Alexandr Aravkin, IBM T.J. Watson Research Center, 1101 Kitchawan Rd., Yorktown Heights, NY, 10598, United States of America, sasha.aravkin@gmail.com

1 - Composite Self-Concordant Minimization

Anastasios Kyrillidis, PostDoc, University of Texas at Austin, 1616 Guadalupe, UTA 6.416, Austin, TX, 78751, United States of America, anastasios@utexas.edu, Quoc Tran-Dinh, Volkan Cevher

We propose a variable metric framework for minimizing the sum of a self-concordant function and a possibly non-smooth convex function, endowed with an easily computable proximal operator. We theoretically establish the convergence of our framework without relying on the usual Lipschitz gradient assumption on the smooth part. An important highlight of our work is a new set of analytic step-size selection and correction procedures based on the structure of the problem. We describe concrete algorithmic instances of our framework for several interesting applications and demonstrate them numerically on both synthetic and real data.

2 - Compressed Sensing with Support Information

Hassan Mansour, Mitsubishi Electric Research Laboratories (MERL), mansour@merl.com, Rayan Saab

Compressed sensing is a signal acquisition paradigm that uses the sparsity of a signal to efficiently reconstruct it from very few linear measurements. These measurements often take the form of inner products with random vectors drawn from appropriate distributions, and the reconstruction is typically done using convex optimization algorithms or computationally efficient greedy algorithms. Under the additional, often practical, assumption that we have a possibly inaccurate estimate of the support we discuss using weighted l1-norm minimization as a reconstruction method. We give reconstruction guarantees that improve on the standard results when the support information is accurate enough and when the weights are chosen correctly.

3 - Embracing the Non-convexity of Low-rank Matrix Estimation

Sujay Sanghavi, University of Texas, sanghavi@mail.utexas.edu

Fitting a low-rank matrix to data is a fundamental step in several modern data applications. It is commonly posed as an optimization problem over the set of low-rank matrices - making it inherently non-convex due to the non-convexity of the set of low-rank matrices. In this talk we focus on settings where this is the "only" source of non-convexity; that is, the optimization of (certain) convex functions over this set. We show that - under the common statistical assumptions which guarantee the consistency of recently popular convex relaxations - one can also establish the consistency of much faster procedures that operate directly on the efficient but non-convex factored form of the low-rank matrix.

■ FD09

09- Kings Garden 5

Large-Scale Nonlinear Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: Roummel Marcia, Associate Professor, University of California, Merced, 5200 N. Lake Road, Merced, CA, 95343, United States of America, rmarcia@ucmerced.edu

1 - A High-accuracy Sr1 Trust-region Subproblem Solver for Large-scale Optimization

Jennifer Erway, Associate Professor, Wake Forest University, Winston-Salem, NC, United States of America, erwayjb@wfu.edu, Roummel Marcia, Johannes Brust

In this talk we present an SR1 trust-region subproblem solver for large-scale unconstrained optimization. This work makes use the exact leftmost eigenvalue, obtainable from the compact representation of an SR1 matrix, to address the so-called "hard case". In all cases, we are able to obtain high-accuracy solutions. Numerical results will be presented.

2 - Preconditioning for Optimization Problem with Nonlocal Operators

Ekkehard Sachs, University of Trier, Trier, Germany, sachs@uni-trier.de

Nonlocal operators occur in peridynamics, cell adhesion processes and the modeling of option prices of jump diffusion type. Optimization comes into play when parameters have to be estimated by fitting the output data. It is obvious that for a fast numerical solution preconditioning is essential. Often the point of view is taken that the diffusive, i.e. local, part of the operator needs preconditioning whereas the integral, i.e. nonlocal part is of smoothing type, even a compact operator, and hence no preconditioning is necessary. However, we show in this talk that this is misleading because the smoothing property depends strongly on the shape of the distribution function or kernel. We underscore this observation by numerical experiments.

3 - Recent Developments in SQP Methods for Large-Scale Nonlinear Optimization

Elizabeth Wong, University of California, San Diego, Department of Mathematics, 9500 Gilman Drive, # 0112, La Jolla, CA, 92093-0112, United States of America, elwong@ucsd.edu, Philip E. Gill, Michael Saunders

We discuss some practical issues associated with the formulation of sequential quadratic programming (SQP) methods for large-scale nonlinear optimization. Numerical results are presented for the software package SNOPT, which uses a positive-definite quasi-Newton approximate Hessian or an exact Hessian.

■ FD10

10- Kings Terrace

Stochastic Programming in Financial Engineering

Cluster: Finance and Economics

Invited Session

Chair: Pavlo Krokhmal, University of Iowa, pavlo-krokhmal@uiowa.edu

1 - Weak Continuity of Risk Functionals with Applications to 2-stage Stochastic Programming

Matthias Claus, Universitaet Duisburg-Essen, Thea-Leymann-Str. 9, Essen, Germany, matthias.claus@uni-due.de, Ruediger Schultz

Measuring and managing risk has become crucial in modern decision making under stochastic uncertainty. In 2-stage stochastic programming, mean risk models are essentially defined by a parametric recourse problem and a quantification of risk. From the perspective of qualitative robustness theory, we discuss sufficient conditions for continuity of the resulting objective functions with respect to perturbation of the underlying probability measure. Our approach covers a fairly comprehensive class of both stochastic-programming related risk measures and relevant recourse models and allows us to extend known stability results for two-stage stochastic programs to models with mixed-integer convex recourse and quadratic integer recourse.

2 - Scenario-Tree Decomposition: Bounds for Multistage Stochastic Mixed-Integer Programs

Gabriel Lopez Zenarosa, PhD Candidate, University of Pittsburgh, 3700 O'Hara Street, Benedum Hall 1048, Pittsburgh, PA, 15261-3048, United States of America, glz5@pitt.edu, Oleg A. Prokopyev, Andrew J. Schaefer

Multistage stochastic mixed-integer programming is a powerful modeling paradigm appropriate for many problems involving a sequence of discrete decisions under uncertainty; however, they are difficult to solve. We present scenario-tree decomposition to establish bounds for multistage stochastic mixed-integer programs. Our method decomposes the scenario tree into a number of smaller trees using vertex cuts and combines the solutions of the resulting subproblems to generate bounds. We developed a multithreaded implementation of our method to solve the "embarrassingly parallel" subproblems and evaluated it on test instances from the existing literature. We found our bounds to be competitive with those of a state-of-the art commercial solver.

3 - On the Value of More Stages in Stochastic Programming Models for Portfolio Optimization

Jonas Ekblom, PhD Student, Linköping University, Linköpings Universitet, Linköping, 58183, Sweden, jonas.ekblom@liu.se, John Birge

We compare the performance of two- and multi-stage Stochastic Programming models for portfolio optimization. What is the value of more stages and how does it compare to a finer discretization of the underlying distribution? We study the impact of e.g. different risk aversion, a time-varying investment opportunity set, and the size of transaction costs. We also investigate how, within a single period model, the transaction costs should be set to maximize a long-run objective.

■ FD11

11- Brigade

Convexification Techniques for Structured Problems

Cluster: Global Optimization

Invited Session

Chair: Fatma Kilinc-Karzan, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, fkilinc@andrew.cmu.edu

1 - A Cut Generating Procedure for Cardinality Constrained Optimization Problems (CCOP)

Jinhak Kim, Purdue University, 2353 Yeager Rd Apt 10, West Lafayette, IN, 47906, United States of America, kim598@purdue.edu, Mohit Tawarmalani, Jean-Philippe P. Richard

We develop cutting planes for CCOP that separate the optimal solution of the LP relaxation. Using the optimal simplex tableau, the feasible region of CCOP is relaxed as a disjunctive set in the space of the nonbasic variables. Then, the facet-defining inequalities for the disjunctive set are shown to correspond to extreme solutions of the dual of a transportation problem. The coefficients of the facet-defining inequalities obey ratios that can be obtained from the simplex tableau. The ratios that are eventually tight form a label-connected tree. This allows us to generalize the equate-and-relax procedure recently developed for complementarity problems to CCOP.

2 - On Binary Optimization Problems with Bounded Tree-Width

Gonzalo Munoz, Columbia University, 500 W. 120nd Street, New York, NY, 10027, United States of America, gonzalo@ieor.columbia.edu, Daniel Bienstock

We describe an LP formulation for pure binary optimization problems where individual constraints are available through a membership oracle; the formulation is exact and if the intersection graph for the constraints has bounded tree-width our construction is of linear size. This improves on a number of results in the literature, both from the perspective of formulation size and generality, and it also yields to a class of linear programming approximations for mixed-integer polynomial optimization problems that attain any desired tolerance.

3 - Disjunctive Cuts for the Second-Order Cone and its Cross-Sections

Sercan Yildiz, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, syildiz@andrew.cmu.edu, Fatma Kilinc-Karzan, Gerard Cornuejols

We study the convex hull of a two-term disjunction on the second-order cone (SOC). We exploit the structure of undominated valid linear inequalities and derive a family of convex inequalities describing the resulting convex hull. We identify cases where these convex inequalities can be expressed in SOC form and where a single inequality from this family is sufficient to describe the convex hull. In more recent work, we extend these results to cross-sections of the SOC. We show that a single convex inequality is sufficient to characterize the convex hull of all two-term disjunctions on ellipsoids and paraboloids and a wide class of two-term disjunctions -including split disjunctions- on hyperboloids.

■ FD13

13- Rivers

Randomized, Distributed, and Primal-Dual Methods II

Cluster: Nonsmooth Optimization

Invited Session

Chair: Peter Richtarik, Professor, University of Edinburgh, Peter Guthrie Tait Road, EH9 3FD, Edinburgh, EH9 3FD, United Kingdom, peter.richtarik@ed.ac.uk

1 - Distributed Optimization with Arbitrary Local Solvers

Jakub Konecny, University of Edinburgh, James Clerk Maxwell Building, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom, kubo.konecny@gmail.com

With the growth of data businesses collect, problems needed to be solved are not suitable for usual optimization techniques. When the data are large so that it cannot be stored on a single computer, communication between individual computers is a significant bottleneck. In this work we develop a general primal-dual framework for distributed optimization. We formulate different ways of formulating local subproblems, which are solved approximately on each computer independently, using an arbitrary optimization algorithm. We provide experiments that demonstrate the strength of the framework and possibility of using various local optimization algorithms.

2 - Randomized Dual Coordinate Ascent with Arbitrary Sampling

Zheng Qu, Dr., University of Edinburgh, James Clerk Maxwell Building, Peter Guthrie Tait Road, Edinburgh, EH9 3FD, United Kingdom, zheng.qu@ed.ac.uk

We study the problem of minimizing the average of a large number of smooth convex functions penalized with a strongly convex regularizer. We propose and analyze a novel primal-dual method (Quartz) which at every iteration samples and updates a random subset of the dual variables, chosen according to an arbitrary distribution. Depending on the choice of the sampling, we obtain efficient serial, parallel and distributed variants of the method. Our bounds match the best known bounds for SDCA in the serial case and with standard mini-batching predict data-independent speedup as well as additional data-driven speedup which depends on spectral and sparsity properties of the data.

3 - Convergence Analysis of Block-Coordinate Primal-Dual Algorithms with Arbitrary Random Sampling

Audrey Repetti, University of Paris-Est, 5, Boulevard Descartes, Champs sur Marne, Marne la Vallee Cedex 2, 77454, France, audrey.repetti@u-pem.fr, Jean-christophe Pesquet, Emilie Chouzenoux

In many application areas, one must solve minimization problems involving the sum of proper lower-semicontinuous convex functions composed with linear operators. Such problems can be efficiently solved using primal-dual proximal algorithms. When the number of variables is very large, it can be interesting to adopt a block-coordinate strategy in order to limit the occupied memory. In this work, we propose two subclasses of block-coordinate primal-dual algorithms based on the forward-backward iterative scheme. At each iteration, only a subpart of the variables, selected with an arbitrary random rule, is updated. The almost sure convergence of the iterates generated by the algorithms to a solution of the considered problem is proved.

■ FD16

16- Sterlings 1

Risk-Constrained Stochastic Programs

Cluster: Stochastic Optimization

Invited Session

Chair: James Luedtke, University of Wisconsin-Madison, 1513 University Ave, Madison, WI, 53706, United States of America, jrluedt1@wisc.edu

1 - Decomposition Algorithms for Two-Stage Chance-Constrained Programs

Xiao Liu, Ohio State University, 320 Baker Systems Building 1971 Neil Ave, Columbus, 43202, United States of America, liu.2738@buckeyemail.osu.edu, Simge Kucukyavuz, James Luedtke

We study a class of chance-constrained two-stage stochastic optimization problems where second-stage feasible recourse decisions incur additional cost. In addition, we propose a new model, where ``recovery” decisions are made for the infeasible scenarios to obtain feasible solutions to a relaxed second-stage problem. We develop decomposition algorithms with specialized optimality and feasibility cuts to solve this class of problems. Computational results on a chance-constrained resource planing problem indicate that our algorithms are highly effective in solving these problems compared to a mixed-integer programming reformulation and a naive decomposition method.

2 - Nonanticipative Duality, Relaxations, and Formulations for Chance-Constrained Stochastic Programs

Weijun Xie, Georgia Institute of Technology, School of ISYE, 755 Ferst Drive, NW, Atlanta, GA, 30332-0205, United States of America, wxie33@gatech.edu, Yongjia Song, Shabbir Ahmed, James Luedtke

We propose two new Lagrangian dual problems for chance-constrained stochastic programs based on relaxing nonanticipativity constraints. We compare the strengths of the associated dual bounds and derive two new related primal formulations. We demonstrate that for chance-constrained linear programs, the continuous relaxations of these primal formulations yield bounds equal to the proposed dual bounds. We propose a new heuristic method and two new exact algorithms based on these duals and formulations, and present computational evidence demonstrating their effectiveness.

3 - Cut Generation in Optimization Problems with Multivariate Risk Constraints

Nilay Noyan, Associate Professor, Sabanci University, Sabanci University, Istanbul, Turkey, nnoyan@sabanciuniv.edu, Simge Kucukyavuz

We consider a class of multicriteria stochastic optimization problems that features benchmarking constraints based on conditional value-at-risk and second-order stochastic dominance. We develop alternative mixed-integer programming formulations and solution methods for cut generation problems arising in optimization under such multivariate risk constraints. We give the complete linear description of two non-convex substructures appearing in these cut generation problems. We present computational results that show the effectiveness of our proposed models and methods.

■ FD17

17- Sterlings 2

New Multiobjective Optimization Methods

Cluster: Multi-Objective Optimization

Invited Session

Chair: Kenza Oufaska, International University of Rabat, ELIT, Technopolis Rabat-Shore Rocad, Rabat - Salé, Morocco, Kenza.oufaska@uir.ac.ma

1 - Output-Sensitive Complexity of Multiobjective Combinatorial Optimization Problems

Fritz Bökler, TU Dortmund, Otto-Hahn-Strasse 14, Dortmund, 44227, Germany, fritz.boekler@tu-dortmund.de, Petra Mutzel

In this talk, we study output-sensitive algorithms and complexity for multiobjective combinatorial optimization (MOCO) problems. We develop two methods for enumerating the extreme nondominated points of MOCO problems and prove their output-sensitive running time for each fixed number of objectives under weak assumptions on the MOCO problem. Further, we show the practicability of the algorithms. On the negative side, we show a few first results on the output sensitive complexity of multiobjective shortest path problems.

2 - A New Method for Multi-Objective Optimization

Kenza Oufaska, International University of Rabat, ELIT, Technopolis Rabat-Shore Rocad, Rabat - Salé, Morocco, Kenza.oufaska@uir.ac.ma, Khalid El Yassini

Optimization problems often have several conflicting objectives to be improved simultaneously. It is important to turn to a multi-objective (MO) type of optimization which offers all compromise solutions. In this work, we propose a new approach by using, iteratively, the e-constraint method to generate better bounds for all objective functions of the problem. Several approaches can contribute including the penalty method. Thereafter, we proceed to a transformation to a weighted single-objective problem with new constraints on the initial objectives.

■ FD18

18- Sterlings 3

Paths to Smoothing in Convex Optimization

Cluster: Nonlinear Programming

Invited Session

Chair: James Burke, Prof., University of Washington, Box 354350, Seattle, WA, 98195, United States of America, jvburke@uw.edu

1 - A New Class of Matrix Support Functionals with Applications

Tim Hoheisel, PostDoc, University of Würzburg, Campus Hubland Nord, Emil-Fischer-Strasse 30, Würzburg, 97074, Germany, hoheisel@mathematik.uni-wuerzburg.de, James Burke

A new class of matrix support functionals is presented which establish a connection between optimal value functions for quadratic optimization problems, the matrix-fractional function, the pseudo matrix-fractional function, the nuclear norm, and multi-task learning. The support function is based on the graph of the product of a matrix with its transpose. Closed form expressions for the support functional and its subdifferential are derived. In particular, the support functional is shown to be continuously differentiable on the interior of its domain, and a formula for the derivative is given when it exists.

2 - Iterative Re-Weighted Linear Least Squares for Exact Penalty Subproblems on Products Sets

Jiashan Wang, University of Washington, Box 354350, Seattle, WA, 98195, United States of America, jsw1119@uw.edu, James Burke, Frank E. Curtis, Hao Wang

We present two matrix-free methods for solving exact penalty subproblems on product sets that arise when solving large-scale optimization problems. The first approach is a novel iterative re-weighting algorithm (IRWA), which iteratively minimizes quadratic models of relaxed subproblems while automatically updating a relaxation vector. The second approach is based on alternating direction augmented Lagrangian (ADAL) technology applied to our setting. Global convergence and complexity are established for both algorithms.

3 - Level Sets Methods in Convex Optimization

James Burke, Professor, University of Washington, Box 354350, Seattle, WA, 98195, United States of America, jvburke@uw.edu, Alexandr Aravkin, Dmitriy Drusvyatskiy, Michael P. Friedlander, Scott Roy

We present an algorithmic framework for solving convex optimization problems by exchanging the the objective with one of the constraint functions. The approach has classical origins and is the basis for the SPGL1 algorithm of Van den Berg and Friedlander. In this talk we discuss a general framework for these methods, their complexity, and their numerical performance on a range of applications.

■ FD19

19- Ft. Pitt

Combinatorial Problems in Scheduling and Routing

Cluster: Logistics Traffic and Transportation

Invited Session

Chair: Daniele Catanzaro, Assistant Professor, Université Catholique de Louvain, Chaussée de Binche 151, bte M1.01.01, Mons, 7000, Belgium, daniele.catanzaro@uclouvain.be

1 - Multi-Vehicle Arc Routing Connectivity Problem (K-ARCP)

Vahid Akbarighadikolaei, PhD Candidate, Koc University, Rumelifeneri Yolu, Koc Univeristy, Sariyer, Istanbul, 34450, Turkey, vakbarighadkolaei@ku.edu.tr, Fatma Sibel Salman

We define an emergency road clearing problem with the goal of restoring network connectivity in the shortest time. Given a set of closed edges, teams positioned at depot nodes are dispatched to open a subset of them that reconnects the network. Closed roads are traversable only after they are cleared by one of the teams. The problem is to find efficient coordinated routes for the clearing teams that: 1) connectivity of the network is regained, and 2) none of the closed roads are traversed unless their unblocking/clearing procedure is finished. In this study we develop two exact mixed integer programming formulation to solve this problem. Furthermore, we propose a local search algorithm to improve heuristic methods used in the literature.

2 - Exact Solution Frameworks for the Consistent Traveling Salesman Problem

Anirudh Subramanyam, Graduate Student, Carnegie Mellon University, DH3122, 5000, Forbes Ave., Pittsburgh, PA, 15213, United States of America, asubramanyam@cmu.edu, Chrysanthos Gounaris

We present two exact approaches for the Consistent Traveling Salesman Problem (ConTSP), a routing problem in which arrival-time consistency across multiple periods is enforced for each customer. For our first approach, which is based on branch-and-cut, we compare alternative formulations and we propose a new class of cutting planes to enforce consistency dynamically. For our second approach, which is based on decomposing the ConTSP into a sequence of single-period TSPs with time windows, we enforce consistency implicitly by successively tightening the time windows during a branch-and-bound process with separable branching rules. We compare our two approaches on a set of benchmark instances derived from the TSPLIB.

3 - Improved Integer Linear Programming Formulations for the Job Sequencing and Tool Switching Problem

Daniele Catanzaro, Assistant Professor, Université Catholique de Louvain, Chaussée de Binche 151, bte M1.01.01, Mons, 7000, Belgium, daniele.catanzaro@uclouvain.be, Luis Neves Gouveia, Martine Labbé

We investigate the job Sequencing and tool Switching Problem (SSP), a NP-hard combinatorial optimization problem arising from computer and manufacturing systems. Starting from the results described in Tang and Denardo (1987), Crama et al. (1994) and Laporte et al. (2004), we develop new integer linear programming formulations for the problem that are provably better than the alternative ones currently described in the literature. Computational experiments show that the lower bound obtained by the linear relaxation of the considered formulations improve, on average, upon those currently described in the literature and suggest, at the same time, new directions for the development of future exact solution approaches.

■ FD20

20- Smithfield

Uncertainty Management in Healthcare

Cluster: Life Sciences and Healthcare

Invited Session

Chair: Omid Nohadani, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States of America, nohadani@northwestern.edu

1 - Reliable Facility Location Model for Disaster Response

Osman Ozaltin, North Carolina State University, Raleigh, NC, United States of America, oyozalti@ncsu.edu, Abdelhalim Hiassat, Fatih Safa Erenay

We formulate a reliable facility location model for disaster response, and consider the problem of staffing aid facilities with volunteers. Candidate facility locations might become unavailable after the disaster, and volunteers serve at available facilities based on their preferences. We decompose the problem into volunteer subproblems and propose a Lagrangian-based branch-and-bound method. Our computational results show the efficiency of the solution approach and the significance of incorporating volunteer preferences into the model.

2 - Robust Fractionation in Radiotherapy

Ali Ajdari, University of Washington, BOX 352650, Seattle, Wa, 98195, United States of America, ali.adr86@gmail.com, Archis Ghate

The optimal fractionation problem in radiotherapy involves finding the number of treatment sessions and the corresponding doses in each session. The linear-quadratic dose-response model is commonly used to formulate this problem. One criticism of this approach is that the parameters of this dose-response model are not known. We provide a robust optimization framework to tackle this uncertainty in fractionation problems.

3 - Robust Parameter Estimation for Multi-Objective Radiation Therapy Planning

Omid Nohadani, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208-3119, United States of America, nohadani@northwestern.edu, Arkajyoti Roy

Radiation therapy planning is an inverse problem. To guide this iterative process, institutional and standardized recommendations for planning and quality assurance are followed. In practice one or more goals cannot be satisfied, leading to trade-offs. We present the analysis of a large set of clinical cases, revealing sizable uncertainties in human decisions. For reliable observations, we present a framework for robust estimators. It is shown that the treatment planning process often inherently prevents the clinical goals to be concurrently satisfied. The results shed new insights on the multi-objective optimization methodology in the presence of uncertainties.

■ FD21

21-Birmingham

Models for Integration of Intermittent and Decentralized Energy

Cluster: Optimization in Energy Systems
Invited Session

Chair: Yves Smeers, Center for Operations Research and Econometrics, Voie du Roman Pays, 34, Louvain-la-Neuve, 1348, Belgium, yves.smeers@uclouvain.be

1 - Analyzing Unilateral Market Power in Two-Settlement Electricity Market

Mahir Sarfati, KTH Royal Institute of Technology, Electric Power Systems, Teknikringen 33, Stockholm, 10044, Sweden, sarfati@kth.se, Mohammad Reza Hesamzadeh

This paper studies single-dominant producer's bidding behavior in two-settlement electricity markets in the presence of wind power integration. The day-ahead market and the real-time market are formulated as two MPEC problems. One MPEC is solved at a time and the results are fed into the other MPEC iteratively. In each iteration, the total profit from both markets will improve until an equilibrium point is found. The numerical results show effectiveness of the developed model.

2 - Impact of Inter- and Intra-regional Coordination in Markets with a Large Renewable Component

Stefanos Delikaraoglou, PhD Candidate, Technical University of Denmark, Akademivej, Building 358, Kgs. Lyngby, 2800, Denmark, stde@elektro.dtu.dk, Juan Miguel Morales Gonzalez, Pierre Pinson

The uncertainty associated with the forecast errors of stochastic renewables calls for revised market designs to enable spatial and temporal integration of day-ahead and balancing trading floors. In the absence of a specific target model for the European balancing market, we introduce a framework to compare different inter- and intra-regional coordination schemes that may emerge towards a complete pan-European electricity market. The proposed models are formulated as stochastic equilibrium problems and compared against an optimal setup that achieves full spatio-temporal market coupling. The simulation results reveal significant efficiency loss in case of partial coordination and diversity of market structure among regional power systems.

3 - Effect of Ramping Requirement and Price Cap on Energy Price in a System with High Wind Penetration

Sebastian Martin, sebastian.ii05@gmail.com, Yves Smeers, Jose Aguado

The European power market is currently retiring or mothballing large capacities of conventional plants, and at the same time incorporating a significant amount of non-dispatchable renewable generation, in particular wind. We analyse the mothballing process (and the resulting system) and study how they are affected by a price cap implemented in the energy only market, and by a possible implementation of ramping products in the system.

■ FD22

22- Heinz

Mechanism Design without Money

Cluster: Game Theory
Invited Session

Chair: Vasilis Gkatzelis, Stanford University, 353 Serra Street, Stanford, CA, 94305, United States of America, gkatz@cs.stanford.edu

1 - Who to Trust for Truthfully Maximizing Welfare?

Dimitris Fotakis, Assistant Professor, National Technical University of Athens, Iroon Polytechneiou 9, Athens, 15780, Greece, fotakis@cs.ntua.gr, Christos Tzamos, Emmanouil Zampetakis

We introduce a general approach based on selective exact verification and obtain approximate mechanisms without money for maximizing the social welfare in general domains. Having a good allocation in mind, a mechanism with verification selects few critical agents and detects, using verification, whether they report truthfully. If yes, the mechanism produces the desired allocation. Otherwise, the mechanism ignores any misreports. We obtain randomized truthful mechanisms without money that verify only ln(m)/\eps agents, where m is the number of outcomes, and are (1-\eps)-approximate for the social welfare. A remarkable property of our mechanisms is robustness, namely that their outcome depends only on the reports of the truthful agents.

2 - One-Dimensional Strategyproof Facility Location

Itai Feigenbaum, Columbia University, United States of America, iif2103@columbia.edu, Jay Sethuraman, Chun Ye

Consider a set of agents on an interval, where a planner wishes to locate a facility so as to maximize some social benefit function. The agents have linear preferences over the location of the facility, and their locations are unknown to the planner. Thus, the planner wishes to locate the facility in a strategyproof manner while approximating social benefit. We discuss mechanisms, lower bounds, and characterizations for various versions of this model.

3 - Truthful Mechanisms for Generalized Assignments

Nick Gravin, PostDoc, Microsoft Research New England, One Memorial Drive, Cambridge, Ma, 02142, United States of America, ngravin@microsoft.com, Ning Chen, Pinyan Lu

A set of jobs is to be assigned to a set of machines with given capacity constraints. In the generalized assignment problem every job-machine pair has a specific value and specific capacity for the assignment. The goal is to find an assignment that maximizes the sum of values under machine capacity constraints. [Dughmi and Ghosh '10] proposed a mechanism design framework in which jobs behave selfishly, each aiming to maximize its own value in the assignment. We give a poly-time algorithm that achieves constant approximation to the optimal assignment and satisfies necessary incentive requirements.

■ FD23

23- Allegheny

Finding Subgraphs

Cluster: Combinatorial Optimization
Invited Session

Chair: Bernard Knueven, University of Tennessee, 504 John D. Tickle Building, 851 Neyland Drive, Knoxville, TN, 37996, United States of America, bknueven@vols.utk.edu

1 - Maximal Induced k-regular Subgraphs

Torkel Andreas Haufmann, University of Oslo, Department of Mathematics, N. H. Abels Hus, Moltke Moes vei 35, Oslo, 0851, Norway, torkelah@math.uio.no, Agostinho Agra, Geir Dahl, Sofia Pinheiro

An induced k-regular subgraph is a graph induced by a subset of the vertices, such that each vertex has degree k in the induced graph. We consider the problem of finding the largest cardinality subset of vertices inducing a k-regular subgraph. This covers the problems of finding maximal independent sets, induced matchings, minimum-length cycles and maximal cliques. This problem is known to be NP-hard in general. A review of existing bounds relating to the adjacency matrix and the (signless) Laplacians is given, and some computational and theoretical results are presented for an integer linear programming formulation. Furthermore, some results on a tractable special case are given: When k = 1 and the graph is a tree.

2 - Almost Symmetries in Graphs

Bernard Knueven, University of Tennessee, 504 John D. Tickle Building, 851 Neyland Drive, Knoxville, TN, 37996, United States of America, bknueven@vols.utk.edu, Sebastian Pokutta, Jim Ostrowski

This work addresses the following question. Given an arbitrary graph, G, and a budget, k, find a subgraph of G formed by removing at most k edges that contains the most symmetry. If such a subgraph contains non-trivial symmetries, we call the symmetries "almost symmetries". We discuss how to find such symmetries and the effect these have on solving combinatorial optimization problems.

3 - Packing Non-zero A-paths via Matroid Matching

Yutaro Yamaguchi, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan, yutaro_yamaguchi@mist.i.u-tokyo.ac.jp, Shin-ichi Tanigawa

A group-labeled graph is a directed graph in which each edge is associated with an element of a group. For a vertex subset A, a path is called a non-zero A-path if it starts and ends in A and the ordered product of the labels along it is not the identity. We show that the problem of packing non-zero A-paths reduces to the matroid matching problem, and discuss the efficient solvability via such a reduction.

■ FD24

24- Benedum

Convex Relaxations of Mixed-Integer Quadratic Programming Problems

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Juan Pablo Vielma, MIT, 100 Main Street, E62-561, Cambridge, MA, 02142, United States of America, jvielma@mit.edu

1 - Polyhedral Relaxations for Discrete Product Terms in Nonconvex 0/1 MINLPs

Akshay Gupte, Clemson University, Department of Mathematical Sciences, Clemson, SC, 29634, United States of America, agupte@clemson.edu, Shabbir Ahmed, Santanu Dey

We study polyhedral relaxations in the original space for constraints defined by sum of product of continuous variable and monotone function of 0/1 variables. This substructure appears frequently in nonconvex 0/1 MIQCPs and more general MINLPs. We exploit the supermodular structure in this set and devise a cut generation scheme. Under certain assumptions, the convex hull is described explicitly by tilting appropriate inequalities. We also discuss aggregation of valid inequalities.

2 - Convex Hull of Two Quadratic or a Conic Quadratic and a Quadratic Inequality

Sina Modaresi, PhD Student, University of Pittsburgh, 1048 Benedum Hall, Pittsburgh, PA, 15261, United States of America, sim23@pitt.edu, Juan Pablo Vielma

We consider an aggregation technique introduced by Yildiran [2009] to study the convex hull of regions defined by two quadratic or by a conic quadratic and a quadratic inequality. Yildiran shows how to characterize the convex hull of sets defined by two quadratics using Linear Matrix Inequalities (LMI). We show how this aggregation technique can be easily extended to yield valid conic quadratic inequalities for the convex hull of sets defined by two quadratic or by a conic quadratic and a quadratic inequality. We also show that in many cases, these valid inequalities characterize the convex hull exactly.

3 - Learning in Combinatorial Optimization: How and What to Explore

Denis Saure, Universidad de Chile, Republica 701, Santiago, Chile, dsaure@dii.uchile.cl, Sajad Modaresi, Juan Pablo Vielma

We study sequential combinatorial optimization under model uncertainty. We show that for balancing the implied exploration vs exploitation trade-off it is critical to resolve the issue of what information to collect and how to do so. Our answer to these questions lies in solving an adjunct formulation, which looks for the cheapest solution-based optimality guarantee. We develop fundamental limit on performance, and develop an efficient policy implementable in real-time.

■ FD29

29- Commonwealth 1

MINLP: Theory and Applications

Cluster: Mixed-Integer Nonlinear Programming

Invited Session

Chair: Carsten Schaefer, TU Darmstadt, Dolivostrafle 15, Darmstadt, 64293, Germany, cschaefer@mathematik.tu-darmstadt.de

1 - Optimal Actuator Placement for Dynamical Systems

Carsten Schaefer, TU Darmstadt, Dolivostrafle 15, Darmstadt, 64293, Germany, cschaefer@mathematik.tu-darmstadt.de, Stefan Ulbrich

Vibrations occur in many areas of industry and produce undesirable side effects. To avoid or suppress these effects, actuators are attached to the structure. The appropriate positioning of actuators is of significant importance for the controllability of the structure. Using controllability measures, a method for determining the optimal actuator placement is presented, which leads to an optimization problem with binary and continuous variables and linear matrix inequalities. Numerical results show the optimal actuator placement for a truss structure.

2 - On a Novel Versatile Trust-Tech Based Methodology for Nonlinear Integer Programming

Hsiao-Dong Chiang, Professor, School of Electrical and Computer Engineering, 328 Rhodes Hall, Cornell University, Ithaca, NY, 14853, United States of America, chiang@ece.cornell.edu, Tao Wang

We propose a new methodology to guide numerical methods and solvers for nonlinear integer programming and improve the solution quality by adopting the Transformation Under Stability-reTraining Equilibrium Characterization (Trust-Tech) method. The effectiveness is examined by simulating the popular and state-of-the-art methods/solvers (Branch-and-Bound, GAMS/BARON, GAMS/SCIP, LINDO/MINLP, EA-based methods) and those guided by the proposed methodology. Simulation results show that global search capability, solution quality and consistency are considerably improved, and the global-optimal solutions are usually obtained, after applying the methodology. When properly integrated, it also can lead to substantial reduction of computing time.

3 - Error Bounds for Nonlinear Granular Optimization Problems

Oliver Stein, Karlsruhe Institute of Technology (KIT), Institute of Operations Research, Kaiserstr. 12, Karlsruhe, 76131, Germany, stein@kit.edu

We study a-priori and a-posteriori error bounds for optimality and feasibility of a point generated as the rounding of an optimal point of the relaxation of a mixed integer convex optimization problem. Treating the mesh size of integer vectors as a parameter allows us to study the effect of different `granularities' in the discrete variables on the error bounds. Our analysis mainly bases on the construction of a so-called grid relaxation retract. Relations to proximity results and the integer rounding property in the linear case are highlighted.

■ FD30

30- Commonwealth 2

Approximation and Online Algorithms XIV

Cluster: Approximation and Online Algorithms

Invited Session

Chair: R. Ravi, Professor, Tepper School of Business - Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States of America, ravi@cmu.edu

1 - The a Priori Traveling Repairman Problem

Martijn van Ee, PhD Student, VU University Amsterdam, De Boelelaan 1105, Amsterdam, 1081 HV, Netherlands, m.van.ee@vu.nl, René Sitters

The field of a priori optimization is an interesting subfield of stochastic combinatorial optimization that is well suited for routing problems. In this setting, one has to construct a tour in the first stage and there is a probability distribution over active sets, which are vertices to be visited in the second stage. For a fixed first-stage tour, the second-stage tour on an active set is obtained by restricting the tour to this set. In the a priori traveling repairman problem, the goal is to find a tour that minimizes the expected sum of latencies of the second-stage tour. The latency of a vertex is the distance traveled from the root to the vertex along the tour. Here, we present the first constant factor approximation for this problem.

2 - Improved Approximations for Cubic and Cubic Bipartite Graph-TSP

Anke van Zuylen, College of William and Mary, 200 Ukrop Way, Mathematics Department, Williamsburg, VA, 23185, United States of America, anke@wm.edu

We show improved approximation guarantees for the traveling salesman problem on graph metrics where the graph is cubic or cubic and bipartite. For cubic bipartite graphs with n nodes, we improve on recent results of Karp and Ravi (2014) by giving a much simpler algorithm that finds a tour of length at most $5/4n-2$. For cubic graphs, we show that the techniques of M\"omke and Svensson (2011) can be combined with the techniques of Correa, Larr\'e and Soto (2012), to obtain a tour of length at most $(4/3-1/8754)n$.

3 - Improved Approximations for Graph-TSP in Regular Graphs

R. Ravi, Professor, Tepper School of Business - Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States of America, ravi@cmu.edu, Alantha Newman, Satoru Iwata, Jeremy Karp

A tour in a graph is a connected walk that visits every vertex at least once, and returns to the starting vertex. We give improved approximation results for a tour with the minimum number of edges in regular graphs.

Friday, 4:35pm - 5:25pm

■ FE01

01- Grand 1

Mathematical Optimization for Packing Problems

Cluster: Plenary

Invited Session

Chair: R. Ravi, Professor, Tepper School of Business - Carnegie Mellon University, Carnegie Mellon University, Pittsburgh, PA, 15213, United States of America, ravi@cmu.edu

1 - Mathematical Optimization for Packing Problems

Frank Vallentin, University of Koeln, Koehn, Germany, frank.vallentin@uni-koeln.de

How densely can one pack given objects into a given container? Such packing problems are fundamental problems in geometric optimization. Next to being classical mathematical challenges there are many applications in diverse areas such as information theory, materials science, physics, logistics, approximation theory. Studying packing problems one is facing two basic tasks: Constructions: How to construct packings which are conjecturally optimal? Obstructions: How to prove that a given packing is indeed optimal? For the first basic task researchers in mathematics and engineering found many heuristics which often work well in practice. In the talk I want explain computational tools for the second basic task. These tools are a blend of tools coming from infinite-dimensional semidefinite optimization and harmonic analysis, together with computational techniques coming from real algebraic geometry and polynomial optimization. I will report on computational results, which are frequently the best-known.

■ FE02

02- Grand 2

Recent Advances in Trust-Region Algorithms

Cluster: Plenary

Invited Session

Chair: Xiaojun Chen, Professor, The Hong Kong Polytechnic University, Department of Applied Mathematics, The Hong Kong Polytechnic University, Hong Kong, China, xiaojun.chen@polyu.edu.hk

1 - Recent Advances in Trust-Region Algorithms

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Trust-region methods are a class of numerical methods for optimization. Unlike line search type methods where a line search is carried out in each iteration, trust-region methods compute a trial step by solving a trust-region subproblem where a model function is minimized within a trust region. Due to the trust-region constraint, nonconvex models can be used in trust-region subproblems, and trust-region algorithms can be applied to nonconvex and ill-conditioned problems. Normally it is easier to establish the global convergence of a trust-region algorithm than that of its line search counterpart. In the paper, we review recent results on trust-region methods for unconstrained optimization, constrained optimization, nonlinear equations and nonlinear least squares, nonsmooth optimization and optimization without derivatives. Results on trust-region subproblems and regularization methods are also discussed.