Wednesday, 10:30am - 12:00pm

■ WA01

Marriott - Chicago A

On the Approximability of Scheduling and Resource Allocation Problems

Cluster: Approximation Algorithms
Invited Session

Chair: Andreas Schulz, Massachusetts Institute of Technology, E53-357, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, schulz@mit.edu

1 - (Acyclic) Job Shops Are Hard to Approximate

Monaldo Mastrolilli, IDSIA, Galleria 2, Manno, Switzerland, monaldo@idsia.ch, Ola Svensson

We consider the approximability of the notorious job and flow shop scheduling problems. We close a major open problem in scheduling theory by providing stronger inapproximability results for job shops and for the general version of flow shops, where jobs are not required to be processed on each machine.

2 - (Almost Always) Near-optimal Solutions for Single-machine Precedence-constrained Scheduling

Nelson Uhan, Assistant Professor, Purdue University, 315 N. Grant Street, Grissom Hall 262, West Lafayette, IN, 47907, United States of America, nuhan@purdue.edu, Andreas Schulz

We study the classic single-machine precedence-constrained scheduling problem with the weighted sum of completion times objective. In particular, we study so-called 0-1 bipartite instances of this problem, whose approximability is virtually identical to the approximability of arbitrary instances (Woeginger 2003). We show various “almost all”-type results for these instances, including that almost always, all feasible schedules are arbitrarily close to optimal.

3 - An FPTAS for the Santa Claus Problem with a Fixed Number of Agents and Related Problems

Shashi Mittal, Massachusetts Institute of Technology, E40-131 Operations Research Center, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, mshashi@MIT.EDU, Andreas Schulz

We present a novel framework for designing fully polynomial-time approximation schemes for a wide variety of resource allocation, scheduling and other combinatorial optimization problems, including the Santa Claus problem with a fixed number of agents.

■ WA02

Marriott - Chicago B

Linear Programs with Complementarity Constraints: Applications and Algorithms

Cluster: Complementarity Problems and Variational Inequalities
Invited Session

Chair: John Mitchell, Professor, Rensselaer Polytechnic Institute, Math Sciences, 325 Amos Eaton, 110 8th St, Troy, NY, 12180, United States of America, mitchj@rpi.edu

1 - Finding a Global Optimum In Cross-validated Support Vector Machine

Yu-Ching Lee, IESE, Univ. of Illinois at Urbana-Champaign, 117 Transportation Bldg., 104 S. Mathews, Urbana, IL, 61801, United States of America, ylee77@illinois.edu, Kristin Bennett, John Mitchell, Jong-Shi Pang

Formulated as a convex quadratic program with 2 key parameters (the regularization parameter and the tube size), the cross-validated support vector machine (SVM) is a well-known statistical method for data classification and regression. We investigate the optimal choice of these 2-parameters via a bilevel programming approach applied in a set of training data and the testing data. Various approaches for finding a global minimum of this non-convex bilevel program are discussed.

2 - A Disjunctive Programming Approach to LPCC

Bin Yu, Graduate Student, Rensselaer Polytechnic Institute, CII 5015, 110 Eighth Street,, Troy, NY, 12180, United States of America, yub@rpi.edu, Jing Hu, John Mitchell, Jong-Shi Pang

A linear program with complementarity constraints (LPCC) can be modeled as a disjunctive program. By imposing one pair of disjunctive constraints at a time, we are able to use a cut generating LP to generate a disjunctive cut for the LPCC problem. We present a branch and cut algorithm to globally solve the LPCC problem, where the cutting planes are disjunctive cuts. The algorithm is able to characterize infeasible and unbounded LPCC problems as well as solve problems with finite optimal value.

3 - An LPCC Approach to Indefinite Quadratic Programs

John Mitchell, Professor, Rensselaer Polytechnic Institute, Math Sciences, 325 Amos Eaton, 110 8th St, Troy, NY, 12180, United States of America, mitchj@rpi.edu, Jing Hu, Jong-Shi Pang

The best KKT point for a quadratic program (QP) can be found by solving a linear program with complementarity constraints (LPCC). We show that determining whether a QP has a finite optimal value can also be resolved using an LPCC formulation. We describe cuts based on second order optimality conditions that can be used to tighten the LPCC formulation. We exploit the second order cuts to show that certain classes of nonconvex quadratic programs can be solved in polynomial time.

■ WA03

Marriott - Chicago C

Conic Complementarity Problems II

Cluster: Complementarity Problems and Variational Inequalities
Invited Session

Chair: Akiko Yoshise, University of Tsukuba, Graduate School of, Systems and Information Engineering, Tsukuba Ibaraki, 305-8573, Japan, yoshise@sk.tsukuba.ac.jp

1 - A Continuation Method for Nonlinear Complementarity Problems over Symmetric Cone

Chek Beng Chua, Assistant Professor, Nanyang Technological Univerity, Sch of Phy & Math Sci / Div of Math Sci, 21 Nanyang Link, Singapore, 637371, Singapore, cbchua@ntu.edu.sg, Peng Yi

We introduce a new P-type property for nonlinear functions defined over Euclidean Jordan algebras, and study a continuation method for nonlinear complementarity problems over symmetric cones. This new P-type property represents a new class of nonmonotone nonlinear complementarity problems that can be solved numerically.

2 - Homogeneous Cone Complementarity Problems and P Properties

Lingchen Kong, University of Waterloo, 200 University Avenue West, Waterloo, ON, N2L 3G1, Canada, konglchen@126.com, Levent Tuncel, Naihua Xiu

This talk aims to present existence and uniqueness properties of a solution to homogeneous cone complementarity problem (HCCP). We prove that if a continuous function has either the order-P0 and R0, or the P0 and R0 properties then the associated HCCPs have solutions. If it has the trace-P property then the associated HCCP has a unique solution. A necessary condition for the GUS property is presented. We give some applications about our results.

3 - On Interior Point Trajectories for Conic Complementarity Problems

Akiko Yoshise, University of Tsukuba, Graduate School of, Systems and Information Engineering, Tsukuba Ibaraki, 305-8573, Japan, yoshise@sk.tsukuba.ac.jp

We will discuss some theoretical aspects of a class of complementarity problems over symmetric cones in terms of interior point maps, interior point trajectories and their limiting behavior. The class includes monotone complementarity problems over nonnegative orthants, second-order cones and semideinite matrix cones.

■ WA04

Marriott - Denver

Combinatorial Optimization D

Contributed Session

Chair: Yazgi Tutuncu, Doctor, IESEG School of Management, 3 Rue de la Digue, Lille, France, y.tutuncu@ieseg.fr

1 - An Exact Algorithm for the Pickup and Delivery Problem with Time Windows

Enrico Bartolini, Department of Computer Science, University of Bologna, Via Sacchi 3, Cesena, FC, 47521, Italy, ebartoli@cs.unibo.it, Aristide Mingozzi, Roberto Baldacci

We present an exact method for the Pickup and Delivery Problem with Time Windows (PDPTW) based on a set partitioning-like formulation with additional cuts. The algorithm uses column-and-cut generation to compute a dual solution that is used to generate a reduced integer problem. If it has moderate size, it is solved using CPLEX; otherwise, it is solved by branch-and-cut-and-price. Computational results on benchmark instances show that the new method outperforms the currently best known method.

2 - An Exact Method for the Double TSP with Multiple Stacks

Richard Lusby, Technical University of Denmark, Department of Management Engineering, Lyngby, 2800, Denmark, rmlu@man.dtu.dk, Jesper Larsen, Matthias Ehrgott, David Ryan

The double travelling salesman problem with multiple stacks is a pickup and delivery problem in which all pickups must be completed before any deliveries can be made. A solution consists of two tours and a stacking plan for the container (which cannot be re-packed) that is used for the delivery. We present an exact solution method based on matching k-best TSP solutions for each of the separate pickup and delivery TSP problems. Computational results confirm the efficiency of this methodology.

3 - Optimization Approaches to Bed Capacity Planning Problem in Hospital Management

Yazgi Tutuncu, Doctor, IESEG School of Management, 3 Rue de la Digue, Lille, France, y.tutuncu@ieseg.fr, Ceki Franko, Femin Yalcin, Murat Ozkut

Bed capacity planning is an important management subject for hospitals that should be considered in order to satisfy the needs of patients,organize departments and improve the service quality.In this study, an application of the bed capacity planning problem is presented and different types of solution techniques such as branch-and-bound method, M/M/s algorithm, and Genetic Algorithm are proposed.The comparison of these techniques has been given to illustrate the efficiencies of these methods.

■ WA05

Marriott - Houston

Combinatorial Optimization S

Contributed Session

Chair: Myoung-Ju Park, Seoul National University, San 56-1 Shilim-Dong, Kwanahk Gu, Seoul, 151-742, Korea, Republic of, pmj0684@snu.ac.kr

1 - Unmanned Aerial Vehicle Routing with Limited Risk

Siriwat Visoldilokpun, Kasikorn Bank, 1 Soi. Kasikornthai, Radburana Rd., Bangkok, 10140, Thailand, siriwatvi@yahoo.com, Dr. Jay Rosenberger

We study Unmanned Aerial Vehicle routing problem with limited risk (URPR) in which considered risk is a fuel burn variation. The URPR is modeled as a set-partitioning problem with a quadratic variance constraint. However the quadratic constraint is simplified to a single linear constraint. We discuss URPR with time windows (URPRTW) and URPR without time windows (URPR) and present algorithms in Branch-and-Cut-and-Price (BCP) methodology in which variables with negative reduced costs are generated and added in the pricing step, and minimum dependent set (MDS) constraints are generated in the cutting step to encourage solution‚Äôs integrality. Computational experiments show that medium-sized URPRTWs and small-sized URPRs were solved optimally.

2 - An Exact Method for the Minimum Caterpillar Spanning Problem

Luidi Simonetti, Institute of Computing (IC) - University of Campinas (UNICAMP), Caixa Postal 6176, Campinas, SP, 13083-970, Brazil, luidi@ic.unicamp.br, Cid de Souza, Yuri Frota

A spanning caterpillar in a graph is a tree which has a path such that all vertices not in the path are leaves. In the Minimum Spanning Caterpillar Problem (MSCP) each edge has two costs: a path cost when it belongs to the path and a connection cost when it is incident to a leaf. The goal is to find a spanning caterpillar minimizing the sum of all path and connection costs. Here we formulate the MSCP as a minimum Steiner arborescence problem. This reduction is the basis for the development of an efficient branch-and-cut algorithm for the MSCP. Computational experiments carried out on modified instances from TSPLib 2.1 revealed that the new method is capable to solve to optimality MSCP instances with up to 300 nodes in reasonable time.

3 - Approximation Algorithm for the Capacitated Set Cover Problem

Myoung-Ju Park, Seoul National University, San 56-1 Shilim-Dong, Kwanahk Gu, Seoul, 151-742, Korea, Republic of, pmj0684@snu.ac.kr, Yun-Hong Min, Sung-Pil Hong

The capacitated set cover problem consists of a set of items and a collection of sets of items. Each item has a demand which can be split into sets that contain it. Each set cannot receive a total demand exceeding its capacity. The goal is to find a minimum size set cover. When the maximum size of sets, k, is fixed, we suggest a (1/2+H_k)-approximation algorithm where H_k=1+1/2+...+1/k. For the case k=2, we show that the problem is Max-SNP-hard and develop a 3/2-approximation algorithm.

■ WA06

Marriott - Kansas City

Computational Game Theory

Cluster: Conic Programming

Invited Session

Chair: Javier Pena, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jfp@andrew.cmu.edu

1 - Constructing “Nice” Prox Functions for Sets Arising from a Class of Multistage Optimization Problems

Samid Hoda, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, shoda@andrew.cmu.edu, Andrew Gilpin, Javier Pena

A nice prox function for a convex set is any strongly convex function over the set with an easily computable conjugate. We present a procedure for constructing nice prox functions for polytopes arising from a class of multistage optimization problems. Certain parameters in the construction directly affect the quality of the prox function for use in first-order smoothing methods. We show how to set the parameters to achieve practical iteration complexities when solving very large-scale problems.

2 - On the Computation of Nash Equilibria of Sequential Games

Javier Pena, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jfp@andrew.cmu.edu, Tuomas Sandholm, Samid Hoda, Andrew Gilpin

We describe specialized algorithms for saddle-point problems arising in the Nash equilibrium of two-person, zero-sum sequential games. For sequential games with multiple rounds, the saddle-point formulations are immense but highly structured. By taking advantage of key structural features, our algorithms achieve unmatched computational performance as well as strong theoretical complexity results.

3 - Automated Abstraction and Equilibrium-finding Algorithms for Sequential Imperfect Information Games

Andrew Gilpin, gilpin@cs.cmu.edu, Javier Pena, Samid Hoda, Tuomas Sandholm

I will discuss three abstraction classes for sequential imperfect information games: information abstraction, action abstraction, and stage abstraction. In the context of poker, I will describe how our abstraction algorithms, in conjunction with our specialized equilibrium-finding algorithms based on non-smooth convex optimization and sampling, successfully created competitive game theory-based agents.

■ WA07

Marriott - Chicago D

Integer and Mixed Integer Programming D

Contributed Session

Chair: H.Paul Williams, Professor, London School of Economics, Houghton Street, London, WC2A2AE, United Kingdom, h.p.williams@lse.ac.uk

1 - Engagement Planning in Sequence Dependant Cost Structures

Kristian Lundberg, Linkoping University, Olaus Magnus, Linkoping, Sweden, krlun@mai.liu.se

Sequence dependant cost structures(SDCS) covers a very complex combinatorial problem related to sequencing and allocation problems, such as VRP and multiple TSP. However SDCS also covers mutual and cooperative dependencies between nodes. This functionality is implemented in the cost structure. The presentation will focus on suitable solving methods such as decomposition techniques. Related applications to the SDCS problem can be found in planning of military and civil security operations.

2 - The Chvatal Dual of a Pure Integer Programme

H.Paul Williams, Professor, London School of Economics, Houghton Street, London, WC2A2AE, United Kingdom, h.p.williams@lse.ac.uk

We give a graphical way of representing Chvatal functions. Also we will show some limited ways in which they can be simplified by removing unnecessary rounding operations. A method of calculating Chvatal functions for an IP over acone will be given. Finally it will be shown that when the rounding operations are removed from a Chvatal function it may correspond to extreme or interior points of the dual LP polytope.

■ WA08

Marriott - Chicago E

Trends in Mixed Integer Programming VI

Cluster: Integer and Mixed Integer Programming

Invited Session

Chair: Robert Weismantel, Professor, Otto-von-Guericke University Magdeburg, Institute for Mathematical Optimization, Universitaetsplatz 2, Magdeburg, 39106, Germany, weismant@mail.math.uni-magdeburg.de

Co-Chair: Andrea Lodi, DEIS, University of Bologna, Viale Risorgimento, 2, Bologna, 40136, Italy, andrea.lodi@unibo.it

1 - Grammar-based Integer Programing Models for Multi-activity Shift Scheduling

Louis-Martin Rousseau, Professor, Ecole Polytechnique de Montreal, CP 6079 Succ Centre-Ville, Montreal, H3C 3A7, Canada, louis-martin.rousseau@polymtl.ca, Bernard Gendron, Marie-Claude Cote

This paper presents an implicit formulation for shift scheduling problems, using context-free grammars to model restrictions in the planning of shifts. From the grammar, we generate an IP model allowing the same set of shifts as Dantzig's set covering model. While solving times on small instances are comparable to other implicit compact models in the literature, on instances where a lot of shifts is allowed, our method is more efficient and can encode a larger set of constraints. Among others, work stretch restrictions as well as multi-activity cases can easily be modeled with grammars. We present comparative experimental results on a both known and new shift scheduling problems.

2 - Core Concepts for Multidimensional Knapsack Problems

Ulrich Pferschy, Professor, University of Graz, Dept. of Statistics and Operations Research, Universitaetsstr. 15, Graz, 8010, Austria, pferschy@uni-graz.at, Jakob Puchinger, Guenther Raidl, Martin Nussbaumer

A classical approach for the 0-1 knapsack problem identifies items with high efficiency and packs them into the knapsack, while leaving items with low efficiency unpacked. A relatively small core problem remains to be solved consisting of items with intermediate efficiency and a residual knapsack capacity. We study the core concept for the multidimensional knapsack problem and discuss the choice of the efficiency measure, the influence of different core sizes and the behavior of CPLEX and an evolutionary algorithm for solving the core problem. We also present a so-called squeaky wheel heuristic which turns out to be quite effective in complementing a core constructed by classical efficiencies. Extensive experiments will be summarized.

3 - Using Lagrangean Relaxation of Resource Constraints for Open Pit Mining Production Scheduling

Ambros Gleixner, Zuse-Institute Berlin, Takustr. 7, Berlin, 14195, Germany, gleixner@zib.de

We consider a recent mixed-integer programming formulation for the Open Pit Mining Production Scheduling Problem with block processing selectivity and study its properties. We demonstrate the use of Lagrangean relaxation of the resource constraints in several ways: rapid computation of dual bounds provably as strong as given by the linear programming relaxation, determining approximate cutoff grades and effective primal heuristics.

■ WA09

Marriott - Chicago F

California Integer Programming

Cluster: Integer and Mixed Integer Programming

Invited Session

Chair: Jon Lee, IBM TJ Watson Research Center, P.O. Box 218, Yorktown Heights, NY, 10598, United States of America, jonlee@us.ibm.com

1 - Large-scale Linear Algebra Relaxations of Combinatorial Problems

Peter Malkin, Postdoctoral Researcher, UC Davis, One Shields Avenue, Davis, CA, 95616, United States of America, malkin@math.ucdavis.edu, Jesus De Loera, Pablo A. Parrilo

We discuss techniques to create large-scale linear algebra relaxations of a combinatorial problem using Border bases of systems polynomial equations that encode the combinatorial problem. By solving these relaxations we can determine the feasibility of combinatorial problems and find feasible solutions. Both computational and theoretical results can be obtained with this method. We report on theoretical and computational results of applying this approach to graph vertex colorability.

2 - The Summation Method for Integer and Continuous Optimization

Matthias Koeppe, Professor, UC Davis, One Shields Avenue, Davis, CA, 95616, United States of America, mkoeppe@math.ucdavis.edu, Velleda Baldoni, Nicole Berline, Jesus De Loera, Michele Vergne

By viewing the maximum of a function as the limit of certain sums or integrals, efficient summation / integration procedures yield approximation algorithms for optimization problems. We study exact integration procedures for polynomial functions. Via Euler-Maclaurin formulas, these are useful also in the integer setting. The methods are related to Brion's formulas, Barvinok's exponential sums, and to the polynomial Waring problem (polynomials as sums of few linear forms).

3 - Estimation of the Number of Solutions for Integer Programs via Convex Optimization

Jesus De Loera, Professor, University of California-Davis, Dept of Mathematics, One Shields Avenue, Davis, CA, 95616, United States of America, deloera@math.ucdavis.edu

Counting or estimating lattice points inside polyhedra has applications in Discrete Optimization. Recently Barvinok and Hartigan outlined theorems estimating the number of lattice points or 0-1 points inside a polyhedron. These predictions do not need to prior knowledge about integer feasibility. I report on the experimental performance of two estimation algorithms. Our test sets included Knapsacks, multiway transportation problems, Market split problems, and b-matching problems from various dimensions.

■ WA10

Marriott - Chicago G

Optimization Under Uncertainty and Applications

Cluster: Global Optimization

Invited Session

Chair: Cole Smith, The University of Florida, Industrial and Systems Engineering, P.O. Box 116595, Gainesville, FL, 32611, cole@ise.ufl.edu

1 - Connectivity and Flow Problems on Networks under Uncertainty and Robustness Considerations

Vladimir Boginski, Professor, University of Florida / REEF, boginski@reef.ufl.edu

We consider some issues of network reliability in terms of connectivity and flows. We use several characteristics of network robustness, as well as incorporate quantitative risk measures into the corresponding mathematical programming formulations.

2 - The Stochastic Lot-sizing Problems with Deterministic Demands and Wagner-Within Costs

Zhili Zhou, University of Florida, Industrial and Systems Engineering, Gainesville, FL, 32611, United States of America, zhilizhou@ou.edu, Yongpei Guan

In this paper, we consider stochastic lot-sizing problems with deterministic demands and Wagner-Within costs. We examine properties for the optimal inventory and backlogging levels and provide extended formulations. In our formulations, the integral polyhedra can be described by linear inequalities. These formulations can solve the single-item uncapacitated case (SULS) and the single-item uncapacitated case with backlogging (SULSB) respectively, regardless of the scenario tree structure.

3 - Expectation and Chance-constrained Models and Algorithms for Insuring Critical Paths

Siqian Shen, University of Florida, Industrial and Systems Engineering, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611, sshen@ufl.edu, Shabbir Ahmed, Cole Smith

We consider a class of two-stage stochastic optimization problems arising in the protection of vital arcs in a critical path network. We provide decomposition strategies to solve this problem with respect to either convex or nonconvex penalties, and employ RLT to remodel the problem to be amenable to solution via Benders decomposition. We also propose an algorithm for a chance-constrained formulation. We employ SAA for scenario generation and demonstrate the computational efficacy.

■ WA11

Marriott - Chicago H

Global Optimization B

Contributed Session

Chair: Oleksii Ursulenko, Texas A&M University, 241 Zachry, 3131 TAMU, College Station, TX, 77843-3131, United States of America, ursul@tamu.edu

1 - A Fast Algorithm for Solving the Minimum Maximal Problem

Sukwon Chung, Stanford, 450 Serra Mall, Stanford, CA, 94305, United States of America, sukwonchung@stanford.edu, Jianming Shi, Wenjie Chen

A flow x on a network is said to be maximal if there does not exist another y on the network such that y is elementwise equal to or greater than x, but x is not equal to y. We consider the problem of minimizing the flow value on the maximal flow set of a connected network. This problem is formulated as a minimization of a linear function over a nonconvex efficient set. We propose an algorithm using methods that differ from existing ones to find an epsilon-optimal solution.

2 - An Improved Column Generation Algorithm for Minimum Sum-of-squares Clustering

Daniel Aloise, PhD Candidate, Ecole Polytechnique de Montreal, C.P. 6079, Succ. Centre-Ville, Montreal, H3C 3A7, Canada, daniel.aloise@gerad.ca, Pierre Hansen, Leo Liberti

Given a set of entities associated with points in Euclidean space, minimum sum-of-squares clustering (MSSC) consists in partitioning this set into clusters such that the sum of squared distances from each point to the centroid of its cluster is minimized. A column generation algorithm for MSSC was given by du Merle, Hansen, Jaumard and Mladenovic in SIAM J. Sci. Comput. 21, 1485-1505, 2000. The bottleneck of that algorithm is the solution of the auxiliary problem of finding a column with negative reduced cost. We propose a new way to solve this auxiliary problem based on geometric arguments. This greatly improves the efficiency of the whole algorithm and leads to exact solution of instances 10 times larger than previously done.

3 - Solving Sum of Ratios Fractional Combinatorial Optimization Problems

Oleksii Ursulenko, Texas A&M University, 241 Zachry, 3131 TAMU, College Station, TX, 77843-3131, United States of America, ursul@tamu.edu, Sergiy Butenko, Oleg Prokopyev

We consider the sum of linear ratios versions of several classical combinatorial problems: Minimum Spanning Tree, Shortest Path and Shortest Cycle. We discuss complexity of these problems and attempt to solve them using mixed integer programming, and a global optimization approach. The computational results show that the suggested approach by far outperforms the MIP formulations, and may be used to solve large problem instances, provided that the number of ratios is small.

■ WA12

Marriott - Los Angeles

Derivative-free Algorithms: Local and Global Methods

Cluster: Derivative-free and Simulation-based Optimization
Invited Session

Chair: Ana Luisa Custodio, New University of Lisbon, Dep. Mathematics FCT-UNL Quinta da Torre, Caparica, 2829-516, Portugal, alcustodio@fct.unl.pt

1 - Incorporating Minimum Frobenius Norm Models in Direct-search

Ana Luisa Custodio, New University of Lisbon, Dep. Mathematics FCT-UNL Quinta da Torre, Caparica, 2829-516, Portugal, alcustodio@fct.unl.pt, Humberto Rocha, Luis N. Vicente

Direct-search methods of directional type exhibit interesting convergence properties for nonsmooth functions and are relatively easy to implement, but can be very slow when compared to model-based methods. The goal of this talk is to show that the use of minimum Frobenius norm quadratic models can improve the performance of these methods. Our approach maintains the structure of these directional methods, organized around a search and a poll step, and uses the set of previously evaluated points generated during a direct-search run to build the models. The minimization of the models within a trust region provides an enhanced search step. Our numerical results show that such a procedure can lead to a significant improvement of direct search.

2 - Evolutionary Algorithms Guiding Local Search (EAGLS)

Josh Griffin, Operations Research Specialist, SAS Institute, Inc., 100 SAS Campus Drive, Cary, NC, 27513, United States of America, Joshua.Griffin@sas.com, Katie Fowler, Genetha Anne Gray

A parallel hybrid derivative-free algorithm is described for handling mixed-integer nonlinear programming. We focus on problems of relatively small dimension, with (possibly) expensive function evaluations, which we compute in parallel. To handle integer variables, we utilize an evolutionary algorithm; continuous variables are refined in parallel by multiple local search instances.

3 - Heuristics and Nonmonotonous Approaches in DF methods: A Good Combination for Global Optimization

Ubaldo Garcia-Palomares, Professor, Universidad Simon Bolivar, Departamento de Procesos y Sistemas, Valle de Sartenejas, Caracas, 89000, Venezuela, ubaldo@det.uvigo.es

In this talk we explain how to incorporate heuristic procedures in known Derivative Free methods without impairing convergence to a stationary point of a box constrained minimization problem. The inclusion of heuristics does not impose additional convergence conditions, although we should expect more function evaluations. Numerical results show the influence of simulated annealing and evolutionary programming. We also argue that parallelism might improve the algorithm’s performance.

■ WA13

Marriott - Miami

Risk Management, Networks & Pricing

Cluster: Optimization in Energy Systems
Invited Session

Chair: Panos Pardalos, Distinguished Professor of Industrial and Systems Engineering, University of Florida, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611, United States of America, pardalos@ufl.edu

Co-Chair: Steffen Rebennack, University of Florida, Industrial & Systems Engineering, 303 Weil Hall, Gainesville, Fl, 32611, United States of America, steffen@ufl.edu

1 - Pricing Operational Flexibility

Stan Uryasev, Professor, University of Florida, ISE Department, 303 Weil Hall, P.O. Box 116595, Gainesville, FL, 32611, United States of America, uryasev@ufl.edu, Valeriy Ryabchenko

We introduce a new approach for pricing energy derivatives known as tolling agreement contracts. The pricing problem is reduced to a linear program. We prove that the optimal operating strategy for a power plant can be expressed through optimal exercise boundaries (similar to the exercise boundaries for American options). We find the boundaries as a byproduct of the pricing algorithm. The suggested approach can incorporate various real world power plant operational constraints. We demonstrate computational efficiency of the algorithm by pricing a 10-year tolling agreement contract.

2 - Pool Strategy of a Producer with Endogenous Formation of Prices

Carlos Ruiz, Univ. Castilla - La Mancha, Electrical Engineering, Campus Universitario s/n, Ciudad Real, 13071, Spain, Carlos.RMora@uclm.es, Antonio J. Conejo

This presentation considers a strategic producer that trades electric energy in a pool and provides a procedure to derive its optimal offering strategy. A multi-period network-constrained market-clearing algorithm is considered. Uncertainty on demand bids and offering strategies of rival producers is modeled. The proposed procedure to derive strategic offers relies on a bilevel programming model whose upper-level problem represents the profit maximization of the strategic producer while the lower-level one represents the market clearing and the corresponding price formation. This model is reduced to a MILP problem using the duality theory and the KKT optimality conditions. Results from an illustrative example and a case study are discussed.

3 - Introducing Risk Management Concepts from Finance to Networked Industries

Alexei Gaivoronski, Professor, NTNU, Alfred Getz vei 2, Trondheim, 7491, Norway, alexei.gaivoronski@iot.ntnu.no

In this paper we show how modern risk management methodology developed in finance can be utilized in order to develop optimization based planning tools for networked industries under conditions of uncertainty. The planning purpose goes beyond simple profit maximization or cost minimization: our explicit aim is to strike a balance between profits/costs and risks. Another important feature in such industries is the presence of different actors. We provide examples from telecom, service and water resources.

■ WA14

Marriott - Scottsdale

Optimization and Game Theory for Spectrum Management

Cluster: Game Theory
Invited Session

Chair: Tom Luo, Professor, University of Minnesota, 200 Union Street SE, Minneapolis, 55455, United States of America, luozq@ece.umn.edu

1 - Dynamic Spectrum Management with the Competitive Market Model

Benjamin Armbruster, Northwestern University, armbrusterb@gmail.com, Yao Xie, Dongdong Ge, Yinyu Ye

[Ye2007,LinTsai2008] have shown for the dynamic spectrum allocation problem that a competitive equilibrium (CE) model (which sets a price for transmission power on each channel) leads to a greater social utility than the Nash equilibrium (NE). We show that the CE is the solution of an LCP (like the NE), and when users of a channel experience the same noise levels and the cross-talk effects between users are low-rank and weak, then any tatonnement process for adjusting the prices will converge.

2 - Green DSL

Mung Chiang, Professor, Princeton University, chiangm@princeton.edu

We provide an overview of the emerging area of Green DSL: using spectrum management optimization to reduce energy consumption in DSL-based broadband access networks. We show how nonconvex optimization techniques can be used to provide 85% of data rate with only 50% of the energy budget, and to distribute the price of greening to interfering users in a fair way. This is joint work with Paschalis Tsiaflakis, Yung Yi, and Marc Moonen.

3 - Approaching User Capacity in a Multiuser Communication System via Harmonic Mean-rate Maximization

Tom Luo, Professor, University of Minnesota, 200 Union Street SE, Minneapolis, 55455, United States of America, luozq@ece.umn.edu, Yao Huang, Ramy Gohary

We consider the nonconvex optimization problem of optimally allocating power across the spectrum in a multiuser communication system. Given a certain power budget, our goal is to determine a power allocation that enables a maximum number of users to be supported by the system, defined as the user capacity, where each user is guaranteed to have a data rate that lies within a prescribed range. Finding such a power allocation directly is hard because it involves solving a (non-convex) mixed integer program. In order to circumvent this difficulty, we propose an alternate approach that is based on exploiting the fairness and per-tone convexity of the harmonic mean-rate objective. Using these features, we devise a computationally-efficient power allocation technique to approach the user capacity of a multiuser communication system.

■ WA15

Gleacher Center - 100

Stochastic Network Design

Cluster: Stochastic Optimization
Invited Session

Chair: Stein W. Wallace, Lancaster University, Department of Management Science, Lancaster University Management School, Lancaster, LA1 4YX, United Kingdom, Stein.W.Wallace@lancaster.ac.uk

1 - Meta-heuristic for Stochastic Service Network Design

Teodor Gabriel Crainic, Professor, Ecole des sciences de la gestion, UQAM, C.P. 8888, succ. centre-ville, Montreal, QC, H3C3P8, Canada, crainic.teodor@uqam.ca, Arnt-Gunnar Lium, Arild Hoff, Arne Lokketangen

We consider the time-dependent service network design problem with stochastic demand represented by scenarios. The goal is to select and schedule services and route freight to minimize the expected total system cost. The recourse combines the optimization of the flow distribution and the possibility to use extra capacity at a cost. We propose a meta-heuristic to address real life-size instances of this problem. Computational results are reported on a set of large new problem instances.

2 - Progressive Hedging-based Meta-heuristics for Stochastic Network Design

Walter Rei, Professor, University of Quebec in Montreal (UQAM), 315 Sainte-Catherine East, C.P. 8888, succ. Centre-ville, Montreal, QC, H3C 3P8, Canada, walter@crt.umontreal.ca, Michel Gendreau, Stein W. Wallace, Teodor G. Crainic, Xiaorui Fu

We consider the two-stage stochastic fixed-charge capacitated multicommodity network design (CMND) problem in which demands are stochastic. To solve this problem, we propose a meta-heuristic framework inspired by the progressive hedging algorithm, which takes advantage of efficient methods to solve deterministic CMND problems. We also propose and compare different strategies aimed at penalizing non-consensus amongst scenario subproblems to approximate the global design.

3 - Single Commodity Stochastic Network Design

Stein W. Wallace, Lancaster University, Department of Management Science, Lancaster University Management School, Lancaster, LA1 4YX, United Kingdom, Stein.W.Wallace@lancaster.ac.uk, Biju Kr. Thapalia, Teodor G. Crainic, Michal Kaut

We investigate how network designs from stochastic models differ from those of deterministic models, and hence, what structures that provide robustness in the design. As a first step we check the case of one single supply node serving many demand nodes.

■ WA16

Gleacher Center - 200

Efficient Stochastic Approximation Algorithms

Cluster: Stochastic Optimization
Invited Session

Chair: Alexander Shapiro, Georgia Institute of Technology, ISYE, 443 Groseclose Building, Atlanta, GA, 30332, United States of America, ashapiro@isye.gatech.edu

1 - Acceleration by Randomization: Randomized First Order Algorithms for Large-scale Convex Optimization

Arkadi Nemirovski, Professor, Georgia Institute of Technology, 765 Ferst Dr NW, Atlanta, GA, 30332, United States of America, nemirovs@isye.gatech.edu, Alexander Shapiro, Anatoli Juditsky, Guanghui Lan

We discuss the possibility to accelerate solving extremely large-scale well structured convex optimization problems by replacing computationally expensive in the large scale case deterministic first order oracles with their computationally cheap stochastic counterparts and subsequent utilizing state of the art techniques of Convex Stochastic Programming. We show that when medium-accuracy solutions are sought, there are situations where this approach allows to provably outperform the best known deterministic algorithms. This includes solving matrix games and bilinear Nash Equilibrium problems, minimizing convex polynomials over simplexes, recovering signals via L1 minimization, and eigenvalue minimization.

2 - Primal-dual Stochastic Subgradient Methods for Uniformly Convex Minimization

Anatoli Juditsky, UJF, Laboratoire J. Kuntzmann, BP 53, Grenoble Cedex 9, 38041, France, anatoli.juditsky@imag.fr, Yurii Nesterov

We discuss non-Euclidean stochastic approximation algorithms for optimization problems with strongly and uniformly convex objectives. These algorithms are adaptive with respect to the parameters regularity and of strong or uniform convexity of the objective: in the case when the total number of iterations N is fixed, their accuracy coincides, up to a logarithmic in N factor with the accuracy of optimal algorithms.

3 - Stochastic Approximation Approach to Stochastic Programming

Alexander Shapiro, Georgia Institute of Technology, ISYE, 443 Groseclose Building, Atlanta, GA, 30332, United States of America, ashapiro@isye.gatech.edu, Anatoli Juditsky, Arkadi Nemirovski, Guanghui Lan

A basic difficulty with solving stochastic programming problems is that it requires computation of expectations given by multidimensional integrals. One approach, based on Monte Carlo sampling techniques, is to generate a reasonably large random sample and consequently to solve the constructed so-called Sample Average Approximation (SAA) problem. The other classical approach is based on Stochastic Approximation (SA) techniques. In this talk we discuss some recent advances in development of SA type numerical algorithms for solving convex stochastic programming problems. Numerical experiments show that for some classes of problems the so-called Mirror Descent SA Method can significantly outperform the SAA approach.

■ WA17

Gleacher Center - 204

Optimization in Supply Chain Planning

Cluster: Logistics and Transportation
Invited Session

Chair: Joseph Geunes, University of Florida, 303 Weil Hall, Gainesville, FL, 32611, United States of America, geunes@ise.ufl.edu

1 - Economic Lot-sizing with Perishable Inventories

H. Edwin Romeijn, Professor, University of Michigan, Industrial and Operations Engineering, Ann Arbor, United States of America, romeijn@umich.edu, Mehmet Onal, Amar Sapra

We consider extensions of the classical dynamic economic lot sizing problem where items perish after a number of periods that depends on the period in which the item was produced. We distinguish between settings in which (i) the retailer has the power to supply customer demands in each period with any non-perished items, and (ii) the customer has the power to select from the collection of available items. We develop polynomial-time dynamic programming algorithms for several problem variants.

2 - Exact Algorithms for Integrated Facility Location and Production Planning Problems

Joseph Geunes, University of Florida, 303 Weil Hall, Gainesville, FL, 32611, United States of America, geunes@ise.ufl.edu, Thomas Sharkey, H. Edwin Romeijn, Max Shen

We consider a class of location problems with a time dimension, which requires assigning each customer in every time period to a facility and meeting customer demands through production and inventory decisions at the facility. We provide exact branch-and-price algorithms for this problem class. The pricing problem requires selecting a set of demands that maximize profit. We provide a polynomial-time dynamic programming algorithm for this problem class, as well as for several extensions of the problem. Computational testing compares the performance of our branch-and-price algorithm to solutions obtained via commercial software packages, and characterizes the value of integrating these decisions, rather than considering them sequentially.

3 - Robust Lot-sizing Problems with the Consideration of Disruptions

Yongpei Guan, Assistant Professor, Department of Industrial and Systems Engineering, University of Florida, Gainesville, FL, 32611, United States of America, guan@ise.ufl.edu, Zhili Zhou

In this paper, we consider lot-sizing problems in which severe events may happen such that the normal process will be disrupted. Our objective is to provide a robust schedule such that the total cost is minimized with the consideration of uncertain extreme events. A robust optimization formulation is studied to address the uncertainty in possible disruption periods. Several cases are studied and corresponding algorithms are developed. Our preliminary study verifies the effectiveness of our approaches. The applications of our models include production and inventory planning problems.

■ WA18

Gleacher Center - 206

MINLP Modeling and Applications

Cluster: Nonlinear Mixed Integer Programming
Invited Session

Chair: Pietro Belotti, Visiting Professor, Lehigh University, 200 W Packer Ave, Bethlehem, PA, 18015, United States of America, belotti@lehigh.edu

1 - A Bilevel Integer Nonlinear Programming Model for Cross-layer Network Design Optimization

Scott Denegre, Lehigh University, Industrial and Systems Engineering, 200 West Packer Avenue, Bethlehem, PA, 18015, sdenegre@lehigh.edu, Ted Ralphs

We consider the problem of cross-layer network design optimization. This problem is encountered in mobile ad hoc networks (MANET) consisting of moving nodes equipped with cognitive radios that dynamically adjust their transmission power and constellation size in response to channel and interference states. The objective is to minimize transmission power in the network's physical layer, while maximizing the throughput in the network layer. Previously, cross-layer network design optimization and transmit power minimization were treated as separate problems. We provide motivation for combining these problems and reformulate the problem as a bilevel integer nonlinear program. Exact and heuristic solution methods are given.

2 - Strengthening of Lower Bounds for Global Optimization of Nonconvex Generalized Disjunctive Programs

Ignacio Grossmann, Rudolph R. and Florence Dean University Professor, CMU, 5000 Forbes, Pittsburgh, PA, 15213, United States of America, grossmann@cmu.edu, Juan Ruiz

We present a framework to find relaxations that yields strong lower bounds for the global optimization of Bilinear and Concave Generalized Disjunctive Programs (GDPs). This framework combines linear relaxation strategies proposed in the literature for nonconvex MINLPs with the work of Sawaya & Grossmann for Linear GDPs. We exploit the theory behind Disjunctive Programming to guide the generation of relaxations efficiently. The performance of the method is shown through a set of test problems.

3 - A Hybrid Approach to Beam Angle Optimization in Intensity-modulated Radiation Therapy

Valentina Cacchiani, DEIS, University of Bologna, Viale Risorgimento 2, Bologna, 40136, Italy, valentina.cacchiani@unibo.it, Dimitris Bertsimas, Omid Nohadani, David Craft

Two decisions are fundamental in Intensity-Modulated Radiation Therapy: to select beam angles and to compute the intensity of the beams used to deliver the radiation, with the aim of reaching the dose prescription in the target while sparing the critical structures. We face the problem of optimizing both decisions, developing a hybrid heuristic method, which combines a simulated annealing procedure with the knowledge of the gradient. Experimental results are performed on real-life case studies.

■ WA19

Gleacher Center - 208

Nonlinear Programming B

Contributed Session

Chair: Ioannis Akrotirianakis, Operations Research Specialist, SAS Institute, Inc., 100 SAS Campuse Drive, Cary, NC, 27513, United States of America, ioannis.akrotirianakis@sas.com

1 - A Variant of Nonlinear Conjugate Gradient that Incorporates Second Order Information

Sahar Karimi, University of Waterloo, 200 University Ave. W., Waterloo, ON, N2L3G1, Canada, s2karimi@math.uwaterloo.ca, Steve Vavasis

In this talk we discuss a generalization of the nonlinear conjugate gradient algorithm for unconstrained optimization problems that incorporates some second order information via automatic differentiation. We evaluate the performance of the algorithm. For a certain class of strongly convex problems, the algorithm is close to optimal in the sense of Nemirovski and Yudin.

2 - A Modified CG Method for Large-scale Nonconvex Optimization

Wenwen Zhou, Operations Research Specialist, SAS Institute Inc., 100 SAS Campus Dr., Cary, NC, 27513, United States of America, wenwen.zhou@sas.com, Josh Griffin, Ioannis Akrotirianakis

We present a new matrix-free algorithm for large-scale nonlinear nonconvex optimization that incorporates inherited strengths of line-search and trust-region approaches. Krylov-based search directions are constructed based upon local geometry. The merit of new approach is demonstrated by numerical results.

3 - Simultaneous Solution of the Trust Region and the Minimum Eigenvalue Subproblems

Ioannis Akrotirianakis, Operations Research Specialist, SAS Institute, Inc., 100 SAS Campuse Drive, Cary, NC, 27513, United States of America, ioannis.akrotirianakis@sas.com, Josh Griffin, Wenwen Zhou

We describe a trust-region algorithm for large-scale nonconvex optimization that combines several existing preconditioned Krylov subspace strategies. Special small dimensional subspaces permit the simultaneous approximation of solutions to 1) the trust-region subproblem and 2) the minimum eigenvalue subproblem, with negligible computational overhead. Comprehensive numerical results demonstrate the algorithm's strength.

■ WA20

Gleacher Center - 300

Stability and Sensitivity Analysis in Cone and General Nonlinear Programming

Cluster: Nonlinear Programming
Invited Session

Chair: Henry Wolkowicz, Professor of Math., University of Waterloo, Dept of Combinatorics & Optimization, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, hwolkowicz@uwaterloo.ca

1 - Bi-parametric Convex Quadratic Optimization

Tamas Terlaky, Lehigh University, 200 West Packer Avenue, Department of Industrial and Systems Eng, Bethlehem, PA 18015-1, United States of America, terlaky@Lehigh.EDU, Oleksandr Romanko, Alireza Ghaffari-Hadigheh

We consider the Convex Quadratic Optimization problem with simultaneous perturbation in the RHS and the linear term of the objective function with different parameters. The regions with invariant optimal partitions are investigated as well as the behavior of the optimal value function on the regions. We show that identifying these regions can be done in polynomial time in the output size. A computable algorithm for identifying all invariancy regions is presented.

2 - Feasibility and Constraint Analysis of Sets of Linear Matrix Inequalities

Rick Caron, Professor, University of Windsor, Math and Stats, 401 Sunset Avenue, Windsor, ON, N9B3P4, Canada, rcaron@uwindsor.ca, Tim Traynor, Shafiu Jibrin

We present a constraint analysis methodology for LMI constraints that seeks either a minimal representation (feasible case) or an irreducible infeasible system (infeasible case). The work is based on the solution of a set covering problem where each row corresponds to a sample point and is determined by constraint satisfaction. We develop a hit and run sampler that provides information for constraint analysis, and that find a feasible point, if one exists, with probability one.

3 - Strong Duality and Minimal Representations for Cone Optimization

Henry Wolkowicz, Professor of Math., University of Waterloo, Dept of Combinatorics & Optimization, University of Waterloo, Waterloo, ON, N2L 3G1, Canada, hwolkowicz@uwaterloo.ca, Levent Tuncel

The elegant results for strong duality and strict complementarity for LP can fail for nonpolyhedral cones. We take a fresh look at known and new results for duality, optimality, CQs, and strict complementarity.

■ WA21

Gleacher Center - 304

Network Optimization

Cluster: Telecommunications and Networks

Invited Session

Chair: Bruce Shepherd, McGill University, 805 Sherbrooke West, Montreal, QC, H3H1J2, Canada, bruce.shepherd@mcgill.ca

1 - Preserving Element-connectivity and Packing Steiner Forests

Nitish Korula, University of Illinois at Urbana-Champaign, 201, N. Goodwin Ave., Urbana, IL, 61801, United States of America, nkorula2@illinois.edu, Chandra Chekuri

In an undirected graph G with terminal set T \subseteq V(G), the element-connectivity of terminals u, v is the maximum number of u-v paths that share no edges and no non-terminals. We show that a graph reduction operation of Hind and Oellerman preserves the element-connectivity of all pairs of terminals, and illustrate the usefulness of this operation with an application to packing Steiner Forests: We prove that the connectivity of terminals is related to the number of element-disjoint forests.

2 - Flow-cut Gap for Integer and Fractional Multiflows

Christophe Weibel, Postdoctoral Fellow, McGill University, 805 Sherbrooke West, Montreal, QC, H3H1J2, Canada, christophe.weibel@gmail.com, Bruce Shepherd, Chandra Chekuri

In multicommodity flows, the max-flow/min-cut gap is the ratio between the edge capacity necessary to route every demand and the capacity verifying the cut condition. In the case of fractional flows, it was recently proved that the gap can be at most 2 for series-parallel graphs. In the case of integral flows, we prove an upper bound of 5 for the same series-parallel graphs. We also conjecture, and show some evidence, that the actual upper bound is 2 as in fractional flows.

3 - Solving Convex Programs in Mobile Ad-hoc Networks

Matthew Andrews, Member Technical Staff, Bell Laboratories, 600 Mountain Ave, Murray Hill, NJ, 07974, United States of America, andrews@research.bell-labs.com

In many instances the desired behavior of a mobile ad-hoc network can be formulated using a convex optimization problem. In this talk we shall show how such problems can be solved in a distributed manner using a set of networking protocols that are only slightly different from traditional ad hoc networking protocols such as those used by the 802.11 standard.

■ WA22

Gleacher Center - 306

Algorithms and Software for Semidefinite Programming

Cluster: Implementations, Software

Invited Session

Chair: Brian Borchers, New Mexico Intitute of Mining & Technology, Socorro, NM, 87801, United States of America, borchers@nmt.edu

1 - Preconditioners for Semidefinite Programming

Michael Overton, New York University, Courant Institute, New York, NY, United States of America, overton@cs.nyu.edu, Chen Greif, Ming Gu

We consider preconditioners for solving the linear systems that arise in interior point methods for semidefinite programming. These depend on computing or approximating the smallest eigenvalues of the dual slack matrix, and also the largest eigenvalues of the primal matrix variable when a primal-dual method is used. We present some theoretical results making centrality and nondegeneracy assumptions. The preconditioner can be improved by updating it during the conjugate gradient iteration.

2 - Multiple Precision Arithmetic Versions of SDP Solvers; SDPA-GMP, SDPA-QD and SDPA-DD

Maho Nakata, Postdoctoral fellow, RIKEN, 2-1 Hirosawa, Wako, Saitama, 351-0198, Japan, maho.nakata@gmail.com

In this talk, we introduce multiple precision arithmetic versions of semidefinite programming (SDP) solvers; SDPA-GMP, SDPA-QD and SDPA-DD. SDPA-GMP solves in arbitrary (variable) accuracy by utilizing GNU Multiple precision library. SDPA-QD, DD use QD library and solve in quasi octuple precision and quasi quadruple precision. These solvers solve some small SDPs very accurately; primal dual gap can be smaller than 1e-50. All program packages are available at the SDPA project home page.

3 - Issues In Implementing the Primal-dual Method for SDP

Brian Borchers, New Mexico Intitute of Mining & Technology, Socorro, NM, 87801, United States of America, borchers@nmt.edu

CSDP is an open source software package for semidefinite programming that has been under continuous development since 1997. We discuss accuracy and performance issues in the implementation of the primal-dual interior point method and lessons learned from applications of the software.

■ WA23

Gleacher Center - 308

Compressed Sensing, Sparse Recovery and Sparse PCA

Cluster: Sparse Optimization

Invited Session

Chair: Paul Tseng, Professor, University of Washington, Department of Mathematics, Box 354350, Seattle, WA, 98195, United States of America, tseng@math.washington.edu

Co-Chair: Peter Richtarik, Center for Operations Research and Econometrics (CORE), Batiment Euler (A-116), Avenue Georges Lemaitre 4, Louvain-la-Neuve, B-1348, Belgium, Peter.Richtarik@uclouvain.be

1 - Generalized Power Method for Sparse Principal Component Analysis

Peter Richtarik, Center for Operations Research and Econometrics (CORE), Batiment Euler (A-116), Avenue Georges Lemaitre 4, Louvain-la-Neuve, B-1348, Belgium, Peter.Richtarik@uclouvain.be, Yurii Nesterov, Rodolphe Sepulchre, Michel Journee

In this paper we propose two single-unit and two block penalty formulations of the sparse PCA problem. While the initial formulations involve nonconvex functions, and are thus computationally intractable, we rewrite them into the form of an optimization program involving maximization of a convex function on a compact set. We then propose and analyze a simple gradient method suited for the task. Finally, we demonstrate numerically that our approach leads to very fast scalable algorithms.

2 - Phase Transitions Phenomenon in Compressed Sensing

Jared Tanner, Reader, University of Edinburgh, JCBM, Edinburgh, eh16 5nj, United Kingdom, jared.tanner@ed.ac.uk, Coralia Cartis, Jeffrey Blanchard, David L. Donoho

Compressed Sensing reconstruction algorithms exhibit a phase transition phenomenon for large problem sizes, where there is a domain of problem sizes for which successful recovery occurs with overwhelming probability, and there is a domain of problem sizes for which recovery failure occurs with overwhelming probability. The mathematics underlying this phenomenon will be outlined for ℓ^1 regularization and non-negative feasibility point regions. Both instances employ a large deviation analysis of the associated geometric probability event. These results give precise if and only if conditions on the number of samples needed in Compressed Sensing applications. Lower bounds on the phase transitions implied by the Restricted Isometry Property for Gaussian random matrices will also be presented for the following algorithms: ℓ^q-regularization for $q\in (0,1]$, CoSaMP, Subspace Pursuit, and Iterated Hard Thresholding.

3 - Sparse Recovery by Non-convex Optimization — Instance Optimality

Ozgur Yilmaz, University of British Columbia, 1984 Mathematics Rd, Vancouver, BC, V6T 1Z2, Canada, oyilmaz@math.ubc.ca, Rayan Saab

It has been recently shown that one can recover/decode estimates of sparse signals from an "incomplete" set of noisy measurements via one-norm minimization methods under certain conditions on the "measurement matrix" that are satisfied, e.g., when it is a random Gaussian. In this talk, we present the theoretical recovery guarantees obtained when decoding by p-quasinorm minimization with p between 0 and 1: we prove that the corresponding guarantees are better than those one can obtain in the case of one-norm minimization. We show that these decoders are (2,p) instance optimal. Moreover, they are (2,2) instance optimal in probability (this relates to distances of p-convex bodies to their convex hulls).

■ WA25

Gleacher Center - 404

Computational Convex Analysis

Cluster: Variational Analysis
Invited Session

Chair: Yves Lucet, University of British Columbia, 3333 University Way, Kelowna, BC, V1V 1V7, Canada, yves.lucet@ubc.ca

1 - Convexity of the Proximal Average

Valentin Koch, University of British Columbia, Faculty of Mathematics, 3333 University Way, Kelowna, BC, V1V 1V7, Canada, valentin.koch@gmail.com, Jennifer Johnstone, Yves Lucet

We complete the study of the convexity of the proximal average by proving it is convex as a function of each one of its parameters but not as a function of any two of each parameters. An application to the efficient plotting of the family of proximal averages is presented.

2 - Numerical Computation of Fitzpatrick Functions

Bryan Gardiner, University of British Columbia, 3333 University Way, Kelowna, BC, V1V 1V7, Canada, khumba@gmail.com, Yves Lucet

The study of Fitzpatrick functions aids the understanding of the structure of operators. They are related to Rockafellar functions and operator antiderivatives. Using fast algorithms for computing Fenchel conjugates, we improve the existing quartic-time algorithm for computing Fitzpatrick functions on a 2-dimensional grid to quadratic time, and demonstrate a linear-time algorithm for constructing antiderivatives from a special case of the Fitzpatrick function.

3 - Applications of Computational Convex Analysis

Yves Lucet, University of British Columbia, 3333 University Way, Kelowna, BC, V1V 1V7, Canada, yves.lucet@ubc.ca

We review applications of Computational Convex Analysis in image processing (computing the distance transform, the generalized distance transform, and mathematical morphology operators), and partial differential equations (solving Hamilton-Jacobi equations, and using differential equations numerical schemes to compute the convex envelope). We will also mention applications in computer vision, robot navigation, thermodynamics, electrical networks, medical imaging, and network communication.

■ WA28

Gleacher Center - 600

Rank Minimization: Theory and Applications

Cluster: Nonsmooth and Convex Optimization
Invited Session

Chair: Lieven Vandenberghe, UCLA, 66-147L Engineering IV, Los Angeles, CA, 90095, United States of America, vandenbe@EE.UCLA.EDU

Co-Chair: Maryam Fazel, University of Washington, Department of Electrical Engineering, Campus Box 352500, Seattle, WA, 98195-2500, United States of America, mfazel@u.washington.edu

1 - Robust Recovery of Low-rank Matrices

Maryam Fazel, University of Washington, Department of Electrical Engineering, Campus Box 352500, Seattle, WA, 98195-2500, United States of America, mfazel@u.washington.edu

Compressed Sensing has demonstrated that sparse signals can be recovered from incomplete measurements even in the presence of noise. In this work, we focus on sensing and recovery of low-rank matrices. We consider two approaches, one based on a restricted isometry property, and the other based on sensing the row and column spaces of the matrix. We discuss the robustness of low-rank recovery in cases where measurements are noisy and the matrix is not perfectly low-rank.

2 - Null Space Conditions and Thresholds for Rank Minimization

Benjamin Recht, California Institute of Technology, 1200 E California Blvd, MC 136-93, Pasadena, CA, 91125, United States of America, brecht@caltech.edu, Babak Hassibi, Weiyu Xu

We assess the practical performance of the nuclear norm heuristic for finding the minimum rank matrix satisfying linear constraints. We obtain thresholds on the number of constraints beyond which the nuclear norm heuristic succeeds for almost all instances of the affine rank minimization problem. These thresholds are only in terms of dimensions of the decision variable and the true minimum rank. Our bounds agree empirically with the heuristic's performance in non-asymptotic scenarios.

3 - Nuclear Norm Minimization for the Planted Clique and Biclique Problems

Steve Vavasis, University of Waterloo, MC 6054, 200 University Avenue W., Waterloo, ON, N2L 3G1, Canada, vavasis@math.uwaterloo.ca, Brendan Ames

We consider the problems of finding a maximum clique in a graph and finding a maximum-edge biclique in a bipartite graph. Both problems are NP-hard. We write both problems as matrix rank minimization and then relax them using the nuclear norm. In special cases that the input graph has a planted clique or biclique (i.e., a single large clique or biclique plus diversionary edges) our algorithm successfully provides an exact solution to the original instance. For each problem, we provide two analyses of when our algorithm succeeds. In the first analysis, the diversionary edges are placed by an adversary. In the second, they are placed at random.

■ WA29

Gleacher Center - 602

Computational Methods for Dynamic Models in Economics - Part I

Cluster: Finance and Economics
Invited Session

Chair: Che-Lin Su, Assistant Professor of Operations Management, The University of Chicago Booth School of Business, 5807 S. Woodlawn Ave, Chicago, IL, 60637, United States of America, chelin.su@gmail.com

1 - Improving the Numerical Performance of BLP Discrete Choice Random Coefficients Demand Estimation

Jeremy Fox, Assistant Professor of Economics, The University of Chicago Department of Economics, Chicago, IL, United States of America, jeremyfox@gmail.com, Jean-Pierre Dube, Che-Lin Su

The nested-fixed point algorithm typically used for Berry, Levinsohn and Pakes (1995) random-coefficient demand estimation is computationally intensive, largely because a system of market-share equations must be repeatedly numerically inverted. We recast both static and dynamic BLP estimation as constrained optimization problems. Several Monte Carlo and real-data experiments support the advantages of the constrained optimization method.

2 - Dynamic Strategic Investment

Sevin Yeltekin, Associate Professor of Economics, Tepper School of Economics, CMU, sevin@andrew.cmu.edu

We present a general method for computing the entire set of equilibrium payoffs for dynamic games with state variables, with and without complete information. We extend our earlier methods (Judd, Yeltekin, Conklin (Econometrica, 2003)) to games with physical states variables, and apply the procedure to a dynamic oligopoly game with costly capacity investment. Our algorithm allows us to study the nature of cooperation and whether investment decisions increase the gains from cooperation.

3 - Estimating Dynamic Models with Smart Transformation

Panle Jia, Assistant Professor of Economics, MIT, Department of Economics, pjia@mit.edu

We propose a new method of calculating the Bellman equation in dynamic models that eliminates discretizing and interpolating the value function entirely. The method only requires solving the value function at a small number of points. Such a method makes it feasible to study dynamic models with a large number of the state variables, for example, 20-50 state variables.

Wednesday, 1:15pm - 2:45pm

■ WB01

Marriott - Chicago A

Online Algorithms

Cluster: Approximation Algorithms
Invited Session

Chair: Cliff Stein, Columbia University, 326 S W Mudd Building, 500 W. 120th Street, New York, NY, 10027, cliff@ieor.columbia.edu

1 - Stochastic Dominance for Comparing Online Algorithm

Tjark Vredeveld, Maastricht University, P.O.Box 616, Maastricht, 6200MD, Netherlands, T.Vredeveld@ke.unimaas.nl, Benjamin Hiller

In this talk, we consider a probabilistic method for comparing online algorithms, which is based on the notion of stochastic dominance. We consider the online bin coloring problem, in which colored items need to be assigned to bins so as to minimize the maximum colorfulness. Using methods for the stochastic comparison of Markov chains we establish a result that gives a more realistic view than competitive analysis and explains the behavior observed in simulations.

2 - Flooding Overcomes Small Covering Constraints

Christos Koufogiannakis, University of California, Riverside, Dept of Computer Science and Engineering, Engineering Building Unit II, Room 351, Riverside, CA, 92521, United States of America, ckou@cs.ucr.edu, Neal Young

We show d-approximation algorithms for covering problems, where d is the maximum number of variables on which any constraint depends. Results include: A d-approximation algorithm for CMILP running in nearly linear time. Online d-competitive algorithms for the setting where constraints are revealed in an online fashion. For $d=2$, a distributed algorithm taking $O(\\log n)$ rounds. For general d, a d-approximation algorithm taking $O(\\log^2 |E|)$ rounds.

3 - Online Scheduling of Weighted Packets with Deadlines in a Bounded Buffer

Fei Li, Assistant Professor, George Mason University, Department of Computer Science, Fairfax, VA, 22030, United States of America, lifei@cs.gmu.edu

We consider online scheduling of packets. Packets arrive over time, each has a positive value w_p and an integer deadline d_p. If p is transmitted by d_p, p contributes our objective w_p. At any time, the buffer can store at most b packets. In each step, at most one packet can be sent. We maximize the total value of the packets sent by their deadlines. We provide a deterministic 3-competitive, a randomized 2.618-competitive online algorithms, and a lower bound 2 for a broad family of algorithms.

■ WB02

Marriott - Chicago B

Joint Session Comp/Energy: Complementarity Models in Energy

Cluster: Complementarity Problems and Variational Inequalities
Invited Session

Chair: Daniel Ralph, University of Cambridge, Judge Business School, Trumpington Street, Cambridge, CB2 1AG, United Kingdom, d.ralph@jbs.cam.ac.uk

1 - A Stochastic Multiperiod Equilibrium Model in Generation Capacity Expansion with Plant (or Firm) Specific Discount Rates

Yves Smeers, Professor, Universite Catholique de Louvain, 34, Voie du Roman Pays, Louvain-la-Neuve, Belgium, smeers@core.ucl.ac.be

Starting from a CAPM formulation we construct an equilibrium model of investments in generation capacities where firms or plants have different cost of capital. The problem takes the form of a stochastic quasi-variational inequality problem for which we want to find a particular solution that reflects the diversity of costs of capital. We report numerical results.

2 - An Extended Mathematical Programming Framework

Michael Ferris, University of Wisconsin-Madison, 4381 Computer Sciences and Statistics, 1210 W Dayton Street, Madison, WI, 53706, United States of America, ferris@cs.wisc.edu

We outline a mechanism to describe an extended mathematical program by means of annotating the existing relationships that make up a model. These extensions facilitate higher level structure identification within a model. The structures, which often involve constraints on the solution sets of other models or complementarity relationships, can be exploited by modern large scale mathematical programming algorithms for efficient solution. Specific application to energy models will be given.

3 - Hybrid Bertrand-cournot Models of Electricity Markets with Strategic Decoupling

Shmuel Oren, Professor, University of California-Berkeley, Dept of I EO R, Rm 4119 Etcheverry Hall, Berkeley, CA, 94720, United States of America, oren@ieor.berkeley.edu, Jian Yao, Ben Hobbs

Nash-Cournot models of competition among electricity generators do not account for strategic decoupling due to permanently congested interfaces. We propose a hybrid Bertrand-Cournot model of such markets in which firms are assumed to behave a la Cournot regarding inter-subnetwork transmission quantities, but a la Bertrand regarding intra-subnetwork transmission prices. We also consider a Bertrand type model where frequently congested lines are designated as “common knowledge constraint” and treated as equality constraints by all generation firms and the ISO.

■ WB03

Marriott - Chicago C

Duality and Algorithms in Global Optimization-II

Cluster: Global Optimization
Invited Session

Chair: David Gao, Professor, Virginia Tech, Mathematics, 524 McBryde Hall, Blackburg, VA, 24061, United States of America, gao@vt.edu

1 - Linear Relaxations for Sum of Linear Ratios Problem

Jianming Shi, Muroran Institute of Technology, 27-1 Mizumoto Chou, Muroran, Japan, shi@mmm.muroran-it.ac.jp, Lianbo Gao

The difficulty of the problem mainly arises from the number of ratios. The main idea of the existing algorithms is to transfer the objective into the sum of single-variable ratios with curtain linear constrains. Then make a concave envelop of the sum of single-variable ratios’. So a number-of-ratios dimensional region is needed to look for an optimal solution. An algorithm on a space with a smaller dimension is proposed in this talk. Some numerical experiments will be reported as well.

2 - Unified Solutions to a Class of Global Optimization Problems

David Gao, Professor, Virginia Tech, Mathematics, 524 McBryde Hall, Blackburg, VA, 24061, United States of America, gao@vt.edu, Ning Ruan, Hanif D. Sherali

Canonical duality theory is a potentially useful methodology, which can be used to model complex systems with a unified solution to a wide class of discrete and continuous problems in global optimization and nonconvex analysis. This talk will present recent developments of this theory with applications to some well-know problems, including general polynomial minimization, Euclidean distance geometry, fractional programming, nonconvex minimization with nonconvex constraints, etc.

3 - Terrain and Barrier-terrain Methods of Global Optimization

Angelo Lucia, Professor, University of Rhode Island, Chemical Engineering Dept, Kingston, RI, 02881, lucia@egr.uri.edu

A survey of terrain and barrier-terrain methods of global optimization is presented with a focus on their ability to solve challenging problems in multi-phase equilibrium, simultaneous heat and mass transfer with reaction, and other applications in chemical engineering. Numerical results and geometric illustration will be presented to elucidate key ideas.

■ WB04

Marriott - Denver

Combinatorial Optimization E

Contributed Session

Chair: Bea Karla Machado, Student, UFRJ, Vitoria, 29060300, Brazil, profbea@hotmail.com

1 - Coloring of Polygon-circle Graphs and Sorting of Rail Cars

Ronny Hansmann, Technical University of Braunschweig, Pockelsstrasse 14, Braunschweig, 38106, Germany, r.hansmann@tu-bs.de, Uwe Zimmermann

We start the talk with an overview of various versions for sorting rail cars at hump yards and we show that many of these particular sorting problems can be formulated as Min Coloring of Polygon-Circle Graphs. For computing such minimal colorings we present heuristical as well as exact solution methods. We compare two integer programming models: a classical coloring IP and a new IP-formulation as Min Cost Flow with side constraints. Exploiting this network flow structure we propose a Branch-and-Bound algorithm using Min Cost Flows and Lagrangian Relaxation for determining lower bounds. Finally, we discuss the computational results, in particular for real-world data from the above-mentioned application.

2 - Integer Flow with Multipliers 1 and 2 and a Freight Car Disposition Problem

Birgit Engels, University of Cologne, Weyertal 80, Cologne, Germany, engels@zpr.uni-koeln.de, Rainer Schrader, Sven Krumke, Christiane Zeck

The problem to find a valid integer generalized flow is long known to be NP-complete (S. Sahni, 1974). We show that the problem is still hard restricted to multipliers 1 and 2 and that optimal solutions with (almost) arbitrary fractions can occur.In some (still NP-hard) application motivated network instances optimal solutions are halfintegral. To solve the latter (optimally) we modify the Successive Shortest Path Algorithm and try to (heuristically) find acceptable integral solutions.

3 - A Study of the Itineraries of Some Subway-bus Express Lines of Integration in the City of Rio de Janeiro

Bea Karla Machado, Student, UFRJ, Vitoria, 29060300, Brazil, profbea@hotmail.com

The present work introduces a proposal of itineraries for some subway-bus express lines of integration in the city of Rio de Janeiro, comprising the neighborhoods Andara, Estacio, Graja, Maracanã, Muda, Rio Comprido, Tijuca, Usina and Vila Isabel, aiming at using paths of minimum length, targeting an installed subway net in operation until the 30th of June, 2006. As a restriction, it has been established that each integration line must serve one exclusive subway station, so that the representative cycle of the bus itineraries contains only one point associated to each subway station.

■ WB05

Marriott - Houston

Combinatorial Optimization T

Contributed Session

Chair: A. Yu. Gornov, Institute of System Dynamics and Control Theory of SB of RAS, Lermontov Str., 134, Irkutsk, Russian Federation, 664033, gornov@icc.ru

1 - Test Collection of the Nonconvex Optimal Control Problems

T.S. Zarodnyuk, Institute of System Dynamics and Control Theory SB RAS, Irkutsk Lermontov St., 134, Irkutsk 664033, Russia, tz@icc.ru

We consider collection of nonconvex optimal control test problems. The source of collection are model and meaningful problems, published in the scientific literature and obtained with the fulfillment of applied projects. Construction procedures of new nonconvex test problems are developed. Now collection contains more than 100 tests. A number of technologies for testing the optimal control search methods is realized.

2 - On Viability for a Affine Nonlinear Control System

Yan Gao, School of Management, University of Shanghai for Science and Technology, Shanghai 200093, China, gaoyan@usst.edu.cn

This paper is devoted to verifying the viability condition for a affine nonlinear control system on a region which is expressed by inequality constraints.Based on convex analysis and nonsmooth analysis, a method of determining the viability condition at a point is given. In this method, determining the viability is transformed into determining the consistency of a system of convex inequalities, that is convex feasibility problem. Then, a project method is used to solving convex inequalities.

3 - The Global Extremum Search Methods in Optimal Control Problem

A. Yu. Gornov, Institute of System Dynamics and Control Theory of SB of RAS, Lermontov Str., 134, Irkutsk, Russian Federation, 664033, gornov@icc.ru

We discuss methods and new approaches to the solution of global extremum search problem in the optimal control problems. Four families of heuristic methods are considered: “random multi-start”, convexification, reduction to finite dimensional problem, approximation of attainability set. Proposed algorithms are realized in software OPTCON-III. Computational experiments confirm the effectiveness of algorithms.

■ WB06

Marriott - Kansas City

Algorithms for Large Scale Optimization

Cluster: Conic Programming

Invited Session

Chair: Renato Monteiro, Professor, Georgia Tech, School of Industrial & Systems Engineeri, 765 Ferst Drive, NW, Atlanta, GA, 30332, United States of America, renato.monteiro@isye.gatech.edu

1 - An Augmented Lagrangian Approach for Sparse Principal Component Analysis

Zhaosong Lu, Assistant Professor, Simon Fraser University, 8888 University Drive, Burnaby, BC, V3T 0A3, Canada, zhaosong@sfu.ca, Yong Zhang

We formulate sparse PCA as an nonsmooth constrained optimization problem, aiming at finding sparse, orthogonal and nearly uncorrelated PCs while explaining most of the variance. Then we develop a novel augmented Lagrangian (AL) method for a broad class of nonsmooth problems, whose global convergence is established. We also propose two methods for solving the subproblems of the AL method. Their global and local convergence are established. Finally we present some computational results.

2 - On the Complexity of the Hybrid Proximal Extragradient Method

Renato Monteiro, Professor, Georgia Tech, School of Industrial & Systems Engineering, 765 Ferst Drive, NW, Atlanta, GA, 30332, United States of America, renato.monteiro@isye.gatech.edu, Benar Svaiter

We analyze the iteration-complexity of the hybrid proximal extragradient (HPE) method for finding a zero of a maximal monotone operator (MMO). One of the key points of our analysis is the use of a new termination criteria based on the $epsilon$-enlargement of a MMO. We then show that Korpelevich’s extragradient method for solving monotone variational inequalities falls in the framework of the HPE method. As a consequence, we obtain new complexity bounds for Korpelevich’s extragradient method which do not require the feasible set to be bounded. We also study the complexity of a variant of a Newton-type extragradient algorithm for finding a zero of a smooth monotone function with Lipschitz continuous Jacobian.

3 - A Nonsymmetric Interior-point Solver for Linear Optimization with Sparse Matrix Cone Constraints

Martin Andersen, PhD Candidate, University of California, Los Angeles, Electrical Engineering Department, 66-124 Engineering IV, 6-06, Los Angeles, CA, 90095, United States of America, martin.andersen@ucla.edu, Joachim Dahl, Lieven Vandenberghe

We describe an implementation of nonsymmetric interior-point methods for linear cone programs defined by chordal sparse matrix cones. The implementation takes advantage of fast recursive algorithms for evaluating the function values and derivatives of the logarithmic barrier functions for these cones and their dual cones. We present extensive experimental results of two implementations, one of which is based on the augmented system approach.

■ WB07

Marriott - Chicago D

Integer and Mixed Integer Programming E

Contributed Session

Chair: Chuangyin Dang, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong - ROC, mecdang@cityu.edu.hk

1 - A Strengthened Integer Programming Model for Conflict Minimization in Cartographic Label Placement

Miguel Constantino, University of Lisbon - Faculty of Science, DEIO-CIO edC6 Campo Grande, Lisbon, 1749-016, Portugal, miguel.constantino@fc.ul.pt, Glaydston Ribeiro, Luiz Lorena

We address a variant of the point-feature cartographic label placement problem, in which all labels must be placed and the number of labels in conflict should be minimized. We consider an Integer Programming formulation by Ribeiro et al. which is an extension of the standard IP node packing formulation. Valid inequalities for the set of feasible solutions are obtained and used to strengthen the model. We present computational results with a set of benchmark instances from the literature.

2 - Constraint Integer Programming for Scheduling Problems

Jens Schulz, Dipl. Math. oec., TU Berlin, Str. des 17. Juni 135, Berlin, 10623, Germany, jschulz@math.tu-berlin.de, Timo Berthold, Stefan Heinz, Rolf Moehring, Marco Luebbecke

Scheduling problems occur in many real-world applications. Solving these to optimality has been done by MIP and CP techniques. Recently, hybrid approaches gain in importance. One of the outcomes is the Constraint Integer Programming paradigm where both techniques are integrated in one search tree. We follow this paradigm and report on our study how the techniques can be best brought together. Our testcases are based on the RCPSP and Labor Constraint Scheduling Problem.

3 - A New Arbitrary Starting Variable Dimension Algorithm for Computing an Integer Point in a Class of Polytopes

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

Let P be a polytope satisfying that each row of the defining matrix has at most one positive entry. Determining whether there is an integer point in P is an NP-complete problem. A new arbitrary starting simplicial algorithm is developed in this paper for computing an integer point in P. Starting from an arbitrary integer point of the space, the algorithm follows a finite simplicial path that either leads to an integer point in the polytope or proves no such point exists.

■ WB08

Marriott - Chicago E

Trends in Mixed Integer Programming VII

Cluster: Integer and Mixed Integer Programming
Invited Session

Chair: Robert Weismantel, Professor, Otto-von-Guericke University Magdeburg, Institute for Mathematical Optimization, Universitaetsplatz 2, Magdeburg, 39106, Germany, weismant@mail.math.uni-magdeburg.de

Co-Chair: Andrea Lodi, DEIS, University of Bologna, Viale Risorgimento, 2, Bologna, 40136, Italy, andrea.lodi@unibo.it

1 - Mixing and Lot-sizing with Stock Variable Upper Bounds

Marco Di Summa, UCL - CORE, Voie du Roman Pays, 34, Louvain-la-Neuve, 1348, Belgium, marco.disumma@uclouvain.be, Laurence Wolsey

We study the discrete lot-sizing problem with an initial stock variable and an associated variable upper bound constraint. This problem is of interest in its own right, and is also a natural relaxation of the constant capacity lot-sizing problem with upper bounds and fixed charges on the stock variables (LS-CC-SVUB). We show that the convex hull of solutions of the discrete lot-sizing problem is the intersection of two simpler sets. For these two sets we derive both inequality descriptions and compact extended formulations of their respective convex hulls. Finally we carry out some limited computational tests on LS-CC-SVUB in which we use the extended formulations derived above to strengthen the initial MIP formulations.

2 - 2-Level Supply Chains: MIP Formulations and Computation

Rafael de Melo, CORE - University Catholique de Louvain, Rue Voie du Roman Pays, 34, Louvain-la-Neuve, B1348, Belgium, rafael.demelo@uclouvain.be, Laurence Wolsey

We consider first the two-level production-in-series model whose two-levels can be viewed as production and transportation. We derive a compact and tight extended formulation with O(n3) variables for both the general and nested cases. We also analyze a family of valid inequalities related to the projection of the standard multi-commodity reformulation. We then consider the two-level multi-item supply chain in which the 0-level consists of production facilities and the 1-level of retail centers.

3 - Two-period Convex Hull Closures for Big Bucket Lot-sizing Problems

Kerem Akartunali, Research Fellow, University of Melbourne, Dept. of Mathematics and Statistics, Parkville, 3010, Australia, kerema@ms.unimelb.edu.au, Andrew Miller

Despite significant amounts of research, big bucket lot-sizing problems remain notoriously difficult to solve. We consider a two-period model, which is the simplest single-machine, multi-period, capacitated submodel. We propose a methodology that would approximate the closure of the convex hull of this submodel by generating violated inequalities using a distance function. We discuss the polyhedral characteristics of this submodel, as well as how to apply them to the original problem, and we conclude with detailed computational results.

■ WB09

Marriott - Chicago F

MILP Methodologies for Non-Convex Optimization

Cluster: Integer and Mixed Integer Programming
Invited Session

Chair: Anureet Saxena, Research Associate, Axioma Inc, 2313 Charleston Place, Atlanta, GA, 30338, United States of America, anureet@cmu.edu

1 - Modeling Disjunctive Constraints with a Logarithmic Number of Binary Variables and Constraints

Juan Pablo Vielma, ISyE, Georgia Institute of Technology, 765 Ferst Drive, NW, Atlanta, GA, 30332, United States of America, jvielma@isye.gatech.edu, George Nemhauser

For specially structured disjunctive constraints we give sufficient conditions for constructing mixed integer programming (MIP) formulations with a number of binary variables and extra constraints that is logarithmic in the number of terms of the disjunction. Using these conditions we introduce formulations with these characteristics for SOS1, SOS2 constraints and piecewise linear functions. We present computational results showing that they can significantly outperform other MIP formulations.

2 - Generalized Disjunctive Programming Relaxation for the Global Optimization of QCQPs

Juan Ruiz, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, jpruiz@andrew.cmu.edu, Ignacio Grossmann

We present a framework to find strong relaxations for the global optimization of Quadratically Constrained Quadratic Programs. The main idea consists of representing the partition of the domain of each bilinear/quadratic term with a set of disjunctions. This leads to a Bilinear Generalized Disjunctive Program (GDP) that can be relaxed by using some of our recent results for the Global Optimization of Nonconvex GDPs. The performance of the method is shown through a set of test problems.

3 - Linear Programming Relaxations of Non-convex Mixed Integer Quadratically Constrained Problems

Andrea Qualizza, Tepper School of Business, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15217, United States of America, qualizza@cmu.edu, Anureet Saxena, Francois Margot, Pietro Belotti

This talk concerns linear programming relaxations of non-convex Mixed Integer Quadratically Constrained Problems (MIQCP). We investigate cutting planes based approaches to approximate the well known SDP+RLT relaxations of MIQCP both in the lifted space containing the Yij=xi*xj variables, and in the space of original variables. We study linear inequalities arising from the outer-approximation of the cone of PSD matrices, sparsification of these inequalities using prinipal minors, and linearization of various convex quadratic inequalities including the class of projected SDP cuts recently proposed by Saxena, Bonami and Lee. Computational results based on instances from the literature will be presented.

■ WB10

Marriott - Chicago G

Global Optimization Methods and Applications

Cluster: Global Optimization
Invited Session

Chair: Sergiy Butenko, Texas A & M University, Dept. of Industrial Engineering, College Station, TX, 77843, United States of America, butenko@tamu.edu

1 - On Equivalent Reformulations for Absolute Value Equations and Related Problems

Oleg Prokopyev, University of Pittsburgh, Industrial Engineering, Pittsburgh, PA, 15260, United States of America, prokopyev@engr.pitt.edu, Sergiy Butenko, Andrew Trapp

We study absolute value equations (AVE) of the form Ax+B|x|=c. This problem is known to be NP-hard. We discuss relations of AVE with linear complementarity problem and mixed integer programming. Related problems in checking strong and weak solvability of linear interval equations and inequalities are also considered.

2 - Risk Optimization with p-Order Conic Constraints

Paul Krokhmal, Assistant Professor, University of Iowa, 3131 Seamans Center, Iowa City, IA, 52242, United States of America, krokhmal@engineering.uiowa.edu

We consider p-order conic programming problems that are related to a certain class of stochastic programming models with risk objective or constraints. The proposed solution approach is based on construction of polyhedral approximations for p-order cones, and then invoking a cutting-plane scheme that allows for efficient solving of the approximating problems. The conducted case study demonstrates that the developed computational techniques compare favorably against a number of benchmark methods.

3 - A GRASP for a Biobjective Critical Node Detection Problem

Altannar Chinchuluun, University of Florida, Gainesville, United States of America, altannar@ufl.edu, Ashwin Arulselvan, Panos Pardalos

In this talk, we focus on a biobjective Critical Node Detection Problem. The problem finds applications in biomedicine, telecommunications, energy and military strategic planning. The goal of the problem is to find a set of nodes in the graph whose deletion results in the maximum network fragmentation while minimizing the total cost of removing the nodes. We propose a multistart metaheursitic (Greedy Randomized Adaptive Search Procedure) for solving the problem.

■ WB11

Marriott - Chicago H

New Developments in Robust Optimization: Multistage and Nonconvex Problems

Cluster: Robust Optimization
Invited Session

Chair: Dimitris Bertsimas, MIT, Sloan School of Management, E40-147, MIT, Cambridge, MA, 02139, United States of America, dbertsim@mit.edu

1 - A Hierarchy of Near-optimal Policies in Multi-stage Robust Optimization

Dan Iancu, Massachusetts Institute of Technology, Operations Research Center, E40-130, Cambridge, Ma, 02139, United States of America, daniancu@mit.edu, Dimitris Bertsimas, Pablo A. Parrilo

In this work, we examine the performance of disturbance-feedback policies in the context of multi-stage robust optimization. For the one-dimensional case, we prove the optimality of affine policies. For the general case, we introduce a hierarchy of near-optimal policies, which can be computed efficiently, by solving a single semidefinite programming problem, and we demonstrate their performance numerically, in the context of two inventory management applications.

2 - On the Power of Robustness in Two-stage Mixed Integer Optimization Problems

Vineet Goyal, Postdoctoral Associate, Massachusetts Institute of Technology, 77 Massachusetts Ave, E40-111, Cambridge, MA, 02139, United States of America, goyalv@mit.edu, Dimitris Bertsimas

We show that the benefit of adaptivity is bounded by a constant factor in a two-stage problem under fairly general assumptions for uncertainty sets. In particular, for a two-stage mixed integer optimization problem with uncertain costs and right hand side of constraints that belong to a convex and symmetric uncertainty set, we show that the worst-case cost of an optimal one-stage robust solution is at most four times the worst-case cost of an optimal fully adaptive two-stage solution.

3 - Nonconvex Robust Optimization for Constrained Problems

Omid Nohadani, MIT, ORC, MIT, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, nohadani@MIT.EDU, Dimitris Bertsimas

Most robust optimization techniques assume that underlying cost functions are given explicitly. We discuss a novel method for problems with objective functions that may be computed via numerical simulations and incorporate constraints that need to be feasible under perturbations. We generalize the algorithm further to model parameter uncertainties. We demonstrate its practicability in a real-world application in optimizing the Intensity Modulated Radiation Therapy for cancer treatment.

■ WB12

Marriott - Los Angeles

Inequality Constrained Optimization with PDEs

Cluster: PDE-constrained Optimization
Invited Session

Chair: Michael Ulbrich, Technische Universitaet Muenchen, Department of Mathematics, Boltzmannstr. 3, Garching, 85748, Germany, mulbrich@ma.tum.de

1 - Interior Point Methods in Function Space for Hyperthermia Treatment Planning

Anton Schiela, ZIB, Division Scientific Computing, Takusstr. 7, Berlin-Dahlem, 14195, Germany, schiela@zib.de

Regional hyperthermia aims at heating a tumor by microwaves. The aim is to heat the tumor, while not damaging the healthy tissue. This yields a state constrained optimal control problems subject to a non-linear partial differential equation. We consider an algorithm in function space for the solution of this problem. The state constraints are tackled by a structure exploiting interior point method. A composite step method is used for its globalization in the presence of non-convexity.

2 - State-constrained Optimal Control of a Quasilinear Parabolic-elliptic System

Christian Meyer, TU Darmstadt, Graduate School CE, Dolivostr. 15, Darmstadt, 64289, Germany, meyer@wias-berlin.de

The talk is dealing with an optimal control problem governed by a quasilinearly coupled system of a parabolic and an elliptic PDE, known as the thermistor equations. This PDE system models the heating of a conducting material by means of direct current. As pointwise restrictions on the temperature field are essential in many applications, we impose pointwise state constraints on the optimization. This requires higher regularity of the state which is proven by means of maximum regularity results for elliptic and parabolic PDEs. This allows to derive associated optimality conditions. The theoretical results are illustrated by a numerical example motivated by an application from the automotive industry.

3 - On Goal-oriented Adaptivity for Elliptic Optimal Control Problems

Martin Weiser, Zuse Institute Berlin, Division Scientific Computing, Takusstr. 7, Berlin-Dahlem, 14195, Germany, weiser@zib.de

The talk discusses goal-oriented error estimation and mesh refinement for optimal control problems with elliptic PDE constraints. The value of the reduced cost functional is used as quantity of interest. Error representation and practical hierarchical error estimators are derived. For state constrained problems, their relation to barrier methods is discussed. The effectivity is demonstrated at numerical examples and compared to previous approaches.

■ WB13

Marriott - Miami

Electricity Markets I

Cluster: Optimization in Energy Systems
Invited Session

Chair: Andres Ramos, Professor, Universidad Pontificia Comillas, Alberto Aguilera 23, Madrid, 28015, Spain, andres.ramos@upcomillas.es

1 - A MILP Model for the Resourse Scheduling Problem of a Power Producer with Market Share Maximization

Maria Teresa Vespucci, Professor, University of Bergamo, viale Marconi, 5, Dalmine, BG, 24044, Italy, maria-teresa.vespucci@unibg.it, Dario Siface, Mario Innorta

A model for the medium-term resource scheduling problem of a power producer of large dimension is introduced, that maximizes the producer's market share while garanteeing a minimum preassigned profit level and satisfying technical constraints. The nonlinearities, introduced into the model by representing the power producer influence on hourly zonal equilibrium prices and quantities, are linearized by means of binary variables. A case study related to the Italian electricity market is discussed.

2 - A Primal Dual Algorithm for Simulation-based Computation of Cournot Equilibrium

Mingyi Hong, University of Virginia, Charlotesville, 22904, United States of America, mh4tk@virginia.edu, Alfredo Garcia

We consider an oligopolistic model of competition among spatially separated electricity generators. Clearing prices may differ on a zonal basis depending upon specific congestion events. We are interested in computing Nash Cournot equilibrium via a primal-dual algorithm in which power flow is simulated at each iteration. This feature alleviates the computational burden vis-a vis other methods in which power flow is modeled explicitly. We present convergence analysis and experimental results on large-scale networks.

3 - Sequential Stochastic Unit Commitment for Large-scale Integration of RES and Emerging Technologies

Andres Ramos, Professor, Universidad Pontificia Comillas, Alberto Aguilera 23, Madrid, 28015, Spain, andres.ramos@upcomillas.es, Jesus M. Latorre, Luis Olmos, Kristin Dietrich, Ignacio J. Pérez-Arriaga

RES and emerging technologies are modeled by a UC as a SIP problem that represents the daily operation considering the distribution of RES generation. Once planning is done some events, such as forced failures of units or actual generation of RES, may happen and corrective actions are heuristically decided. Random events are obtained by simulation. The SIP and the stochastic simulation models are sequentially run for every day of the scope. Main stochastic variables are simulated by scenarios.

■ WB14

Marriott - Scottsdale

Network Game Theory

Cluster: Game Theory
Invited Session

Chair: Asu Ozdaglar, Associate Professor, Massachusetts Institute of Technology, 77 Massachusetts Ave, 32-D630, Cambridge, MA, 02139, United States of America, asuman@mit.edu

1 - Game Dynamics, Equilibrium Selection and Network Structure

Amin Saberi, Stanford University, saberi@stanford.edu, Andrea Montanari

Coordination games describe social or economic interactions in which the adoption of a common strategy has payoff. They are classically used to model the spread of conventions, behaviors, and technologies in societies. Since the pioneering work of Ellison (1993), specific network structures have been shown to have dramatic influence on the convergence of such dynamics. In this talk, I will try to make these results more precise and use the intuition for designing effective algorithms.

2 - Communication and Learning in Social Networks

Kostas Bimpikis, MIT, 77 Massachusetts Ave, Cambridge, MA, United States of America, kostasb@mit.edu, Daron Acemoglu, Asu Ozdaglar

We study a model of costly network formation, information aggregation through communication and decision making in large societies. We identify conditions under which there will be asymptotic learning, i.e., as the society grows, the fraction of agents taking correct actions converges to one. We identify properties of the communication cost structure that lead to topologies, that facilitate learning. Finally, we apply our results to random graph models, such as power law and Erdos-Renyi graphs.

3 - Distributed Spectrum Balancing via Game Theoretical Approach

Yao H. Morin, Research Assistant, University of Minnesota, 200 Union ST SE, Minneapolis, MN, 55414, United States of America, yaohuang@umn.edu, Tom Luo

In a multi-user communication system, users compete for spectrum. Service provider aims to devise a scheme to regulate users' power so its utility is maximized. We develop a distributed scheme based on a game theoretic model and a price of service, which enables the scheme to be executed in a distributed fashion and entitles the service provider to control users' power. We study the existence of Nash equilibrium and provide convergence conditions. The scheme is scalable to multi-system case.

■ WB15

Gleacher Center - 100

Algorithm Developments in Stochastic Integer Programming

Cluster: Stochastic Optimization
Invited Session

Chair: Lewis Ntaimo, Assistant Professor, Texas A&M University, 3131 TAMU College Station, College Station, TX, 77843, United States of America, ntaimo@tamu.edu

1 - Prioritization via Stochastic Optimization

Ali Koc, The University of Texas at Austin, Graduate Program in Operations Research, Austin, TX, 78703, United States of America, alikoc@mail.utexas.edu, David Morton, Elmira Popova

The operations research literature handles activity selection problems by forming an optimal portfolio of activities, as opposed to a common approach in industry which forms a prioritized list. We develop a novel prioritization approach incorporating both views. We illustrate our approach on stochastic k-median and capital budgeting models. We formulate two-stage and multi-stage stochastic integer programs and develop valid inequalities. We use parallel branch-cut price to improve solution time.

2 - Mixed-integer Stochastic Decomposition for Two-stage Stochastic Integer Programming

Yang Yuan, PhD Candidate, The Ohio State University, 210 Baker Systems Engineering, 1971 Neil Avenue, Columbus, OH, 43210, United States of America, yuan.65@osu.edu, Suvrajeet Sen

Most studies in stochastic integer programming represent uncertainty by a finite number of scenarios. In this talk, we propose a statistical algorithm for two-stage stochastic integer programming problems with infinitely many scenarios by extracting information from the empirical scenario pool through sequential sampling. This algorithm can be referred to as mixed-integer stochastic decomposition.

3 - Fenchel Decomposition for Stochastic Mixed-integer Programming

Lewis Ntaimo, Assistant Professor, Texas A&M University, 3131 TAMU College Station, College Station, TX, 77843, United States of America, ntaimo@tamu.edu

In this talk, we present a new cutting plane method for two-stage stochastic mixed-integer programming (SMIP) called Fenchel decomposition (FD). FD is based on a new class of valid inequalities termed, FD cuts, which are based on Fenchel cutting planes in integer programming. We consider FD cuts based on both the first- and second-stage variables, and based only on the second-stage variables. Preliminary computational results will be presented.

■ WB16

Gleacher Center - 200

Risk-averse Optimization via Stochastic Dominance

Cluster: Stochastic Optimization
Invited Session

Chair: Darinka Dentcheva, Professor, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, darinka.dentcheva@stevens.edu

1 - Optimization with Stochastic Dominance Constraints and Sampling

Tito Homem-de-Mello, Northwestern University, 2145 Sheridan Rd, Evanston, IL, 60208, United States of America, tito@northwestern.edu, Jian Hu, Sanjay Mehrotra

In this talk we discuss some approaches to model optimization problems where the constraints are formulated using the concept of stochastic dominance. The notion of stochastic dominance provides a way to compare risks; its use in the optimization context has only recently been introduced. We discuss how such models can be integrated with sampling techniques, which is a crucial step for the development of algorithms for this class of problems when the underlying distributions are either continuous or have a large number of scenarios. We present some properties of the resulting approximating problems as well as procedures to calculate statistical bounds for the estimates obtained with finitely many samples. Numerical results are presented.

2 - An Enhanced Model for Portfolio Choice with SSD Criteria: A Constructive Approach

Csaba Fabian, Professor, Kecskemet College, 10 Izsaki ut, Kecskemet, H-6000, Hungary, fabian@cs.elte.hu, Diana Roman, Viktar Zviarovich, Gautam Mitra

We formulate a portfolio choice model applying Second-order Stochastic Dominance. This model is an enhanced version of the multi-objective model proposed by Roman, Darby-Dowman, and Mitra (2006). The proposed model can be formulated as minimisation of a convex risk measure. Moreover it offers a natural generalisation of the SSD-constrained model of Dentcheva and Ruszczynski (2006). We present a computational study comparing solution methods and demonstrating modelling capabilities.

3 - Inverse Dominance Constraints Duality and Methods

Darinka Dentcheva, Professor, Stevens Institute of Technology, 1 Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, darinka.dentcheva@stevens.edu, Andrzej Ruszczynski

We consider optimization problems with second order nonlinear stochastic dominance constraints formulated as a relation of Lorenz curves (inverse dominance). We present two subgradient methods for solving the problems and discuss their convergence. We compare their performance to other methods. We infer rank dependent utility optimization problems and mean-risk models with coherent measures of risk which are equivalent to the problem with inverse dominance constraints.

■ WB17

Gleacher Center - 204

Logistics and Transportation A

Contributed Session

Chair: Kazuhiro Kobayashi, National Maritime Research Institute, 6-38-1 Shinkawa Mitaka, Tokyo, Japan, kobayashi@nmri.go.jp

1 - A Branch-and-price Algorithm for a 3-Level Location-routing Problem

Leonardo Ribeiro, Petrobras, Av. Nilo Pensanha 151 7o Andar, Rio de Janeiro, RJ, Brazil, leonardosribeiro@petrobras.com.br, Laura Bahiense, Virgilio Ferreira

We consider a 3-level location-routing problem, were products are transported from factories to depots and from there to clients, according to routes designed in the solution procedure. We present a set partitioning formulation for this problem. In order to generate integer solutions, we developed a branch-and-price algorithm and two heuristic pricing procedures. Optimal solutions were found for instances with 25, 40 and 60 clients.

2 - An Advanced Integer Programming Based Hybrid Heuristic for Generalized VRP-like Problems

Diego Klabjan, Northwestern University, 2145 Sheridan Road, Room C210, Evanston, IL, 60208, United States of America, d-klabjan@northwestern.edu, Anupam Seth, Placid Ferreira

Production planning for PCB assembly defies standard OR approaches due to the size and complexity of the problems. We examine the problem on the popular collect-and-place type machines and model it as a generalized vehicle routing problem. We present a hybrid heuristic consisting of an initial constructive phase with a worst-case guarantee and an improvement phase based on integer-linear programming. Computational results are presented to demonstrate the effectiveness of the technique.

3 - An Approximate Dynamic Programming Approach for Ship Scheduling Problems

Kazuhiro Kobayashi, National Maritime Research Institute, 6-38-1 Shinkawa Mitaka, Tokyo, Japan, kobayashi@nmri.go.jp, Takahiro Seta, Mikio Kubo

An approximate dynamic programming approach for ship scheduling problems is studied. The ship scheduling problem is the planning problem to determine the ship schedules with minimum cost. It is formulated as a set covering problem. In this set covering problem, it is assumed that the data are static. However, in ship operations, there is much uncertainty. In order to deal with uncertainty, we use an approximate dynamic programming approach. We show the formulation to incorporate the approximate dynamic programming framework in the set covering formulation, and also show some numerical experiments.

■ WB18

Gleacher Center - 206

Branch-and-Bound for MINLP

Cluster: Nonlinear Mixed Integer Programming
Invited Session

Chair: Jon Lee, IBM TJ Watson Research Center, P.O. Box 218, Yorktown Heights, NY, 10598, United States of America, jonlee@us.ibm.com

1 - Nonlinear Branch-and-bound Revisited

Sven Leyffer, Argonne National Laboratory, MCS Division 9700 South Cass Avenue, Argonne, IL, 60439, United States of America, leyffer@mcs.anl.gov

We present a new open-source implementation of nonlinear branch-and-bound that pays special attention to how the nonlinear subproblems are solved. In particular, we develop new warm-starting techniques and explore their effectiveness in the context of nonlinear strong-branching rules. We present preliminary numerical results.

2 - A Local Branching Heuristic for MINLPs

Giacomo Nannicini, Ecole Polytechnique, LIX, Ecole Polytechnique, Palaiseau, 91128, France, giacomon@lix.polytechnique.fr, Pietro Belotti, Leo Liberti

Local branching is an improvement heuristic, developed within the context of branch-and-bound algorithms for MILPs, which has proved to be very effective in practice. For the binary case, it is based on defining a neighbourhood of the current incumbent solution by allowing only a few binary variables to flip their value. The neighbourhood is then explored with a branch-and-bound solver. We propose a local branching scheme for (nonconvex) MINLPs which is based on iteratively solving MILPs and NLPs. Preliminary computational experiments within the open source solver Couenne show that this approach is able to improve the incumbent solution on the majority of the test instances, requiring only a very short CPU time.

3 - Heuristics for Mixed Integer Nonlinear Programming

João Goncalves, IBM Resarch, 1101 Kitchawan Road, Yorktown Heights, United States of America, jpgoncal@us.ibm.com, Pierre Bonami

We show how several heuristics for finding feasible solutions of Mixed Integer Linear programs can be adapted to Mixed Integer Nonlinear programs (MINLPs). We present computational results on a set of convex MINLP instances. The results show that the heuristics can find good feasible solutions faster than the branch-and-bound algorithm and also that they can help the branch-and-bound algorithm reduce the computational time to solve those instances.

■ WB19

Gleacher Center - 208

Nonlinear Programming C

Contributed Session

Chair: Laura Kettner, Graduate Student, Northern Illinois University, Department of Mathematical Sciences, DeKalb, IL, 60115, United States of America, kettner@math.niu.edu

1 - A Newton Method for Vector Optimization

Fernanda M. P. Raupp, Professor, PUC-Rio, Rua Marques de S. Vicente, 225 sala 959, Rio de Janeiro, 22453-900, Brazil, fraupp@puc-rio.br, L. M. Grama Drummond, Benar Svaiter

We propose a Newton method for solving smooth unconstrained vector optimization problems under partial orders induced by general closed convex pointed cones with nonempty interior. The method extends the one proposed by Fliege, GraÒa Drummond and Svaiter for multicriteria, which in turn is an extension of the classical Newton method for scalar optimization. We prove local existence of an efficient point and q-quadratic convergence to this point, under semi-local assumptions.

2 - Parallel Multistart Strategies for Nonlinear Optimization

S. Ilker Birbil, Associate Professor, Sabanci University, FENS, Orhanli-Tuzla, Istanbul, 34956, Turkey, sibirbil@sabanciuniv.edu, Figen Oztoprak

The basic motivation of most parallel nonlinear optimization algorithms is to speed up the execution of sequential tasks. In this study, we argue that parallel processing can provide further performance improvements by means of parallel generation and exchange of information. We apply our idea to some well-known methods and present theoretical as well as numerical results on how appropriate interaction strategies may create advantages by modifying the mechanisms of original algorithms.

3 - Well-posed Vector Optimization Problems

Laura Kettner, Graduate Student, Northern Illinois University, Department of Mathematical Sciences, DeKalb, IL, 60115, United States of America, kettner@math.niu.edu, Sien Deng

This presentation will focus on well-posedness of vector optimization problems. We will discuss some new results based on scalarization and convex analysis techniques, including a result pertaining to well-posedness by Hausdorff distance of epsilon-optimal solution sets. We will also discuss results concerning properties of extended well-posedness in vector optimization.

■ WB20

Gleacher Center - 300

On Formulating and Solving Subproblems in Nonlinear Optimization

Cluster: Nonlinear Programming
Invited Session

Chair: Anders Forsgren, KTH - Royal Institute of Technology, Department of Mathematics, Stockholm, SE-100 44, Sweden, andersf@kth.se

1 - A Regularized Method for General Quadratic Programming

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

We propose a general quadratic programming method designed for use in an SQP method for large-scale nonlinearly constrained optimization. The method reflects recent developments in mixed-integer nonlinear programming and optimization subject to differential equation constraints that require fast QP methods capable of being hot started from a good approximate solution.

2 - On Solving a Quadratic Program Approximately

Anders Forsgren, KTH - Royal Institute of Technology, Department of Mathematics, Stockholm, SE-100 44, Sweden, andersf@kth.se, Fredrik Carlsson, Philip E. Gill

Minimization of a strictly convex quadratic function is a fundamental optimization problem. The conjugate-gradient method is in a sense an ideal method for solving this problem approximately. We view the conjugate-gradient method in a column generation framework with a steepest-descent problem in the Euclidean norm as subproblem. We also discuss extensions to other norms and nonnegativity constraints on the variables. Our motivation comes from intensity-modulated radiation therapy.

3 - Globally Convergent Optimization Methods Based on Conservative Convex Approximations

Krister Svanberg, Professor, KTH - Royal Institute of Technology, Department of Mathematics, Stockholm, SE-100 44, Sweden, krille@kth.se

This presentation deals with a certain class of globally convergent optimization methods, based on sequential conservative convex separable approximations. These methods, which are frequently used in structural- and topology optimization, are intended primarily for inequality-constrained nonlinear programming problems for which the set of feasible solutions has a non-empty interior. The possible incorporation of equality constraints will also be discussed.

■ WB21

Gleacher Center - 304

Emerging Communication Networks

Cluster: Telecommunications and Networks
Invited Session

Chair: Iraj Saniee, Head, Math of Nertworks and Communications, Bell Labs, Alcatel-Lucent, 600 Mountain Avenue, Murray Hill, NJ, 07974, United States of America, iis@research.bell-labs.com

1 - Optimization of Collaborative P2P and Service Provider Traffic Engineering

Qiong Wang, Bell Labs, Lucent Technologies, Murray Hill, United States of America, qwang@research.bell-labs.com, Anwar Walid

P4P is a new paradigm for collaboration between peer-to-peer (P2P) applications and service providers (SP's). The objective of P4P is to improve P2P download times and reduce ISP network congestion by allowing certain information exchange. We consider an enhanced P4P model which includes content caches. We develop a mathematic programming model that matches content demand and supply, routes network traffic, and places content caches to preserve network resource and save infrastructure cost.

2 - Dantzig-Wolfe Algorithms for Packing LPs: Comparing Additive vs Multiplicative Weight Updates

Matthew Andrews, Member Technical Staff, Bell Laboratories, 600 Mountain Ave, Murray Hill, NJ, 07974, United States of America, andrews@research.bell-labs.com

In this talk we examine Dantzig-Wolfe algorithms for packing linear programs and compare the performance of additive weight updates vs multiplicative updates. We show that the running time of multiplicative schemes can be quadratic in the desired error whereas for additive schemes the running time can be linear. We also study how small the error needs to be before the linear behavior manifests itself.

3 - Continuing Work on Power Flow Problems

Abhinav Verma, Student, Columbia University, 500 West, 120th Street, S.W.Mudd Building, Rm 313, New York, NY, 10027, United States of America, av2140@columbia.edu, Daniel Bienstock

We present work on 3 topics in power transmission systems. First we address a new model for vulnerability analysis that scales to large network size and provides useful insight. In the last part of the talk we consider the throughput maximization problem. Flows are governed by balance equations, and, significantly, by the laws of physics which are typically described by nonlinear, non-convex systems of equations. Our work has produced scalable algorithms. Joint work with Daniel Bienstock.

■ WB22

Gleacher Center - 306

SQP Methods and Software

Cluster: Implementations, Software
Invited Session

Chair: Klaus Schittkowski, Professor, University of Bayreuth, Universitaetsstr. 1, Bayreuth, 95440, Germany, klaus.schittkowski@uni-bayreuth.de

1 - An SQP Method Without Hessian or Jacobian Evaluations

Torsten Bosse, Humboldt University, Unter den Linden 8, Berlin, 10099, Germany, bosse@mathematik.hu-berlin.de, Andreas Griewank

We propose an SQP approach that avoids the evaluation of the active constraint Jacobian through the use of low rank updates. The matrix approximations utilize an adjoint secant condition involving Jacobian traspose vector products. For the linear algebra we provided a null-space and a range-space version with a compact storage and limited memory option for the Hessian approximation. We present numerical results on the usual test sets and several special test problems.

2 - FA_SQP, A Feasible Arc Algorithm Based on SQP Method

Jose Herskovits, Professor, COPPE - Federal University of Rio de Janeiro, Caixa Postal 68503, Rio de Janeiro, RJ, 21945970, Brazil, jose@optimize.ufrj.br

Given a point at the interior of inequality constraints, FA_SQP produces a sequence of feasible point with decrescent values of the objective. At each iteration a feasible descent arc is computed employing the SQP search direction, a restoring direction and an arc that involves second order approximations of the constraints. These requires de solution of two linear systems. We present strong theoretical results and a very auspicious numerical study. In particular, Maratos, effect is avoided.

3 - SQP Codes - 30 Years Later

Klaus Schittkowski, Professor, University of Bayreuth, Universitaetsstr. 1, Bayreuth, 95440, Germany, klaus.schittkowski@uni-bayreuth.de

The success story of SQP methods started in 1979, when Mike Powell implemented the code VF02AD. Meanwhile, SQP codes are routinely used for solving practical optimization problems and became part of most engineering design and control systems. The talk gives a review of practical applications of a typical implementation and its development over a period of 25 years. It is shown, how SQP methods are extended to other areas, e.g., to solve large scale, mixed integer, or least squares problems.

■ WB23

Gleacher Center - 308

Optimization in Machine Learning I

Cluster: Sparse Optimization
Invited Session

Chair: Stephen Wright, Professor, University of Wisconsin-Madison, Computer Sciences, 1210 West Dayton Street, Madison, WI, 53706, United States of America, swright@cs.wisc.edu

1 - Simple and Efficient Optimization Techniques for Machine Learning

Olivier Chapelle, Yahoo! Research, 2181 Mission College Blvd, Santa Clara, CA, 95054, United States of America, chap@yahoo-inc.com

In this talk, I will present various machine learning problems such as ranking, boosting, structured output learning, multiple kernel learning and graph-based classification. In all cases, variants of simple optimization techniques can be used to solve these problems efficiently.

2 - Large Scale Transductive Relational Learning

Sathiya Keerthi, Senior Scientist, Yahoo! Research, 2821 Mission College Blvd, Santa Clara, CA, 95054, United States of America, selvarak@yahoo-inc.com, S Sundararajan

This talk will look at optimization methods and issues related to the solution of large scale transductive relational learning problems arising in web mining.

3 - Large-scale Machine Learning and Stochastic Gradient Learning Algorithm

Leon Bottou, NEC Laboratories, 4 Independence Way, Suite 200, Princeton, NJ, 08540, United States of America, leon@bottou.org, Olivier Bousquet

During the last decade, data sizes have outgrown processor speed. Computing time is then the bottleneck. The first part of the presentation theoretically uncovers qualitatively different tradeoffs for the case of small-scale and large-scale learning problems. The large-scale case involves the computational complexity of the underlying optimization algorithms in non-trivial ways. Unlikely optimization algorithm such as stochastic gradient descent show amazing performance for large-scale machine learning problems. The second part makes a detailed overview of stochastic gradient learning algorithms, with both simple and complex examples.

■ WB25

Gleacher Center - 404

Generalized Derivatives and Derivative Free Optimization Methods

Cluster: Variational Analysis
Invited Session

Chair: Vaithilingam Jeyakumar, Professor, University of New South Wales, Department of Applied Mathematics, Sydney, Australia, v.jeyakumar@unsw.edu.au

1 - Various Lipschitz like Properties for Functions and Sets: Directional Derivative and Tangential Characterizations

Pedro Gajardo, Universidad Tecnica Federico Santa Maria, Avda Espana 1680, Valparaiso, Chile, pedro.gajardo@usm.cl, Lionel Thibault, Rafael Correa

In this talk we introduce for extended real valued functions, defined on a Banach space X, the concept of K directionally Lipschitzian behavior where K is a bounded subset of X. For different types of sets K (e.g. zero, singleton or compact), the K directionally Lipschitzian behavior recovers well-known concepts in variational analysis (locally Lipschitzian, directionally Lipschitzian or compactly epi-Lipschitzian properties respectively). Characterizations of this notion are provided in terms of the lower Dini subderivatives. We also adapt the concept for sets and establish characterizations of the mentioned behavior in terms of the Bouligand tangent cones. The special case of convex functions and sets is also studied.

2 - On Solving Generalized Nash Equilibrium Problems via Optimization

Barbara Panicucci, University of Pisa, Italy, panicucc@mail.dm.unipi.it

This talk concerns the generalized Nash equilibrium problem (GNEP). We consider an equivalent optimization reformulation of GNEP using a regularized Nikaido-Isoda function so that solutions of GNEP coincide with global minima of theoptimization problem. We then propose a derivative-free descent type method with inexact line search to solve the equivalent optimization problem and we prove that the algorithm is globally convergent. Finally, we present some numerical results

3 - Learning Lessons Across Deterministic and Stochastic Direct Search Methods

Mason Macklem, Doctor, University of British Columbia Okanagan, Kelowna, V1V1V7, Canada, mason.macklem@gmail.com

The terms "direct search" and "derivative-free" are often used to refer to both deterministic grid-sampling continuous optimization and evolutionary strategy algorithms. In this talk, we compare issues surrounding performance comparisons of both methods, and introduce some examples of how lessons learned in one class of methods can improve performance in the other.

■ WB28

Gleacher Center - 600

Nonsmooth Optimization: Theory and Applications

Cluster: Nonsmooth and Convex Optimization
Invited Session

Chair: Dominikus Noll, Professor, University of Toulouse, 118, Route de Narbonne, Toulouse, 31062, France, noll@mip.ups-tlse.fr

1 - Incremental-like Bundle Methods with Application to Energy Planning

Gregory Emiel, Doctor, IMPA, Estrada Dona Castorina 110, Rio de Janeiro, 22460-320, Brazil, gregoryemiel@gmail.com, Claudia Sagastizabal

An important field of application of non-smooth optimization refers to decomposition of large-scale problems by Lagrangian duality: the dual problem consists in maximizing a convex non-smooth function defined as the sum of sub-functions, some of them being hard to evaluate. We propose to take advantage of such separable structure by making a dual bundle iteration after having evaluated only a subset of the dual sub-functions and apply this incremental approach to generation planning.

2 - A Bundle Method for Non-smooth and Non-convex Optimization

Dominikus Noll, Professor, University of Toulouse, 118, Route de Narbonne, Toulouse, 31062, France, noll@mip.ups-tlse.fr

We discuss a bundle algorithm to minimize non-smooth and non-convex functions. Trial steps are obtained by solving convex quadratic programs, or in some cases, SDPs. The major difference with convex bundle methods is that cutting planes have to be replaced by a new technique. We prove that every accumulation point of the sequence of serious iterates is critical. The option of second order steps is included and in a variety of situations allows local super-linear convergence.

3 - Nonsmooth Methods for Robust Feedback Controller Synthesis

Olivier Prot, Doctor, University of Limoges, 123, Avenue Albert Thomas, Limoges, 87060, France, olivier.prot@unilim.fr, Dominikus Noll, Pierre Apkarian

We consider the problem of robust feedback controller synthesis. For this problem the Kalman-Yakubovitch-Popov Lemma leads to a program with bilinear matrix inequality constraint. We use a different approach in order to avoid the identification of Lyapunov variables. Problem is reformulated as a semi-infinite optimization program and solved using a non-smooth spectral bundle method. We present some numerical examples in the case of H_infinity and Integral Quadratic Constraint synthesis.

■ WB29

Gleacher Center - 602

Computational Methods for Dynamic Models in Economics - Part II

Cluster: Finance and Economics
Invited Session

Chair: Che-Lin Su, Assistant Professor of Operations Management, The University of Chicago Booth School of Business, 5807 S. Woodlawn Ave, Chicago, IL, 60637, United States of America, chelin.su@gmail.com

1 - Computational Approaches for Markov Inventory Games

Rodney Parker, Assistant Professor of Operations Management, The University of Chicago Booth School of Business, 5807 S. Woodlawn Ave, Chicago, IL, 60637, United States of America, Rodney.Parker@chicagobooth.edu

We discuss two separate approaches for computationally determining the Markov equilibrium policies in two dynamic inventory games. In the first game, two capacity-limited firms in a serial supply chain face stochastic market demand, choosing inventory levels in every period. In the second game, two retailers compete with stockout-based substitution.

2 - Competition and Innovation in the Microprocessor Industry

Ron Goettler, Assistant Professor of Marketing, The University of Chicago Booth School of Business, 5807 S. Woodlawn Ave, Chicago, IL, 60637, United States of America, ron.goettler@gmail.com

We propose and estimate a model of dynamic oligopoly with durable goods and endogenous innovation to examine the relationship between market structure and the evolution of quality. We estimate the model for the PC microprocessor industry and perform counterfactual simulations to measure the benefits of competition. Consumer surplus is 2.5 percent higher (\$5 billion per year) with AMD than if Intel were a monopolist. Innovation, however, would be higher without AMD present.

3 - Structural Estimation of Games with Multiple Equilibria

Che-Lin Su, Assistant Professor of Operations Management, The University of Chicago Booth School of Business, 5807 S. Woodlawn Ave, Chicago, IL, 60637, United States of America, chelin.su@gmail.com

We consider a model of an empirical pricing game with multiple equilibria and propose the constrained optimization formulation for estimation of the game. We present numerical results of our method on a Bertrand pricing example.

Wednesday, 3:15pm - 4:45pm

■ WC01

Marriott - Chicago A

Steiner Trees and Forests

Cluster: Approximation Algorithms
Invited Session

Chair: Cliff Stein, Columbia University, 326 S W Mudd Building, 500 W. 120th Street, New York, NY, 10027, cliff@ieor.columbia.edu

1 - Node-weighted Steiner Tree and Group Steiner Tree in Planar Graphs

Mohammad Hajiaghayi, Research Afflliate, MIT, Computer Science, 77 Massachusettes Avenue, Cambridge, MA 02139, hajiagha@mit.edu

We improve the approximation ratios for two optimization problems in planar graphs. For nodeweighted Steiner tree, a classical network-optimization problem, the best achievable approximation ratio in general graphs is O(log n), and nothing better was previously known for planar graphs. We give a constant-factor approximation for planar graphs. Our algorithm generalizes to allow as input any nontrivial minor-closed graph family, and also generalizes to address other optimization problems such as Steiner forest, prize-collecting Steiner tree, and network-formation games. The second problem we address is group Steiner tree: given a graph with edge weights and a collection of groups (subsets of nodes), find a minimum-weight connected subgraph that includes at least one node from each group. The best approximation ratio known in general graphs is $O(\log^{3n})$, or $O(\log^{2n})$ when the host graph is a tree. We obtain an O(log n polyloglog n) approximation algorithm for the special case where the graph is planar embedded and each group is the set of nodes on a face. We obtain the same approximation ratio for the minimum-weight tour that must visit each group.

2 - Polynomial-time Approximation Schemes for Connectivity Problems in Planar Graphs

Glencora Borradaile, Oregon State University, EECS, Corvallis, OR, United States of America, glencora@eecs.oregonstate.edu

We present a framework for designing polynomial-time approximation schemes for network design problems such as Steiner tree and 2-edge connectivity in planar graphs. For a fixed epsilon, a polynomial-time approximation scheme finds, in polynomial time, a solution whose value is within 1+epsilon of the optimal solution. This work is joint with Philip Klein and Claire Mathieu.

3 - Improved Approximation Algorithms for Prize-collecting Steiner Tree and TSP

Howard Karloff, ATT Labs—Research, 180 Park Ave., Room C231, Florham Park, NJ, 07932, United States of America, howard@research.att.com

We study the prize-collecting versions PCST of Steiner tree and PCTSP of TSP: find a tree (for PCST) or cycle (for PCTSP) in a graph minimizing the sum of the edge costs in the tree/cycle and the node penalties of the unspanned nodes. The previously best(2-approximation)-algorithm appeared in 1992. The LP relaxation of PCST has integrality ratio 2. We present (2-epsilon)-approximation algorithms for both problems. With Aaron Archer, Mohammad Hossein Bateni, and MohammadTaghi Hajiaghayi.

■ WC02

Marriott - Chicago B

Algorithms for Variational Inequalities and Related Problems I

Cluster: Complementarity Problems and Variational Inequalities
Invited Session

Chair: Andreas Fischer, TU Dresden, Institute of Numerical Mathematics, Dresden, 01062, Germany, Andreas.Fischer@tu-dresden.de

1 - Newton's Method for Computing a Generalized Nash Equilibrium Through Fixed Point Formulation

Anna von Heusinger, University of Wuerzburg, Department of Mathematics, Am Hubland, Wuerzburg, 97074, Germany, heusinger@mathematik.uni-wuerzburg.de, Masao Fukushima, Christian Kanzow

The generalized Nash equilibrium problem (GNEP) differs from the standard Nash equilibrium problem in that not only the players' cost functions depend on the rivals' decision variables, but also their strategy spaces. Fixed point formulations are typically connected with showing existence of a Nash equilibrium. Here we use a particular single-valued fixed point formulation in order to develop numerical methods for the computation of a generalized Nash equilibrium.

2 - Generalized Complementarity as Unconstrained Optimization

Mohamed Tawhid, Doctor, Thompson Rivers University, Department of Mathematics and Statistics, 900 McGill Road, P.O. Box 3010, Kamloops, BC, V2C 5N3, Canada, Mtawhid@tru.ca

We consider an unconstrained minimization reformulation of the generalized complementarity problem GCP(f,g). We show under appropriate conditions, a local/global minimum of a merit function (or a "stationary point" of a merit function) is coincident with the solution of the given generalized complementarity problem. Further, we give some conditions on the functions f and g to get a solution of GCP(f,g) by introducing the concepts of relative monotonicity and {\bf P_0}-property and their variants. Our results further give a unified/generalization treatment of such results for the nonlinear complementarity problem.

3 - Regulating HazMat Transportation: A Game Theory Approach

Veronica Piccialli, Dipartimento di Ingegneria dell'Impresa Universita' degli Studi di Roma Tor Vergata, Via del Politecnico 1, Rome, Italy, piccialli@disp.uniroma2.it, Massimiliano Caramia, Stefano Giordani, Lucio Bianco

Hazardous materials transportation is characterized by the risk of accidental release of hazardous materials. We propose a game theory approach to regulate the hazmat transportation flow. We assume that the authority is able to introduce different tax levels on the links to force carriers to take routes where the induced risk is lower and to reduce the risk concentration on a single link. Taxes imply a mutual influence of the carriers on their costs, and this naturally leads to a Nash game.

■ WC03

Marriott - Chicago C

New Game Theory Applications to Electricity

Cluster: Optimization in Energy Systems
Invited Session

Chair: Marcia Fampa, COPPE UFRJ, Brigadeiro Trompowski s/n, Rio de Janeiro, Brazil, fampa@cos.ufrj.br

1 - Worst-case Analysis for Modelling the Interaction Between Forward and Spot Markets

Nalan Gulpinar, Warwick University, Warwick Business School, Coventry, United Kingdom, Nalan.Gulpinar@wbs.ac.uk, Fernando Oliveira

In this paper we consider worst-case analysis of strategic decisions in oligopolistic future markets under uncertainty. The interaction between futures and spot prices is modelled by taking into consideration the players in the industry. The two-stage risk-neutral stochastic model is extended to a minimax model with rival demand scenarios. We investigate the impact of demand uncertainty at the level of players in terms of robust optimal strategies and compare the performance of the robust optimization with the cases of no uncertainty, and risk-neutral uncertainty.

2 - Computing Core Allocations for Firm Energy Rights: A MIP and a Randomized Procedures

Marcia Fampa, COPPE UFRJ, Brigadeiro Trompowski s/n, Rio de Janeiro, Brazil, fampa@cos.ufrj.br, Sergio Granville, Juliana Pontes, Luiz Barroso, Mario Pereira

Firm energy is the maximum constant production achieved by a set of hydro plants in a dry period. There is a synergic gain whenever a cooperative operation occurs. The key question is to find a distribution of the benefits shares among the hydro plants which is fair, i.e., a core element. The core constraints increase exponentially with the number of players. We propose a MIP algorithm, based on constraint generation and a randomized procedure in which a constraint sampling is applied.

■ WC04

Marriott - Denver

Combinatorial Optimization F

Contributed Session

Chair: Sylvia Boyd, Professor, SITE, University of Ottawa, 800 King Edward Ave., Ottawa, ON, K1N 6N5, Canada, sylvia@site.uottawa.ca

1 - A Large-scale Computational Study of Optimal Tour Lengths for Geometric Instances of the TSP

David S. Johnson, AT&T Labs - Research, 180 Park Avenue, Room C239, Florham Park, NJ, 07932, United States of America, dsj@research.att.com, Neil Sloane, David Applegate, William Cook

We report on a computational study of optimal TSP solutions for points distributed uniformly in the unit square, both as a function of n and of the particular topology chosen (planar, toroidal, projective plane, etc.). With the Concorde optimization code, we can now test millions of instances for each n <= 100, and thousands for n = 1,000. Earlier, more limited studies yielded conflicting estimates of the Beardwood-Halton-Hammersley asymptotic constant and missed some interesting (and as-yet-unexplained) "small n" behavior that our experiments reveal.

2 - On a Time-dependent Two Path Formulation for the (Cumulative) TSP

Maria Teresa Godinho, ESTIG-Instituto Politecnico de Beja and CIO, Rua Afonso III, 1, 7800-050, Beja, Portugal, mtgodinho@ipbeja.pt, Luis Gouveia

It is well known that the so-called 2-path multi commodity formulations for the TSP do not improve upon the linear programming bound of the corresponding 1-path multi commodity formulation. We introduce a new 2-path time dependent formulation which produces a tighter linear programming bound than the corresponding 1-path formulation and present computational results showing that the new formulation appears to produce very tight linear bounds (with emphasis on the so-called cumulative TSP).

3 - Structure of the Extreme Points of the Subtour Elimination Polytope of the STSP

Sylvia Boyd, Professor, SITE, University of Ottawa, 800 King Edward Ave., Ottawa, ON, K1N 6N5, Canada, sylvia@site.uottawa.ca, Paul Elliott-Magwood

Knowledge of the structure of the extreme solutions of LP relaxations has been useful in obtaining new approximation algorithms for several NP-hard problems. We study the extreme solutions of the Subtour Elimination Problem (SEP), which is an LP relaxation of the STSP, and give some new results on the underlying structure and the defining cobasis structure of these solutions. We use our results to find the exact integrality gap for the metric SEP for some new small values of n.

WC05

Marriott - Houston

Complementarity Problems and Variational Inequalities A

Contributed Session

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

1 - Minty Variational Principle for Set-valued Variational Inequalities

Giovanni P. Crespi, Professor, Universite de la Valle d'Aoste, Faculty of Economics and Business Management, Loc. Grand Chemin, 73/75, Saint-Christophe, 11020, Italy, g.crespi@univda.it, Matteo Rocca, Ivan Ginchev

For scalar functions, a solution of a Minty variational inequality of differential type is also a solution to the primitive optimization problem. The variational inequality is defined as some directional derivative of the objective function of a minimization problem. This result, also known as Minty Variational Principle, holds under mild lower semicontinuity assumption. Several attempt to extend the principle to the vector case has been undertaken. Yang, Yang and Teo proved it holds true only for pseudoconvex functions. Here we try to extend the result to set-valued optimization.

2 - Some Properties of a Smoothing Function Based on the Fischer-Burmeister Function for SOCCP

Yasushi Narushima, Tokyo University of Science, 1-3, Kagurazaka, Shinjyuku-ku, Tokyo, 162-8601, Japan, narusima@rs.kagu.tus.ac.jp, Hideho Ogasawara, Nobuko Sagara

The second-order cone complementarity problem (SOCCP) is an important class of problems containing a lot of optimization problems. By using an SOC complementarity function, the SOCCP can be transformed into a system of nonsmooth equations. To solve this nonsmooth system, smoothing techniques are often used. In this talk, we consider a smoothing function based on the Fischer-Burmeister function for SOCCP. We present some favorable properties on it and propose an algorithm.

3 - New Applications of Ekeland's Epsilon-variational Principle

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

Since 1972, Ekeland's variational principle has been one of the most important tools in all of optimization and nonlinear analysis. We first give an overview of some of its most important applications to date. We then give several new applications, to the existence of solutions in some optimization problems, asymptotic analysis of solutions, and to some new results of implicit function type.

WC06

Marriott - Kansas City

High Performance Solvers and Techniques for SDP

Cluster: Conic Programming

Invited Session

Chair: Makoto Yamashita, Tokyo Instittute of Technology, 2-12-1-W8-29 Ookayama Meguro-ku, Tokyo, Japan, Makoto.Yamashita@is.titech.ac.jp

1 - Reduction of SDP Relaxations for Polynomial Optimization Problems

Martin Mevissen, Tokyo Institute of Technology, Meguro-ku, Ookayama 2-12-1-W8-29, Tokyo, Japan, martime6@is.titech.ac.jp, Masakazu Kojima

SDP relaxations for a polynomial optimization problem (POP) were constructed by Lasserre and Waki et al. Still, the size of the SDP relaxation remains the major obstacle for POPs of higher degree. An approach to transform general POPs to quadratic optimization problems (QOPs) is proposed, that reduces the size of the SDP relaxation substantially. We introduce different heuristics resulting in equivalent QOPs and show how sparsity is maintained under the transformation procedure. As the most important issue we discuss how to increase the quality of the SDP relaxation for QOPs. We increase the accuracy of the SDP relaxation by applying local optimization techniques and by imposing additional polynomial bounds to the QOP.

2 - New Technologies in the SDPA Project

Katsuki Fujisawa,Chuo University, 1-13-27, Kasuga, Bunkyo, Tokyo 112-8551, Japan, fujisawa@indsys.chuo-u.ac.jp

The SDPA Project started in 1995 have provided several software packages for solving large-scale Semidefinite Programs(SDPs). Further improvements are necessary for the software packages since optimization problems become larger and more complicated. We show some current works and new technologies in the SDPA project as follows; (I) The memory hierarchy is carefully considered to specify the bottleneck of the algorithm and improve the performance. The latest version of the SDPA supports the multi-thread computing on multi-core processor, and solves large-scale SDPs quickly and efficiently. (II) We have developed a web portal system utilizing the cloud computing technology for some software packages in the SDPA Project.

3 - Parallel Software for SemiDeinfite Programming with Sparse Schur Complement Matrix

Makoto Yamashita, Tokyo Instittute of Technology, 2-12-1-W8-29 Ookayama Meguro-ku, Tokyo, Japan, Makoto.Yamashita@is.titech.ac.jp, Kazuhide Nakata, Maho Nakata, Mituhiro Fukuda, Kazuhiro Kobayashi, Masakazu Kojima, Yoshiaki Futakata, Katsuki Fujisawa

When primal-dual interior-point methods are employed to solve SemiDefinite Programming (SDP) Problem, evaluating Schur complement matrix (SCM) and its Cholesky factorization occupy most computation time. To shorten the computation time, SDPARA (SemiDefinite Programming Algorithm paRAllel version) applies parallel computation to these two bottlenecks. However, the SCM turns out to be considerably sparse in some SDP applications. To address both dense and sparse Schur complement matrix, we add a new distributed computation using sparse/dense evaluation formulas for the SCM. Numerical results verifies SDPARA can solve extremely large SDPs with sparse SCM more efficiently than handling SCM in dense format.

WC07

Marriott - Chicago D

Integer and Mixed Integer Programming F

Contributed Session

Chair: Eduardo Uchoa, Professor, Universidade Federal Fluminense, Rua Passo da Patria 156 D-440, Niterai, 24210-240, Brazil, uchoa@producao.uff.br

1 - Computationally Tractable Stochastic Integer Programming Models for Air Traffic Management

Charles N. Glover, PhD Candidate, University of Maryland, 3117 AV Williams, College Park, MD, 20742, United States of America, cnglover@math.umd.edu, Michael O. Ball

Convective weather is a major contributor to air traffic delays. Responding to predictions of convective weather requires the solution of resource allocation problems that assign a combination of ground delay and route adjustments to many flights. Since there is much uncertainty associated with weather predictions, stochastic models are necessary. We describe a multi-period stochastic integer program for this problem. We show that under certain conditions the LP-Relaxation yields integer optimal solutions. For more general cases we compare the strength of alternate formulations and provide computationally tractable formulations.

2 - On BFC-MSMIP Strategies for Scenario Cluster Partitioning, and Twin Node Family Branching Selection

Maria Araceli Garin, Doctor, University of the Basque Country, Lehendakari Aguirre, 83, Bilbao, 48015, Spain, mariaaraceli.garin@ehu.es, Maria Merino, Laureano Escudero, Gloria Pérez

In the Branch-and-Fix Coordination algorithm for solving large-scale multistage stochastic mixed integer programming problems, we can find it is crucial to decide the stages where the nonanticipativity constraints are explicitly considered in the model. This information is materialized when broken down the full model in a scenario cluster partition with smaller subproblems. In this paper we present a scheme for obtaining strong bounds and branching strategies for the Twin Node Families to increase the efficiency of the procedure BFC- MSMIP. Some computational experience is reported to support the efficiency of the new scheme.

3 - Time Dependent Traveling Salesman Problem: Polyhedra and Branch-cut-and-price

Eduardo Uchoa, Professor, Universidade Federal Fluminense, Rua Passo da Patria 156 D-440, Niterai, 24210-240, Brazil, uchoa@producao.uff.br, Ricardo Fukasawa, Hernan Abeledo, Artur Pessoa

The TDTSP is a generalization of the TSP, where arc costs depend on their position in the tour with respect to a chosen source node. We study the polyhedra associated to the TDTSP formulation by Picard and Queyranne, determining their dimension and finding some families of facet defining cuts. It is worthy noting that known TSP facets correspond to quite low dimensional TDTSP faces. Very good computational results were obtained with a BCP algorithm using the new cuts.

■ WC08

Marriott - Chicago E

Trends in Mixed Integer Programming VIII

Cluster: Integer and Mixed Integer Programming
Invited Session

Chair: Robert Weismantel, Professor, Otto-von-Guericke University Magdeburg, Institute for Mathematical Optimization, Universitaetsplatz 2, Magdeburg, 39106, Germany, weismant@mail.math.uni-magdeburg.de

Co-Chair: Andrea Lodi, DEIS, University of Bologna, Viale Risorgimento, 2, Bologna, 40136, Italy, andrea.lodi@unibo.it

1 - An Integer Programming Approach to Robust Tail Assignment

Ivan Dovica, Zuse Institute Berlin, Takustrasse 7, Berlin, Germany, dovica@zib.de, Ivo Nowak, Ralf Borndoerfer, Thomas Schickinger

This talk considers a robust version of the tail assignment problem, which considers the routing of individual aircraft. We model this problem as optimization problem in which non-robustness costs are minimized. Our approach is based on a stochastic model of the operation of an airline. In our talk we propose possible measures of robustness such as expected propagated delay, and solve the robust tail assignment problem by column generation technique.

2 - A Tricriteria Steiner Tree Problem

Leizer Pinto, PhD Student, Federal University of Rio de Janeiro, Department of Systems Engineering and Computer Science, Centro de Tecnologia, Bloco H, Sala 319, Rio de Janeiro, 21941-972, Brazil, leizer@cos.ufrj.br, Gilbert Laporte

The problem considered in this paper is a tricriteria Steiner tree problem, where the objective functions consist of maximizing the revenue and of minimizing the maximum distance between each pair of interconnected nodes and the maximum number of arcs between the root and each node. A polynomial algorithm is developed for the generation of a minimal complete set of Pareto-optimal Steiner trees.

3 - Application of Network Design with Orientation Constraints

Emiliano Traversi, DEIS - University of Bologna, Viale Risorgimento 2, Faculty of Engineering, Bologna, Italy, emiliano.traversi2@unibo.it, Alberto Caprara, Joerg Schweizer

We address the problem of orienting the edges of an undirected graph so as to minimize the sum of the distances between a given set of origin-destination pairs in the resulting directed graph. The problem originates from the design of Personal Rapid Transit (PRT) networks. We present also the real-world version with nonlinear travel costs depending on the congestion. For both versions exact and heuristic methods are presented.

■ WC09

Marriott - Chicago F

The Complexity of Integer Hulls

Cluster: Integer and Mixed Integer Programming
Invited Session

Chair: Andreas Schulz, Massachusetts Institute of Technology, E53-357, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, schulz@mit.edu

1 - Small Chvatal Rank and Stable Set Polytopes

Annie Raymond, Massachusetts Institute of Technology, 6360 Duquesne, Montreal, QC, H1M3K5, Canada, away@mit.edu, Rekha Thomas, Tristram Bogart

Given a rational polyhedron, the small Chvatal rank is the number of rounds of a Hilbert basis procedure needed to generate all of the normals of the facets of its integer hull. We will discuss how certain interesting normals appear within two steps of this procedure when applying it to the fractional stable set polytope.

2 - On the Rank of Cutting-plane Proof Systems

Sebastian Pokutta, Technische Universitat Darmstadt, Schlossgartenstr. 7, Darmstadt, 64289, Germany, pokutta@mathematik.tu-darmstadt.de, Andreas Schulz

We introduce a natural abstraction of cutting-plane proof systems, which includes well-known operators such as Gomory-Chvatal, lift-and-project, Sherali-Adams, Lovasz-Schrijver, and split cuts. We exhibit a family of lattice-free polytopes contained in the n-dimensional 0/1-cube that has rank Omega(n/log n) for any proof system in our family. We also construct a new cutting-plane procedure that has worst-case rank n/log n for any lattice-free polytope, showing that the lower bound is tight.

3 - On the Membership Problem for the {0,1/2}-Closure

Andreas Schulz, Massachusetts Institute of Technology, E53-357, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, schulz@mit.edu, Sebastian Pokutta, Adam Letchford

Caprara and Fischetti introduced {0,1/2}-cuts and showed that the associated separation problem is strongly NP-hard. We show that separation remains strongly NP-hard, even when all integer variables are binary, even when the integer linear program is a set packing problem, and even when the matrix of left-hand side coefficients is the clique matrix of a graph containing a small number of maximal cliques. We show these results for the membership problem, which is weaker than separation.

■ WC10

Marriott - Chicago G

Recent Advances in Global Optimization

Cluster: Global Optimization
Invited Session

Chair: Oliver Stein, University of Karlsruhe (TH), Institute of Operations Research, Karlsruhe, 76128, Germany, stein@wior.uni-karlsruhe.de

1 - Global Optimization of Fixed-point Iterations

Paul Barton, Lammot du Pont Professor, MIT, Room 66-464, 77 Massachusetts Avenue, Cambridge, MA, 02139, United States of America, pib@mit.edu, Matthew Stuber

A method for globally solving nonconvex optimization problems constrained by functions defined through embedded fixed-point iterations is presented. Embedded fixed-point iterations are encountered when the decision variables cannot be expressed explicitly but only numerically by solving for an implicit function. Interval methods and McCormick's relaxations are utilized to calculate valid convex/concave relaxations of the implicitly defined constraint, and refined using the Branch-and-Bound framework.

2 - Difference of Convex Monotonic Functions. Applications in Continuous Location Problems

Emilio Carrizosa, Professor, Universidad de Sevilla, Fac Matematicas. Reina Mercedes s/n, Sevilla, C.P. 41012, Spain, ecarrizosa@us.es, Rafael Blanquero

A function is said to be dcm if it can be expressed as a difference of two convex monotonic functions. For dcm functions, it is possible to combine convexity and monotonicity properties to obtain sharp bounds, to be used in global optimization procedures such as Branch and Bound. In this talk we will illustrate the use of dcm-based bounds in some continuous location problems. Numerical comparison with standard dc-based bounds will be made, showing the usefulness of our procedure.

3 - Enhancing RLT Relaxations for Polynomial Problems with a Class of v-Semidefinite Cuts

Evrim Dalkiran, PhD Candidate, Virginia Polytechnic Institute and State University, Grado Dept. of Industrial&Systems Eng., 250 Durham Hall (0118), Blacksburg, VA, 24061, United States of America, dalkiran@vt.edu, Hanif D. Sherali, Jitamitra Desai

We enhance RLT-based relaxations for polynomial programs with a class of v-semidefinite cuts that are derived by imposing positive semidefiniteness on (constraint-factor scaled) dyadic variable-product matrices. We explore various strategies for generating cuts, and exhibit their relative effectiveness for tightening relaxations and solving the underlying polynomial programs. Insights are provided to reveal classes of v-semidefinite cuts that significantly improve performance.

■ WC11

Marriott - Chicago H

Methodology and Applications of Robust Optimization

Cluster: Robust Optimization
Invited Session

Chair: David Brown, Duke University, dbbrown@duke.edu

1 - Beyond First and Second Moment Constraints in Distributionally Robust Optimization

Erick Delage, Assistant Professor, HEC Montréal, Montreal, Qc, H3T 2A7, Canada, erick.delage@hec.ca, Yinyu Ye

Although distributionally robust optimization can account for uncertainty in the stochastic program, its solution can be unnecessarily conservative if the uncertainty set only uses first and second order moment information. We present a class of distributional set which can account for a much wider range of moment information while ensuring that the resulting decision model is tractable for many applications. Experiments with portfolio selection will provide valuable insights on this problem.

2 - Distributionally Robust Optimization

Joel Goh, National University of Singapore, Department of Decision Sciences, 1 Business Link, Singapore, 117592, Singapore, bizgwj@nus.edu.sg, Melvyn Sim

We study a linear optimization problem with uncertainties, having expectations in the objective and in the set of constraints. We present a modular framework to approximate its solution using linear decision rules (LDRs), by first affinely-extending the set of primitive uncertainties to generate new (LDRs) of larger dimensions. Next, we present new piecewise-linear decision rules which allow a more flexible re-formulation of the original problem. We also demonstrate how to construct upper bounds to approximate the re-formulated problem, and conclude with an example illustrating how our framework can be applied to robustly optimize a multi-period inventory management problem with service constraints.

3 - From CVaR to Uncertainty Set: Implications in Joint Chance Constrained Optimization

Melvyn Sim, Professor, National University of Singapore, National University of Singapore, Singapore, Singapore, dscsimm@nus.edu.sg, Jie Sun, Chung-Piaw Teo, Wenqing Chen

We review the different tractable approximations of individual chance constraint problems using robust optimization on a varieties of uncertainty set, and show their interesting connections with bounds on the condition-value-at-risk CVaR measure. We also propose a new formulation for approximating joint chance constrained problems that improves upon the standard approach that decomposes the joint chance constraint into a problem with m individual chance constraints and then applies safe robust optimization approximation on each one of them.

4 - A Satisficing Alternative to Prospect Theory

David Brown, Duke University, dbbrown@duke.edu, Melvyn Sim, Enrico De Giorgi

We introduce a target-based model of choice that allows decision makers to be both risk averse and risk seeking, depending on the security of a position's payoff relative to a given target. The approach captures in spirit two celebrated ideas: the satisficing concept from Simon and the switch between risk aversion and risk seeking behaviors popularized by Kahneman and Tversky's prospect theory. Our axioms are simple and practical use of our theory involves only specification of decision maker goals. We show that this approach is dual to a known approach using risk measures. Though our approach is intended to be normative, we also show that our approach results in resolution of some of the classical ``paradoxes" of Allais and Ellsberg.

■ WC12

Marriott - Los Angeles

Simulation Based Algorithms for PDE-constrained Optimization

Cluster: PDE-constrained Optimization
Invited Session

Chair: Andreas Griewank, Professor, Humboldt University, Unter den Linden 8, Berlin, 10099, Germany, griewank@mathematik.hu-berlin.de

1 - One-shot Design Optmization with Bounded Retardation

Andreas Griewank, Professor, Humboldt University, Unter den Linden 8, Berlin, 10099, Germany, griewank@mathematik.hu-berlin.de

We consider a methodology for converting fixed point solvers for state equations into one-shot iterations on associated equality constrained optimization problems. We attempt to estimate and bound the resulting deterioration of the convergence rate in terms of a retardation factor. It depends on the the interplay between the Hessian of the Lagrangian and the particular state equation solver, e.g. Jacobi and its multigrid variants. We present numerical results from aerodynamics.

2 - Real-time Control of Hydrodynamic Models on Networks

Johannes Hild, Friedrich-Alexander-Universitaet Erlangen-Nuernberg, AM2, Martensstrasse 3, Erlangen, 91058, Germany, hild@am.uni-erlangen.de, Guenter Leugering

We present a software framework to compute the weir control for an urban drainage system in real-time. The framework generates an infinite control sequence in a moving horizon setting in real-time. A hydrodynamic model based on shallow water equations is discretized on networks via FVM, the state variables - water mass, flow rate and pollution - are computed by an explicit Godunov scheme. Interfacing of the AD-tool ADOL"C with a C++-template technique grants fast and robust gradients.

3 - Optimization of Fluid Flows with Reduced Order Methods

Andrea Walther, Professor, Universitaet Paderborn, Warburger Str. 100, Paderborn, 33098, Germany, andrea.walther@uni-paderborn.de

This talk presents first results for the optimal steering of fluid flows with electromagnetic forces when the optimization is performed for a reduced order method. A sophisticated simulation software is used to generate a corresponding POD basis. Subsequently, this information is applied for an adjoint calculation and hence a gradient-based optimization approach. Numerical results are presented for the flow around an obstacle.

■ WC13

Marriott - Miami

Models for Unit Commitment and Transmission Switching

Cluster: Optimization in Energy Systems
Invited Session

Chair: Michael Ferris, University of Wisconsin-Madison, 4381 Computer Sciences and Statistics, 1210 W Dayton Street, Madison, WI, 53706, United States of America, ferris@cs.wisc.edu

1 - Optimal Transmission Switching

Emily Fisher, PhD Candidate, The Johns Hopkins University, 3400 N. Charles St., Ames Hall 313, Baltimore, MD, 21218, United States of America, ebartho3@jhu.edu, Richard O'Neill, Michael Ferris, Kory Hedman

In this paper, we formulate the problem of finding an optimal generation dispatch and transmission topology to meet a specific inflexible load as a mixed-integer program. In our model binary variables represent the state of the equipment and linear relationships describe the physical system. We also analyze first order conditions of the optimal solution to gain insight on prices, or dual variables, for the non-continuous (switching) primal variables.

2 - Optimal Multi-period Generation Unit Commitment and Transmission Switching with N-1 Reliability

Kory Hedman, PhD Candidate, University of California at Berkeley, 4124 Etcheverry Hall, University of California, Berkeley, Berkeley, CA, 94720, United States of America, kwh@berkeley.edu, Michael Ferris, Emily Fisher, Shmuel Oren, Richard O'Neill

There is a national push for a smarter electric grid, one that is more controllable and flexible. Current electric transmission optimization models do not incorporate the full control of transmission lines. Optimal transmission switching is a straightforward way to leverage grid controllability; it is a smart grid application where we co-optimize generation and the network topology. We present the generation unit commitment and optimal transmission switching problem with reliability constraints.

3 - Representing Voltage Constraints in a Proxy-limited DC Optimal Power Flow

Bernard Lesieutre, Associate Professor, University of Wisconsin, 1415 Engineering Drive, Madison, WI, 53706, lesieutre@engr.wisc.edu

This presentation proposes a mixed-integer programming formulation that finds the best proxy power flow line limits to represent the effects of a known voltage problem in a simplified DC optimal power flow. The two-part objective minimizes error in both locational marginal prices (LMPs) and generator dispatch. The technique was tested with three models: IEEE 9-bus, 30-bus, and 118-bus cases. Tests were carried out for various real power system demand levels in GAMS using CPLEX.

■ WC14

Marriott - Scottsdale

The Complexity of Equilibria in Markets and Games

Cluster: Game Theory
Invited Session

Chair: Constantinos Daskalakis, MIT, 97 Hancock Street, Apt. 7,, Cambridge, MA, 02139, United States of America, costis@csail.mit.edu

1 - Combinatorial Algorithms for Convex Programs: Market Equilibria and Nash Bargaining

Vijay Vazirani, Professor, Georgia Tech, vv.vazirani@gmail.com

The primal-dual paradigm has had two highly successful ``lives" — in combinatorial optimization and in approximation algorithms. It has not only yielded efficient and practically useful algorithms, but also deep insights into the combinatorial structure underlying the problems solved. Recently, motivated by some fundamental problems from game theory, a third life appears to be emerging: efficient algorithms for solving certain classes of convex programs.

2 - Computing Market Equilibria in Polynomial Time for Fixed Number of Goods or Agents

Nikhil Devanur, Microsoft Research, One Microsoft Way, Redmond, WA, 98033, United States of America, nikdev@microsoft.com

We show that for general (non-separable) Piecewise Linear Concave utilities, an exact equilibrium can be found in polynomial time if the number of goods is constant. Note that if the number of goods and agents both can vary, the problem is PPAD hard even for the special case of Leontief utilities. The algorithm has 2 phases: a ``cell-decomposition" of the space of price vectors using polynomial surfaces, followed by an LP-duality based method to solve the problem inside each cell.

3 - Settling the Complexity of Arrow-Debreu Equilibria in Markets with Additively Separable Utilities

Xi Chen, Postdoctoral Researcher, Princeton University, 301 Trinity Court Apt. 11, Princeton, NJ, 08540, United States of America, csxichen@gmail.com

We prove that the problem of computing an approximate Arrow-Debreu market equilibrium is PPAD-complete (or equivalently, as hard as the computational version of Brouwer's fixed point problem), even when all traders use additively separable, piecewise-linear and concave utility functions. The result follows from a reduction from the two-player Nash equilibrium problem.

4 - The Complexity of Nash Equilibria

Constantinos Daskalakis, MIT, 97 Hancock Street, Apt. 7,, Cambridge, MA, 02139, United States of America, costis@csail.mit.edu

We review recent results on the complexity of Nash equilibria. We argue that finding a Nash equilibrium is computationally equivalent to computing Brouwer fixed points of continuous piecewise linear functions, in a precise technical sense captured by the complexity class PPAD. We proceed to show examples of games in which Nash equilibria can be computed efficiently, such as anonymous games, and networks with strictly competitive (zero-sum) games on their edges.

■ WC15

Gleacher Center - 100

Stochastic Optimization and Financial Applications

Cluster: Stochastic Optimization
Invited Session

Chair: Chanaka Edirisinghe, University of Tennessee, 610 Stokely Management Center, 916 Volunteer Boulevard, Knoxville, TN, 37996, United States of America, chanaka@utk.edu

1 - Scenario Generation for Financial Modelling: Desirable Properties and a Case Study

Leelavati Mitra, Brunel University, CARISMA, Brunel University, Uxbridge, UB8 3PH, United Kingdom, Leelavati.Mitra@brunel.ac.uk, Gautam Mitra, Viktar Zviarovich

Investment decisions are made ex ante, that is based on parameters that are not known at the time of decision making. Scenario generators are used not only in the models for (optimum) decision making under uncertainty, they are also used for evaluation of decisions through simulation modelling. We review those properties of scenario generators which are regarded as desirable; these are not sufficient to guarantee the ``goodness" of a scenario generator. We also review classical models for scenario generation of asset prices. In particular we consider some recently reported methods which have been proposed for distributions with `heavy tails'.

2 - An Algorithm for Finding the Complete Efficient Frontier

Yuji Nakagawa, Professor, Kansai University, Faculty of Informatics, Ryozenjicho, Takatsuki-City, Japan, kunakagawa@gmail.com, Chanaka Edirisinghe, Ross James, Sakuo Kimura

The Sayin-Kouvelis algorithm is a state-of-the-art algorithm for finding all efficient solutions to the bicriteria 0-1 multi-knapsack problems within a given level of precision. We propose a new algorithm, based on surrogate constraint techniques, to find all efficient solutions. Experiments confirm that this approach outperforms the Sayin-Kouvelis algorithm and can be used to solve problems that are relatively large, multi-valued, nonlinear, and multi-constrained which previously could not be solved. One prominent application of our method is risk-return financial optimization with integrality restrictions.

3 - Risk Neutral/Averse DEA Models of Fundamental Analysis under Stochastic Data and Applications

Chanaka Edirisinghe, University of Tennessee, 610 Stokely Management Center, 916 Volunteer Boulevard, Knoxville, TN, 37996, United States of America, chanaka@utk.edu, Xin Zhang

Traditional models of Data Envelopment Analysis (DEA) assume deterministic data. We present risk-based stochastic versions of the DEA model when parameters are random variables described by discrete probability distributions. The robustness of performance evaluation of underlying firms under the stochastic DEA model is established relative to the standard DEA model. These results are applied within the framework of generalized DEA model by Edirisinghe/Zhang (2007) for fundamental Analysis toward equity selection for portfolio optimization. Limited computational results are presented for validation of the proposed methodology.

■ WC16

Gleacher Center - 200

Stochastic Optimization for National Security and Military Applications

Cluster: Stochastic Optimization
Invited Session

Chair: Nedialko Dimitrov, University of Texas at Austin, 1 University Station C2200, Austin, TX, 78712, United States of America, ned.dimitrov@gmail.com

1 - Path Optimization for Multiple Searchers

Johannes Royset, Assistant Professor, Naval Postgraduate School, 1411 Cunningham Rd, Monterey, CA, 93943, United States of America, joroyset@nps.edu, Hiroyuki Sato

We consider a discrete time-and-space path-optimization problem where multiple searchers seek to detect one or more probabilistically moving targets across a given time horizon. We present a convex mixed-integer nonlinear program for this problem, along with equivalent linearizations for important special cases, and develop a cut for use with Kelley's cutting plane method. We empirically compare the calculation times of the resulting algorithm with those of standard solvers.

2 - Interdicting a Network by Securing Edges

Feng Pan, Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, NM, 87545, United States of America, fpan@lanl.gov, Michael Chertkov, Nandakishore Santhi

In an evasion network, edge reliability is the probability that the evader will traverse the edge successfully. Interdicting/Securing an edge will reduce the edge reliability. Consider all paths between a set of origin-destination pairs, and the goal is to thwart the evasion by securing at least one edge in each path. A min-max-min interdiction model is developed for this problem. We will discuss the solution techniques and its stochastic variants.

3 - Adversarial Markov Decision Process Design

David Morton, University of Texas, Graduate Program in Operations Research, Austin, TX, 78712, United States of America, morton@mail.utexas.edu, Nedialko Dimitrov

We formulate a bi-level adversarial MDP design problem. First, with limited budget, we remove actions from an MDP to minimize the MDP's optimal value. Second, an adversary operates the MDP to maximize its value. We apply our model to interdict nuclear smuggling. A smuggler operates an MDP to select a path from his origin to destination. Uncertainty in the smuggler's origin, destination, and other attributes add further stochastics to our adversarial MDP design problem.

■ WC17

Gleacher Center - 204

Logistics and Transportation B

Contributed Session

Chair: Vladimir Deineko, Associate Professor, Warwick University, Warwick Business School, Coventry, CV49JA, United Kingdom, v.deineko@warwick.ac.uk

1 - Partial Path Column Generation for the Vehicle Routing Problem with Time Windows

Bjorn Petersen, PhD Student, Technical University of Denmark, Produktionstorvet bygn. 424, Kgs. Lyngby, 2800, Denmark, bjorn@diku.dk, Mads Kehlet Jepsen

This talk presents a column generation algorithm for the VRPTW. Traditionally, column generation models of the VRPTW have consisted of a Set Partitioning master problem with each column representing a route. We suggest to relax that `each column is a route' into `each column is a part of the giant tour'; a so-called partial path. This way, the length of the partial path can be bounded and a better control of the size of the solution space for the pricing problem can be obtained.

2 - The Combinatorics of (S,M,L,XL) or the Best Fitting Delivery of T-shirts

Joerg Rambau, University of Bayreuth, Universitätsstr. 30, Bayreuth, 95440, Germany, joerg.rambau@uni-bayreuth.de, Constantin Gaul, Sascha Kurz

A fashion discounter supplies its branches with apparel in various sizes. Apparel is ordered in pre-packs three months in advance from overseas: replenishment impossible. Thus, the supply in each size and branch must be consistent with the demand right away. We present new ILP-models for the resulting lot-type design problem: For each branch, find lot types and delivery volumes so that the demand is met best. The results are applied by a german fashion discounter with over 1000 branches.

3 - Local Search for Capacitated Vehicle Routing Problems: Dynamic Programming Revisited

Vladimir Deineko, Associate Professor, Warwick University, Warwick Business School, Coventry, CV49JA, United Kingdom, v.deineko@warwick.ac.uk

We consider the capacitated vehicle routing problem (VRP) and its practical siblings in waste collection services provided by Coventry City Council. We suggest a local search procedure to improve a feasible solution of the VRP. The algorithm behind the procedure is the well-known Held & Karp dynamic programming algorithm for the travelling salesman problem. Results of computational experiments on known benchmark problems show the competitiveness of our algorithm with the best known heuristics.

■ WC18

Gleacher Center - 206

Polynomial Programming

Cluster: Nonlinear Mixed Integer Programming
Invited Session

Chair: Jon Lee, IBM TJ Watson Research Center, P.O. Box 218, Yorktown Heights, NY, 10598, United States of America, jonlee@us.ibm.com

1 - Comparing Convex Relaxations of Quadrilinear Terms

Sonia Cafieri, Ecole Polytechnique, LIX, Ecole Polytechnique, Rue de Saclay, Palaiseau, F-91128, France, cafieri@lix.polytechnique.fr, Jon Lee, Leo Liberti

Branch and Bound based optimization methods, applied to formulations involving multivariate polynomials, rely on convex envelopes for the lower bound computation. Although convex envelopes are explicitly known for bilinear and trilinear terms on arbitrary boxes, such a description is unknown, in general, for multilinear terms of higher order. We present four different ways to compute a convex linear relaxation of a quadrilinear monomial on a box and analyze their relative tightness. We apply our results to the Molecular Distance Geometry Problem and the Hartree-Fock Problem.

2 - Strong Relxations and Computations for Global Optimization Problems with Multilinear Terms

Jeff Linderoth, Associate Professor, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States of America, linderot@cae.wisc.edu, Mahdi Namazifar, James Luedtke

Multilinear functions appear in many global optimization problems, including blending and electricity transmission. A common technique for creating relaxations for these problems is to decompose the functions into bilinear terms and then use a relaxation (the McCormick envelope) for each term separately. We study an approach which generates a relaxation directly from the multilinear term. We will demonstrate via numerical examples the advantages of such an approach.

3 - Mixed Integer Second Order Cone Programming

Sarah Drewes, Technische Universitaet Darmstadt, Department of Mathematics, Schlossgartenstr. 7, Darmstadt, 64289, Germany, drewes@mathematik.tu-darmstadt.de, Stefan Ulbrich

We present different linear and convex quadratic cut generation techniques for mixed integer second-order cone problems. These cuts are applied in the context of two algorithms: A nonlinear branch-and-cut method and a branch-and-bound based outer approximation approach. The latter is an extension of outer approximation based approaches for continuously differentiable problems to subdifferentiable second order cone constraint functions. Convergence is guaranteed,since subgradients are identified that satisfy the KKT conditions. Computational results for test problems and real world applications are given.

■ WC19

Gleacher Center - 208

Multicriteria and Global Optimization A

Contributed Session

Chair: Delphine Sinoquet, Doctor, IFP, 1-4, avenue de Bois-Préau, Rueil Malmaison, 92852, France, delphine.sinoquet@ifp.fr

1 - A Provably Efficient Algorithm for the Multicriteria Linear Programming

Yoshio Okamoto, Tokyo Institute of Technology, 2-12-1-W8-88, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan, okamoto@is.titech.ac.jp, Takeaki Uno

We propose a poly-time-delay poly-space algorithm to enumerate all efficient extreme solutions of a multicriteria minimum-cost spanning tree problem by reverse search, while only the bicriteria case was studied so far. We also show that the same technique works for enumeration of all efficient extreme solutions of a multicriteria linear program. If there is no degeneracy, it runs in poly-time delay and poly space. To best of our knowledge, they are the first algorithms with such guarantees.

2 - Feasibility in Reverse Convex Mixed-Integer Programming

Wieslawa Obuchowska, East Carolina University, Department of Mathematics, Greenville, NC, 27858, United States of America, obuchowskaw@ecu.edu

We discuss the problem of infeasibility of systems defined by reverse convex inequality constraints, where some or all of the variables are integer. In particular, we provide an algorithm that identifies a set of all constraints critical to feasibility (CF), that is constraints that may affect feasibility status of the system after some perturbation of the right-hand sides. We also show that all irreducible infeasible sets and infeasibility sets are subsets of the set CF.

3 - Multi-objective Optimization and Global Map Optimization for Engine Calibration

Delphine Sinoquet, Doctor, IFP, 1-4, avenue de Bois-Préau, Rueil Malmaison, 92852, France, delphine.sinoquet@ifp.fr, Hoél Langouét

The optimization problem of engine calibration consists of the determination of engine tuning parameters that minimize the cumulated fuel consumption and pollutant emissions on a driving cycle generally associated with legislation norms. The engine responses are modelled from experimental data obtained at test bench. We illustrate the difficulties associated with this application and propose adapted optimization methodologies applied on real dataset: LoLiMoT models for engine map parameterization in order to handle intrinsic constraints on the map regularity, multi-objective optimization method based on CMA-ES approach.

■ WC20

Gleacher Center - 300

Model Management for Optimization with PDE Based Simulations

Cluster: Nonlinear Programming
Invited Session

Chair: Natalia Alexandrov, NASA Langley Research Center, Mail Stop 442, Hampton, VA, 22681-2199, United States of America, n.alexandrov@nasa.gov

1 - Assessing the Quality of Approximate Models

Stephen Nash, Professor, George Mason University, Engineering Building, Room 2100, Mail Stop 4A6, Fairfax, VA, 22030-4444, United States of America, snash@gmu.edu

Model management can be used to optimize a high-fidelity model via less expensive approximate models. Convergence can be guaranteed if first-order approximate models are used. We go beyond this to examine practical tools that measure properties of the approximate models that influence the performance of the model-management framework, i.e., to determine whether it significantly improves over applying traditional optimization directly to the high-fidelity model.

2 - Numerical Experience with a Multilevel Optimization Approach

Robert Michael Lewis, Associate Professor, College of William & Mary, Department of Mathematics, P.O. Box 8795, Williamsburg, VA, 23187-8795, United States of America, buckaroo@math.wm.edu

We discuss numerical tests of a multilevel optimization method based on the MG/Opt approach. Some of these tests are intended to exercise the self-diagnostics in the MG/Opt method and to examine whether we have correctly identified the interactions between optimization algorithm and problem structure that make multilevel/multigrid solution possible with MG/Opt. In particular,

some of these problems are designed to be resistant to a multigrid solution. Other tests, such as those involving a dissimilarity parameterized approach to graph embedding, are intended to be more benign from the perspective of multilevel solution.

3 - Self-adaptive Metamodels for Numerical Optimization

Daniele Peri, Researcher, INSEAN - The Italian Ship Model Basin, Via di Vallerano 139, Rome, Italy, D.Peri@insean.it, Emilio Campana, Giovanni Fasano

Optimization with PDE-based analyses often needs simplified models to facilitate solution. Metamodels have been adopted widely. We use the disagreement between two different metamodels as a criterion for new training point computation. We build a multidimensional linear interpolation metamodel and add new training points where the differences between this and a Kriging metamodel are large. The technique yields a more efficient training set and enhances global predictive qualities of the model.

■ WC21

Gleacher Center - 304

Optimization in Networks

Cluster: Telecommunications and Networks
Invited Session

Chair: S. (Raghu) Raghavan, University of Maryland, 4345 Van Munching Hall, College Park, MD, 20742, United States of America, raghavan@umd.edu

1 - Cutting Plane Algorithms for Solving a Robust Edge-partition Problem

Cole Smith, The University of Florida, Industrial and Systems Engineering, P.O. Box 116595, Gainesville, FL, 32611, cole@ise.ufl.edu

We consider an edge-partition problem that arises in SONET design problems. The edge-partition problem considers an undirected weighted graph, and partitions edges among several subgraphs, subject to various subgraph capacity constraints. The objective is to minimize the total number of induced nodes in the subgraphs. We consider a stochastic version of this problem, and compare the use of a two-stage integer cutting-plane approach with an alternative IP/constraint-programming algorithm.

2 - The Generalized Regenerator Location Problem

Si Chen, Assistant Professor, Murray State University, Dept. of CSIS, School of Business and Public Affairs, Murray, KY, 42071, United States of America, si.chen@murraystate.edu, Ivana Ljubic, S. (Raghu) Raghavan

In the generalized regenerator location problem (in optical networks) we are given a set of terminal nodes T that need to communicate. It is necessary to install regenerators if the distance between a pair of nodes in T is greater than L. Regenerators can only be installed at a subset of nodes S in the network. We wish to minimize the number of regenerators (or a weighted combination). We describe heuristics for the problem, and an MIP model, and our computational experiences with both.

3 - Exact Solution Algorithms for a Selective Vehicle Routing Problem to Minimize the Longest Route

Alexandre Salles da Cunha, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil, acunha@dcc.ufmg.br, Christiano A. Valle, Geraldo Mateus, Leonardo C. Martinez

In this paper, we study a non-capacitated Vehicle Routing Problem where not necessarily all clients need to be visited and the goal is to minimize the length of the longest vehicle route. An Integer Programming Formulation, a Branch-and-Cut (BC) method, and a Local Branching (LB) framework that uses BC as the inner solver are presented. Sharper upper bounds are obtained by LB, when the same time limit was imposed on the execution times of both approaches. Our results also suggest that the min-max nature of the objective function combined with the fact that not all vertices need to be visited make such problem very difficult to solve.

■ WC22

Gleacher Center - 306

Open-source Modeling Frameworks for Mathematical Programming

Cluster: Implementations, Software
Invited Session

Chair: Jean-Paul Watson, Principal Member of Technical Staff, Sandia National Laboratories, P.O. Box 5800, MS 1318, Albuquerque, NM, 87185-1318, United States of America, jwatson@sandia.gov

1 - Instance-specific Generation in POAMS

Leonardo Lopes, University of Arizona, Department of Systems and Industrial Engineering, Tucson, AZ, leo@sie.arizona.edu, Kate Smith-Miles

POAMS optimization models support object-oriented semantics. They have interfaces, can be composed and specialized from each other, etc. This makes possible a stronger separation between model and instance. We demonstrate generating different instance types (integer programs, constraint programs, etc.) depending on characteristics of the specific input and on the performance measures relevant to the analyst. We demonstrate this technique and its benefits using time-tabling problems.

2 - Coopr: A Python Optimization Package

William Hart, Distinguished Member of T echnical Staff, Sandia National Laboratories, P.O. Box 5800, MS 1318, Albuquerque, NM, 87185-1318, United States of America, wehart@sandia.gov

We describe Coopr, a Common Optimization Python Repository. Coopr provides a set of optimization packages that support modeling and solution of math programming applications. A core element of Coopr is Pyomo, which provides a modling capability that is commonly associated with algebraic modeling languages like AMPL and GAMS. This talk will provide an overview of these capabilities and describe motivating applications at Sandia National Laboratories.

3 - PySP: Modeling and Solving Stochastic Mixed-Integer Programs in Python

Jean-Paul Watson, Principal Member of Technical Staff, Sandia National Laboratories, P.O. Box 5800, MS 1318, Albuquerque, NM, 87185-1318, United States of America, jwatson@sandia.gov, David L Woodruff

We describe PySP, an open-source extension of Pyomo - a Python-based modeling language for mathematical programming - that enables modeling and solution of stochastic mixed-integer programs. PySP contains a number of generic decomposition-based solution strategies made possible through Python language features such as introspection. We discuss the design and implementation of these generic strategies, in addition to computational results on standard stochastic benchmarks.

■ WC23

Gleacher Center - 308

Some Advances in First-order Methods for Sparse Optimization

Cluster: Sparse Optimization
Invited Session

Chair: Yu-Hong Dai, Chinese Academy of Sciences (CAS), LSEC, Institute of Computational Mathema, P.O. Box 2719, Beijing, 100190, China, dyh@lsec.cc.ac.cn

1 - On the Trust Region Subproblem for Nonlinear L_1 Norm Minimization Problem

Xin LIU, Dr., Academy of Mathematics and Systems Science, Chinese Academy of Sciences, 518, ICMSEC(LanBai Building), 55, ZhongGuanCunDongLu, HaiDian District, Beijing, 100190, China, liuxin@lsec.cc.ac.cn

In this talk, the trust region subproblem for nonlinear L_1 norm minimization problem is considered. We prove that this kind of nonsmooth trust region subproblem is NP-hard, and propose a sequential 2-dimensional subspace minimization method for it. The convergence properties are also studied.

2 - Several Advances on Gradient and Conjugate Gradient Methods

Yu-Hong Dai, Chinese Academy of Sciences (CAS), LSEC, Institute of Computational Mathema, P.O. Box 2719, Beijing, 100190, China, dyh@lsec.cc.ac.cn

Both the steepest descent method and the conjugate gradient method are fundamental nonlinear optimization methods and only requires a storage of several vectors. In this talk, I shall briefly address several advances on the two classes of methods, making them more attractive for large-scale problems.

3 - A Study of Algorithms and Models for Sparse Solution Recovery via L1-Minimization

Junfeng Yang, Dept. Math., Nanjing University, 22 Han-kou Road, Nanjing, 210093, China, jfyang2992@gmail.com, Yin Zhang

Based on the classical approach of alternating directions method, we propose a primal-dual algorithm for solving L1-minimization problems for sparse solution recovery. The proposed algorithm is simple and applicable to several L1-models. Extensive numerical results are given to demonstrate the superiority of the proposed algorithm and an L1-L1 model. Besides, we put forward some basic ideas on how to evaluate algorithmic speed relative to solution accuracy.

■ WC25

Gleacher Center - 404

Calculus of Variations on Time Scales

Cluster: Variational Analysis
Invited Session

Chair: Delfim F. M. Torres, Professor, University of Aveiro, Department of Mathematics, Aveiro, 3810-193, Portugal, delfim@ua.pt

1 - Natural Boundary Conditions in the Calculus of Variations

Agnieszka B. Malinowska, Post-Doc, University of Aveiro, Aveiro, Portugal, abmalinowska@ua.pt, Delfim F. M. Torres

We prove necessary optimality conditions for problems of the calculus of variations on time scales with a Lagrangian depending on the free end-point.

2 - On the Dubois-Reymond Equation on Time Scales

Natalia Martins, Professor, University of Aveiro, Department of Mathematics, Aveiro, Portugal, natalia@ua.pt, Zbigniew Bartosiewicz, Delfim F. M. Torres

The fundamental problem of the calculus of variations on time scales concerns the minimization of a delta-integral over all trajectories satisfying given boundary conditions. In this paper we prove a Du Bois-Reymond necessary optimality condition for optimal trajectories. As an example of application of the main result, we give an alternative and simpler proof to the Noether theorem on time scales recently obtained in [J. Math. Anal. Appl. 342 (2008), no. 2, 1220—1226].

3 - Calculus of Variations on Time Scales With Delta-nabla Iterated Integrals

Delfim F. M. Torres, Professor, University of Aveiro, Department of Mathematics, Aveiro, 3810-193, Portugal, delfim@ua.pt

The discrete, the quantum, and the continuous calculus of variations have been recently unified and extended by using the theory of time scales. Two approaches are followed in the literature of time scales: one dealing with minimization of delta integrals; the other dealing with minimization of nabla integrals. Here we propose a unifying approach that allows to obtain both delta and nabla results as particular cases.

■ WC28

Gleacher Center - 600

Structured Nonsmooth Optimization

Cluster: Nonsmooth and Convex Optimization
Invited Session

Chair: Claudia Sagastizabal, Electric Energy Research Center, P.O. Box 68007, Rio de Janeiro, 21944-970, Brazil, sagastiz@impa.br

1 - Algorithms for Convex Minimization Based on VU-theory

Robert Mifflin, Professor, Washington State University, Mathematics Department, P.O. Box 643113, Pullman, WA, 99164, United States of America, mifflin@math.wsu.edu, Claudia Sagastizabal

For many nonsmooth functions a VU-algorithm converges superlinearly by alternating U-space predictor steps with V-space corrector steps. The latter come from a proximal bundle subroutine that constructs cutting-plane models of the objective function while the former depend on quadratic models of an associated U-Lagrangian. Numerical results showing rapid convergence for both U-Newton and U-quasi-Newton versions are given.

2 - Bundle Methods for Nonconvex Optimization

Warren Hare, Assistant Professor, UBC-O, Department of Mathematics, 3333 University Way, Kelowna, BC, V1V 1V7, Canada, whare@irmacs.sfu.ca, Claudia Sagastizabal

Proximal bundle methods have been shown to be highly successful optimization methods for nonsmooth convex optimization. We address the question of whether bundle methods can be extended to work for nonconvex problems. We review some past results for proximal bundle methods and demonstrate a method for extending bundle methods to a nonconvex setting. The method is based on generating cutting planes model not of the objective function but of a local convexification of the objective function. The convexification parameter is calculated "on the fly," which allows for both strong convergence results and the ability to inform the user on when proximal parameters are too small to ensure a unique proximal point of the objective function.

3 - A Proximal Bundle Method for Composite Minimization

Claudia Sagastizabal, Electric Energy Research Center, P.O. Box 68007, Rio de Janeiro, 21944-970, Brazil, sagastiz@impa.br

We consider minimization of nonsmooth functions which can be represented as the composition of a positively homogeneous convex function and a smooth mapping. This is a sufficiently rich class that includes max-functions, largest eigenvalue functions, and norm 1-regularized functions. The bundle method uses an oracle that is able to compute separately the function and subgradient information for the convex function and the function and derivatives for the smooth mapping. With this information, it is possible to solve approximately certain proximal linearized subproblems in which the smooth mapping is replaced by its Taylor-series linearization around the current serious step.

■ WC29

Gleacher Center - 602

Computational Methods in Economics and Finance - Part III

Cluster: Finance and Economics
Invited Session

Chair: Che-Lin Su, Assistant Professor of Operations Management, The University of Chicago Booth School of Business, 5807 S. Woodlawn Ave, Chicago, IL, 60637, United States of America, chelin.su@gmail.com

1 - Fast LCP Computational Methods for American Options Pricing

Jose Luis Morales, Doctor, ITAM, Selva 45-104. Edificio Omega, Insurgentes Cuicuilco, Mexico, jmorales@itam.mx

In this talk we present numerical results with LCP-based methods for American options pricing. The solution of the LCPs is computed by means of an algorithm that combines: a) cycles of projected Gauss-Seidel; b) subspace minimization iterations that make use of preconditioned GMRES(m). We illustrate the performance of the methods on models with/without stochastic volatility.

2 - Multigrid Solvers for Calibration and Estimation of Dynamic Structural Models

Adam Speight, Georgia State University, 198 15th St NW, Atlanta, GA, United States, aspeight@gmail.com

A new methodology for calibrating parameters of dynamic structural models is developed. It also allows for formal estimation and hypothesis testing in a Generalized Method of Moment framework. The method is based on multigrid techniques used in many state of the art solvers from engineering applications. These techniques are adapted to solve Bellman and Euler-type equations and to handle subtleties arising from the interaction of statistical and numerical errors.

3 - A User's Guide to Solving Dynamic Stochastic Games Using the Homotopy Method

Ron Borkovsky, Rotman School of Management, University of Toronto, Toronto, Canada Ron.Borkovsky@rotman.utoronto.ca

This paper provides a step-by-step guide to solving dynamic stochastic games using the homotopy method. The homotopy method facilitates exploring the equilibrium correspondence in a systematic fashion; it is especially useful in games that have multiple equilibria. We discuss the theory of the homotopy method and its implementation and present two detailed examples of dynamic stochastic games that are solved using this method.