# Technical Sessions

## Wednesday, 9:00 - 10:00

### ■ WA-01

*Wednesday, 9:00 - 10:00*
*Room 101*

#### Opening Session

Stream: Contributed session
*Plenary session*

Chair: *Laura Palagi*, Dipartimento di Ingegneria informatica automatica e gestionale, La Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, palagi@dis.uniroma1.it
Chair: *Fabio Schoen*, Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Firenze, via di Santa Marta, 3, 50139, Firenze, Italy, fabio.schoen@unifi.it

## Wednesday, 10:10 - 11:10

### ■ WB-01

*Wednesday, 10:10 - 11:10*
*Room 101*

#### Plenary I

Stream: Plenary Lectures
*Invited session*

Chair: *Laura Palagi*, Dipartimento di Ingegneria informatica automatica e gestionale, La Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, palagi@dis.uniroma1.it

**1 - Optimization and machine learning**

*Chih-Jen Lin*, Department of Computer Science, National Taiwan University, -, Taipei, Taiwan, cjlin@csie.ntu.edu.tw

In this talk I will discuss my experiences on kernel and linear classification. In particular, we discuss support vector machines (SVM), which involve some challenging optimization problems. As a machine learning researcher with an optimization background, I will show lessons learned in the past and how we eventually construct some widely used machine learning software.

# Wednesday, 11:40 - 13:00

## ■ WC-01

*Wednesday, 11:40 - 13:00*
*Room 101*

### Equilibrium problems I

Stream: Invited sessions
*Invited session*
Chair: *Jong-Shi Pang*, ISE, University of Illinois, Urbana-Champaign, IL 61801, Urbana, Illinois, United States, jspang@illinois.edu

**1 - Complementarity formulations for L0 norm optimization problems**

*John Mitchell*, Math Sciences, Rensselaer Polytechnic Institute, 110 Eighth St, 325 Amos Eaton, RPI, 12180, Troy, NY, United States, mitchj@rpi.edu, *Jong-Shi Pang*, *Andreas Waechter*, *Lijie Bai*, *Mingbin Feng*, *Xin Shen*

There has been interest recently in obtaining sparse solutions to optimization problems, eg in compressed sensing. Minimizing the number of nonzeroes (also known as the L0 norm) is often approximated by minimizing the L1 norm. In contrast, we give an exact formulation as a mathematical program with complementarity constraints; our formulation does not require a big-M term. We discuss properties of the exact formulation such as stationarity conditions, and solution procedures for determining local and global optimality. We compare our solutions with those from an L1 norm formulation.

**2 - Pertfectly Competitive Capacity Expansion with Risk-Averse Participants and Price Externality**

*Jong-Shi Pang*, ISE, University of Illinois, Urbana-Champaign, IL 61801, Urbana, Illinois, United States, jspang@illinois.edu, *Dane Schiro*, *Ben Hobbs*

This paper presents Nash equilibrium models of perfectly competitive capacity expansion involving risk-averse participants in the presence of state uncertainty and price externality. Based on the nonlinear complementarity formulations of the respective models, existence of solutions are established. This study extends two recent special models, complements the fairly extensive work on games with strategic players, and provides an extended treatment of games with price-taking players whose feasible sets may be unbounded.

**3 - VI-constrained Hemivariational Inequalities: Distributed Algorithms and Power Control in Ad-Hoc Networks**

*Francisco Facchinei*, La Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, facchinei@dis.uniroma1.it, *Jong-Shi Pang*, *Gesualdo Scutari*, *Lorenzo Lampariello*

We consider centralized and distributed algorithms for the numerical solution of a hemivariational inequality (HVI) where the feasible set is given by the intersection of a closed convex set with the solution set of a lower-level monotone variational inequality (VI). The algorithms consist of a main loop wherein a sequence of one-level, strongly monotone HVIs are solved by a combination of proximal and Tikhonov regularization to handle the lower-level VI constraints. The methods developed in the paper are then used to solve a new power control problem in ad-hoc networks.

**4 - Iterative methods for solving variational inequalities**

*Rafał Zalas*, Faculty of Mathematics, Computer Science and Econometrics, University of Zielona Góra, ul. Szafrana 4a, 65-516, Zielona Góra, Lubuskie, Poland, r.zalas@wmie.uz.zgora.pl

In this talk we will consider an abstract variational inequality problem (VIP) in a real Hilbert space H, defined over a closed and convex subset C. We present a few examples of an iterative methods which can be used for solving such VIP in case when subset C is a finite intersection of a closed and convex subsets of H. Proposed methods are based on the so called general hybrid steepest descent method combined with a string averaging procedure. These methods show an application of approximately shrinking operators.

## ■ WC-02

*Wednesday, 11:40 - 13:00*
*Room 107*

### Global Optimization I

Stream: Contributed session
*Contributed session*
Chair: *Marco Locatelli*, Ingegneria dell'Informazione, Universita' di Parma, Italy, locatell@ce.unipr.it

**1 - Global optimization with noise corrupted function evaluations**

*Jim Calvin*, Computer Science, New Jersey Institute of Techno, University Heights, 07102, Newark, New Jersey, United States, calvin@njit.edu

In many practical problems, one is interested in finding or approximating a parameter value that minimizes a cost function associated with some system. Typically, the optimizer is assumed able to evaluate the cost function at some adaptively chosen parameter values. Sometimes the exact function values are not available, and the optimizer must make do with noisy estimates of the values. We model this situation with Gaussian models for the cost function and the measurement error. An algorithm is described that has the optimal convergence rate up to logarithmic factors.

**2 - Continuous GRASP for global optimization with general nonlinear constraints**

*Joao Lauro D. Faco'*, Dept. of Computer Science, Universidade Federal do Rio de Janeiro, Av. do PEPE, 1100 / 203, 22620-171, Rio de Janeiro, RJ, Brazil, jldfaco@ufrj.br, *Mauricio Resende*, *Ricardo Silva*

A new variant of the global optimization method Continuous GRASP (C-GRASP) incorporating general nonlinear constraints in addition to box constraints is presented. C-GRASP solves continuous global optimization problems subject to box constraints by adapting the greedy randomized adaptive search procedure (GRASP) of Feo and Resende (1989) for discrete optimization. It has been applied successfully to a wide range of continuous optimization problems. We consider the box constraints as implicit and handle the nonlinear equality/ inequality constraints explicitly by quadratic penalty.

**3 - Advantages of Simplicial Partitioning for Lipschitz Optimization Problems with Linear Constraints**

*Remigijus Paulavičius*, Recognition Processes, Vilnius University Institute Mathematics and Informatics, Vilnius, Lithuania, remigijus.paulavicius@mii.vu.lt, *Julius Zilinskas*

We consider a global optimization problem with a Lipschitz continuous objective function and linear constraints. Well-know DIRECT (DIviding RECTangles) algorithm requires bound constrains on variables, but does not naturally address additional linear and nonlinear constraints. For problems with linear constraints, a recently proposed simplicial partitions based DISIMPL algorithm may tackle linear constraints in a delicate way. Experimental investigation reveals advantages of DISIMPL algorithm to such problems comparing with different constraint-handling methods, proposed for use with DIRECT.

## ■ WC-03

*Wednesday, 11:40 - 13:00*

*Room 108*

## First order methods in optimization

Stream: Invited sessions
*Invited session*

Chair: *Gerardo Toraldo*, DIAAT, Università di Napoli Federico II, Via Università 100,, 80055, Portici, Italy, toraldo@unina.it

### 1 - Filtering effect of first-order methods for linear least-squares

*Federica Porta*, Dipartimento di Scienze Fisiche, Informatiche e Matematiche, Università di Modena e Reggio Emilia, Via Campi 213/B, 41125, Modena, Italy, federica.porta@unimore.it, *Anastasia Cornelio*, *Marco Prato*, *Luca Zanni*

A typical way to compute a meaningful solution of a linear least squares problem involves the introduction of a filter factors array, whose aim is to avoid noise amplification due to the presence of small singular values. Beyond the classical direct regularization approaches, iterative gradient methods can be thought as filtering methods. We analyze some classical and recent first-order algorithms by looking at their way of filtering the singular values, showing in particular which benefits can be gained in recovering the filters of the true solution by means of a suitable scaling matrix.

### 2 - A feasible direction method for l1-constrained least squares problems.

*Elena Loli Piccolomini*, Mathematics, University of Bologna, Piazza di Porta San Donato, 5, 40141, Italy, elena.loli@unibo.it, *Germana Landi*

In this talk we present a feasible direction method for the solution of a least squares problem under a constraint on the L1 norm . The method is applied to inverse problems in imaging. Some numerical experiments in deblurring and tomographic applications are presented and discussed.

### 3 - Spectral properties of gradient methods

*Gerardo Toraldo*, DIAAT, Università di Napoli Federico II, Via Università 100,, 80055, Portici, Italy, toraldo@unina.it, *Roberta De Asmundis*, *Daniela di Serafino*

In the last two decades fast gradient methods for function minimization have been proposed, which proved to be effective in several applications. We discuss how a better understanding of some of these methods can be based on the spectral properties of the classical Steepest Descent method, which also suggest the design of new algorithms.

[DDRT] R. De Asmundis, D. di Serafino, F. Riccio, and G. Toraldo. On spectral properties of steepest descent methods. IMA Journal on Numerical Analysis, 2013. to appear.

### 4 - On the application of new gradient methods to image restoration problems

*Roberta De Asmundis*, Università di Roma "La Sapienza", Via Benedetto De Falco 2, 80136, Napoli, Napoli, Italy, roberta.deasmundis@uniroma1.it, *Salvatore Cuomo*, *Daniela di Serafino*, *Germana Landi*, *Elena Loli Piccolomini*, *Gerardo Toraldo*

In [1] some new gradient methods for convex quadratic problems (QPs) have been introduced, able to force the search of the solution in one-dimensional subspaces, and hence escaping from the zigzagging of the Steepest Descent (SD) method. We test the methods in [1] on some image restoration problems formulated as unconstrained QPs. A comparison with other well-established methods show the effectiveness of the new algorithms which share with SD a smoothing, regularizing effect and whose spectral properties appear attractive for the applications at hand.

[1] See [DDRT] in the previous talk.

## ■ WC-04

*Wednesday, 11:40 - 13:00*

*Room 109*

## Multiobjective optimization

Stream: Contributed session
*Contributed session*

Chair: *Tibor Illés*, Differential Equations, Budapest University of Technology and Economics, Egry J. u. 1., 1111, Budapest, Hungary, illes@math.bme.hu

### 1 - A Projected Subgradient Algorithm for Multiobjective Optimization

*Sissy Souza*, Mathematics, Federal University of Piauí, Rua Acésio do Rego Monteiro, 1184, 64049610, Teresina, Piauí, Brazil, sissy@ufpi.edu.br, *Paulo Sergio Marques Santos*, *João Xavier da Cruz Neto*, *Glaydston Carvalho Bento*

We propose a projected subgradient algorithm for solving multiobjective minimization problems on a nonempty closed convex subset of Euclidean space. This algorithm extends the classical projected subgradient method using a divergent series steplength rule. Under convexity assumption and existence of solution, we show that the generated sequence by the method converges to an Pareto optimal point of the problem. Some numerical results are reported.

### 2 - Variable Orderings in Vector Optimization: Proper Optimality and Numerical Approaches

*Gabriele Eichfelder*, Institute of Mathematics, Ilmenau University of Technology, PF 10 05 65, 98684, Ilmenau, Germany, Gabriele.Eichfelder@tu-ilmenau.de, *Refail Kasimbeyli*

In vector optimization one usually assumes that the outcome space is partially ordered by a convex cone. Recently, several applications have given the motivation to study also problems where the preferences of a decision maker vary dependently on the actual values. Such ordering structures are modeled by set-valued maps that associate to each element of the linear space a cone of dominated or preferred directions.

We introduce notions of proper optimality and present scalarization results based on which such multiobjective optimization problems can be solved in practice.

**3 - Approximation of the Whole Pareto-Optimal Solution Set for Vector Optimization Problems**

*Tibor Illés*, Differential Equations, Budapest University of Technology and Economics, Egry J. u. 1., 1111, Budapest, Hungary, illes@math.bme.hu, *Gábor Lovics*

In this talk we generalize the subdivision algorithm of Schütze and others for linearly constrained multi objective optimization problem. The objective functions in our case need to be differentiable convex functions. The main idea of the method to find feasible joint decreasing direction, for the objective functions. Further generalization of the more general class of problems (convex constrained and convex objective function for mineralization problem) seems to be possible. Practical applicability of the new algorithm has tested on the Markowitz portfolio optimization problem.

# Wednesday, 14:20 - 15:40

## ■ WD-01

*Wednesday, 14:20 - 15:40*

*Room 101*

### The abstract equilibrium problem I: theory, methods and applications

Stream: Invited sessions

*Invited session*

Chair: *Giancarlo Bigi*, Dipartimento di Informatica, Universita' di Pisa, Largo B.Pontecorvo 3, 56127, Pisa, Italy, giancarlo.bigi@di.unipi.it

**1 - A Tikhonov-type regularization for equilibrium problems in Hilbert spaces**

*Paulo Sergio Marques Santos*, Mathematics, Federal University of Piaui, Campus Ministro Petronio Portella, Bairro Ininga, 64049-550, Teresina, Piauí, Brazil, psergio@ufpi.edu.br, *Paulo Oliveira*, *Afonso Norberto Silva*

In this work we consider a general equilibrium problem in a Hilbert space defined on a closed and convex set. We show a Tikhonov-type regularization method that can be extended for the equilibrium problem. Under mild assumptions we establish the equivalence between the existence of solution of the original problem and the boundedness of the sequence generated by regularized problems.

**2 - On a Generalized Proximal Point Method for Equilibrium Problems in Banach spaces**

*Gabor Kassay*, Mathematics, Babes-Bolyai University, 1 M Kogalniceanu 1, 400084, Cluj, Romania, kassay@math.ubbcluj.ro, *Regina Burachik*

We propose a regularized equilibrium problem in a Banach space via generalized Bregman functions, and we establish existence and uniqueness of solutions. These regularizations induce a new proximal-like method for solving equilibrium problems in Banach spaces. We prove the proximal sequence is an asymptotically solving sequence if the dual space is uniformly convex. Moreover, we prove that all weak accumulation points are solutions if the equilibrium function is lower semicontinuous in its first variable. Under additional assumptions we also prove that the proximal sequence converges weakly.

**3 - Generalized Nash Equilibria for Platform-as-a-Service Clouds**

*Mauro Passacantando*, Department of Computer Science, University of Pisa, Largo B. Pontecorvo 3, 56127, Pisa, Italy, mpassacantando@di.unipi.it, *Danilo Ardagna*, *Jonatha Anselmi*

Cloud computing is an emerging technology that allows to access computing resources on a pay-per-use basis. In this paper we model the service provisioning problem of Cloud Platform-as-a-Service systems as a Generalized Nash Equilibrium Problem. We show that a potential function for the game exists and we propose several solution algorithms based on the best response dynamics that are convergent to generalized Nash equilibria. Numerical results show that our algorithms are scalable and very efficient and thus they can be adopted for the run-time management of very large systems.

**4 - Revising the gap function approach for equilibria**

*Giancarlo Bigi*, Dipartimento di Informatica, Universita' di Pisa, Largo B.Pontecorvo 3, 56127, Pisa, Italy, giancarlo.bigi@di.unipi.it, *Mauro Passacantando*

Computing the gap function of equilibrium problems (EPs) amounts to solving a convex optimization problem, and it may be an expensive task; the minimization of the gap function is often a constrained problem too. We address 2 approaches to face these issues: EPs with nonlinear constraints are solved exploiting polyhedral approximations of the feasible set together with possibly unfeasible search directions which requires exact penalties; gap functions are combined to formulate EPs through unconstrained minimization and search directions simpler than the usual ones are exploited to solve them.

## ■ WD-02

*Wednesday, 14:20 - 15:40*

*Room 107*

### Global Optimization II

Stream: Contributed session
*Contributed session*

Chair: *Jim Calvin*, Computer Science, New Jersey Institute of Techno, University Heights, 07102, Newark, New Jersey, United States, calvin@njit.edu

**1 - Exploiting Symmetry in the Global Optimisation of Atomic Clusters**

*Mark Oakley*, School of Chemistry, University of Birmingham, College of Engineering and Physical Sciences, Edgbaston, B15 2TT , Birmingham, United Kingdom, m.t.oakley@bham.ac.uk, *Roy Johnston*

For atomic clusters with multiple-funnel energy landscapes, such as Lennard-Jones clusters with 38 or 98 atoms, the global minima are difficult to locate. We describe the core orbits symmetrisation method, which exploits approximate symmetry. This improves the efficiency of basin-hopping or a genetic algorithm by up to two orders of magnitude for these difficult cases. It also offers a small improvement for clusters with single-funnel energy landscapes.

**2 - Efficient dimension reduction in interest rate modelling by global optimization**

*Ralf Werner*, Institut für Mathematik, Universität Augsburg, Universitätsstr. 14, 86159, Augsburg, Germany, werner_ralf@gmx.net

We investigate the behaviour of different formulations for the calibration problem of low parametric models to real world yield curves. We highlight problems using a simple approach based on standard optimization routines currently followed in financial industry. We improve the standard approach by using a suitable deterministic adaptive global optimization routine based on sparse grids, while keeping computation times within reasonable limits. We close the talk with a description of the benefits based on an application within the risk capital model of an insurance company.

**3 - An Enhanced Spatial Branch-and-Bound Method in Global Optimization with Nonconvex Constraints**

*Peter Kirst*, Karlsruhe Institute of Technology, Germany, peter.kirst@kit.edu, *Oliver Stein*, *Paul Steuermann*

We discuss some difficulties in determining valid upper bounds in spatial branch-and-bound methods for global minimization in the presence of nonconvex constraints. In fact, an example illustrates that standard techniques for the construction of upper bounds may fail in this setting. Instead, we propose to perturb infeasible iterates along Mangasarian-Fromovitz directions to feasible points whose objective function values serve as upper bounds. These directions may be calculated by the solution of a single linear optimization problem per iteration.

## ■ WD-03

*Wednesday, 14:20 - 15:40*

*Room 108*

### Derivative-free Optimization I

Stream: Invited sessions
*Invited session*

Chair: *Gianni Di Pillo*, Dept. of Computer Control and Management Engineering, University of Rome, via Ariosto 25, Sapienza Universita' di Roma, 00185, Rome, RM, Italy, dipillo@dis.uniroma1.it

**1 - Derivative-free Approaches for Nonsmooth Constrained Optimization**

*Giovanni Fasano*, Department of Management, University Ca'Foscari of Venice, San Giobbe, Cannaregio 873, 30121, Venice, Italy, fasano@unive.it, *Giampaolo Liuzzi*, *Stefano Lucidi*, *Francesco Rinaldi*

We consider the solution of Lipschitz continuous inequality constrained optimization problems. We propose a general globally convergent scheme, including different algorithms, each one endowed with different convergence properties. Our proposal relies on a linesearch-based approach, where the global convergence to Clarke-stationary points is proved using a set of search directions, which is dense in the unit sphere. An exact penalty method is also used, in order to treat the nonlinear inequality constraints. A numerical comparison with NOMAD and BOBYQA is given, proving our efficiency.

**2 - Derivative-free methods for multiobjective Lipschitz problems**

*Giampaolo Liuzzi*, IASI, CNR, 00185, Rome, Italy, giampaolo.liuzzi@iasi.cnr.it, *Giovanni Fasano*, *Stefano Lucidi*, *Francesco Rinaldi*

This work focuses on the solution of a constrained multiobjective optimization problems, with both nonlinear inequality constraints and bound constraints. We assume that the vector of the objective functions and the constraints are Lipschitz continuous. We show equivalence between the original constrained multiobjective problem, and a multiobjective problem with simple bounds, by means of an exact penalty function approach. We propose a line search based derivative free framework and report some numerical results proving the effectiveness of the proposed approach.

**3 - Global Rates for Zero-Order Methods**

*Luis Nunes Vicente*, University of Coimbra, Coimbra, Portugal, lnv@mat.uc.pt

In some DFO methods, it is possible to develop complexity bounds in terms of the number of evaluations to reach stationarity. Such global rates complement analyses of global convergence by providing additional insight.

We show that the broad class of direct-search methods of directional type, based on imposing sufficient decrease, exhibits the

same global rates of the gradient method for smooth functions, both in the nonconvex and convex cases.

A smoothing direct search approach is also discussed capable of deliver a global rate in the nonsmooth nonconvex setting.

# ■ WD-04

*Wednesday, 14:20 - 15:40*

*Room 109*

## Applied Optimization I

Stream: Contributed session
*Contributed session*

Chair: *Ludmilla Koshlai*, Systems analysis and OR, Institute of Cybernetics, Gonchar str.,65-a,apt.20, 01054, Kiev, Ukraine, koshlai@ukr.net

### 1 - Solving time-dependent scheduling problems via interior point method

*Stanislaw Gawiejnowicz*, Faculty of Mathematics and Computer Science, Adam Mickiewicz University, Umultowska 87, 61-614, Poznan, Poland, stgawiej@amu.edu.pl, *Wieslaw Kurc*

We propose a variant of an interior point method to a matrix time-dependent scheduling problem. We reformulate the problem as a non-linear minimization problem over a subpolytope of a permutohedron and attach to each vertex of this subpolytope, in one-to-one way, a permutation matrix. Next, we express our problem in terms of such matrices, prove an analogon of a Birkhoff's theorem on the convex hull of these matrices and formulate a relaxed version of our problem. Finally, we apply to the relaxed version the primal-dual interior point method using only quadratic number of constraints.

### 2 - SLaSi: a spin-lattice simulation tool

*Oleksandr Pylypovskyi*, Radiophysical, Taras Shevchenko National Univesity Of Kyiv, 252187, Kyiv, Ukraine, o.pylypovskyi@gmail.com, *Denis Sheka*

This presentation introduces a new software SLaSi for the analysis of the specific field in physics such as magnetization statics and dynamics. The main purpose of the tool is to simulate the full 3-dimensional cubic lattices, where the classical Landau-Lifshitz-Gilbert equation is solved for each node. The considered lattice with N nodes, where N takes values up to million, generates the resulting system with 3N nonlinear differential equations. SLaSi is designed as a MPI-software which can be extended to solve a wide range of large multidimensional problems in economy, industry and control.

### 3 - Pickup and delivery problem — case study

*Jan Pelikan*, Econometrics, University of Economics Prague, W. Churchill sq. 4, 13067, Prague, Czech Republic, pelikan@vse.cz

The new pickup and delivery problem with transfers and split delivery is studied. The goal is to propose cyclical routes which ensure transport of required goods among main centres of regions. A set of shipments demands is given, where each demand is specified by the place of pickup, the place of delivery and quantity of goods. There are available vehicles of given capacities. The objective is to find cyclical routes for these vehicles with minimal costs. The mathematical model and main features of the problem is presented.

### 4 - Modelling of Technological Changes in the Economy of Ukraine

*Ludmilla Koshlai*, Systems analysis and OR, Institute of Cybernetics, Gonchar str.,65-a,apt.20, 01054, Kiev, Ukraine, koshlai@ukr.net, *Petro Stetsyuk*, *Oleksandr Pylypovskyi*

We consider optimization models for improvement of the existed and implementation of new technologies necessary for Ukrainian economy. Decreasing of the production cost and creating the possibilities for noninflational wage growth are proposed as the main goals to be achieved. Presented models belong to the class of aggregated interindustry models (input-output Leontiev models). The efficient subgradient method has been proposed to solve them. Models, methods and computer programs are integrated into specialized DSS, which is designed as open menu-driven software.

# Wednesday, 16:20 - 17:20

## ■ WE-01

*Wednesday, 16:20 - 17:20*
*Room 101*

### The abstract equilibrium problem II: theory, methods and application

Stream: Invited sessions
*Invited session*
Chair: *Mauro Passacantando*, Department of Computer Science, University of Pisa, Largo B. Pontecorvo 3, 56127, Pisa, Italy, mpassacantando@di.unipi.it

**1 - Smoothness Properties of a Regularized Gap Function for Quasi-Variational Inequalities**

*Oliver Stein*, Institute of Operations Research, Karlsruhe Institute of Technology, 76131, Karlsruhe, Germany, stein@kit.edu, *Nadja Harms*, *Christian Kanzow*

We study continuity and differentiability properties for a reformulation of a finite-dimensional quasi-variational inequality (QVI) problem using a regularized gap function approach. Since the regularized gap function is nonsmooth in general, we take a closer look at its nondifferentiability points and show, in particular, that under mild assumptions all locally minimal points of the reformulation are, in fact, differentiability points. The results are specialized to generalized Nash equilibrium problems, and consequences for numerical methods are discussed.

**2 - Existence results for variational inequalities with surjectivity consequences related to generalized monotone operators**

*Mihaela Miholca*, Facultatea de Matematica si Informatica,, Universitatea Babe¸s-Bolyai Cluj-Napoca, 400084, Cluj-Napoca, Romania, mihaela.miholca@yahoo.com, *Gabor Kassay*

We present existence results for equilibrium problems and variational inequalities given by generalized monotone bifunctions and generalized monotone operators, respectively. As a consequence we deduce the existence of zeroes, or even more, surjectivity of some classes of set-valued operators. We show that by strengthening the continuity assumptions, similar surjectivity results can be obtained without any monotonicity assumption. In the framework of reflexive Banach spaces, we extend a related result due to Inoan and Kolumban (Nonlinear Analysis, 68(2008), pp.47-53)).

**3 - Penalty methods for general non monotone equilibrium problems**

*Igor Konnov*, System Analysis & IT, Kazan University, ul. Kremlevskaya, 18, 420008, Kazan, Russian Federation, konn-igor@ya.ru

We consider a general equilibrium problem (EP) in a Euclidean space setting. Most solution methods for EPs were substantiated under certain (generalized) monotonicity conditions. We now consider a general penalty method for EPs under mild coercivity conditions without monotonicity properties. Moreover, we show that a regularized version of the penalty method enables us to further weaken the coercivity condition.

## ■ WE-02

*Wednesday, 16:20 - 17:20*
*Room 107*

### Large Scale Nonlinear Optimization I

Stream: Invited sessions
*Invited session*
Chair: *Giovanni Fasano*, Department of Management, University Ca'Foscari of Venice, San Giobbe, Cannaregio 873, 30121, Venice, Italy, fasano@unive.it

**1 - Adaptive Observations And Multilevel Optimization In Data Assimilation**

*Maria Monserrat Rincon Camacho*, CERFACS (Centre for Research and Advanced Training in Scientific Computation), Toulouse, France, rincon@cerfacs.fr, *Serge Gratton*, *Philippe L. Toint*

We propose a decomposition of large-scale incremental four dimensional data assimilation problems based on exploiting an adaptive hierarchy of observation sets. Starting with a low-cardinality set and the solution of its corresponding optimization problem, observations are adaptively added based on a posteriori error estimates.Using the RPCG variant of the conjugate gradient that is well suited to this application, we present illustrate the bahaviour of the method on the 1D-wave equation and on the Lorenz-96 system, that represents problems encountered in Numerical Weather Prediction.

**2 - New preconditioner updates in Newton-Krylov methods for nonlinear systems**

*Margherita Porcelli*, Istituto di Scienza e Tecnologie dell'Informazione "A. Faedo", CNR, via G. Moruzzi 1, 50134, Pisa, Italy, porcelli@math.unifi.it, *Stefania Bellavia*, *Benedetta Morini*

We address the problem of preconditioning sequences of large sparse indefinite systems of linear equations arising in the solution of large nonlinear systems via Newton-Krylov methods. We present two new strategies to construct approximate updates of a factorized preconditioner for a reference matrix of the sequence. Both updates are based on the availability of an incomplete factorization for one matrix of the sequence and differ in the approximation of the so-called ideal updates. Furthermore, nearly matrix-free implementations are discussed.

**3 - AINVk: a Class of Approximate Inverse Preconditioners based on Krylov-subspace methods, for Large Indefinite Linear Systems**

*Massimo Roma*, Dipartimento di Ingegneria Informatica, Automatica e Gestionale, Universita' di Roma, via Ariosto 25, 00185, ROMA, Italy, roma@dis.uniroma1.it, *Giovanni Fasano*

We propose a class of preconditioners for symmetric indefinite linear systems arising from numerical analysis and nonconvex optimization frameworks. They may be obtained as by-product of Krylov-subspace solvers. We provide theoretical properties of our preconditioners, discussing the relation with other proposals. We study structural properties of our class of preconditioners, and report the results of a comparative numerical experience with LMP preconditioners. Then, we embed our preconditioners within a linesearch-based truncated Newton method and perform an extensive numerical testing.

## ■ WE-03

*Wednesday, 16:20 - 17:20*
*Room 108*

### Advances in Optimization and Control, and Their Applications I

Stream: Invited sessions
*Invited session*
Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr

**1 - On structure and computation of generalized Nash equilibria**
*Vladimir Shikhman*, Center of Operations Research and Econometrics, Catholic University of Louvain, Voie du Roman Pays 34, 1348, Louvain-la-Neuve, Belgium, vladimir.shikhman@uclouvain.be, *Hubertus Th. Jongen*, *Dominik Dorsch*

Generalized Nash equilibrium problems (GNEPs) are studied from structural and computational perspectives. Basic in our approach is the representation of Nash equilibria (NE) as zeros of an underdetermined system of nonsmooth equations. The set of NE - generically - constitutes a Lipschitz manifold. Its dimension is (N-1)J, where N is the number of players and J is the number of active common constraints. This number encodes both the possible degeneracies for the players' parametric subproblems and the dimension of the set of NE. We propose and discuss a nonsmooth projection method for GNEP.

**2 - Optimization Approaches for Production Networks with Discontinuous Conservation Laws**
*Patrick Schindler*, Mathematics, Uni Mannheim, A5,6 B101 - B105, 68161, Mannheim, Rhineland-Palatinate, Germany, schindler@math.uni-mannheim.de, *Simone Göttlich*

In this talk, we introduce a production network model with discontinuous conservation laws. Under the assumption that no parts are lost, the interaction between several production units can be described by a queueing system. We are interested in solving and optimizing the models in an accurate and fast way. Therefore we discuss a front tracking approach to solve these kind of equations. This numerical scheme is useful to derive optimization approaches, e.g. discrete adjoint equation system and mixed integer problems.

**3 - Recent Advances on Stochastic Hybrid Systems with Jumps in Finance and Related Fields**
*Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr, *Yeliz Yolcu Okur*, *Busra Temocin*, *Sirma Zeynep Alparslan Gok*

We introduce into Stochastic Hybrid Differential Systems with Jumps, a new and wide modeling frame involving diffusion, impulsiveness and the local (regional) - global differentiation. They are emerging in the financial sector, in economics, game theory, etc.. We discuss market incompleteness and, especially, insider information and speculation. Control problems of optimal wealth are studied subject to these systems by Hamilton-Jacobi Bellman equations and a generalized discretization and approximation scheme is presented.

## ■ WE-04

*Wednesday, 16:20 - 17:20*
*Room 109*

### NonSmooth optimization I

Stream: Contributed session
*Contributed session*
Chair: *Didier Aussel*, Lab.PROMES UPR 8521, University of Perpignan, Technosud, Rambla de la thermodynamique, 66100, Perpignan, France, aussel@univ-perp.fr

**1 - Primal-dual subgradient method for huge-scale conic optimization problems and its application to shape design**
*Shpirko Sergey*, Control and Applied Math., Moscow Physics and Tech., 9, Institutskii per., Moscow Region, 141700, Dolgoprudny, Russian Federation, shpirko@yahoo.com, *Yurii Nesterov*

For huge-scale Linear Conic Optimization problems, we develop primal-dual subgradient method. Our main assumption is that the primal cone is formed as a direct product of many small-dimensional convex cones, and that the matrix of corresponding linear operator is uniformly sparse. Our scheme is based on the recursive updating technique suggested by Nesterov. It makes the total cost of iteration logarithmically depended in the problem size. As an application, we consider a classical problem of finding an optimal shape design.

**2 - Optimal Covering of Solid Bodies by Spheres Via Hyperbolic Smoothing Technique**
*Adilson Elias Xavier*, Systems Engineering and Computer Sciences Department, Federal University of Rio de Janeiro, P.O. Box 68511, Ilha do Fundão - Centro Tecnologia - H319, 21941-972, Rio de Janeiro, RJ, Brazil, adilson@cos.ufrj.br, *Antonio Alberto Fernandes Oliveira*, *Daniela Lubke*, *Vinicius Layter Xavier*

We consider the problem of optimally covering solid bodies by a given number of spheres. The mathematical modelling of this problem leads to a min-max-min formulation which, in addition to its intrinsic multi-level nature, has the significant characteristic of being non-differentiable. The use of the Hyperbolic Smoothing technique engenders a simple one-level non-linear programming problem and allows overcoming the main difficulties presented by the original one. To illustrate the performance of the method we present computational results in a medical application: coverage of brain tumors.

**3 - About points where multivalued maps are single-valued**
*Didier Aussel*, Lab.PROMES UPR 8521, University of Perpignan, Technosud, Rambla de la thermodynamique, 66100, Perpignan, France, aussel@univ-perp.fr

An important literature has been dedicated, in the last decades, to the study of situations/hypothesis in which a monotone set-valued map is single-valued. This can be considered from different points of view: pointwise, locally or densely. Our aim, in this talk, is to prove that the same kind of results can be obtained for quasimonotone operators. Additionally, most of the monotone cases can be deduces from the quasimonotone case.

# Wednesday, 17:30 - 18:50

## ■ WF-03

*Wednesday, 17:30 - 18:50*
*Room 108*

### Advances in Optimization and Control, and Their Applications II

Stream: Invited sessions
*Invited session*

Chair: *Gerhard-Wilhelm Weber*, Institute of Applied Mathematics, Middle East Technical University, ODTÜ, 06531, Ankara, Turkey, gweber@metu.edu.tr
Chair: *Sevtap Kestel*, Actuarial Sciences, Applied Mathematics Institute, Middle East Technical University, Institute of Applied Mathematics, 06531, Ankara, Turkey, skestel@metu.edu.tr

**1 - A new hybrid model to forecast day-ahead electricity prices: wavelet-mars**

*Miray Hanım Yıldırım*, Institute of Applied Mathematics, Middle East Technical University; Department of Industrial Engineering, Çankaya University; European Commission, Joint Research Centre, Institute for Energy and Transport, Institute of Applied Mathematics Middle East Technical University, 06531, Ankara, Turkey, e160106@metu.edu.tr, *Özlem Türker Bayrak*, *Gerhard-Wilhelm Weber*

The impact of electricity price on energy market requires more accurate forecasting techniques. Aiming maximum utilities under highly volatile market conditions, both supplier and consumer sides seek to monitor and response the changes in the electricity prices. In this study, we present a new hybrid model, wavelet-Multivariate Adaptive Regression Splines, to forecast day-ahead electricity prices. Unlike classical techniques, the new method does not require any assumption neither for the data nor for the solution progress. The results compared with the classical techniques are also presented.

**2 - Distance geometry model for multiextremal optimisation and kriging**

*Leonidas Sakalauskas*, Operational Research, Institute of Mathematics & Informatics, Akademijos 4, LT-08663, Vilnius, Lithuania, sakal@ktl.mii.lt

The application of the distance geometry model to probabilistic modelling by Gaussian fields of multivariate data structures is considered. A simple extrapolator is developed by means of a matrix of distances between pairs of the points of objective function computation. The model is rather simple and can be defined only by the mean and variance parameters, efficiently evaluated by maximal likelihood method. The results of application of the extrapolator developed to kriging and multiextremal optimisation are considered too.

# Thursday, 9:00 - 10:00

## ■ TA-01

*Thursday, 9:00 - 10:00*
*Room 101*

### Equilibrium Problems II

Stream: Invited sessions
*Invited session*
Chair: *Francisco Facchinei*, La Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, facchinei@dis.uniroma1.it

**1 - Inexact Relaxation Methods for Mathematical Programs with Equilibrium Constraints**

*Christian Kanzow*, University of Wuerzburg, Insitute of Mathematics, Am Hubland, 97074, Wuerzburg, Germany, kanzow@mathematik.uni-wuerzburg.de, *Alexandra Schwartz*

Mathematical programs with equilibrium (or complementarity) constraints, MPECs for short, form a difficult class of optimization problems violating most constraint qualifications. One prominent class of algorithms are the relaxation (or regularization) methods. Starting with Scholtes (2001), there exist a whole bunch of relaxation methods. Here we investigate the convergence properties when the subproblems are solved only inexactly. Surprisingly, these properties are completely different from the corresponding methods, where the subproblems are solved exactly.

**2 - Cyber foraging as a generalized Nash equilibrium problem**

*Veronica Piccialli*, Dipartimento di Ingegneria Civile e Ingegneria Informatica, Università degli Studi di Roma Tor Vergata, via del Politecnico, 00133, Rome, Italy, piccialli@disp.uniroma2.it, *Francisco Facchinei*, *Valeria Cardellini*, *Valerio Di Valerio*, *Vincenzo Grassi*, *Francesco Lo Presti*, *Vittoria De Nitto Personè*

Cyber foraging dynamically augments computing resources of mobile devices by exploiting external computing infrastructures. In the system we consider, applications functionality is dynamically partitioned between the mobile, cloudlet nodes that represent the wireless access points the mobile connects to, and distant cloud servers. As the load increases, resources sharing can cause delays and performance degradation. In order to capture the effects of interactions of users we model the system as a generalized Nash equilibrium problem and propose a distributed algorithm for its solutions.

**3 - Error Bound Results for Generalized Nash Equilibrium Problems**

*Andreas Fischer*, Department of Mathematics, Technische Universität Dresden, Institute of Mathematics, 01062, Dresden, Germany, Andreas.Fischer@tu-dresden.de, *Axel Dreves*, *Francisco Facchinei*, *Markus Herrich*

We consider the Karush-Kuhn-Tucker (KKT) system belonging to a Generalied Nash Equilibirum Problem (GNEP). Since a solution of the GNEP is typically nonisolated, error bound results for these problems are nonstandard. However, for several reasons like the application within algorithms or sensitivity it is quite useful to know an error bound that is valid around a certain solution of the KKT system. In this talk we will discuss some recent error bound results for the KKT system.

## ■ TA-02

*Thursday, 9:00 - 10:00*
*Room 107*

### Nonlinear Constrained Optimization

Stream: Invited sessions
*Invited session*
Chair: *Giampaolo Liuzzi*, IASI, CNR, 00185, Rome, Italy, giampaolo.liuzzi@iasi.cnr.it

**1 - Spectral Projected Gradients: reviewing ten years of applications**

*Ernesto G. Birgin*, Dept. of Computer Science, University of São Paulo, Rua do Matão, 1010, Cidade Universitária, 05508-090, São Paulo, SP, Brazil, egbirgin@gmail.com

The Spectral Projected Gradient method (SPG) seeks the minimization of a smooth function over a convex set for which the projection operation can be inexpensively computed. The SPG is based on projected gradients and combines the spectral steplength with nonmonotone line searches. Since its introduction in 2000, many successful usages on a variety of fields have been reported, comprising Machine Learning, Medical Imaging, Meteorology, and Image Reconstruction, including Compressive Sensing, just to name a few. In this talk, some of those applications will be reviewed and analyzed.

**2 - A projection algorithm for multiresolution optimisation**

*Duy Luong*, Computing, Imperial College London, 180 Queens Gate, SW7 2RH, London, United Kingdom, vu.luong@imperial.ac.uk, *Panos Parpas*, *Daniel Rueckert*, *Berc Rustem*

Solving a large scale optimisation problem at the original resolution is expensive. We present a projection method that utilises coarse level information to improve the performance of finer level. The approach assumes existence of hierarchy of models and solving coarse levels is less expensive than fine levels. We show that an iteration of the multiresolution framework satisfies the contraction principle under certain conditions. Using coarse information in the fine iteration improves the performance in practice as well as sharpen the convergence properties. Experimental results are followed.

**3 - A primal-dual augmented Lagrangian method for nonlinear optimization**

*Paul Armand*, XLIM Laboratory, University of Limoges, 123, avenue Albert Thomas, 87060, Limoges, France, paul.armand@unilim.fr, *Joël Benoist*, *Riadh Omheni*

We present a primal-dual augmented Lagrangian algorithm for NLP. The algorithm is based on the Newton method applied to a sequence of perturbed KKT systems which comes by introducing both an augmented Lagrangian and a log-barrier penalty. The globalization is done by means of a control of the iterates in the primal-dual space all along the iterations. Global and asymptotic convergence results are shown. Numerical tests are also presented. We show that the method is robust in the sense that it is able to solve degenerate problems for which the Jacobian of constraints is rank deficient.

## ■ TA-03

*Thursday, 9:00 - 10:00*
*Room 108*

### Stochastic bilevel optimization

Stream: Invited sessions
*Invited session*
Chair: *Georg Pflug*, Department of Statistics and Decision Support Systems, University of Vienna, Universitaetsstrasse 5, A-1010, Vienna, Austria, georg.pflug@univie.ac.at

**1 - Stochastic bilevel problems: Models and structures**
*Georg Pflug*, Department of Statistics and Decision Support Systems, University of Vienna, Universitaetsstrasse 5, A-1010, Vienna, Austria, georg.pflug@univie.ac.at
We review some models for bilevel stochastic programs. In view of the existing literature on deterministic bilevel problems, we look at necessary conditions for stationary points in an MPEC formulation. Some extensions of necessary optimality conditions to the stochastic case will be presented. A typical problem is the pricing problem of electricity swing options, where the lower level problem is a linear stochastic multistage problem and the upper level is a stochastic single stage bilinear problem with bilinear constraints.

**2 - Decomposition method for linear stochastic bilevel problems**
*Charlotte Henkel*, Mathematics, University of Duisburg-Essen, Forsthausweg 2, 47057, Duisburg, Germany, charlotte.henkel@uni-due.de
Compared to linear stochastic two-stage programs, linear stochastic bilevel problems (LSBP) exhibit a strongly increased complexity. Nonetheless, decomposition methods known from the former can be used to derive optimal solutions of LSBPs. An algorithm for optimistic LSBPs with discrete distributions is presented as well as an evaluation of the performance.

**3 - Optimality conditions and solution algorithms for the swing option pricing problem**
*Raimund Kovacevic*, Statistics and Decision Support Systems, University Vienna, Universitätsstr. 5, 1010, Wien, Wien, Austria, raimund.kovacevic@univie.ac.at, *Georg Pflug*
Swing options are an important type of electricity delivery contracts. Due to the nonstorability of electricity and the incompleteness of electricity markets it is hard to apply classical finance methods for calculating the related strike price. The pricing problem therefore has been reformulated as a bilevel optimiazation problem of Stackelberg type. We analyze (necessary) optimiality conditions and solution algorithms.

## ■ TA-04

*Thursday, 9:00 - 10:00*
*Room 109*

### Stability and convergence analysis in continuous optimization

Stream: Invited sessions
*Invited session*
Chair: *Diethard Klatte*, IBW, Universität Zürich, Moussonstr. 15, CH-8044, Zürich, Switzerland, klatte@ior.uzh.ch

**1 - Uniqueness of solutions under metric regularity of Karush-Kuhn-Tucker systems for cone constrained programs**
*Diethard Klatte*, IBW, Universität Zürich, Moussonstr. 15, CH-8044, Zürich, Switzerland, klatte@ior.uzh.ch, *Bernd Kummer*

In this talk, we study nonlinear optimization problems under canonical perturbations in a setting which includes standard nonlinear programs as well as cone constrained programs. We discuss conditions for metric regularity of the Karush-Kuhn-Tucker (KKT) system, or, equivalently, for the Aubin property of the KKT solution set map. Our focus is on conditions under which metric regularity and strong regularity of the KKT system coincide. In particular, we show that constraint nondegeneracy and uniqueness of the multiplier is necessary for the metric regularity of the KKT system.

**2 - A nonsmooth Newton method for disjunctive optimization problems**
*Stephan Buetikofer*, Institute of Data Analysis and Process Design, Zurich University of Applied Sciences, Rosenstrasse 3, 8401, Winterthur, Switzerland, stephan.buetikofer@zhaw.ch, *Diethard Klatte*

In recent works of the authors a nonsmooth Newton method was developed in an abstract framework and applied to certain finite dimensional optimization problems with C1,1 data. Such problems arise from general semi-infinite optimization problems (GSIP) under suitable assumptions. Recent results show that under some weaker assumptions there is a reformulation of a GSIP as a disjunctive optimization problem. We will apply this method to disjunctive optimization problems. For this we reformulate stationary points of a disjunctive optimization problem as a zero of a suited nonsmooth function.

**3 - Metric regularity in nonlinear semidefinite programming**
*Peter Fusek*, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava, Mlynska dolina, 84248, Bratislava, Slovakia, peto.fusek@gmail.com

We study the interplay between metric regularity and strong regularity of the Kojima function corresponding to the nonlinear semidefinite programming problem. Having in mind the topological structure of the positive semidefinite cone we identify a class of locally Lipschitz functions which turn out to have coherently oriented B-subdifferentials under metric regularity. This class is general enough to contain the Kojima function. We arrive at an equivalence between metric regularity and strong regularity provided that an assumption involving the topological degree is fulfilled.

# Thursday, 10:10 - 11:10

## ■ TB-01

*Thursday, 10:10 - 11:10*
*Room 101*

### Plenary II

Stream: Plenary Lectures
*Invited session*
Chair: *Fabio Schoen*, Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Firenze, via di Santa Marta, 3, 50139, Firenze, Italy, fabio.schoen@unifi.it

**1 - Towards better bounds: The interplay of convex underestimators, branching rules and domain reductions**

*Marco Locatelli*, Ingegneria dell'Informazione, Universita' di Parma, Italy, locatell@ce.unipr.it

In this talk we present some results about convex envelopes of bivariate functions over polytopes and we show, through some examples, how the ability of computing good convex underestimators over regions different from classical ones, like boxes, allows to define branching strategies which improve the performance of branch and bound algorithms based on the standard subdivision of boxes into subboxes. The same examples are also employed to illustrate the strong impact of domain reduction techniques.

# Thursday, 11:40 - 13:00

## ■ TC-01

*Thursday, 11:40 - 13:00*
*Room 101*

### Variational Analysis and Optimization I

Stream: Invited sessions
*Invited session*
Chair: *Michel Théra*, Maths-Info, XLIM, UMR-CNRS 6172, 123, Avenue Albert Thomas, 87060, Limoges Cedex, France, michel.thera@unilim.fr

**1 - Error Bounds and Metric Subregularity**

*Alexander Kruger*, School of Science, Information Technology & Engineering, University of Ballarat, University Drive, Mount Helen, P.O. Box 663, 3353, Ballarat, Victoria, Australia, a.kruger@ballarat.edu.au

In this talk, I am going to demonstrate how metric subregularity/calmness of set-valued mappings can be treated in the framework of the theory of error bounds of real-valued functions. For this purpose, the machinery of error bounds needs to be extended to functions defined on the product of (metric or normed) spaces.

Several kinds of primal space and subdifferential slopes for real-valued functions and set-valued mappings will be discussed.

**2 - Calmness modulus of linear semi-infinite programs**

*Maria Josefa Cánovas*, Operations Research Center, Miguel Hernández University, Avda. del Ferrocarril s/n, (Edif. Torretamarit), 03202, Elche, Alicante, Spain, canovas@umh.es, *Alexander Kruger*, *Marco A. López-Cerdá*, *Juan Parra*, *Michel Théra*

Our main goal is to compute or estimate the calmness modulus of the argmin mapping of linear semi-infinite optimization problems under canonical perturbations, i. e., perturbations of the objective function together with continuous perturbations of the right-hand-side of the constraint system (with respect to an index ranging in a compact Hausdorff space). The relationship between the calmness of the argmin mapping and the same property for the (sub)level set mapping (with respect to the objective function is explored too. Illustrative examples are provided.

**3 - Tilt stability in nonlinear and conic programming**

*Jiri Outrata*, Dep. of decision-making theory, UTIA Praha, Pod vodarenskou vezi 4, 18208, Praha 8, Czech Republic, outrata@utia.cas.cz

Tilt stability is useful property of optimization problems having important consequences mainly in numerics. The first part of the talk is devoted to analysis of this property in classical nonlinear programs with inequality constraints under either the Mangasarian-Fromovitz constraint qualification (MFCQ) or under MFCQ combined with the constant rank constraint qualification. We provide necessary and sufficient conditions for tilt stability and a relationship with strong metric regularity of a multifunction associated with necessary optimality conditions. These results complement a recent deve

**4 - Primal Solvability in Infinite-Dimensional Convex Optimization**

*Marco A. López-Cerdá*, Statistics and Operations Research, Alicante University, Ctra. San Vicente de Raspeig s/n, 3071, Alicante, Spain, marco.antonio@ua.es

In this talk we are presenting some results guarateeing that the optimal value of a given convex infinite optimization problem and its corresponding Lagrangian dual coincide and the primal optimal value is attainable. The conditions ensuring this so-called 'converse strong duality' involve the weakly-inf-(locally) compactness of suitable functions and the linearity or relative closedness of some sets depending on the data. Applications are given to different areas of convex optimization, including an extension of the Clark-Duffin Theorem for ordinary convex programs.

## ■ TC-02

*Thursday, 11:40 - 13:00*
*Room 107*

### Recent Advances in Computational Algorithms for Image Analysis

Stream: Invited sessions
*Invited session*

Chair: *William Hager*, Mathematics, University of Florida, 358 Little Hall, 32611, Gainesville, FL, United States, hager@ufl.edu

**1 - Alternating Direction Approximate Newton Method for Magnetic Resonance Image Reconstruction**

*Maryam Yashtini*, Department of Mathematics, University of Florida, Gainesville, Florida, United States, myashtini@ufl.edu, *William Hager*, *Cuong Ngo*, *Hongchao Zhang*

It has been shown that the BOSVS algorithm is globally convergent and efficient for magnetic resonance image reconstruction. However, the convergence of the algorithm relies on the choice of a number of parameters. In this talk, we present a new algorithm, Alternating Direction Approximate Newton Method. Experimental results and computational analysis are given using PPI. We show that the new algorithm yields comparable performance to BOSVS, but it is simpler to implement and employs fewer parameters.

**2 - A blind deconvolution method for astronomical imaging**

*Marco Prato*, Dipartimento di Scienze Fisiche, Informatiche e Matematiche, Università di Modena e Reggio Emilia, Via Campi 213/b, 41125, Modena, Italy, marco.prato@unimore.it, *Andrea La Camera*, *Silvia Bonettini*, *Mario Bertero*

We consider a blind deconvolution problem with data perturbed by Poisson noise. The problem is nonconvex and we approach it by means of an inexact alternating minimization method, whose global convergence to stationary points of the objective function has been recently proved in a general setting. We introduce a specific constraint on the PSF, that is an upper bound derived from the Strehl ratio between the peak value of an aberrated versus a perfect wavefront. The results obtained on numerical experiments indicate that the approach is very promising in the reconstruction of stellar fields.

**3 - L1-regularized image restoration: an approach using Newton projection methods**

*Germana Landi*, Department of Mathematics, Bologna University, Piazza di Porta San Donato, 5, 40126, Bologna, Italy, germana.landi@unibo.it

Regularization approaches to image restoration often need to minimize an objective function consisting of a quadratic data-fitting term plus an L1-norm regularization term. L1-regularized problems can be equivalently formulated as nonnegatively constrained quadratic programming problems. For their solution, this work proposes a Newton projection method where the Hessian of the objective function is approximated so that the Newton system can be solved by Fast Fourier Transforms. Computational experiments show that the proposed approach performs well compared to state-of-the-art methods.

**4 - Inexact Bregman Iteration with applications to Poisson data reconstruction**

*Alessandro Benfenati*, Università di Ferrara, Italy, bnflsn@unife.it, *Valeria Ruggiero*

The well-known Bregman iteration has been used in image restoration problems to obtain improved results. Any iteration of this scheme requires to exactly compute the minimizer of a function. However obtaining exact solutions of the subproblems could be extremely expensive. In order to improve the efficiency of the method we propose an inexact scheme which preserves the convergence. The introduction of this inexactness allows to address image reconstruction problems for data corrupted by Poisson noise also when only an overestimation of the regularization parameter is known.

## ■ TC-03

*Thursday, 11:40 - 13:00*
*Room 108*

### Advances in Portfolio Optimization and Related Subjects

Stream: Invited sessions
*Invited session*

Chair: *Nuno Azevedo*, Mathematics, Cemapre, Rua do Quelhas n.º 6, 1200-781, Lisboa, Portugal, ncazevedo@gmail.com

**1 - A stochastic optimal control problem with multiple random time horizons**

*Diogo Pinheiro*, CEMAPRE - ISEG, Technical University of Lisbon, Rua do Quelhas, 6, 1200-781, Lisboa, Portugal, dpinheiro@iseg.utl.pt

We consider a family of stochastic optimal control problems with the property that the objective functional depends on multiple random time horizons, assumed to be independent and identically distributed continuous random variables. The state variable follows a stochastic differential equation driven by a standard multi-dimensional Brownian motion. We resort to the concept of order statistics to restate the stochastic optimal control problem as one with a fixed planning horizon, deriving a dynamic programming principle and the corresponding HJB equation.

**2 - On a stochastic logistic growth model with a predation term**

*Susana Pinheiro*, Mathematics, University of Porto, 4000, Porto, Portugal, spinheiro09@gmail.com

We consider a logistic growth model with a predation term and a diffusive stochastic perturbation. We start by describing the asymptotic properties of such dynamical system, before considering the corresponding optimal harvesting problem for such model.

**3 - Subjective Beliefs and Unintended Consequences in a Class of Differential Games with Economic Applications**

*Pedro Mendonça*, Centre for Complexity Science, Warwick Mathematics Institute, The University of Warwick, Zeeman Building, CV4 7AL, Coventry, United Kingdom, G.P.A.de-Mendonca@warwick.ac.uk

We discuss the implications of decisions based on subjective beliefs for a class of N-player non-cooperative differential games. In the framework proposed, players lack the relevant information to pursue their optimal strategies and have to base their decisions on subjective beliefs. We argue that solutions to this class of games are optimal if decisions based on beliefs are consistent with the existence of a stable self-confirming equilibrium. To portray these conjectures in a game where asymmetric players seeks to maximize consumption utility, given the evolution of their portfolio.

**4 - Dynamic programming for a jump-diffusion with Markov switching coefficients**

*Nuno Azevedo*, Mathematics, Cemapre, Rua do Quelhas n.º 6, 1200-781, Lisboa, Portugal, ncazevedo@gmail.com

We prove a dynamic programming principle for a finite horizon optimal control problem for which the state variable dynamics are defined by a Markov-switching jump-diffusion stochastic differential equation. As an application of our results, we study a finite horizon consumption-investment problem in a financial market consisting of one risk free asset and one risky asset. The financial asset prices follow a jump-diffusion with stochastic coefficients depending on the state of a continuous time finite state Markov process. We provide a detailed study of the optimal strategies for this problem.

## ■ TC-04

*Thursday, 11:40 - 13:00*
*Room 109*

## Applied Optimization II

Stream: Contributed session
*Contributed session*
Chair: *Boukedroun Mohammed*, math, Etudiant, mohfou, mohfou, Algeria, medbkedroun@yahoo.fr

**1 - An Integrated Land-Use and Transportation Optimization Model**

*Narges Shahraki*, industrial engineering, koc university, koc university, istanbul, Turkey, nshahraki@ku.edu.tr, *Metin Turkay*

In this paper we formulate a non-linear stochastic single-stage land use and transportation optimization model. We consider minimizing the travel cost as the objective function and satisfying a target reliability index, defined as the probability that flow in each link of the network is less than the design capacity, as a constraint. We compare the results of our integrated single-stage model with a bi-level formulation of the problem on an example. The results indicate that the integrated approach finds optimal solution with improved throughput of the system.

**2 - Convergence of iterated projections in non-convex settings: maiden voyage of the restricted normal cone**

*Russell Luke*, Institute for Numerical and Applied Math, Universität Göttingen, Lotzetrasse 16-18, 37083, Göttingen, Niedersachsen, Germany, r.luke@math.uni-goettingen.de

The method of alternating projections (MAP) is a fundamental method for solving feasibility problems. In 2009 Lewis, Luke and Mallick developed workable regularity requirements for convergence of this algorithm for nonconvex sets. The conditions in that paper, however, were very strong, and did not capture the entire convex case as one might want. In this paper we extend the Lewis-Luke-Malick framework so that the convex case is covered. The key to our analysis is the newly developed restricted normal cone. The use of this tool is demonstrated on timely applications.

**3 - Improving an approach of robustness scheduling for one machine problem**

*Boukedroun Mohammed*, math, Etudiant, mohfou, mohfou, Algeria, medbkedroun@yahoo.fr

This article presents an improving of a robust scheduling for one machine problem based on interval structure and dominating partial orders .In literature, Briand and all present two approaches of robust scheduling, one of them is based on the determination of partial order using Carliers'methods "method of Schrage "and he other one based on the solution and the optimal sequence of Carlier, our contribution is based on the improvement of these scheduling approach.

# Thursday, 14:20 - 15:40

## ■ TD-01

*Thursday, 14:20 - 15:40*
*Room 101*

### Variational Analysis and Optimization II

Stream: Invited sessions
*Invited session*
Chair: *Marco A. López-Cerdá*, Statistics and Operations Research, Alicante University, Ctra. San Vicente de Raspeig s/n, 3071, Alicante, Spain, marco.antonio@ua.es

**1 - Chain rules for linear openness and applications to metric regularity of solution mapping for some mathematical programs**

*Marius Durea*, Mathematics, University Al. I. Cuza, 700506, Iasi, Iasi, Romania, durea@uaic.ro

The purpose of this talk is to present some general results concerning chain rules for linear openness of set-valued mappings acting between metric spaces. In some particular cases, we obtain classical and also some new results in this field of research. As application, we study the well-posedness of the solution mappings associated to parametric systems, giving sharp estimates for the involved regularity moduli. To this aim we introduce a local chain stability notion which preserve the Aubin property for compositions of multifunctions. Applications to vector optimization are also envisaged.

**2 - Calmness of the argmin mapping in linear semi-infinite optimization**

*F. Javier Toledo-Melero*, Operations Research Center, Miguel Hernández University, Avda. de la Universidad, s/n, 03202, Elche, Alicante, Spain, javier.toledo@umh.es, *Maria Josefa Cánovas*, *Abderrahim Hantoute*, *Juan Parra*

We characterize the calmness property of the argmin mapping in the framework of linear semi-infinite optimization problems under canonical perturbations; i.e., continuous perturbations of the right hand side of the constraints (inequalities) together with perturbations of the objective function coefficient vector. This characterization is new for semi-infinite problems without requiring uniqueness of minimizers. As a key tool in this paper, we appeal to a certain supremum function associated with our nominal problem, not involving problems in a neighborhood, which is related to sub)level sets.

**3 - On one-sided Lipschitz stability of set-valued contractions**

*Michel Théra*, Maths-Info, XLIM, UMR-CNRS 6172, 123, Avenue Albert Thomas, 87060, Limoges Cedex, France, michel.thera@unilim.fr

In this presentation which is based on a recent joint work with S. Adly and A. Dontchev, we present a a generalization of a theorem by Arutyunov regarding fixed points of composition of mappings. This result permits to sharpen a fixed point theorem by Lim. We apply the generalization of Lim's result to derive one-sided Lipschitz properties of the solution mapping of a dierential inclusion with a parameter.

**4 - Local convergence of quasi-Newton methods under metric regularity**

*Francisco Javier Aragón Artacho*, School of Mathematical and Physical Sciences, The University of Newcastle, University Drive, 2308, Callaghan, NSW, Australia, fran.aragon@gmail.com, *Anton Belyakov*, *Asen Dontchev*, *Marco A. López-Cerdá*

We consider quasi-Newton methods for generalized equations in Banach spaces under metric regularity. Our first result is a sufficient condition for q-linear convergence. Then we show that the well-known Broyden update satisfies this sufficient condition in Hilbert spaces. We also discuss q-superlinear convergence of the Broyden update in finite and infinite dimensions. Simple numerical examples illustrate the results.

## ■ TD-02

*Thursday, 14:20 - 15:40*
*Room 107*

### Nonlinear Optimization I

Stream: Contributed session
*Contributed session*
Chair: *François Glineur*, CORE, Université catholique de Louvain (UCLouvain), Voie du Roman Pays, 34 bte L1.03.01, B-1348, Louvain-la-Neuve, Belgium, Francois.Glineur@uclouvain.be

**1 - Fast QP and QPQC algorithms for the solution of large problems**

*Zdenek Dostal*, Applied Mathematics, VSB-Technical University Ostrava, 17. listopadu 15, CZ 708 33, Ostrava, Czech Republic, zdenek.dostal@vsb.cz

We first discuss the quantitative refinement of the KKT conditions for QPQC. Then we review our results in the development of optimal algorithms for the minimization of a strictly convex quadratic function subject to separable convex constraints (linear, spherical, elliptic) and/or equality constraints. When applied to convex QP or QPQC problems with the spectrum in a given positive interval and a sparse Hessian matrix, the algorithms enjoy optimal complexity. The performance of the algorithm is demonstrated by the solution of variational inequalities discretized by more than 1e8 variables.

**2 - Implementation of Strictly Convex QP Solver with Multiple Precision Arithmetic**

*Hiroshige Dan*, Kansai University, 3-3-35, Yamate-cho, 564-8680, Suita-shi, Osaka, Japan, dan@kansai-u.ac.jp

Optimization solvers are usually implemented with so-called double precision arithmetic because it was defined rigorously in the IEEE754-1985 standard and can perform high-speed floating point arithmetic. Double precision arithmetic for optimization basically works well, but it sometimes fails to solve some ill-posed problems. On the other hand, multiple precision arithmetic has attracted much attention recently. In this research, we have implemented a solver for strictly convex QPs by using multiple precision arithmetic.

**3 - Novel Frank-Wolfe Methods for Training Support Vector Machines**

*Emanuele Frandi*, Dipartimento di Scienza e Alta Tecnologia, Università degli Studi dell'Insubria, Italy, emanuele.frandi@uninsubria.it

We discuss a variation of the classical Frank-Wolfe algorithm with applications to Machine Learning. Our method, of which we present a specialization to the Support Vector Machine training problem, consists in a modification of the classical away-step strategy used to accelerate Frank-Wolfe iterations. We present some theoretical results and practical experiments on large-scale datasets. We show that the algorithm improves on similar approaches to SVM training and compares favourably with traditional SVM software, obtaining shorter running times without sacrificing the accuracy of the model.

**4 - Convergence of first-order methods with inexact information**

*François Glineur*, CORE, Université catholique de Louvain (UCLouvain), Voie du Roman Pays, 34 bte L1.03.01, B-1348, Louvain-la-Neuve, Belgium, Francois.Glineur@uclouvain.be, *Olivier Devolder*, *Yurii Nesterov*

Standard analysis of first-order methods for convex optimization typically assume availability of exact information (function and gradient values). However, this is often not the case, e.g. when finite differences are used for the gradient, when computations suffer from numerical errors, or when the function itself is computed as the (approximate) optimal value of another problem. We analyze the consequences of inexact information on the convergence rate of standard first-order methods, taking into account the level of smoothness and strong convexity, with two different types of inexact oracle

# ■ TD-03

*Thursday, 14:20 - 15:40*
*Room 108*

## Iterative methods for linear algebra in optimization I

Stream: Invited sessions
*Invited session*
Chair: *Jacek Gondzio*, School of Mathematics, University of Edinburgh, Edinburgh, United Kingdom, j.gondzio@ed.ac.uk

**1 - Second Order Methods for Large Scale Strongly Convex L1-Regularization**

*Kimon Fountoulakis*, School of Mathematics, University of Edinburgh, United Kingdom, K.Fountoulakis@sms.ed.ac.uk, *Jacek Gondzio*

Efficient techniques to overcome the non-smoothness of the l1-norm lead the way for approximate Newton methods for l1-regularization problems. In this talk we discuss truncated-damped and approximate Newton methods which offer a highly competitive alternative to the prevalent first-order methods. Theoretical analysis and computational results on large scale strongly convex problems are provided to support the applicability of the methods.

**2 - Preconditioner updating techniques for sequences of KKT systems in quadratic programming**

*Daniela di Serafino*, Dipartimento di Matematica e Fisica, Seconda Università di Napoli, viale A. Lincoln, 5, 81100, Caserta, Italy, daniela.diserafino@unina2.it, *Stefania Bellavia*, *Valentina De Simone*, *Benedetta Morini*

Constraint Preconditioners (CPs) are very effective in the iterative solution of KKT systems arising in large-scale optimization methods. However, their setup may still account for a significant part of the computational cost of the optimization procedure, thus motivating the interest towards cheaper CP approximations. In this talk we discuss some techniques to build approximate CPs for KKT sequences arising in interior point methods for quadratic programming, through low-cost updates of a seed CP preconditioner. Numerical results showing the performance of these techniques are presented.

**3 - Efficiently preconditioned Inexact Newton methods for large symmetric eigenvalue problems**

*Luca Bergamaschi*, Civil Environmental and Archiectural Engineering, University of padua, via Trieste 63, 35200, Padova, Italy, luca.bergamaschi@unipd.it, *Angeles Martinez*

We propose an efficiently preconditioned Newton method for the computation of the leftmost eigenpairs of large and SPD matrices. A sequence of preconditioners based on the BFGS update formula is proposed, for the PCG solution of the Newton system to solve A u = q(u) u, q(u) being the Rayleigh Quotient. We give theoretical evidence that the sequence of preconditioned Jacobians remains close to the identity matrix if the initial preconditioned Jacobian is so. Numerical sequential/parallel results onto very large and realistic problems account for the efficiency of the proposed algorithm.

# ■ TD-04

*Thursday, 14:20 - 15:40*
*Room 109*

## Derivative-free Optimization II

Stream: Invited sessions
*Invited session*
Chair: *Alessandra Papini*, Dipartimento di Ingegneria Industriale, Università degli Studi di Firenze, Viale Morgagni 40/44, 50134, Firenze, Italy, alessandra.papini@unifi.it

**1 - A new implementation of the model- based derivative free trust-region (DFTR) framework**

*Andrew Conn*, IBM TJ Watson Research Center, 10598, New York, United States, arconn@us.ibm.com, *Sébastien Le Digabel*

This talk presents a new implementation of a model- based (as opposed to pattern-search) derivative-free trust-region framework, for problems for which some derivatives are not available. The implementation inherits the model- based features described in the book Conn, Scheinberg and Vicente, Introduction to Derivative Free Optimization, 2009 SIAM. One of its main contributions is in the handling of constraints where, for example, in addition, to other features from direct search methods, we incorporate the progressive barrier of Audet and Dennis in order to treat general constraints.

**2 - A derivative-free approach to constrained global optimization based on exact penalty functions**

*Gianni Di Pillo*, Dept. of Computer Control and Management Engineering, University of Rome, via Ariosto 25, Sapienza Universita' di Roma, 00185, Rome, RM, Italy, dipillo@dis.uniroma1.it, *Stefano Lucidi*, *Francesco Rinaldi*

We propose an exact penalty approach for constrained problems which combines an unconstrained derivative-free global minimization technique for minimizing an exact penalty function for given values of the penalty parameter, and an automatic updating of the penalty parameter that occurs only a finite number of times. The approach is enriched by resorting to derivative-free local searches. Indeed we prove that, under suitable assumptions, for every global minimum point there exists a neighborhood of attraction for the local search. An extensive numerical experience is reported.

**3 - On a class of multilevel derivative-free algorithms**

*Alessandra Papini*, Dipartimento di Ingegneria Industriale, Università degli Studi di Firenze, Viale Morgagni 40/44, 50134, Firenze, Italy, alessandra.papini@unifi.it, *Emanuele Frandi*

We present a multilevel derivative-free scheme to solve discretized optimization problems, and show how it can greatly improve the practical behaviour of generating set search methods (GSS). In particular we see that, using the set of positive and negative coordinate directions as generating set, suitable polling strategies of Jacobi or Gauss-Seidel type can yield effective acceleration steps. The resulting procedure is able to tackle problems well above the size typically handled by classical GSS algorithms. Implementation issues and performance on large-scale test problems are discussed.

# Thursday, 16:20 - 17:20

## ■ TE-01

*Thursday, 16:20 - 17:20*
*Room 101*

### Minimization and variational methods related to nonlinear boundary value problems I

Stream: Invited sessions
*Invited session*
Chair: *Dumitru Motreanu*, Mathematics, University of Perpignan, 66860, Perpignan, France, motreanu@univ-perp.fr

**1 - A priori bounds for elliptic and parabolic equations with nonstandard growth**

*Patrick Winkert*, Technische Universität Berlin, Institut für Mathematik, Germany, winkert@math.tu-berlin.de

This talk is concerned with global a priori bounds for elliptic and parabolic equations with nonlinear conormal derivative boundary conditions which may contain nonlinearities with variable growth exponents. By means of the localization method and De Giorgi's iteration technique we derive global a priori bounds for weak solutions of such problems.

**2 - Existence of constant sign and sign-changing solutions for parameter-depending quasilinear elliptic equations**

*Pasquale Candito*, DICEAM, University of Reggio Calabria, via Graziella, Feo di Vito, 89124, Reggio Calabria, Italy, pasquale.candito@unirc.it

Some recent results on the existence and multiplicity of solutions for quasilinear elliptic problem depending on a parameter are presented. The variational approach adopted, combined with sub-super solutions and truncation techniques, allows to explicitly describe intervals for the parameter for which the problem under consideration admits nontrivial constant-sign as well as nodal (sign-changing) solutions. In our approach a crucial role plays an abstract local minimum result obtained by Bonanno and Candito, see for instance, JDE (2008).

**3 - Existence and multiplicity of solutions for some elliptic problems**

*Roberto Livrea*, DICEAM, University of Reggio Calabria, Italy, roberto.livrea@unirc.it

The aim of the talk is to present some recent results about the existence and the multiplicity of solutions for some classes of elliptic boundary value problems depending on a parameter. Putting together some arguments of nonlinear analysis related to the calculus of variations, as well as to sub-supersolutions methods and comparison principles, it will be investigated the existence of positive intervals of parameters for which the considered differential problems admit at least one or multiple solutions. Some extra information about the sign of the obtained solutions will be pointed out.

## ■ TE-02

*Thursday, 16:20 - 17:20*
*Room 107*

## Nonlinear Optimization II

Stream: Contributed session
*Contributed session*
Chair: *Robert Gower*, School of Mathematics and Maxwell Institute for Mathematical Sciences, Edinburgh University, United Kingdom, gowerrobert@gmail.com

### 1 - Convergence of Constrained Gauss-Newton Methods

*Ekaterina Kostina*, Department of Mathematics and Computer Science, University of Marburg, Hans-Meerwein-Str., 35032, Marburg, Germany, kostina@mathematik.uni-marburg.de

Gauss-Newton methods are variants of Newton methods where the Hessian of Lagrangian is approximated by ignoring second order terms. Gauss-Newton methods show good local convergence in so-called small residual problems. In large residual problems, where the second order information is too significant to be ignored the performance of the Gauss-Newton is poor or even divergent. In this talk we show that the bad performance of Gauss-Newton is an advantage rather than a disadvantage of the method, since it indicates ill-posedness of the problem, insufficient modelling or lack of data.

### 2 - A low cost interior point algorithm with application to Support Vector Machines

*Maria Gonzalez-Lima*, Matematicas, Universidad de los Andes, Carrera 1 No. 18a 10, 1 No. 18a 10 Edificio H, Primer Piso, 111711, Bogota, Bogota, Colombia, mdla.gonzalez@uniandes.edu.co, *Esril Guevara*

An algorithm for solving convex quadratic optimization problems with continuous Knapsack constraints is presented. It is a primal-dual interior-point method where the search direction is obtained by approximating the Hessian of the objective function by a multiple of the identity matrix. So, it is well suited for problems where this Hessian is large and dense, as the Support Vector Machines (SVM). Numerical results will be presented.

### 3 - Third Order Methods using slices of the Tensor and AD developments

*Robert Gower*, School of Mathematics and Maxwell Institute for Mathematical Sciences, Edinburgh University, United Kingdom, gowerrobert@gmail.com, *Jacek Gondzio*

What can be gained by incorporating third-order information in the Newton direction? The third-order derivative is a third order tensor: a cube. Calculating and operating on such an object is a fundamental deterrent as dimension grows. We investigate methods that incorporate a handful of tensor-vector products. Each Tensor-vector product is a sparse matrix, thus no three dimensional object is formed. Furthermore, we present a novel Automatic Differentiation method for calculating such slices of the tensor, at a cost comparable to state-of-the-art methods used for calculating Hessian Matrix.

## ■ TE-03

*Thursday, 16:20 - 17:20*
*Room 108*

## Iterative methods for linear algebra in optimization II

Stream: Invited sessions
*Invited session*
Chair: *Benedetta Morini*, Dipartimento di Energetica S.Stecco, Universita di Firenze, Via Lombroso 6/17, 50134, Firenze, Italy, benedetta.morini@unifi.it

### 1 - On the preconditioning of optimal control problems with state gradient constraints

*Susann Mach*, Chemnitz University of Technology, Germany, susann.mach@mathematik.tu-chemnitz.de

Optimal control problems with constraints on the state present a number of challenges, both in terms of analysis and their numerical solution. In this presentation, we consider optimal control problems with constraints acting pointwise on the gradient of the state variable. We address a suitable discretization of the problem by mixed finite elements.

We shall discuss in detail the saddle-point problems arising during the solution of the penalized problems. Their spectral properties will be analyzed and preconditioners for MINRES will be presented along with numerical experiments.

### 2 - Using spectral information to precondition saddle-point systems

*Annick Sartenaer*, Department of Mathematics, University of Namur, Rempart de la Vierge, 8, 5000, Namur, Belgium, annick.sartenaer@unamur.be, *Daniel Ruiz*, *Charlotte Tannier*

We focus on KKT systems where the (1,1) block is symmetric positive definite and (eventually) very badly conditionned, but with only a few very small eigenvalues. Assuming that a good approximation of these eigenvalues and their eigenvectors is available, we consider different approximations of the block diagonal preconditioner of Murphy, Golub and Wathen and show how it is possible to appropriately recombine the available spectral information through a particular Schur complement approximation that allows to build an efficient block diagonal preconditioner with little extra cost.

### 3 - Preconditioning nonlinear least squares problem in the dual space

*Serge Gratton*, ENSEEIHT, 31071, Toulouse, France, serge.gratton@enseeiht.fr, *Selime Gurol*, *Philippe L. Toint*, *Jean Tshimanga*

The problem considered in this talk is the data assimilation problem arising in weather forecasting and oceanography. New linear algebra techniques will be discussed for the iterative solution of the particular nonlinear least-squares formulation of this inverse problem known under the name of 4DVAR. These techniques exploit the problem's underlying geometrical structure in reformulating standard Krylov into significantly cheaper variants. Adapted preconditioning issues for the considered systems of equations will be discussed which exploit limited-memory techniques in a novel way.

## ■ TE-04

*Thursday, 16:20 - 17:20*
*Room 109*

### Derivative-free Optimization III

Stream: Invited sessions
*Invited session*

Chair: *Stefano Lucidi*, Dipartment of Computer, Control, and Management Science, University of Rome, Via Ariosto 25, 00185, Rome, Italy, lucidi@dis.uniroma1.it

**1 - A class of derivative-free nonmonotone optimization algorithms employing coordinate rotations and gradient approximations**

*Francesco Rinaldi*, Matematica, Università di Padova, Italy, rinaldi@math.unipd.it, *Luigi Grippo*

In this paper we study a class of derivative-free unconstrained minimization algorithms employing nonmonotone inexact linesearch techniques along a set of suitable search directions. In particular, we define globally convergent nonmonotone versions of Hooke-Jeeves method and Rosenbrock method and we propose a new algorithm combining Rosenbrock rotations with approximate simplex gradients. Through extensive numerical experimentation, we show that the proposed algorithm is highly competitive in comparison with some of the most efficient methods, on a large set of difficult test problems.

**2 - Randomized model based derivative free optimization**

*Katya Scheinberg*, Industrial and Systems Engineering, Lehigh University, 200 W Packer ave, 18015, Bethlahem, PA, United States, katyas@lehigh.edu

Traditional analysis of model based derivative free optimization methods relies on the worst case behavior of the algorithmic steps and the models involved. There are conditions that the models and the iterates have to satisfy to guarantee convergence. Such requirements are difficult or costly to satisfy in practice and are often ignored in practical implementations. We will present a probabilistic view point for such algorithms, showing that convergence still holds even if some properties fail with some small enough probability. We will discuss several settings where this approach useful.

**3 - Derivative Free Algorithm for Global Black-Box Optimization in Trading**

*Stefania Renzi*, Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti, Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, renzi@dis.uniroma1.it, *Stefano Lucidi*, *Umberto Dellepiane*

A trading strategy strongly depends on some parameters which usually are chosen by the experts using their experience. In this paper we consider the problem to find the values of these parameters by using an optimization technique. Since the objective function is not defined in closed form but through an algorithm, the problem lies within the framework of black-box optimization. Moreover some of the variables of the problems are integer and they cannot be relaxed (e.g. time period). We tackle this difficult optimization problem by using some recent black box algorithms.

# Thursday, 17:30 - 18:50

# Friday, 9:00 - 10:00

## FA-01

*Friday, 9:00 - 10:00*
*Room 101*

### Mathematical programming algorithms for network equilibrium problems

Stream: Invited sessions
*Invited session*
Chair: *Marco Sciandrone*, Dipartimento di Ingegneria dell'Informazione, Universita' di Firenze, Via di Santa Marta 3, 50139 , Firenze, Italy, Italy, sciandro@dsi.unifi.it

**1 - Two-stage bilevel pricing over a transportation network**

*Patrice Marcotte*, DIRO, Université de Montréal, CP 6128 Succursale Centre Ville, H3C 3J7, Montréal, Québec, Canada, marcotte@iro.umontreal.ca, *Shahrouz Mirzaalizadeh*, *Gilles Savard*

We consider a two-stage stochastic extension of the bilevel pricing model introduced by Labbé et al. (1998). In the first stage, the leader sets tariffs on a subset of arcs of a transportation network, with the aim of maximizing profits while, at the lower level, flows are assigned to cheapest paths of a multicommodity transportation network. In the second stage, the situation repeats itself under the constraint that tariffs should not differ too widely from those set at the first stage. We analyze properties of the model and provide numerical illustrations.

**2 - Decomposition methods for optimization problems of network equilibrium models**

*David Di Lorenzo*, Ingegneria dell'Informazione, University of Florence, via di Santa Marta 3, 50139, Firenze, Italy, dilorenzo@dsi.unifi.it, *Andrea Cassioli*, *Marco Sciandrone*

We consider the symmetric network equilibrium problem, formulated as convex minimization problem whose variables represent the path flows. In order to handle the difficulties related to the large dimension of real networks, we adopt an inexact decomposition approach. We present several decomposition algorithms. Global convergence results are established. Computational experiments show that the algorithms are competitive with state-of-the art solvers on medium-large dimensional problems.

**3 - Msa algorithms for large-scale stochastic user equilibrium with variable demand**

*Giulio Erberto Cantarella*, Dept of Civil Engineering, University of Salerno, via Ponte Don Melillo, 1, 84084, Fisciano (SA), Italy, g.cantarella@unisa.it, *Stefano de Luca*, *Massimo Di Gangi*, *Roberta di Pace*

Stochastic User Equilibrium (SUE) describes path choice behaviour more effectively than User Equilibrium. SUE may be expressed by fixed-point models solved with MSA algorithms suitable for large scale applications. Commonly SUE with variable demand is heuristically solved by iteratively computing equilibrium flows and costs for given demand flows, and demand flows for given equilibrium costs. This paper describes and analyses algorithms where demand computation is embedded within the iterations searching for equilibrium between flows and costs; convergence is guaranteed under mild conditions.

## FA-02

*Friday, 9:00 - 10:00*
*Room 107*

### Mixed Integer Non Linear Programming

Stream: Invited sessions
*Invited session*
Chair: *Sourour Elloumi*, Laboratoire CEDRIC, Conservatoire National des Arts et Métiers, 292 Rue Saint Martin, Paris, France, elloumi@cnam.fr

**1 - Hybrid SDP Bounding Procedure**

*Emiliano Traversi*, Fakultät für Mathematik, Technische Universität Dortmund, Germany, emiliano.traversi@gmail.com, *Fabio Furini*

The principal idea of this paper is to exploit Semidefinite Programming (SDP) relaxation within the framework provided by Mixed Integer Nonlinear Programming (MINLP) solvers when tackling Binary Quadratic Problems (BQP). We included the SDP relaxation in a state-of-the-art MINLP solver as an additional bounding technique and demonstrated that this idea could be computationally useful. The Quadratic Stable Set Problem (QSSP) is adopted as the case study. The tests indicate that the Hybrid SDP Bounding Procedure allows a cut of almost one half of the overall computing time.

**2 - Convex reformulations of mixed-integer quadratically constrained programs**

*Amélie Lambert*, CEDRIC, CNAM, 292 rue saint martin, 75141, paris, France, amelie.lambert@cnam.fr, *Alain Billionnet*, *Sourour Elloumi*

We present a solution approach for the general problem (QP) of minimizing a quadratic function of integer variables subject to a set of quadratic constraints. The resolution is divided into two phases. The ?rst phase is to reformulate the initial problem as an equivalent quadratic problem which continuous relaxation is convex; the second phase is to solve the reformulated problem by a branch and bound algorithm. We further extend these results to the mixed-integer case. Finally, we present some computational experiments on pure-integer and mixed-integer instances of (QP ).

**3 - Optimization of quadratic knapsack problem**

*Van Nguyen*, mathematics, University of Trier, Germany, nguyen@uni-trier.de

We discuss a branch and bound algorithm for solving the quadratic knapsack problem, where we maximize a quadratic profit function with binary variables subject to a capacity constraint. An upperbound is obtained by solving the nonlinear standard quadratic problem, in each iteration we obtain a rounded feasible solution and therefore the lowerbound is the best feasible solution found so far. For branching we fix a suitable index. At last we discuss some numerical results based on our branching rule.

## ■ FA-03

*Friday, 9:00 - 10:00*
*Room 108*

### Infinite-dimensional Duality and Applications to Continuous Optimization

Stream: Invited sessions
*Invited session*
Chair: *Patrizia Daniele*, Department of Mathematics and Computer Science, University of Catania, Viale A. Doria, 6, 95125, Catania, Italy, daniele@dmi.unict.it

**1 - Inverse variational formulation for dynamic oligopolistic market equilibrium problem**
*Annamaria Barbagallo*, Department of Mathematics and Applications "R. Caccioppoli", Universitá di Naples "Federico II", 80126, Napoli, Italy, annamaria.barbagallo@unina.it

A dynamic oligopolistic market equilibrium problem can be studied as an evolutionary variational inequality and this problem is approached as a problem of profit optimization for the firms. But in this talk, with the help of an inverse variational formulation, we present the behavior of control policies for an oligopolistic market equilibrium problem whose aim is to regulate the exportation through the adjustment of taxes on the firms. This can be considered as a policy-maker optimization problem. Moreover, an existence result is given and, at last, a numerical example is provided.

**2 - Infinite-dimensional Duality Theory and Elastic-Plastic Torsion Problem**
*Sofia Giuffre'*, D.I.I.E.S., University of Reggio Calabria, via Graziella, Località Feo di Vito, 89122, Reggio Calabria, Italy, sofia.giuffre@unirc.it, *Antonino Maugeri*

In this talk we present recent results on the theory of elastic-plastic torsion. In particular we prove the existence of the Lagrange Multiplier associated to the problem as a positive Radon measure. Introducing a constraint qualification condition that is a necessary and sufficient condition in order that strong duality holds, we obtain the existence of a Lagrange multiplier as an essentially bounded function. Finally we announce very recent improvements about the existence of the Lagrange multiplier in more general settings. The equivalence with the obstacle problem is also discussed.

**3 - Non-convex strong duality via subdifferential.**
*Daniele Puglisi*, of Mathematics, University of Catania, via A. Doria, 6, 95125, Catania, Italy, dpuglisi@dmi.unict.it

It is shown that the strong duality is equivalent to the non-emptiness of the subdifferential of a sort map involving the constrain functions. It is also noted that this technique is useful to verify the Assumption S. Indeed, it is not required the linearity of a constrain equality function as usually in the literature. Applications are in tandem.

## ■ FA-04

*Friday, 9:00 - 10:00*
*Room 109*

### Copositive and second-order cone optimization

Stream: Invited sessions
*Invited session*
Chair: *Immanuel Bomze*, Dept. of Statistics and OR, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, immanuel.bomze@univie.ac.at

**1 - Copositive Optimization Based Bounds on Standard Quadratic Optimization**
*E. Alper Yildirim*, Industrial Engineering, Koc University, 34450, Sariyer, Istanbul, Turkey, alperyildirim@ku.edu.tr, *Gizem Sağol*

A standard quadratic optimization problem (StQOP) can be formulated as an instance of a linear optimization problem over the cone of completely positive matrices. Using an an inner and outer hierarchy of polyhedral approximations of the cone of completely positive matrices, we study the properties of the lower and upper bounds on the optimal value of an StQOP that arise from these approximations. In particular, we give characterizations of instances for which the bounds are exact at a finite level of the hierarchy and of those instances for which the bounds are exact in the limit.

**2 - Disjunctive Conic Cuts and a Branch and Conic Cut Algorithm for Mixed Integer Second Order Cone Optimization (MISOCO) Problems**
*Tamás Terlaky*, Industrial and Systems Engineering, Lehigh University, H.G. Mohler Lab., 200 W. Packer Avenue, 18015, Bethlehem, Pennsylvania, United States, terlaky@lehigh.edu

We present efficiently computable Disjunctive Conic Cuts (DCCs) for MISOCO problems. We investigate the use of DCCs when solving MISOCO problems in a Branch and Conic Cut (B&CC) Algorithm. Various criteria are tested how to select DCCs along searching the branch and bound tree. We explore different criteria for node selection, as well as various branching rules. A sizable MISOCO test set is collected and generated. The experiments help us to develop good understand of the impact of the DCCs on the size of the search tree and solution time.

**3 - Copositive reformulation of quadratically constrained quadratic programs**
*Luis Zuluaga*, Faculty of Business Administration, University of New Brunswick, Canada, lzuluagag@gmail.com

Recently, Burer (2009) showed that (non-convex) quadratic programs with linear constraints and binary variables can be reformulated as copositive programs. Under suitable conditions, his approach also shows that quadratically constrained quadratic programs can be reformulated as copositive programs. Here, we present a refinement of these conditions; which allow us to characterize in more generality the class of (non-convex) problems that can be reformulated using the cone of copositive polynomials.

# Friday, 10:10 - 11:10

## ■ FB-01

*Friday, 10:10 - 11:10*
*Room 101*

### Plenary III

Stream: Plenary Lectures
*Invited session*
Chair: *Benedetta Morini*, Dipartimento di Energetica S.Stecco, Universita di Firenze, Via Lombroso 6/17, 50134, Firenze, Italy, benedetta.morini@unifi.it

**1 - Inexact search directions and matrix-free methods for large-scale optimization**

*Jacek Gondzio*, School of Mathematics, University of Edinburgh, Edinburgh, United Kingdom, j.gondzio@ed.ac.uk

Many large-scale optimization problems cannot be solved with methods which rely on exact directions obtained by factoring matrices. I will argue that second-order methods (including interior point algorithms) which use inexact directions computed by iterative techniques and run in a matrix-free regime offer an attractive alternative to fashionable first-order methods. I will address a theoretical issue of how much of inexactness is allowed in directions and support the findings with computational experience of solving some very large optimization problems.

# Friday, 11:40 - 13:00

## ■ FC-01

*Friday, 11:40 - 13:00*
*Room 101*

### Equilibrium Problems

Stream: Contributed session
*Contributed session*
Chair: *Veronica Piccialli*, Dipartimento di Ingegneria Civile e Ingegneria Informatica, Università degli Studi di Roma Tor Vergata, via del Politecnico, 00133, Rome, Italy, piccialli@disp.uniroma2.it

**1 - A smoothing method with appropriate parameter control based on Fischer-Burmeister function for second-order cone complementarity problems**

*Shunsuke Hayashi*, Graduate School of Information Sciences, Tohoku University, 6-3-09 Aramaki-Aoba, Aoba-Ku, 980-8579, Sendai, Japan, s_hayashi@plan.civil.tohoku.ac.jp, *Yasushi Narushima*, *Hideho Ogasawara*

We deal with complementarity problems over second-order cones. The complementarity problem is an important class of problems in the real world, and involves many optimization problems. The complementarity problem can be reformulated as a nonsmooth system of equations. Based on the smoothed Fischer-Burmeister function, we construct a smoothing Newton method for solving such a nonsmooth system. The proposed method controls a smoothing parameter appropriately. We show the global and the quadratic convergence properties of our method. Finally, some numerical results are given.

**2 - On Monotone Stochastic Variational Inequalities and their applications to equilibrium problems**

*Fabio Raciti*, Mathematics and Computer Science, University of Catania, Viale Andrea Doria 6, 95125, Catania, Italy, fraciti@dmi.unict.it

We present some recent results on stochastic variational inequalities in Lp spaces and compare our approach to stochastic variational inequalities with another approach used extensively by other authors. Finally we present various applications, such as traffic networks and pollution control problems.

**3 - Optimality Conditions for Mathematical Programs with Equilibrium Constraints**

*Helmut Gfrerer*, Institute for Computational Mathematics, Johannes Kepler University Linz, Altenbergerstr 69, A-4040, Linz, Austria, gfrerer@numa.uni-linz.ac.at

We present a new set of optimality conditions called extended M-stationarity conditions which is an equivalent dual characterization of B-stationarity under very weak assumptions. We will also give second-order optimality conditions, both necessary and sufficient. Since extended M-stationarity is still very difficult to verify in practice, we also introduce another stationarity concept, called strong M-stationarity. This stationarity concept builds a bridge between S- and M-stationarity and seems to be ideally suited for numerical purposes.

**4 - A Canonical Duality Approach for the Solution of Affine Quasi-Variational Inequalities**

*Simone Sagratella*, Ingegneria informatica automatica e gestionale A. Ruberti, La Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, sagratella@dis.uniroma1.it, *Vittorio Latorre*

We apply a sequential dual canonical transformation on the global optimization problem resulting from reformulating the KKT conditions of an affine quasi-variational inequality using Fischer-Burmeister C-functions. The resulting formulation is canonically dual to the original one in the sense that there is no duality gap between critical points of the original problem and those of the dual one. By studing the new dual formulation we obtain properties that are not evident from the original one and that can be useful to develop new methods for the solution of quasi-variational inequalities.

## ■ FC-02

*Friday, 11:40 - 13:00*

*Room 107*

### Mathematical Programming I

Stream: Contributed session
*Contributed session*

Chair: *Francesco Rinaldi*, Matematica, Università di Padova, Italy, rinaldi@math.unipd.it

**1 - On practical study of regularity and optimality of linear SDP problems**

*Tatiana Tchemisova*, Departmento of Mathematics, University of Aveiro, Campus Universitario de Santiago, 3810-193, Aveiro, Portugal, tatiana@ua.pt

We use the approach based on the notions of immobile indices and their immobility orders for study linear semidefinite (SDP) problems. For these problems, we formulate new optimality criterion in terms of a basic matrix of the subspacedefine the subspace of immobile indices. This criterion is explicit and do not use any constraint qualifications. A finite algorithm determining a basis of the subspace of immobile indices is suggested. We show how this algorithm can be used for testing regularity of SDP problems and present the results of numerical tests.

**2 - The simplex method and the diameter of a 0-1 polytope**

*Shinji Mizuno*, Industrial Engineering and Management, Tokyo Institute of Technology, 2-12-1 Oh-Okayama, Meguro-ku, 152-8552, Tokyo, Japan, mizuno.s.ab@m.titech.ac.jp, *Tomonari Kitahara*

We will show two results of the primal simplex method by constructing simple LP instances on 0-1 polytopes. One of the results is that, for any 0-1 polytope and any its two vertices, we can construct an LP instance for which the simplex method finds a path between them, whose length is at most the dimension of the polytope. This proves a well-known result that the diameter of any 0-1 polytope is bounded by its dimension. Next we show that an upper bound for the number of distinct solutions generated by the simplex method is tight.

**3 - On semicontinuity properties in generalized semi-infinite programming under coercivity**

*Tomas Bajbar*, Institute of Operations Research, Karlsruhe Institute of Technology, Kaiserstraße 12, 76131, Karlsruhe, Germany, tomas.bajbar@kit.edu, *Oliver Stein*

We study the existence of global solutions of lower level problems in generalized semi-infinite programming and the semi-continuity properties of the corresponding optimal value function under special coercivity assumptions imposed on data functions.

**4 - On smoothness properties of optimal value functions at the boundary of their domain under complete convexity**

*Nathan Sudermann-Merx*, Institute of Operations Research, Karlsruhe Institute of Technology, 76133, Karlsruhe, Germany, sudermann@kit.edu, *Oliver Stein*

We study continuity and directional differentiability properties of optimal value functions, in particular at boundary points of their domain.

In particular, we present sufficient conditions for the inner semi-continuity of feasible set mappings and, using techniques from nonsmooth analysis, provide functional descriptions of tangent cones to the domain of the optimal value function. The latter makes the stated directional differentiability results accessible for practical applications

## ■ FC-03

*Friday, 11:40 - 13:00*

*Room 108*

### New Results on Classic Methods: ADM, SCF and GN

Stream: Invited sessions
*Invited session*

Chair: *Yin Zhang*, Dept. of CAAM, Rice University, 6100 Main Street, Rice University, 77005, Houston, Texas, United States, yzhang@rice.edu

**1 - Slightly modified ADMM for linearly constrained convex optimization with three separable operators**

*Bingsheng He*, Mathematics, Nanjing University, Nanjing, China, hebma@nju.edu.cn

Alternating direction method of multipliers (ADMM) is an effective approach for solving separable convex optimization problems with linear constraints. Both contractive convergence and convergence rate exist for linearly constrained convex optimization problems with two separable operators. However, direct extension of the ADMM to the problems with more than two operators remains open. In this talk, two slightly modified versions of ADMM for convex optimization with three operators are proposed. The contractive convergence and the convergence rate are proved in a simple unified framework.

**2 - Inexact Alternating Direction Based Contraction Methods for Separable Linearly Constrained Convex Programming**

*Guoyong Gu*, Department of Mathematics, Nanjing University, China, ggu@nju.edu.cn, *Bingsheng He*, *Junfeng Yang*

Alternating direction method (ADM) has been well studied in the context of linearly constrained convex programming problems. In the early applications, the objective function of the convex problem is separable into two parts. Recently, the ADM has been extended to the case where the number of the separable parts is a finite number. However, the subproblems are required to be solved exactly. In this talk, we propose two inexact alternating direction based contraction methods, which substantially broaden the applicable scope of the ADM. The convergence and the complexity are included as well.

**3 - On the Convergence of the SCF Iteration for Kohn-Sham Equation**

*Xin Liu*, State Key Laboratory of Scientific and Engineering Computing, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, 55, Zhong Guan Cun East Road, Haidian District, 100190, Beijing, China, liuxin@lsec.cc.ac.cn, *Xiao Wang*, *Zaiwen Wen*, *Ya-Xiang Yuan*

It is well known that the self-consistent field (SCF) iteration for solving the Kohn-Sham (KS) equation often fails to converge, yet there is no clear explanation. In this work, we investigate the SCF iteration from the perspective of minimizing the corresponding KS total energy functional. By analyzing the second-order Taylor expansion of the KS total energy functional and estimating the relationship between the Hamiltonian and the remaining part of the Hessian, we are able to identify some conditions to ensure global and local linear convergence to the solution of the KS equation.

**4 - Symmetric Low-Rank Product Approximation and Gauss-Newton Method**

*Yin Zhang*, Dept. of CAAM, Rice University, 6100 Main Street, Rice University, 77005, Houston, Texas, United States, yzhang@rice.edu

We consider computing an eigenspace of an n by n symmetric matrix A corresponding to a set of k largest positive eigenvalues. Singular value decomposition is a special case of this problem where A is a Gram matrix. We derive an efficient formula for applying the Gauss-Newton method to this problem, formulated as minimizing the Frobenius norm of A-XX' where X is n by k and XX' is called a symmetric low-rank product (SLRP). Preliminary numerical results are presented to demonstrate the potential of the algorithm in suitable applications.

## ■ FC-04

*Friday, 11:40 - 13:00*

*Room 109*

## Copositive and polynomial optimization

Stream: Invited sessions

*Invited session*

Chair: *Tamás Terlaky*, Industrial and Systems Engineering, Lehigh University, H.G. Mohler Lab., 200 W. Packer Avenue, 18015, Bethlehem, Pennsylvania, United States, terlaky@lehigh.edu

**1 - A Unified Algorithmic Framework for Eigenvalues Problems with a Sparsity Constraint**

*Marc Teboulle*, School of Mathematical Sciences, Tel Aviv University, Ramat-Aviv, 69978, Tel-Aviv, Israel, teboulle@math.tau.ac.il

Given a real symmetric matrix, we consider the problem of finding a largest unit eigenvector with at most k-nonzero components. This is a difficult nonconvex quadratic optimization problem which arises in many fundamental applications (e.g., sparse principal component analysis). We introduce an algorithmic framework to tackle directly this nonconvex quadratic problem. It allows to derive a new scheme given by a simple formula, to unify many seemingly different algorithms, and to a rigorous convergence analysis for a family of cheap schemes with very low computational complexity.

**2 - A simple algorithm for nonconvex and nonsmooth minimization problems**

*Shoham Sabach*, Mathematical Sciences, Tel Aviv University, Ramat Aviv, 69978, Tel Aviv, Israel, ssabach@gmail.com, *Marc Teboulle*

We introduce a new algorithm for a broad class of nonconvex and nonsmooth problems. It relies on an elementary mixture of first order methods and data information. We outline a self contained convergence analysis framework describing the main tools and methodology to prove that the sequence generated by the proposed scheme globally converge to a critical point. A by-product of our framework also shows that our results are new even in the convex setting. The resulting scheme involves elementary iterations and is particularly adequate for solving many problems arising in fundamental applications

**3 - On a set-semidefinite representation of quadratic optimisation problems**

*Peter Dickinson*, Institute for Statistics and Operations Research, University of Vienna, BWZ - Brünner Straße 72, A-1210, Vienna, Vienna, Austria, peter.dickinson@cantab.net, *Gabriele Eichfelder*, *Janez Povh*

In this talk we will look at optimisation problems with a quadratic objective function and constraints involving: linear constraints, binary constraints and set constraints. We shall show that, provided some commonly used assumptions hold, these problems can be reformulated as conic optimisation problems over a cone of set-semidefinite matrices. This generalises the well-known completely positive representation result from Burer [Mathematical Programming, 2009]. This also corrects a previous result from Eichfelder and Povh [Optimization Letters, 2012].

**4 - Duality and attainability in copositive optimization**

*Werner Schachinger*, Dept. of Statistics and OR, University of Vienna, Wien, Austria, werner.schachinger@univie.ac.at, *Immanuel Bomze*, *Gabriele Uchida*

We consider a primal-dual pair of copositive optimization which deals with optimizing a linear function over an affine subset of the copositive/completely positive cone. The presentation introduces two construction principles which transform such a primal-dual pair with an arbitrary (zero, positive or infinite) duality gap into another pair with the same values where either the primal or the dual optimal value is not attained. The construction basically doubles the size of the problems and establishes all possible combinations of gaps and attainability.

# Friday, 14:20 - 15:40

## ■ FD-01

*Friday, 14:20 - 15:40*
*Room 101*

### Minimization and variational methods related to nonlinear boundary value problems II

Stream: Invited sessions
*Invited session*
Chair: *Shapour Heidarkhanii*, Mathematics, Razi University, Kermanshah, Iran, Islamic Republic Of, sh.heidarkhani@yahoo.com

**1 - Multiple solutions for nonlinear elliptic problems**
*Dumitru Motreanu*, Mathematics, University of Perpignan, 66860, Perpignan, France, motreanu@univ-perp.fr

This work focuses on the existence of multiple solutions of nonlinear elliptic equations driven by a non-homogeneous differential operator under Dirichlet or Neumann boundary conditions. The solutions are obtained through suitable minimization and variational techniques. The spectrum of the nonhomogeneous differential operator is also studied.

**2 - EXISTENCE RESULTS FOR A NEUMANN PROBLEM INVOLVING THE p(x)-LAPLACIAN**
*Giuseppina Barletta*, DICEAM, Università degli Studi Mediterranea di Reggio Calabria, Via Graziella, Località Feo di Vito, 89100, Reggio Calabria, Italy, giuseppina.barletta@unirc.it

We present some existence and multiplicity results for a parametric Neumann problem driven by the p(x)-Laplacian. The potential f is a Carathéodory function and the variable exponent p(x) is a continuous function satisfying 1 <p- =min p(x), but not necessarily the stronger one p->N. Under a suitable condition on the behavior of the potential at 0+, we obtain an interval ]0, ?* [, such that, for any ? in ]0, ?* [ our problem admits at least a nontrivial weak solution. We show the existence of at least two non trivial solutions for potentials satisfying the Ambrosetti-Rabinowitz condition.

**3 - A local minimum theorem and relations with the mountain pass theorem**
*Gabriele Bonanno*, University of Messina, Italy, Italy, bonanno@unime.it

The existence of a local minimum for a continuously Gâteaux differentiable function, possibly unbounded from below and without any weak continuity assumption, is established. Moreover, a characterization of the mountain pass geometry is presented and relations between the mountain pass theorem and local minima are then pointed out.

**4 - Multiple solutions for a perturbed p-Laplacian boundary value problem with impulsive effects via variational methods**
*Shapour Heidarkhanii*, Mathematics, Razi University, Kermanshah, Iran, Islamic Republic Of, sh.heidarkhani@yahoo.com

Employing a three critical points theorem due to Bonanno and Marano(Theorem 2.6 of the paper: G. Bonanno, S. A. Marano, On the structure of the critical set of non-differentiable functions with a weak compactness condition, Appl. Anal. 89 (2010) 1-10.), we investigate the existence of at least three distinct solutions for a perturbed p-Laplacian boundary value problem with impulsive effects.

## ■ FD-02

*Friday, 14:20 - 15:40*
*Room 107*

### Applied Optimization III

Stream: Contributed session
*Contributed session*
Chair: *David Di Lorenzo*, Ingegneria dell'Informazione, University of Florence, via di Santa Marta 3, 50139, Firenze, Italy, dilorenzo@dsi.unifi.it

**1 - Elastic image registration with local refinement**
*Alena Vasatova*, Applied Mathematics, VSB-Technical University Ostrava, 17. listopadu 15, 708 33, Ostrava, Czech Republic, alena.vasatova@email.cz, *Ales Ronovsky*

Image registration arises whenever we need to extract information from different images. Here we present elastic registration method focused on medical usage. Because medical images usually contain large area of background, it is often convenient to use coarser grid with local refinement based on image foreground. The resulting problems of linear elasticity are solved by the FETI domain decomposition method. We describe the algorithms, review the basic theoretical results including scalability of applied algorithms, and demonstrate the efficiency of the method by numerical examples.

**2 - Optimization of Mutual Information Function for Causal Analysis**
*Alexander Nikolaev*, Department of Industrial and Systems Engineering, University at Buffalo (SUNY), 409 Bell Hall, 14260-2050, Buffalo, NY, United States, anikolae@buffalo.edu

This talk presents an information theory based, optimization approach to making causal inference from observational data. Matching models and algorithms are discussed that minimize mutual information between the covariates and the treatment variable. The non-linearity of the resulting function is treated by using the identified optimality conditions, leading to tractable MIP formulations and efficient heuristic algorithms. Computational experiments are reported demonstrating the advantages of mutual information based matching for accurate treatment effect estimation.

**3 - Disturbance attenuation via optimization**
*Daniela Selvi*, Dipartimento di Ingegneria dell'Informazione, University of Florence (DINFO), Italy, danielaselvi86@gmail.com, *Giorgio Battistelli*, *Alberto Tesi*, *Pietro Tesi*

Disturbance attenuation is a challenging problem in control system design, especially when the frequency profile of the disturbances is uncertain or complex. We address the problem by minimizing a performance criterion which reflects the effects of the disturbances on the output. Depending on the application and by using a convenient parametrization, both the objective function and the constraints can be either linear or quadratic, thus requiring small computational load. Among the possible examples, the technique can be employed to improve image resolution for ground-based telescopes.

# ■ FD-03

*Friday, 14:20 - 15:40*
*Room 108*

## Global Optimization III

Stream: Contributed session
*Contributed session*
Chair: *Stefano Lucidi*, Dipartment of Computer, Control, and Management Science, University of Rome, Via Ariosto 25, 00185, Rome, Italy, lucidi@dis.uniroma1.it

### 1 - Solution methods for expensive optimization problems

*Christine Edman*, University of Trier, Germany, edman@uni-trier.de

We consider expensive optimization problems, that is to say problems, where each evaluation of the objective function is expensive in terms of computing time, consumption of resources, or cost. This often happens in situations where the objective function is not available in analytic form. Therefore it is of central importance to use as few evaluation points as possible within the optimization process. This necessitates a sophisticated strategy to determine the evaluation points. We discuss response surface methods that are tailored to the problems described above.

### 2 - Using SVM for combining continuous heuristics for Global Optimization Problems

*Umberto Dellepiane*, Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti, Sapienza Università di Roma, via Ariosto, 25, 00185, Roma, Italy, dellepiane@dis.uniroma1.it, *Laura Palagi*

We consider a Support Vector Machine (SVM) based approach to combine different heuristics to solve the standard quadratic optimization problem (StQP). In literature different unconstrained formulations have been proposed in connection with simple multistart global scheme. None of them dominates the others in terms of best value found. We propose to combine the three heuristics using SVM to select both the heuristic and the starting point to be used in the multistart framework. To test our method we use StQP deriving from the Maximum Clique problems in the DIMACS challenge collection.

### 3 - Local search based methods for high dimensional global optimization problems

*Fabio Schoen*, Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Firenze, via di Santa Marta, 3, 50139, Firenze, Italy, fabio.schoen@unifi.it, *Marco Locatelli*

In this paper we will present recent algorithms in which local optimization is exploited in order to build an efficient global optimization method. Recent computational results related to the use of population based algorithms for large scale problems, like,e.g., cluster optimization, are presented.

# ■ FD-04

*Friday, 14:20 - 15:40*
*Room 109*

## Copositive optimization and discrete structures

Stream: Invited sessions
*Invited session*
Chair: *Werner Schachinger*, Dept. of Statistics and OR, University of Vienna, Wien, Austria, werner.schachinger@univie.ac.at

### 1 - Standard nonlinear optimization

*Immanuel Bomze*, Dept. of Statistics and OR, University of Vienna, Bruenner Str. 72, A-1210, Vienna, Austria, immanuel.bomze@univie.ac.at, *Stefan Gollowitzer*, *E. Alper Yildirim*

Several problems over the standard simplex, e.g., to minimize quadratic or fractional quadratic functions, have a copositive reformulation. Using tractable approximations of the copositive cone, one may approach a solution to arbitrary accuracy. However, while the standard quadratic problem admits a PTAS, this is unclear for the fractional quadratic case, and other classes with integrality constraints definitely do not allow for it unless P=NP (APX-hardness). Our analysis of the classical discretization method sheds some light on these phenomena, even for the general Lipschitz-continuous case.

### 2 - A CP representation of 0-1 LPs with Joint Probabilistic Constraints

*Abdel Lisser*, LRI, Universite de Paris Sud, Bat. 650, 91405, Orsay, France, lisser@lri.fr, *Jianqiang Cheng*

In this paper, we study \$0-1\$ linear programs with joint probabilistic constraints. The constraint matrix vector rows are assumed to be independent, and the coefficients to be normally distributed. Our main results show this non-convex problem can be approximated by a convex completely positive problem. Moreover, we show that the optimal values of the latter converges to the optimal values of the original problem. Examples randomly generated highlight the efficiency of our approach.

### 3 - A copositive formulation for the stability number of infinite graphs

*Mirjam Duer*, Mathematics, University of Trier, 54286, Trier, Germany, duer@uni-trier.de

We generalize the copositive approach to infinite graphs and show that the stability number of an infinite graph is the optimal solution of some infinite-dimensional copositive program. For this we develop a duality theory between the primal convex cone of copositive kernels and the dual convex cone of completely positive measures. We determine the extreme rays of the latter cone, and we illustrate this theory with the help of the kissing number problem.

Joint work with C.Dobre and F.Vallentin

# Friday, 16:20 - 17:20

## ■ FE-01

*Friday, 16:20 - 17:20*
*Room 101*

### The abstract equilibrium problem III: theory, methods and application

Stream: Invited sessions
*Invited session*
Chair: *Giancarlo Bigi*, Dipartimento di Informatica, Universita' di Pisa, Largo B.Pontecorvo 3, 56127, Pisa, Italy, giancarlo.bigi@di.unipi.it

**1 - On cyclic and n-cyclic monotonicity of bifunctions**
*Rita Pini*, Dipartimento di Matematica e Applicazioni, Università degli Studi Milano Bicocca, Via Cozzi, 53, 20125, Milano, Italy, rita.pini@unimib.it, *Mohammad Hossein Alizadeh*, *Monica Bianchi*, *Nicolas Hadjisavvas*

In the recent literature, the connection between maximal monotone operators and the Fitzpatrick function was investigated. Subsequently, this relation has been extended to maximal monotone bifunctions and their Fitzpatrick transform. We generalize some of these results to maximal n-cyclically monotone and maximal cyclically monotone bifunctions, by introducing and studying the Fitzpatrick transforms of order n or infinite order for bifunctions.

**2 - Existence results for quasivariational inequalities**
*Massimiliano Giuli*, Università di Aquila, 67100, Coppito, Aquila, Italy, massimiliano.giuli@univaq.it, *Marco Castellani*

A quasivariational inequality corresponds to a variational inequality in which the constraint set is subject to modifi

cations depending on the considered point. We provide sufficient conditions for the existence of solutions assuming the set-valued operator pseudomonotone or quasimonotone. The proof is based on an application of the Kakutani Fixed Point Theorem to a suitable set-valued map which represents the solutions of a perturbed variational inequality. Our results generalize and extend to the infinite dimensional case recent results by Aussel and Cotrina.

**3 - Equilibrium Problems: A Proximal Method with outer approximations**
*Susana Scheimberg*, COPPE/ Engenharia de Sistemas e Computação-Instituto de Matemática,COPPE/PESC-IM, Universidade Federal do Rio de Janeiro, Caixa Postal 68511,, Bloco H/319, 21941-972, Rio de Janeiro, RJ, Brazil, susana@cos.ufrj.br, *Paulo Sergio Marques Santos*

We analyze a proximal point method for pseudomonotone equilibrium problems in Hilbert spaces, using outer approximations of the constraint set improving previous results. We prove weak convergence of the generated sequence to a solution under rather mild assumptions. We illustrate the method by applying to particular cases.

## ■ FE-02

*Friday, 16:20 - 17:20*
*Room 107*

### Large Scale Nonlinear Optimization II

Stream: Invited sessions
*Invited session*
Chair: *Massimo Roma*, Dipartimento di Ingegneria Informatica, Automatica e Gestionale, Universita' di Roma, via Ariosto 25, 00185, ROMA, Italy, roma@dis.uniroma1.it

**1 - Alternating Gradient-Step Methods for Large-Scale Optimization**
*Mehiddin Al-Baali*, Maths & Stats, Sultan Qaboos University, DOMAS PO Box 36, 123, Muscat, Oman, albaali@squ.edu.om

Some modified Barzilai-Borwein gradient methods for large-scale unconstrained optimization will be considered. Variational approaches for certain methods will be derived on the basis of the self-scaling and damped techniques for quasi-Newton updates. Certain measures for the quality of steps will be used to propose alternating gradient-step methods. Numerical experiments will be described.

**2 - On the use of gradient methods in cubic regularization for unconstrained optimization**
*Tommaso Bianconcini*, Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Firenze, Via di Santa Marta 3, 50139, Firenze, Italy, tommaso.bianconcini@unifi.it, *Giampaolo Liuzzi*, *Benedetta Morini*, *Marco Sciandrone*

We consider adaptive cubic regularization algorithms for unconstrained optimization. A key issue of these algorithms concerns the computation of the trial step as a suitable unconstrained minimizer of the cubic model. Such computation is usually performed by procedures involving linear algebra and may require a significant computational cost. In order to reduce the cost required, we focus on the employment of gradient methods for minimizing the cubic model and present a version of ARC algorithm using a nonmonotone gradient method. Numerical results are reported.

**3 - Affine scaling inexact dogleg methods for bound-constrained nonlinear systems**
*Sandra Pieraccini*, Dipartimento di Scienze Matematiche, Politecnico di Torino, corso Duca degli Abruzzi 24, 10129, Torino, Italy, sandra.pieraccini@polito.it, *Stefania Bellavia*, *Maria Macconi*

A class of affine-scaling trust-region methods for large scale bound-constrained systems of non-linear equations is presented. Both spherical and elliptical trust-regions are allowed. An inexact dogleg method tailored to constrained problems is used to obtain an approximate minimizer of the linear model within the trust-region and the feasible set. Strictly feasible iterates are formed and a strictly feasible approximation of the solution is ensured. Rather general scaling matrices are allowed to handle the bounds. Global and locally fast convergence is ensured under standard assumptions.

## ■ FE-03

*Friday, 16:20 - 17:20*
*Room 108*

### NonSmooth optimization II

Stream: Contributed session
*Contributed session*
Chair: *Vinicius Layter Xavier*, Systems Engineering and Computer Sciences Depart., Federal University of Rio de janeiro, CT - Bloco H - sala H319, Ilha do Fundao, 21941-972, Rio de Janeiro, RJ, Brazil, viniciuslx@gmail.com

**1 - Flying Elephants: A General Method for Solving Non-Differentiable Problems**

*Vinicius Layter Xavier*, Systems Engineering and Computer Sciences Depart., Federal University of Rio de janeiro, CT - Bloco H - sala H319, Ilha do Fundao, 21941-972, Rio de Janeiro, RJ, Brazil, viniciuslx@gmail.com, *Adilson Elias Xavier*

Flying Elephants (FE) is a generalization and a new interpretation of the Hyperbolic Smoothing approach. The article introduces the fundamental smoothing procedures. It presents a general review of successful applications of the approach for solving five problems: Distance geometry, covering, clustering, Fermat-Weber and hub location. For each problem it is presented the original non-smooth formulation and the succedaneous completely differentiable one. Computational experiments obtained unprecedented results according to the criteria of consistency, robustness and efficiency.

**2 - Weak Exhausters and Optimality Conditions via Reduced Weak Exhausters**

*Yalcin Kucuk*, Department of Mathematics, Anadolu University, anadolu Universitesi Fen Fakultesi Matematik Bolumu, 26470, Eskisehir, Turkey, ykucuk@anadolu.edu.tr, *Mahide Kucuk*, *Ryszard Urbanski*, *Jerzy Grzybowski*, *İlknur Atasever Güvenç*, *Didem Tozkan*, *Mustafa Soyertem*

The concept of exhausters was introduced by Demyanov and Rubinov(1999) and the concept of weak exhausters was defined by Küçük et. al.(2012). In this work, weak upper and weak lower exhausters of positively homogeneous functions are reduced by using boundary points of weak superdifferential and weak subdifferential, respectively. Moreover, using reduction methods given by Roshchina(2008) weak exhausters are reduced again. In addition, some optimality conditions are obtained via reduced weak exhausters mentioned former.

**3 - Existence and non-existence results of bounded non-constant solutions of the EFK equatio**

*Sunra Mosconi*, Mathematics and Computer Sciences, Università di Catania, 95125, Catania, Italy, mosconi@dmi.unict.it

We deal with the existence of bounded solutions of the ODE u""-pu"+F'(u)=0 which for p geq 0 is the EFK-equation. F in C1 is supposed to be coercive. We prove that there are bounded non-constant solutions if and only if F' changes sign at least twice. Moreover the solutions of u""-pu"+F'(u)=0 for p<0 blow up as p uparrow 0 if F' changes sign only once. These results solve a conjecture by Lazer and McKenna on the blow up of travelling waves in suspended bridges as the velocity goes to zero. The techniques used are maximum principles, Morse Theory and Mountain Pass theorem

## ■ FE-04

*Friday, 16:20 - 17:20*
*Room 109*

### Bilevel Optimization, Equilibrium and Variational Analysis

Stream: Contributed session
*Contributed session*
Chair: *Eleftherios Couzoudis*, Economics, University of Zurich, Chair for Quantitative Business Administration, Moussonstrasse 15, 8044, Zurich, Switzerland, eleftherios.couzoudis@business.uzh.ch

**1 - Solving polynomial bilevel problems**

*Philipp Renner*, Economics, University of Zurich, Moussonstrasse 15, 8044, Zuerich, Switzerland, philipp.renner@business.uzh.ch

Bilevel optimization problems are of interest in many applications. In economics the principal agent problem is amongst those models. In it, except in rare cases, the utility of the lower level problem is non convex. Thus the standard techniques from bilevel optimization do not apply. We present a way to solve those problems in case of a polynomial lower level. We use the techniques developed by Lasserre and Parrilo to relax the lower level into a convex optimization problem. We then solve it by non linear programming methods.

**2 - Finding all generalized Nash equilibria**

*Eleftherios Couzoudis*, Economics, University of Zurich, Chair for Quantitative Business Administration, Moussonstrasse 15, 8044, Zurich, Switzerland, eleftherios.couzoudis@business.uzh.ch

Often a generalized generalized Nash equilibrium problem has infinitely many solutions and commonly the solution set isn't connected. The current method is then to only compute the normalized equilibrium in which the Lagrange multipliers are equal. This is only one solution out of the set of normalized equilibria which is a subset of the solution set. For problems with linear constraints an approach is shown where all solutions are given as a union of sets. For this a modified simplex algorithm is used to yield a vertex representation of the equilibrium subsets.

**3 - Elliptic equations with nonstandard growth**

*Giuseppina D'Aguì*, Department of Civil, Information Technology, Enviromental, Construction, Engineering, and Applied Mathematics, University of Messina, C/da di Dio, S. Agata, 98166, Messina, Italy, dagui@unime.it

We present some results on the existence of an unbounded sequence of weak solutions for a class of differential equations with $p(x)-$Laplacian and subject to small perturbations of nonhomogeneous Neumann conditions. The approach is based on variational methods.

# Friday, 17:30 - 18:50

## ■ FF-01

*Friday, 17:30 - 18:50*
*Room 101*

### Closing Session

Stream: Contributed session
*Contributed session*

Chair: *Laura Palagi*, Dipartimento di Ingegneria informatica automatica e gestionale, La Sapienza Università di Roma, Via Ariosto, 25, 00185, Roma, Italy, palagi@dis.uniroma1.it
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