Wednesday, 8:15 - 9:00

■ WA-01

Wednesday, 8:15 - 9:00 - C V

Opening

Stream: Plenaries
Invited session
Chair: *Tibor Illés*
Chair: *Tamás Terlaky*
Chair: *Giancarlo Bigi*

Wednesday, 9:00 - 10:00

■ WB-01

Wednesday, 9:00 - 10:00 - C V

Plenary I

Stream: Plenaries
Invited session
Chair: *Marianna E.-Nagy*

1 - Proximal splitting algorithms in nonlinear spaces
Russell Luke

Motivated by the problem of computing Fréchet means of points in spaces of phylogenetic trees, we examine proximal splitting algorithms in general uniformly convex spaces, possibly with positive curvature. Several key notions from linear space theory no longer apply in this setting and force a reconfiguration of regularity concepts that explicitly accounts for the regularity of the space in which the algorithms run. We present a few convergence results for proximal splitting algorithms that benefit from the analysis of these algorithms when applied to nonconvex problems in linear spaces.

Wednesday, 10:15 - 11:30

■ WC-01

Wednesday, 10:15 - 11:30 - C V

NNO 1 - Applications of nonsmooth optimization

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Alireza Kabgani*

1 - A New Hybrid Algorithm for Multi-Objective Optimal Spatial Sampling Design
Elaheh Lotfian, *Mohsen Mohammadzadeh*

This talk presents a hybrid algorithm for multi-objective optimal spatial sampling design that combines archived multi-objective simulated annealing and nondominated sorting genetic algorithms. The algorithm is applied to a nonsmooth bi-objective soil sampling problem that minimizes the mean ordinary kriging variance, and the distance travelled between sample points. Results show that the algorithm outperforms the two standalone algorithms. The algorithm also solves a nonconvex nonsmooth optimization problem to optimize rain gauge station locations in Iran's Khuzestan province.

2 - Comparing Real-World Efficiency of Primal and Dual Methods for Convex Hull Pricing
Sofiane Tanji, *Yassine Kamri*, *Mehdi Madani*, *François Glineur*

Convex hull pricing (Gribik et al. 2007), used on US electricity markets, is a pricing rule that relies on the Lagrangian dual of a mixed-integer program (MIP) with dualized power balance constraints. Non-smooth convex optimization methods can be used to solve this dual directly. Other methods rely instead on a convexified MIP solved by decomposition (e.g. Dantzig-Wolfe). We test the efficiency of both types of methods on real-world data, and test in particular the proximal level method and the subgradient method with different step size rules: both compare favorably to existing methods.

3 - Parameter-free nonsmooth unadjusted Langevin algorithm
Susan Ghaderi, *Alireza Kabgani*, *Masoud Ahookhosh*, *Yves Moreau*

This talk focuses on Bayesian inference, sampling from a composite potential function $u(x)=f(x)+g(x)$, where the log-likelihood function $f(x)$ is a smooth Hölder gradient, while the log-prior distribution $g(x)$ is nonsmooth. Using the generalized Moreau envelope, we obtain a smooth Hölder gradient composite function. We present two algorithms, the unadjusted Langevin (ULA) Markov chain Monte Carlo (MCMC) method and a parameter-free ULA, which doesn't require Hölder parameters. Numerical experiments confirm the effectiveness of our approaches.

■ WC-02

Wednesday, 10:15 - 11:30 - C VI

DFO 1 - Derivative-free methods for stochastic optimization

Stream: Derivative-free optimization
Invited session
Chair: *Vyacheslav Kungurtsev*

1 - A derivative-free method for stochastic structured optimization problems
Andrea Cristofari, *Francesco Rinaldi*

We consider the derivative-free minimization of a function over the convex hull of atoms. Assuming that the objective function is not computable and only probabilistic estimates are available, we propose a stochastic derivative-free approach where, at every iteration, we solve a reduced problem over a subset of atoms by means of a line search scheme. Then we update the subset of atoms and iterate. Global convergence is established under standard assumptions on the accuracy and the variance of the estimates. Finally, numerical results are provided, showing the efficiency of the proposed method.

2 - A weak tail-bound probabilistic condition for function estimation in stochastic derivative-free optimization
Damiano Zeffiro, *Francesco Rinaldi*, *Luis Nunes Vicente*

In this talk, a new tail bound probabilistic condition for function estimation in stochastic derivative-free optimization is presented, leading to a reduction in the number of samples per iteration and easing algorithmic analyses. Simple stochastic direct-search and trust-region methods will be described, for the optimization of potentially non-smooth objectives whose values can only be estimated via stochastic observations. Finally, convergence and sample complexity results will be presented under the tail bound condition.

3 - Stochastic optimization in random subspaces: trust-region framework and subspace selection strategies
Kwassi Joseph Dzahini, *Stefan M. Wild*

This work introduces STARS, a trust-region method for stochastic derivative-free optimization (DFO), which achieves scalability using random models in low-dimensional affine subspaces. STARS reduces per-iteration costs in terms of function evaluations, thus yielding strong performance on large-scale DFO problems. The dimension of these subspaces can be chosen via Johnson-Lindenstrauss transforms. The quality of the subspaces and the accuracies of estimates and models hold with sufficiently high, but fixed, probabilities. Convergence and complexity results are obtained using martingale theory.

■ WC-03

Wednesday, 10:15 - 11:30 - 104

CVPIE 1 - Complementarity problems, variational inequalities and related topics

Stream: Complementarity problems, variational inequalities and equilibria
Invited session
Chair: *Samr Kumar Neogy*

1 - A second order system with asymptotically vanishing and Hessian-driven damping terms attached to a monotone inclusion
David Alexander Hulett

In a real Hilbert space, we study the asymptotic properties of the trajectories generated by a second order dynamical system. The system features an asymptotically vanishing damping with a Hessian-driven damping term. The system is governed by a monotone and continuous operator defined on the Hilbert space: as the time variable approaches infinity, convergence rates to zero are derived for the operator evaluated at the trajectories, as well as for the gap function associated to a variational inequality which is equivalent to our monotone inclusion problem.

2 - On some open problems in linear complementarity and its importance in pivotal algorithms
Samr Kumar Neogy

Special matrix classes play an important role in studying the theory and algorithms of the linear complementarity problem. We discuss few open problems related to the matrix classes based on principal pivot transforms. Several pivotal algorithms have been designed for the solution of the linear complementarity problem. Many of these methods are matrix class dependent. We discuss the results obtained on these open problems and its impact on pivotal algorithms. The results discussed will be useful for the researchers on complementarity problem, pivotal algorithms and game theory.

3 - The monotone extended second order cone and complementarity problem
Yingchao Gao, *Orizon P Ferreira*, *Sándor Zoltán Németh*, *Roman Sznajder*, *Guohan Zhang*

This talk illustrates a new generalisation of the Lorentz cone, called the monotone extended second-order cone (MESOC). Some properties will be studied. Moreover, we will show that the MESOC can be used to solve the mixed complementarity problem and prove that the problem of projecting onto the MESOC can be reduced to two isotonic regressions in neighbouring dimensions. We will also study the linear complementarity problems on the monotone extended second-order cones and develop an application of monotone extended second-order cone to portfolio optimisation problems.

■ WC-04

Wednesday, 10:15 - 11:30 - 105

GO 1 - Global optimization challenges

Stream: Global optimization
Invited session
Chair: *Janos D. Pinter*

1 - An Efficient Method for Finding the Global Minimum of Large-Scale Multimodal Optimization Problems
Anatolii Kosolap

We propose to use only multimodal problems with unknown solutions to test the effectiveness of methods. Then the best methods will find the best solutions. We use exact quadratic regularization to transform the multimodal problems to maximize the norm of a vector on a convex set. This allows us to effectively solve large-scale multimodal problems. We have carried out numerous numerical experiments and obtained the best solutions for many problems from well-known libraries PrincetonLib and MinlpLib. This confirms the effectiveness of our method for solving large-scale multimodal problems.

2 - Scalable Global Optimization Challenges
Janos D. Pinter

We present several scalable global optimization problem-classes (with unknown optima) which become increasingly hard to solve numerically, as model instance sizes grow. These problem-classes can be implemented in various optimization model development environments (such as AMPL) or in integrated scientific-technical computing systems (such as Mathematica). Among other modeling advantages and features, these development platforms directly support the usage of various nonlinear solver options. The discussion is illustrated by model instances, their numerical solution, and visualization.

3 - The combined Global-local method for Box Constraint Optimization
Ramzi Jafar, *Tobias Seidel*, *Karl-Heinz Kuefer*

In this talk, we introduce a new method to solve box constraint optimization problems globally, which we call the combined Global-local method, that combines the guarantees of a global method and the efficiency of local methods to compute the global optimum. The method starts with computing a solution using a local method, then constructing an inclusion around the solution such that the solution is unique in it, and then excluding it from the search space. Afterwards, the global part will discard all boxes with no better solution until the whole search space is explored.

■ WC-05

Wednesday, 10:15 - 11:30 - 106

OM 1 - Convex and combinatorial optimization on manifolds

Stream: Optimization on manifolds
Invited session
Chair: *Csaba Farkas*

1 - Exploring combinatorial problems with Riemannian manifold structures
Lianghai Xiao, Yitian Qian, Shaohua Pan

In this study, we focus on a class of combinatorial problems that exhibit Riemannian manifold structures. We demonstrate how these problems can be naturally formulated as nonsmooth optimization problems on Riemannian manifolds. The structure of the Riemannian manifold is then exploited to accelerate the process of finding solutions. We develop an exact penalty method for solving these problems, and the convergence of our algorithm is also proven. Numerical experiments demonstrate the superiority of our methods in terms of the quality of the solutions obtained.

2 - Saturation of a nonlocal eigenvalue problem on Riemannian manifolds
Sándor Kajántó, Alexandru Kristaly

We study the Riemannian extensibility of saturation phenomena treated first in the Euclidean framework by Brandolini et al. (Adv. Math., 2011): the first eigenvalue of the perturbation of the Laplace-Beltrami operator by the integral of the unknown function increases with the weight affecting the integral up to a finite critical value. We provide a sufficient condition for the saturation (incompatibility of a system of nonlinear equations involving special functions). Both analytical computations and numerical tests suggest that the required incompatibility always persists.

3 - Fenchel Conjugate via Busemann Function on Hadamard Manifolds
Glaydston Bento, João Xavier da Cruz Neto, Italo Melo

In this talk introduces a Fenchel-type conjugate defined as the supremum of convex functions via Busemann functions. Our study covers the absence of approximations by non-constant affine functions. Besides, it is possible to evidence the influence of the sectional curvature in obtaining the main results. In particular, we have illustrated that the difference between a proper, lsc, convex function and its biconjugate is a constant that depends on the sectional curvature of the manifold, showing that in general a Fenchel-Moreau type theorem is directly influenced by the sectional curvature.

■ WC-06

Wednesday, 10:15 - 11:30 - 107

SCADO 1 - Semidefinite and conic approaches for discrete geometry

Stream: Semidefinite and conic approaches to discrete optimization
Invited session
Chair: *David de Laat*

1 - A semidefinite program for least distortion embeddings of flat tori into Hilbert spaces
Marc-Christian Zimmermann

In this talk we use an infinite-dimensional SDP to compute the least distortion embeddings of flat tori Rn / L, where L is an n-dimensional lattice, into Hilbert spaces. This happens in analogy to the case of embeddings of finite metric spaces. We will illustrate some consequences that we obtain by analyzing the SDP and its dual: We prove a constant factor improvement over the previously best lower bound, show that there always exists a finite dimensional embedding, and determine least distortion embeddings of all 2-dim. flat tori; joint work with A. Heimendahl, M. Luecke, F. Vallentin

2 - On the density of planar sets avoiding unit distances
Gergely Ambrus

We set off to estimate the maximal density of a measurable planar set containing no two points at unit distance. To determine this quantity was asked in the early 1960's by Leo Moser in connection with the famous Hadwiger-Nelson problem. Erdős and Moser conjectured that the density must be less than 1/4. Applying Fourier analytic, combinatorial and linear optimization methods, we prove this conjecture by showing that the density in question cannot exceed 0.247.

3 - Three-point bounds for sphere packing
David de Laat

A fundamental problem in discrete geometry asks for the densest packing in Euclidean space by congruent spheres. The Cohn-Elkies linear programming bound gives upper bounds on the optimal density and has been used to show the E_8 and Leech lattice configurations are optimal in dimensions 8 and 24. In other dimensions (except 1, 2) the linear programming bound is not expected to be sharp and only small improvements are known. I will discuss new three-point bounds for sphere packing which give larger improvements, and which seem to be sharp for some cases of the lattice sphere packing problem.

Wednesday, 12:00 - 13:15

■ WD-01

Wednesday, 12:00 - 13:15 - C V

NNO 2 - Structured nonconvex optimization

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Puya Latafat*

1 - Adaptive nonsmooth trust-region methods via forward-backward envelope
Mohammad Hamed, Alexander Bodard, Masoud Ahookhosh, Panagiotis Patrinos

This study introduces an adaptive nonsmooth Trust-Region (TR) method for minimizing the sum of two functions. One of these functions is smooth but potentially nonconvex while the other is nonsmooth and hypo-convex. We leverage the Forward-Backward Envelope (FBE) as an exact, real-valued, and continuous merit function for the original problem. Our research includes a thorough convergence analysis that covers global convergence as well as local and global convergence rates. The numerical results are promising compared to existing state-of-the-art techniques.

2 - Convergence of Douglas-Rachford Splitting and Primal-Dual Hybrid Gradient in the Absense of Monotonicity
Brecht Evens, Pieter Pas, Puya Latafat, Panagiotis Patrinos

Despite their popularity, convergence results of splitting methods have been largely limited to the convex/monotone setting. In this talk, we study two such methods in the absence of monotonicity and without requiring smoothness, namely Douglas-Rachford splitting (DRS) and the primal-dual hybrid gradient (PDHG) method. In particular, we introduce the concept of semimonotonicity and provide sufficient conditions for global convergence of DRS and PDHG involving the sum of two semimonotone operators. Illustrative examples demonstrate the wide range of problems our theory is able to cover.

3 - High-order proximal-point and Moreau envelope beyond convexity
Alireza Kabgani, Masoud Ahookhosh

The main aim of this talk is to introduce a generalization of Moreau envelope (GME) and proximity operator (GPO) for a class of functions generalizing both hypoconvexity and Paraconvexity which includes convex functions, functions with Hlder continuous gradients, and beyond. In addition to introducing some basic properties of them, we demonstrate that under some conditions, the GPO is single-valued and Hlder continuous. We argue that the GME is differentiable and has Hlder continuous gradient. Then, we introduce a proximal-point algorithm and discuss its convergence rate and complexity.

■ WD-02

Wednesday, 12:00 - 13:15 - C VI

GT 1 - Game Theory and Applications

Stream: Game theory
Invited session
Chair: *André Casajus*

1 - Computing the Common Prior
Miklós Pintér, Marianna E.-Nagy

Morris (1994) and later Feinberg (2000) showed that a finite type space (information structure) attains a common prior if and only if there is no agreeable bet in it.

We also consider finite type spaces and observe that deciding about the existence of a common prior is equivalent with considering the intersection of affine spaces each is spanned by the types of a player. This observation implies that we can apply the Fredholm alternative (Fredholm, 1903), and conclude that the computational complexity of computing a common prior or an agreeable bet is strongly polynomial.

2 - Continuous Generalized Games
Imre Balog, Miklós Pintér

In our presentation, we deal with finite stochastic games and we examine the existence of equilibrium for finite stochastic games. Our goal is to use a new concept - continuous generalized game - in order to provide a different proof of the existence for equilibrium of finite generalized discounted stochastic games. In our proof, we show that all mentioned stochastic games are continuous generalized game and then we show that they have an equilibrium.

3 - Least cores and energy communities
Giancarlo Bigi

Prosumers are energy consumers who can also produce it. They can create communities to share energy through an aggregator and authorities often provide incentives. A model of an energy community is presented as a coalitional TU-game. Properties of its core and quasi cores are studied, providing characterizations as well as estimates for the least core. The latters may facilitate the computation of fair shares of the overall benefits through row generation for LPs with exponentially many constraints.

(joint project with D.Fioriti, A.Frangioni, M.Passacantando, D.Poli)

■ WD-04

Wednesday, 12:00 - 13:15 - 105

GO 2 - Global optimization at work

Stream: Global optimization
Invited session
Chair: *Eligius M.T. Hendrix*

1 - Decomposition Methods for nonconvex MINLP and ML
Ivo Nowak, Eligius M.T. Hendrix, Ouyang Wu

We present new decomposition methods for globally solving complex optimization and machine learning problems based on a generate-refine-and-solve (GRS) approach using inner and outer approximations. The methods are implemented in the open-source frameworks Decogo and Decolearn. Numerical results for nonconvex MINLPs and machine learning problems are presented.

2 - Efficient use of optimality conditions in interval Branch and Bound methods
Boglárka G.-Tóth

Interval Branch and Bound methods can use optimality conditions to eliminate non-optimal boxes. However, this is generally not used due to time consumption and in many cases the tested box cannot be removed. The idea in this research is to investigate the use of the optimality conditions from a geometrical point of view and to minimize the computational effort when the optimality conditions cannot be used to discard a given box. In this way, there is no need to predict when to apply the test on optimality conditions and so it may become more efficient.

3 - On monotonicity in simplicial branch and bound
Eligius M.T. Hendrix, Boglárka G.-Tóth, Leocadio G. Casado, Frédéric Messine

Simplicial branch and bound could use bounds on derivatives to detect monotonicity. This process is easier in box oriented branch and bound, as the orientation of partial derivatives coincides with the coordinate axes. We have been investigating various ways to provide directions over a simplicial partition set to prove that the objective funcion is monotonic in that direction. We will report on our latest theoretical and computational findings. This contribution has been supported by the Spanish fund PID2021-123278OB-I00

■ WD-05

Wednesday, 12:00 - 13:15 - 106

OM 2 - Convexity on manifolds and metric spaces

Stream: Optimization on manifolds
Invited session
Chair: *Sándor Zoltán Németh*

1 - Basic convex analysis in metric spaces with bounded curvature
Adriana Nicolae

Differentiable structure ensures that many of the basics of classical convex analysis extend naturally from Euclidean space to Riemannian manifolds. Without such structure, however, extensions are more challenging. Nonetheless, in Alexandrov spaces with curvature bounded above (but possibly positive), we present several basic building blocks with the main focus on the notion of subdifferential.

2 - Convexity of non-homogeneous quadratic functions on the hyperbolic space
Sándor Zoltán Németh, Orizon P Ferreira, Jinzhen Zhu

In this talk some concepts related to the intrinsic convexity of non-homogeneous quadratic functions on the hyperbolic space are discussed. Unlike in the Euclidean space, the study of intrinsic convexity of non-homogeneous quadratic functions in the hyperbolic space is more elaborate than that of homogeneous quadratic functions. Several characterizations that allow the construction of many examples will be presented.

3 - Convexity of Sets and Quadratic Functions on the Hyperbolic Space
Jinzhen Zhu, Sándor Zoltán Németh, Orizon P Ferreira

This talk, is about some concepts of convex analysis on hyperbolic spaces. We first discuss properties of the intrinsic distance, for instance, we present the spectral decomposition of its Hessian. Next, we speak about the concept of convex sets and the intrinsic projection onto these sets. We also discuss the concept of convex functions and present first- and second-order characterizations of these functions, as well as some optimization concepts related to them. An extensive study of the hyperbolically convex quadratic functions is also considered.

■ WD-06

Wednesday, 12:00 - 13:15 - 107

SCADO 2 - Utilizing SDP & SOCP for integer single- and bilevel programs

Stream: Semidefinite and conic approaches to discrete optimization
Invited session
Chair: *Melanie Siebenhofer*

1 - A semidefinite programming approach for the elementary shortest path problem
Regina Schmidt, Mirjam Duer

The Elementary Shortest Path Problem (ESPP) is the problem of finding an elementary minimum-cost path in a directed graph between two nodes in such a way that each node on the path is visited exactly once. If the arc costs are non-negative, then the problem can be solved efficiently with a polynomial time algorithm like Dijkstra's algorithm. If negative arc costs are allowed, then the problem is NP-hard. We study an exact integer programming formulation for the ESPP and several semidefinite relaxations. We present a solution approach based on these relaxations.

2 - Finding the Right Balance: Trade-Offs in Minimum Cut Edge Expansion with SDPs
Melanie Siebenhofer, Akshay Gupte, Angelika Wiegele

The edge expansion is an NP-hard to compute graph constant and gives us information about the connectivity of a graph. It is the minimum ratio of the number of edges joining two sets and the size of the smaller set over all possible non-trivial bipartitions of the vertices. Applications can be found in clustering or network design. Some heuristics exist to find a bipartition, like the well-known spectral clustering.

We propose different strategies for efficient computation. One is to divide the problem into easier-to-handle subproblems, and another is to apply Dinkelbach's algorithm.

■ WD-07

Wednesday, 12:00 - 13:15 - 108

QCO 1 - Quantum computing and optimization I

Stream: Quantum computing optimization
Invited session
Chair: *Brandon Augustino*

1 - Classical and quantum algorithms for logconcave sampling
Simon Apers

Logconcave sampling is the sampling analog of convex optimization, with the benchmark example being sampling from a high-dimensional Gaussian distribution. We compare classical and quantum algorithms for logconcave sampling. We describe a recent quantum walk speedup, how it can be equalled by more advanced classical algorithms, and what are the remaining opportunities for quantum algorithms in this context.

2 - Quantum gradient computation with Gaussian noise
András Gilyén

Jordan's quantum gradient computation algorithm can estimate the gradient of a smooth or convex function with a single function evaluation, when the function can be efficiently evaluated to high precision. This leads to some quantum speedups for convex optimization, and the algorithm can be used to improve pure and purified quantum state tomography, where the latter requires a variant which produces essentially unbiased estimates. In this talk I present an even further improvement that gives estimates with essentially standard Gaussian noise.

3 - Polyhedral Structure of Penalty Constants in Quadratic Unconstrained Binary Optimization and Applications to Quantum Computing
Rodolfo Alexander Quintero Ospina

In recent years, QUBO problems gained significance for modeling and solving combinatorial optimization problems (COPT). Quantum algorithms like QAOA, VQE, and quantum annealing can solve QUBO models. We present a polyhedral characterization of penalty constants used in reformulating linear and quadratic programs as QUBO. Our approach recovers previous techniques and establishes a bijective correspondence between optimal solutions of QUBO and the original problem. We also address QUBOs for inequality-constrained COPT without binary slack variables. Computational experiments support our ideas.

Wednesday, 14:30 - 15:45

■ WE-01

Wednesday, 14:30 - 15:45 - C V

OML 1 - Optimization in regression models

Stream: Optimization for machine learning
Invited session
Chair: *Paula Amaral*

1 - Binary Kernel Logistic Regression: sparsity and a SMO-type decomposition algorithm
Antonio Consolo, Andrea Manno, Edoardo Amaldi

In binary classification, Kernel Logistic Regression (KLR) machines provide probabilistic predictions but they are generally not sparse. Hastie and Zhu presented the Import Vector Machine (IVM) heuristic to train sparse KLR models. We propose a new exact sparsity-inducing binary KLR formulation, and we devise an asymptotically convergent SMO-type decomposition algorithm to efficiently train such models. Promising re- sults are obtained on 15 well-known datasets from the literature in com- parative experiments with IVMs and Support Vector Machines.

2 - Design of Poisoning Attacks on Linear Regression Using Bilevel Optimization
Zeynep Suvak, Miguel F. Anjos, Luce Brotcorne, Diego Cattaruzza

A poisoning attack is commonly studied in the field of adversarial machine learning. The adversary generating poison attacks knows the training process of a machine learning algorithm and impacts the algorithm by injecting manipulative data while the algorithm is trained. We propose a bilevel optimization model for the adversarial process between an attacker generating poisoning attacks and a learner that tries to learn the best predictive linear regression model. The proposed strategy is superior to a benchmark algorithm from the literature on two realistic public datasets.

3 - Xpress SLP + Xpress MIP = Xpress Global
Imre Polik

In this talk we will present how we combined the existing mixed-integer linear optimization solver and sequential linear optimization-based local nonlinear solver to create a global optimization solver. In the second part of the talk we will present the individual components of the new global solver and discuss their contribution to the overall performance.

■ WE-02

Wednesday, 14:30 - 15:45 - C VI

MO 1 - Bilevel and robust multiobjective optimization

Stream: Multiobjective optimization
Invited session
Chair: *Gabriele Eichfelder*
Chair: *Christian Günther*

1 - A global solution method for optimistic semivectorial bilevel problems
Daniel Hoff, Gabriele Eichfelder

In semivectorial bilevel optimization one considers an optimization problem, the upper-level problem, which contains a solution set of a multiobjective optimization problem, the lower-level problem, as a constraint. We replace the weakly efficient set of the lower-level problem by using its optimal value function and, based on that, present a global solver for optimistic semivectorial bilevel problems. The proposed branch-and-bound method refines suitable partitions until the approximations of the value function, and thus the lower and upper bound on the minimal value, are sufficiently close.

2 - An Algorithm for Bilevel Multiobjective Optimization
Gianluca Priori

We study multiobjective bilevel optimization problems for which the inner level performs the minimization of the sum of smooth and nonsmooth functions. The outer level aims at minimizing m smooth functions over the optimal solutions set of the inner problem. We extend a first order method which is based on an existing fixed-point algorithm for single-objective bilevel problems. The method is based on the use of a nonexpansive mapping and a contraction. Convergence to efficient points is proven.

3 - An epigraphical reformulation for uncertain multiobjective optimization
Gabriele Eichfelder, Ernest Quintana

When choosing a robust approach for uncertain multiobjective problems one ends up with a set-valued optimization problem. However, it is generally very difficult to solve these optimization problems even for specific cases. We present a parametric multiobjective optimization problem for which the optimal solutions are strongly related to the robust solutions of the uncertain multiobjective problem. By this approach we can approximate the robust solution set with desired accuracy. Thereby, we extend the well-known epigraphical reformulation from uncertain single-objective optimization.

■ WE-03

Wednesday, 14:30 - 15:45 - 104

OVIUM 1 - Bundle methods and portfolio optimization

Stream: Optimization, variational inequalities and uncertainty models
Invited session
Chair: *Elena-Andreea Florea*

1 - Projective bundle methods, application to the progressive hedging algorithm
Claudia Sagastizábal

Splitting methods exploit separable structures by introducing copies of variables that yield parallel subproblems. The copies are ensured to coincide asymptotically by means of an augmented Lagrangian.

The corresponding dual problem has a nonsmooth separable objective and a subspace as feasible set. In this setting, easy constraints (like a subspace) could be added directly to the quadratic program defining the iterates. Albeit simple, such technique does not preserve decomposable structures. To address this issue, we introduce a new approach that is applicable to weakly convex problems.

2 - Recent challenges in portfolio optimization
Marcel Marohn, Christiane Tammer

Portfolio optimization problems arise in many practical situations. The origin of modern portfolio theory can be seen in the mean-variance-portfolio model by Harry M. Markowitz. Since then, many extensions like, e.g., models replacing the variance by monetary risk measures in the sense of Artzner et al. have been studied. In this talk, we give some insights in several modern portfolio vector optimization problems being motivated by recent practical trends and challenges. The talk is based on the joint work with Christiane Tammer.

3 - Optimality conditions and duality analysis for a class of conic semi-infinite optimization problem having vanishing constraints
Tamanna Yadav

This work focuses on a non-smooth conic semi-infinite optimization model having vanishing constraints. Firstly, a necessary optimality condition for the optimization model is developed using the limiting constraint qualification. Then, the concept of generalized convexity over cones is introduced and sufficient optimality conditions are developed. Further, Wolfe's and Mond-Weir type dual models are formulated for the semi-infinite optimization problem, and weak, strong, and converse duality results are established under generalized convexity/pseudoconvexity/ quasiconvexity assumptions.

■ WE-04

Wednesday, 14:30 - 15:45 - 105

CONTR 1 - About feasibility

Stream: Contributed talks
Invited session

1 - A new elastic filter for analyzing infeasibility in linear systems
Filiz Bilen

One way an infeasible linear optimization problem can be analyzed to find the cause(s) of infeasibility is by isolating irreducible infeasible subsets (IISs) from the constraint set. In this study we build a special elastic model corresponding to an infeasible problem and solve it using MBU simplex algorithm we developed for solving the linear feasibility problem. The solution of the elasticized problem is then utilized to pinpoint a possible cause of the infeasibility. The method is tested on a set of sample problems.

2 - A universal concept for solving different types of feasibility problems
József Dombi, Petra Renáta Rigó

We present a universal approach that can be used to find feasibility regions given by a combination of linear and nonlinear inequalities. We will define and use the sigmoid-type (distending) function in order to determine feasibility regions. The combinations of the inequalities can be expressed by using continuous-valued logical expressions. Another result here is that we present algorithms to find feasible points of linear, nonlinear, convex and non-convex feasibility problems

3 - Using local optimization to early separate feasible solutions with a global branch-and-reduce-and-expand approach
Raphaël Chenouard, Laurent Granvilliers

Branch-and-reduce algorithms aim at finding all the solutions of constraint satisfaction problems. They combine branching and reduction steps using e.g. interval methods. In this framework, we introduce expansion steps that calculate approximate solutions with a local optimization solver and find enclosing regions of the exact solutions in their neighborhoods. It may result in a better separation of the solutions early in the solving process, hence accelerating the convergence of the algorithm. We expect that such a local/global approach can benefit continuous global optimization.

■ WE-05

Wednesday, 14:30 - 15:45 - 106

NNO 3 - Large-scale optimization

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Emanuel Laude*

1 - Convex relaxations for large-scale manifold-valued nonconvex problems with graphical structure
Robin Kenis

In our work, we derive a moment relaxation for large-scale, nonsmooth and nonconvex optimization problems with graphical structure, and manifold constraints. We exploit the partially separable structure of the optimization problem and leverage optimal transport to decouple the problem. This results in an infinite-dimensional optimization problem formulated over a product space of measures. By leveraging Kantorovich-Rubinstein duality we derive a tractable approximation which allows us to tackle possibly nonpolynomial optimization problems with manifold constraints and geodesic coupling terms.

2 - Pac-Bayesian Learning of Optimization Algorithms
Michael Sucker

We apply the PAC-Bayes theory to the setting of learning-to-optimize. To the best of our knowledge, we present the first framework to learn optimization algorithms with provable generalization guarantees (PAC-bounds) and explicit trade-off between a high probability of convergence and a high convergence speed. Even in the limit case, where convergence is guaranteed, our learned optimization algorithms provably outperform related algorithms based on a (deterministic) worst-case analysis. Our results rely on PAC-Bayes bounds for general, unbounded loss-functions based on exponential families.

3 - ResQPASS: solving huge-scale bounded-variable least squares problems
Bas Symoens, Wim Vanroose

We present the Residual QPAS Subspace method (ResQPASS) that solves huge-scale least-squares problems with bound constraints. The problem is solved through a series of subproblems, that are projections on a basis of residuals. Each subproblem is solved by a warm-started QPAS. ResQPASS coincides with conjugate gradient (CG) if no constraint is active, implying it is a generalization of Krylov methods. We developed a convergence theory that links convergence with active constraints with Krylov subspaces. We also show numerical improvements and an application to nonnegative matrix factorization.

■ WE-06

Wednesday, 14:30 - 15:45 - 107

WCA 1- Worst-case analysis of iterative methods for non-convex problems via semidefinite programming

Stream: Worst-case analysis of iterative methods via semidefinite programming and Lyapunov stability
Invited session
Chair: *Moslem Zamani*

1 - Conditions for linear convergence of the gradient method for non-convex optimization
Hadi Abbaszadehpeivasti, Etienne De Klerk, Moslem Zamani

In this talk, I present a new linear convergence rate for the gradient method with fixed step lengths for non-convex smooth optimization problems satisfying the Polyak-Łojasiewicz (PŁ) inequality. I show that the PŁ inequality is a necessary and sufficient condition for linear convergence to the optimal value for this class of problems. I list some related classes of functions for which the gradient method may enjoy linear convergence rate. Moreover, I investigate their relationship with the PŁ inequality.

2 - Performance estimation of block coordinate descent algorithms
Yassine Kamri, Julien Hendrickx, François Glineur

We analyze the worst-case behavior of block coordinate descent algorithms applied to unconstrained minimization of convex functions with coordinate-wise Lipschitz gradients. For this purpose, we extend the recently proposed Performance Estimation Problem (PEP) methodology to block coordinate-wise algorithms. We report improved worst-case convergence guarantees for cyclic coordinate descent and alternating minimization. We also compare random and cyclic versions of accelerated coordinate descent, and show that the latter does not appear to enjoy an accelerated rate.

3 - Tight Convergence Rates of the Gradient Method on Smooth Nonconvex, Convex and Hypoconvex Functions
Teodor Rotaru, François Glineur, Panagiotis Patrinos

We perform the first tight convergence analysis of the gradient method on the entire range of converging step sizes when applied to smooth hypoconvex (weakly convex) functions, a class which smoothly interpolates between smooth nonconvex and smooth convex functions. Traditionally, convergence rates are derived by relating each iterate with the previous one. Surprisingly, to obtain tight rates it is necessary to link an iterate with the two previous ones, which explains why previously conjectured tight rates for full domain of step-sizes, even for smooth convex functions, were hard to prove.

■ WE-07

Wednesday, 14:30 - 15:45 - 108

IPA 1 - Linear optimization and complementarity problems

Stream: Interior-point algorithms
Invited session
Chair: *Zsolt Darvay*

1 - Interior point methods are not (much) worse than Simplex

Laszlo Vegh

We develop a new interior point method for solving linear programs. The algorithm is universal in the sense that it matches the number of iterations of any interior point method that uses a self-concordant barrier function up to a factor O(n1.5 log n) for an n-variable linear program in standard form. We also show that the algorithm admits a combinatorial upper bound, terminating with an exact solution in O(2n n1.5 log n) iterations. This is joint work with Xavier Allamigeon (INRIA/Ecole Polytechnique), Daniel Dadush (CWI Amsterdam), Georg Loho (U Twente), and Bento Natura (Georgia Tech).

2 - The class of sufficient matrices

Marianna E.-Nagy

The linear complementarity problem (LCP) is an NP-complete problem. The focus of our investigation is one of the several matrix classes defined according to LCP, the sufficient matrix class. Because both in the field of pivot algorithms and in the field of interior point methods, there are effective algorithms for solving LCPs with such a coefficient matrix. During the presentation, we will explore the properties of this matrix class, and examine a parameter that characterizes the sufficient matrices, the so-called handicap. Partially joint work with Péter Paulovics.

3 - A new long-step interior-point framework for solving sufficient linear complementarity problems

Anita Varga, Marianna E.-Nagy

Our research aims to combine two well-known techniques from the literature on interior point algorithms (IPAs). The first is by Ai and Zhang, a long-step IPA with the best known complexity of short-step IPAs. The second is the algebraically equivalent transformation (AET) technique by Darvay. In our case, the transformation function applied in the AET technique is part of the input for the framework. We give sufficient conditions for the transformation function and show that when these are met, the general IPA converges with the best known complexity. We also present our numerical results.

Wednesday, 16:15 - 17:55

■ WF-01

Wednesday, 16:15 - 17:55 - C V

FOM 1 - Nonconvex optimization and applications

Stream: First-order optimization methods
Invited session
Chair: *Radu Ioan Bot*
Chair: *Yura Malitsky*

1 - CCCP is Frank-Wolfe in disguise
Alp Yurtsever, Suvrit Sra

In this talk, we uncover a simple but rather surprising connection: We show that the well-known convex-concave procedure (CCCP) and its generalization to constrained problems are both special cases of the Frank-Wolfe (FW) method. This connection not only provides insight of deep pedagogical value, but also transfers the convergence theory of nonconvex FW methods immediately to CCCP, closing a long-standing gap in its non-asymptotic convergence theory. We hope the viewpoint uncovered in this talk spurs the transfer of other advances made for FW to both CCCP and its generalizations.

2 - Stochastic subgradient method for nonconvex minimization
Tam Le, Jerome Bolte, Edouard Pauwels

We study a stochastic subgradient method on a nonsmooth nonconvex function, used for instance in the training of deep learning models. In this talk, our main focus will be to identify the key elements necessary to establish the convergence of this method in such a setting. We base our analysis on geometric assumptions that are easy to check and met in practical situations, a recent notion of gradient for nonsmooth functions called conservative gradients and an ODE method.

3 - The Cyclic Relaxed Douglas Rachford Algorithm for Phase Retrieval: theory and practice.
Thi Lan Dinh, Russell Luke

We present the Cyclic Relaxed Douglas Rachford Algorithm and apply this to the problem of reconstructing electronic orbitals from angle-resolved photon emission spectroscopy experiments. This is an instance of phase retrieval, which we model as a nonconvex, inconsistent feasibility problem. We present our theoretical analysis and numerical results for this algorithm compared to the current state of the art.

■ WF-02

Wednesday, 16:15 - 17:55 - C VI

MO 2 - Numerical algorithms for multiobjective optimization

Stream: Multiobjective optimization
Invited session
Chair: *Gabriele Eichfelder*
Chair: *Moritz Link*

1 - Multi-Objective Trust-Region Filter Method for Nonlinear Constraints using Inexact Gradients
Manuel Berkemeier, Sebastian Peitz

We present an optimization algorithm for non-linearly constrained multi-objective optimization problems. The algorithm combines a surrogate-assisted trust-region approach with the Filter method known from single-objective optimization. Instead of the true objective and constraint functions, so-called "fully linear" models are employed, and we show how to deal with the gradient inexactness in the composite step setting. The framework allows for both derivative-based and derivative-free models. Besides the convergence analysis, we also show numerical examples and discuss possible extensions.

2 - Direct Multisearch Inexact Restoration Filter for Biobjective Optimization
Everton Silva, Ana Luisa Custodio

We propose the integration of an inexact restoration filter approach in Direct Multisearch, to address biobjective optimization problems with general constraints. Like in any filter approach, infeasibility is addressed as an additional objective that needs to be minimized. The inexact restoration approach attempts to recover feasibility when the poll center is infeasible. We will detail the proposed algorithm, provide theoretical results on convergence of linked sequences, and report numerical experiments that state the good performance of this approach to address general constraints.

3 - Improved Front Steepest Descent for Multi-Objective Optimization
Pierluigi Mansueto, Matteo Lapucci

In this work, we deal with the Front Steepest Descent algorithm for multi-objective optimization. We point out that the algorithm from the literature is often incapable, by design, of spanning large portions of the Pareto front. We thus introduce some modifications within the algorithm aimed to overcome this significant limitation. We prove that the asymptotic convergence properties of the algorithm are preserved and numerically show that the proposed method significantly outperforms the original one.

4 - New algorithms for generating Pareto-optimal points of multi-objective optimization problems
Tibor Illés

In the talk, we present a new algorithm for generating Pareto-optimal points of multi-objective optimisation problems. One of the cornerstones of the algorithm is the way in which the joint decreasing directions of the objective functions are determined. In our case, we use a linear programming auxiliary problem to determine (one of) the joint decreasing directions. The LP auxiliary problem can be solved efficiently in polynomial time. Variants of our new algorithm were also developed for different classes of multi-objective optimisation problems.

■ WF-03

Wednesday, 16:15 - 17:55 - 104

OVIUM 2 - Stochastic approximation for PDE-based models

Stream: Optimization, variational inequalities and uncertainty models
Invited session
Chair: *Miguel Sama*

1 - A Stochastic Optimization Framework for the Stochastic Elasticity Imaging Inverse Problem of Locating Cancerous Tumors
Akhtar Khan

In this talk, we will present a stochastic optimization framework for the stochastic elasticity imaging inverse problem of locating cancerous tumors.

2 - About the finite dimensional noise assumption
Hans-Joerg Starkloff

Please insert the title here.

3 - Stochastic optimization in a Black-Scholes market under insider information
Carlos Escudero

We will briefly expose the problem of portfolio optimization in a Black-Scholes market in which an insider trader is present. The insider is supposed to possess privileged information that is not available to the other traders. The mathematical formulation of this problem presents new difficulties with respect to the usual stochastic optimization of portfolios. Two will be concisely described: how to mathematically express the preferences of the insider, and what stochastic calculi should be chosen to formulate the problem consistently, both from the mathematical and financial viewpoints.

4 - Robust Shape Optimization Framework for an Inverse Problem
Marc Dambrine

We study the inverse problem of reconstructing an obstacle in an elastic medium from boundary measurements. We assume that the data are noisy and that a statistical model for the data is available. We propose and study a reconstruction algorithm based on a weighted combination of the first two moments of the Kohn-Vogelius criterion. By numerical results in dimension two, we show that our approach is effective.

■ WF-04

Wednesday, 16:15 - 17:55 - 105

OML 2 - Optimization in classification and learning

Stream: Optimization for machine learning
Invited session
Chair: *Paula Amaral*

1 - A classification method based on a cloud of spheres
Tiago Dias, Paula Amaral

In this presentation we propose to generate a set of connected spheres to define a separation surface between two or more classes of points. We present a MINLP formulation for this problem and a heuristic approach. We compare the result of the heuristic with the optimal solution of the MINLP formulation, obtained with the solver BARON. We also compare this approach with known classification methods on a set of real instances from state-of-the-art datasets.

2 - Approximating Decision Trees with Neural Networks
Giorgio Grani

In a world where Deep Learning applications are growing day by day, the interpretability of Deep Neural Networks is a relevant issue. In this talk, we present the Interpretable Neural Tree (INT), a Deep Neural Network approximating Decision Trees. INTs can be optimized with gradient-based algorithms and they take advantage of the most common libraries for Deep Neural Networks. We will derive a non-linear formulation for the learning problem behind INTs training. We will show how this formulation generalizes to standard Tree models, and how its solutions are interpretable.

3 - Solving large-scale non-convex optimization problems with Objective Function-Free and Block Decomposition Controlled Minibatch Algorithms
Corrado Coppola, Laura Palagi, Giampaolo Liuzzi

We consider minimizing the sum of a large number of smooth and possibly non-convex functions, which is the typical problem encountered in training deep neural networks on huge datasets. We define two classes of mini-batch algorithms, which require to compute the objective function only when light safeguard rules are not satisfied. We prove convergence under mild assumptions. We further embed this scheme in a block decomposition framework. We perform tests on different architectures, which are showing early promising results in terms of efficiency, with respect to state-of-the-art optimizers.

4 - Spherical SVM-type method for interval valued data
Rui Malha, Paula Amaral

In this presentation we propose a Spherical SVM-type method for symbolic data namely interval valued data. SVM is a popular method for classification and some generalizations use non linear separation structures. On the other hand symbolic data is raising interest in our days, specially in the context of Big Data. The definition of a SVM-type method with spherical separation for structural data posses many challenges. We propose a quadratic formulation and a linear relaxation for this problem. We perform a comparison of these formulations with classical approaches for a set of data.

■ WF-05

Wednesday, 16:15 - 17:55 - 106

AFNO - Algorithms for nonconvex optimization

Stream: Algorithms for nonconvex optimization
Invited session
Chair: *Ignacio Felipe Lara*

1 - A Forward-Backward Algorithm With Different Inertial Terms for Structured Non-Convex Minimization Problems
Szilard Laszlo

We investigate an inertial forward-backward algorithm in connection with the minimization of the sum of a non-smooth and possibly non-convex and a non-convex differentiable function. The inertial parameters in our algorithm can differ and can take negative values too. We also treat the case when the non-smooth function is convex and we show that in this case a better step size can be allowed. Further, we show that our numerical schemes can successfully be used in DC-programming.

2 - Relaxed-inertial proximal point algorithms for problems involving strongly quasiconvex functions
Sorin-Mihai Grad

We propose a relaxed-inertial proximal point type algorithm for solving optimization problems consisting in minimizing strongly quasiconvex functions whose variables lie in finitely dimensional linear subspaces. We also discuss possible modifications of the hypotheses in order to deal with quasiconvex functions. Numerical experiments confirm the theoretical results, in particular, that the relaxed-inertial algorithms outperform their pure proximal point counterparts. This talk is based on joint work with Felipe Lara and Raúl Tintaya Marcavillaca (Universidad de Tarapacá).

3 - Proximal point type algorithms for nonconvex pseudomonotone equilibrium problems
Ignacio Felipe Lara

In this talk, we present an small overview on 4 recent works regarding proximal point type algorithms for nonconvex pseudomonotone equilibrium problems. We present the usual proximal method, the relaxed-inertial method, the two-step extragradient method and the extragradient projected method, all of them for pseudomonotone equilibrium problems which are neither convex nor differentiable on the second argument of the bifunction. Finally, we present applications for classes of mixed variational inequalities based on fractional programming problems.

4 - Stackelberg Games for Adversarial Learning: A Model and Solution Method
David Benfield

Adversarial machine learning concerns the situation where data miners face attacks from active adversaries. In particular, the underlying distribution of the data used by the data miner to train machine learning models is vulnerable to significant changes made by the adversary. For example, spam email senders might alter how they write their emails to evade a filter. We model these interactions using Stackelberg Games to develop a pessimistic bilevel model that captures the nature of adversarial scenarios. Finally, we present a solution method to such a bilevel problem.

■ WF-06

Wednesday, 16:15 - 17:55 - 107

PGMIP - P-graphs and mixed-integer programming

Stream: P-graphs and mixed-integer programming
Invited session
Chair: *András Éles*

1 - Alternative Problem Formulations for P-graph-based Optimal Patient Appointment Planning
Ákos Orosz, Janos Baungartner, Zoltán Süle

The goal of patient scheduling optimization is to reduce patient waiting times, reduce downtime between treatments, and thus utilize healthcare resources more efficiently. The proposed method uses the standard elements of the Fast Healthcare Interoperability Resource standard to determine the input elements of the patient scheduling problem, and then automatically transforms the task into a process optimization problem and solves it by the P-graph methodology. The paper presents alternative problem formulations and their comparison in terms of complexity and computational time.

2 - P-graph based generation and solution of MILP models of industrial scheduling problems
Marton Frits, Botond Bertok

In 1992, Friedler and Fan introduced Process-Network Synthesis as a combinatorial approach for industrial process design, and the P-graph as an axiomatic framework for its solution, which includes many powerful tools from graph representation to optimization algorithms. In addition to structural properties, nodes and arcs of P-graphs can contain a number of attributes for the activities and material flows represented. Such attributes can describe time constraints, such as the estimated duration of activities and time intervals when resources are available. Recent developments include model tra

3 - P-graph Model for Optimal Consumption of Household-size Power Plant Generated Energy
Zsolt Ercsey, Zoltán Kovács, Tamás Storcz

Energy is fundamental for the economy. In reaction to climate change arguments, a transition from fossil toward renewable supplies is happening. The goal of this study is to contribute to the efficient utilization of available energy sources by identifying consumers of private households with operation that can or cannot be interrupted. The p-graph model of the consumers as operating units together with potential breaks is developed, while the various energy resources are considered as raw materials. The proposed framework flexibly exploits the available energy from renewable supplies.

4 - Synergies of P-graphs and MILP in process design
András Éles, István Heckl, Botond Bertok

The P-graph framework was originally developed for Process Network Synthesis, resulting in a complete set of structural alternatives. Applications of P-graphs expect process synthesis not only to determine the best process structures, but also to fine-tune their continuous parameters. As a consequence, P-graph algorithms were extended with continuous optimization modules. On the other hand, P-graph based logical implications and graph compression techniques can help MILP solvers to reduce the number and complexity of the subproblems under investigation.

■ WF-07

Wednesday, 16:15 - 17:55 - 108

OSOCG - Optimal and stochastic optimal control and games

Stream: Optimal and stochastic optimal control and games
Invited session
Chair: *Gerhard-Wilhelm Weber*

1 - Mathematical encouragement of companies to cooperate by using cooperative games with fuzzy approach
Jacek Dominik Śledziński, İsmail Özcan, Sırma Zeynep Alparslan Gök, Gerhard-Wilhelm Weber

The phenomenon of strategic cooperation between previously competing companies will be analyzed. The analysis will concern the actual situation of establishing a strategic alliance between companies. The analysis will consist in evaluating the effects of cooperation for each of the companies, depending on whether and in what composition the companies decide to cooperate. A mathematical model of a cooperative game with fuzzy characteristic functions will be used for the analysis.

2 - Optimal management of defined contribution pension funds under the effect of inflation, mortality and uncertainty
Gerhard-Wilhelm Weber, Ioannis Baltas, Athanasios Yannacopoulos

We study the problem of optimal management of defined contribution pension funds, during the distribution phase, under the effect of inflation, mortality and model uncertainty. More precisely, we consider a class of employees, who, at the time of retirement, enter a life assurance con- tract with the same insurance firm. The fund manager of the firm collects the entry fees to a portfolio savings account and this wealth is to be invested optimally in a Black-Scholes type financial market. We extend our framework, provide closed-form solutions and elucidate effects of inflation and robustness.

3 - Robust Risk Management Operator
Kerem Ugurlu

A new operator for handling the joint risk of different sources has been presented and its various properties are investigated. The problem of risk evaluation of multivariate risk sources has been studied, and a multivariate risk measure, so-called multivariate average-value-at-risk, mAVaRα, is proposed to quantify the total risk. It is shown that the proposed operator satisfies the four axioms of a coherent risk measure while reducing to one variable average-value-at-risk, AVaRα, in case N = 1.

4 - Statement of Mutual Interaction between Finance and Human Factors by VariousTypes of Indicators
Betül Kalaycı, Gerhard-Wilhelm Weber

In our study, we aim to represent the mutual effects between some financial process and investors' sentiment with Multivariate Adaptive Regression Splines (MARS) model. Furhermore, we consider to extend this model by using distinct data mining techniques and compare the gain in accuracy and computational time with its strong alternatives applied in the analyses of the financial data. The goal of this study is to compare the forecasting performance of sentiment index by using two-stage MARS-NN, MARS-RF, RF-MARS, RF-NN, NN-MARS, and NN-RF hybrid models.

Thursday, 9:00 - 10:15

■ TA-01

Thursday, 9:00 - 10:15 - C V

QCO 2 - Quantum computing and optimization II

Stream: Quantum computing optimization
Invited session
Chair: *Brandon Augustino*

1 - A (simple) classical algorithm for estimating Betti numbers
Dániel Szabó, Simon Apers, Sander Gribling

We look at the problem of estimating the k-th normalized Betti number of a simplicial complex. While the runtime of naïve classical algorithms is exponential in k, there is a quantum algorithm that runs in polynomial time if some parameters are not too small. This suggests that there can be an exponential quantum advantage for this problem. As a classical benchmark, we describe an algorithm using the path integral Monte Carlo method. It further pins down the region where we can expect an exponential quantum advantage: its runtime is polynomial for a more restricted set of parameters.

2 - Operator Splitting for Copositive Programming via Quantum Annealers
Karthik Prakhya, Alp Yurtsever, Tolga Birdal

In this talk, we present a new hybrid classical-quantum optimization framework for solving a general class of copositive programs (CP). The proposed framework leverages the power of operator splitting methods in convex optimization by solving the classically-intractable projection steps with a quantum-based Frank-Wolfe algorithm. Given that many non-convex and combinatorial NP-hard problems of practical interest can be cast as convex CPs, the proposed framework paves the way toward a disciplined and systematic approach to constructing and solving NP-hard problems with quantum computing.

3 - Parameterized Quantum Circuits from an Asymptotic Point of View
Gereon Koßmann

Many quantum algorithms use parameterizations of the state space to solve, optimization problems or the like. In this talk we will look at the possibilities and limitations of this approach from a mathematical point of view and use the simple quantum approximate optimization algorithm as an example. Many of the well-known phenomena like vanishing gradient or flat landscapes can be well explained by this. Especially interesting is the point of view that the Lie algebra resulting from the generators of the parameterization has a decisive influence.

■ TA-02

Thursday, 9:00 - 10:15 - C VI

MO 3 - Recent advances in multiobjective optimization

Stream: Multiobjective optimization
Invited session
Chair: *Gabriele Eichfelder*
Chair: *Manuel Berkemeier*

1 - Approximate Multiobjective Optimal Control via Model Predictive Control
Lisa Krügel, Gabriele Eichfelder, Lars Grüne

In optimal control, we aim to find a control law that optimizes an optimality criterion. Extending the optimization to multiple criteria is a natural idea in many applications. This leads to formulating multiobjective optimal control problems for which we introduce a multiobjective model predictive control scheme. We discuss system theoretic properties, performance results for the objective functions, and optimality results in the multiobjective case. Application examples and numerical simulations will illustrate our findings.

2 - Computing the recession cone of a convex upper image via convex projection
Firdevs Ulus, Gabriela Kovacova

We consider unbounded convex vector optimization problems (CVOPs) and propose a solution methodology to compute or approximate the recession cone of the upper image. In particular, we relate the dual of the recession cone with the Lagrange dual of weighted sum scalarization problems whenever the dual problem can be written explicitly. Computing this set requires solving a convex (or polyhedral) projection problem. We show that this methodology can be applied to semidefinite, quadratic, and linear vector optimization problems.

3 - Generalized Polarity and Weakest Constraint Qualifications in Multi-objective Optimization
Maximilian Volk, Oliver Stein

In single-objective optimization, the Guignard Constraint Qualification (GCQ) is the weakest constraint qualification guaranteeing that a local minimum is a KKT point. In multi-objective optimization however, the GCQ does not guarantee positive objective function multipliers even at strict Pareto optima. In a similar way to the recent work by Haeser and Ramos on local weak Pareto optima, in this talk, a family of multi-objective regular normal cones is introduced and investigated to derive the weakest CQs yielding strictly positive multipliers at local proper and strict Pareto optima.

■ TA-03

Thursday, 9:00 - 10:15 - 104

CVPIE 2 - Algorithms for Nash equilibrium problems

Stream: Complementarity problems, variational inequalities and equilibria
Invited session
Chair: *Axel Dreves*

1 - **A branch-and-prune algorithm for discrete Nash equilibrium problems**
Stefan Schwarze, Oliver Stein

We present a branch-and-prune procedure for discrete Nash equilibrium problems with a convex description of each player's strategy set. The derived pruning criterion does not require player convexity, but only strict convexity of some player's objective function in a single variable. If satisfied, it prunes choices for this variable by stating activity of certain constraints. This results in a synchronous branching and pruning method. An algorithmic implementation and numerical tests are performed on randomly generated instances with convex polyhedral strategy sets and convex quadratic as well

2 - **Hierarchical jointly-convex Nash equilibrium problems with nonsmooth payoffs**
Valerio Giuseppe Sasso

We consider a Generalized Nash Equilibrium Problem whose joint feasible region is implicitly defined as the solution set of another Nash game. This structure arises e.g.in multi-portfolio selection whenever agents interact at different hierarchical levels. We consider nonsmooth terms in all players' objectives, to promote, for example, sparsity in the solution. We show that the equilibrium problems we deal with have a nonempty solution set. To compute variational equilibria, we devise a first-order projection Tikhonov-like method, proving convergence and providing complexity bounds.

3 - **Linear and Superlinear Convergence of a Potential Reduction Algorithm for Generalized Nash Equilibrium Problems**
Axel Dreves

The potential reduction algorithm has become a robust method for solving generalized Nash equilibrium problems (GNEPs). Here, we prove Q-linear convergence of the merit function and R-linear convergence of the distance of the iterates to the set of KKT-points of the GNEP for an exact version of the algorithm. Furthermore, we show finite termination of the method for prescribed accuracy. We present a new linesearch strategy with non-fixed parameter to obtain a superlinear convergence rate. Further, we give additional assumptions to transfer the convergence rates to an inexact version.

■ TA-04

Thursday, 9:00 - 10:15 - 105

CONTR 2 - Routing and queuing

Stream: Contributed talks
Invited session

1 - **A Road Network Resilience Optimization Approach to Improve Healthcare Accessibility**
Britt van Veggel

Access to healthcare is a requirement for human well-being. The UN Sustainable Development Goal 3.8 is achieving universal health coverage, including access to quality essential healthcare services. In many developing countries, access to healthcare can be disrupted by floods, as they can cause roads to become inaccessible for a long period of time. Upgrading flood-prone roads could reduce the risk that inaccessible roads pose for healthcare accessibility. In this research, we develop an optimization framework that reduces the impact of floods on healthcare accessibility on large-scale areas,

2 - **Metropolitan-scale railway conflict management optimization with a quantum annealing hybrid solver**
Mátyás Koniorczyk, Krzysztof Krawiec, Ludmila Botelho, Krzysztof Domino

Railway conflict management is a computationally hard problem of significant practical importance. It is amongst the first transportation problems on which quantum annealers were experimented with. Earlier we had described a proof-of-concept demonstration: we had built a quadratic binary unconstrained model and solved it on quantum hardware. In the present contribution we solve a significantly more complex practical dispatching problem on an actual metropolitan-scale railway network in Poland using hybrid quantum annealing solvers, demonstrating the applicability of quantum devices.

3 - **Optimal Design of Queueing Systems using Queueing Systems Assistance (QSA)**
Chesoong Kim, Janos Sztrik

The main aim of our talk is to show how optimization problems in queueing theory can be treated in our software called QSA. It is available at https://qsa.inf.unideb.hu. Decision variables may include, for example, the arrival rates, the service rates, number of servers. Typical benefits and costs include rewards to the customers from being served, waiting costs incurred by the customers while waiting for service, and costs to the facilities for providing the service. The linear objective function is calculated and illustrated. The decision is made with respect to only one variable.

■ TA-05

Thursday, 9:00 - 10:15 - 106

NNO 4 - Non-Euclidean optimization

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Puya Latafat*

1 - Anisotropic Proximal Gradient
Emanuel Laude, Panagiotis Patrinos

In this talk we study a novel algorithm for nonconvex composite minimization which can be interpreted in terms of dual space nonlinear preconditioning for the classical proximal gradient method. The proposed scheme can be applied to additive composite minimization problems whose smooth part exhibits an anisotropic descent inequality relative to a reference function. In the convex case this is a dual characterization of relative strong convexity in the Bregman sense. We provide a detailed analysis of the algorithm and present examples in the context of machine learning.

2 - Non-Euclidean gradient methods: Convergence, complexity, and applications
Masoud Ahookhosh, Susan Ghaderi, Yves Moreau

Non-Euclidean variants of the gradient methods are developed and analyzed for minimizing relatively smooth nonconvex functions using Bregman distances, where both constant and dynamic step-size strategies are considered. We first analyze the convergence of non- Euclidean gradient methods in constant and dynamic regimes. Then, we investigate the convergence rate and complexity of these methods under extra relative strong convexity. The linear convergence will be studied under an error-bound condition. Finally, we report some promising numerical experiments for several applications.

3 - On the Symmetry Coefficient of Bregman Functions
Max Nilsson

We analyze the symmetry coefficient of Bregman functions, a measure that assess the symmetry of the corresponding Bregman divergence. This measure plays a central role in the Proximal Gradient Algorithm without a Lipschitz Continuous Gradient (NoLips), as it determines the maximum step size allowable for guaranteed convergence results. Special attention is given to the symmetry coefficient of positively homogeneous functions, separable functions, and exponential polynomials. Additionally, we demonstrate that the symmetry coefficient can be efficiently computed using a bisection method.

■ TA-06

Thursday, 9:00 - 10:15 - 107

SCADO 3 - Linear optimization and applications

Stream: Semidefinite and conic approaches to discrete optimization
Invited session
Chair: *Julio C. Góez*

1 - An outer approximation for a non-linear optimization model for the deployment of geo-distributed cloud applications
Julio C. Góez, Juan F. Pérez

In this paper, we propose optimization models to support the design of an application deployed on the Cloud that implements data replication. The models aim to minimize the total deployment cost subject to constraints on the application quality of service (QoS). We illustrate how this problem, initially modeled as a non-linear mixed integer problem, can be reformulated with an outer linear approximation, which allows us to exploit efficient solvers. Extensive experimentation demonstrates the effectiveness of the proposed approach in instances based on real data from cloud service providers.

2 - Mixed Integer Linear Programming Formulation for Minimum Sum of Clustering Problem
Kolos Ágoston, Marianna E.-Nagy

The minimum sum of clustering is the most used clustering method. The minimum sum of clustering is usually solved by the heuristic K-means algorithm which converges to a local optimum. Much effort was put into solving such kind of problem, but a mixed integer linear programming formulation (MILP) is still missing. We formulate MILP models and solve them up to sample size 150. The advantage of MILP formulation is that users can extend the original problem with arbitrary linear constraints.

3 - On uniform LP duality of linear problems of Copositive Programming
Tatiana Tchemisova, Olga Kostyukova

New necessary and sufficient conditions guaranteeing the uniform LP duality for linear problems of Copositive Programming and formulate these conditions in different equivalent forms. The main results are obtained using the original approach developed by the authors and based on a concept of immobile indices. This approach, first described for linear SIP problems and then applied to various classes of convex conic problems, permits alternative representations of the set of feasible solutions.

■ TA-07

Thursday, 9:00 - 10:15 - 108

IPA 2 - Search directions for interior-point algorithms

Stream: Interior-point algorithms
Invited session
Chair: *Marianna E.-Nagy*

1 - Predictor-corrector interior-point algorithms based on a new class of algebraically equivalent transformations
Petra Renáta Rigó, Tibor Illés, Roland Török

We introduce a generic predictor-corrector (PC) interior-point algorithm (IPA) for solving sufficient linear complementarity problems. To determine the search directions we use the algebraic equivalent transformation (AET) technique. We propose a whole, new class of AET functions for which a unified complexity analysis of the PC IPA is given. We show that the PC IPA using any function of the new class of AET functions has polynomial iteration complexity in the size of the problem, the handicap of the problem's matrix, the starting point's duality gap and in the accuracy parameter.

2 - Implementation of predictor-corrector interior-point algorithms for solving sufficient linear complementarity problems
Roland Török, Tibor Illés, Petra Renáta Rigó

We consider the implementation of predictor-corrector interior-point algorithms for solving sufficient linear complementarity problems that work in a small neighbourhood of the central path. The determination of the search directions is based on the algebraic equivalent transformation technique and on the approach using kernel functions. In the presentation we show numerical results where we compare the predictor-corrector interior-point algorithms that use different search directions based on the above-mentioned two approaches.

3 - Predictor-corrector algorithm for symmetric cone horizontal linear complementarity problems based on a new class of algebraically equivalent transformations
Zsolt Darvay, Petra Renáta Rigó

Using the algebraically equivalent transformation (AET) technique we extend a generic predictor-corrector interior-point algorithm (IPA) to horizontal linear complementarity problems (LCPs) over Cartesian product of symmetric cones. We consider a new class of AET functions. We show that the proposed IPA has the iteration bound that matches the best known iteration bound for IPAs solving these types of problems. Up to our best knowledge, this is the first class of AET functions for PC IPAs solving horizontal LCPs over Cartesian product of symmetric cones.

Thursday, 10:45 - 12:00

■ TB-01

Thursday, 10:45 - 12:00 - C V

IPA 3 - Advances in interior-point methods

Stream: Interior-point algorithms
Invited session
Chair: *Goran Lesaja*

1 - A predictor-corrector interior-point algorithm with new search directions for sufficient weighted linear complementarity problems
Xiaoni Chi, Guoqiang Wang, Goran Lesaja

In this paper, we present a feasible predictor-corrector interior-point algorithm for sufficient weighted linear complementarity problems based on new search directions. The new search directions are derived from the kernel positive-asymptotic function using the algebraic equivalent transformation of the Newton system which defines the central path. By choosing appropriate parameters, the proposed algorithm is shown to have global convergence and polynomial iteration complexity.

2 - Kernel-based full-Newton step interior-point algorithm for $P_ *(kappa)$-WLCP
Goran Lesaja, Xiaoni Chi, Guoqiang Wang, Florian Potra

A full-Newton step feasible IPM for $P_ *(kappa)$-WLCP is considered. The IPM is based on the specific eligible kernel function that defines proximity measure and search directions with full Newton steps. Assuming strict feasibility of the problem, it is shown that with appropriate choices of the parameters, and a certain condition on the starting point, the iterations always lie in the defined neighborhood of the central path and the method converges to the approximate solution matching the best-known iteration bound for these types of problems.

3 - Set-Limited Functions and Polynomial-Time Interior-Point Methods
Yurii Nesterov

In this talk, the notion of a self-concordant barrier is replaced by a new notion of set-limited function, which forms a wider class. We show that the proper set-limited functions ensure the polynomial time complexity of the corresponding path-following method (PFM). Our new PFM follows a deviated path, which connects an arbitrary feasible point with the solution to the problem. We present some applications of our approach to the problems of unconstrained optimization, for which it ensures a global linear rate of convergence even for non-smooth objective functions.

■ TB-02

Thursday, 10:45 - 12:00 - C VI

MO 4 - Numerical approaches in multiobjective optimization

Stream: Multiobjective optimization
Invited session
Chair: *Gabriele Eichfelder*
Chair: *Akshay Gupte*

1 - An efficient hybrid evolutionary-deterministic method for the multi-objective design-for-control of water distribution networks
Aly-Joy Ulusoy, Ivan Stoianov

We consider the design-for-control of water distribution networks for the joint optimization of performance and cost-related objectives. We present a hybrid method combining the complementary advantages of non-linear programming solvers and evolutionary algorithms to efficiently approximate the Pareto front of the resulting non-convex multi-objective mixed-integer non-linear programs. The proposed algorithm is applied to case study networks from the literature and evaluated against alternative heuristic and global methods based on performance and quality of the solutions returned.

2 - Generalized Conic Scalarization in Vector Optimization
Christian Günther, Bahareh Khazayel, Christiane Tammer

It is well-known that scalarization techniques (e.g., in the sense of Gerstewitz; Kasimbeyli; Pascoletti-Serafini; Zaffaroni) are useful to find efficient solutions of vector optimization problems. One recognized approach is the conic scalarization method proposed by Kasimbeyli (2010, 2013), which is based on augmented dual cones and Bishop-Phelps type (normlinear) scalarization functions. In this talk, we present a generalized version of the conic scalarization method. By using new nonlinear separation theorems for cones, we are able to derive new scalarization results.

3 - Pareto Leap: An Algorithm for Biobjective Mixed-Integer Optimization
Philip de Castro, Margaret Wiecek

We present an algorithm for solving biobjective mixed-integer optimization problems which exploits the structure of the nonconvex outcome set. The algorithm "leaps" between subsets of the outcome set, correctly identifying those that contribute to the global Pareto set. The leaps are performed using tabu constraints (also known as "no-good" constraints) and convex approximations of the nonconvex region dominated by the subsets. We discuss theoretical results, detail the algorithm, and apply it to test instances for demonstrations of the results.

■ TB-03

Thursday, 10:45 - 12:00 - 104

OVIUM 3 - Set valued optimization

Stream: Optimization, variational inequalities and uncertainty models
Invited session
Chair: *Christiane Tammer*

1 - Existence and stability conditions for weak set-equilibrium problems
Marius Durea, Elena-Andreea Florea

We formulate four types of set-equilibrium problems based on some well-known set-order relations and we study the existence of solutions for these problems by means of generalized convexity and Lipschitz conditions. A comparison with some vector equilibrium problems is performed. We are interested as well in an issue concerning the stability of solutions for some related approximate set-optimization problems.

2 - Nonlinear Cone Separation Theorems in Real Topological Linear Spaces
Bahareh Khazayel, Christian Günther, Christiane Tammer

In different areas of mathematics, such as optimization and variational analysis, separating two sets is vital. This talk presents new results for the separation of two not necessarily convex cones by a (convex) cone / conical surface in real (topological) linear spaces. Essentially, we follow and extend the separation approach by Kasimbeyli (2010, SIAM J. Optim. 20), which is based on augmented dual cones and Bishop-Phelps type (normlinear) separating functions. Classical separation theorems for convex sets are the key tool for proving our main nonlinear cone separation theorems.

3 - Some refinements of ABB type theorems in topological vector spaces
Constantin Zalinescu

The celebrated Arrow-Barankin-Blackwell theorem establishes the density of the proper efficient points of a compact convex subset of $mathbbRn$ in the set of its Pareto-efficient points with respect to the partial order defined by $mathbbRn_+$. Meantime, several results of this type were obtained extending the space or/and the ordering convex cone.

Our aim is to provide a unified approach, getting so, as a by-product, slight refinements of such results.

■ TB-04

Thursday, 10:45 - 12:00 - 105

GT 2 - Cooperative Game Theory

Stream: Game theory
Invited session
Chair: *Miklós Pintér*

1 - Conversion of a Collusive Oligopoly Game into a Partition Function Form Game, and Application of Cooperative Game Solution Concepts to It
David Bartl

We propose a methodology to apply the classical solution concepts of TU-games (e.g. the core or the bargaining set) to a cooperative strategic form game. Firstly, the game can be converted into a partition function form game (Thrall & Lucas, 1963) under some assumptions (existence and uniqueness of the Nash equilibrium). Secondly, the classical solution concepts of TU-games can be applied to the partition function form game. We notice that some known concepts (gamma- or delta-core) follow from the proposed methodology naturally and new ones can be introduced too.

2 - Second-order productivity, second-order payoffs, and the Banzhaf value
André Casajus

First, we suggest and discuss second-order versions of solutions for TU games used to characterize the Banzhaf value, in particular, of standardness for two-player games, of the dummy player property, and of 2-efficiency. Then, we provide a number of characterizations of the Banzhaf value invoking these properties.

3 - Stability in shortest path problems
Juan Vidal-Puga, Eric Bahel, María Gómez-Rúa

We study three remarkable cost sharing rules in the context of shortest path problems, where agents have demands that can only be supplied by a source in a network. The demander rule requires each demander to pay the cost of their cheapest connection to the source. The supplier rule charges to each demander the cost of the second-cheapest connection and splits the excess payment equally between her access suppliers. The alexia rule averages out the lexicographic allocations, each of which allows suppliers to extract rent in some pre-specified order. We show that all three rules are anonymous.

■ TB-05

Thursday, 10:45 - 12:00 - 106

NNO 5 - Optimization and machine learning

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Silvia Villa*
Chair: *Cesare Molinari*

1 - Fast convergence of Nesterov-like continuous-time dynamics on Riemannian manifolds
Tejas Natu

To minimize smooth geodesically convex functions, we study continuous-time dynamics on Riemannian manifolds. Alimisis et al. adapted the dynamical system proposed by Su et al. to model Nesterov's Accelerated Gradient algorithm to manifolds. We improve the convergence rate of function values and prove the convergence of the trajectory to the set of minimizers. We also analyze the sub-optimal case. Our analysis handles curvature-related technical difficulties inherent to the setting of manifolds. We present computational experiments that corroborate our theoretical results.

2 - Learning from data via overparametrization
Cristian Vega

Recently, the success of learning is related to over- and re-parametrization, the success of learning is related to over- and re-parametrization. However, there is still an open question of how to find systematically what is the inductive bias hidden behind the model for a particular optimization scheme. The goal of this paper is taking a step in this direction, studying extensively many reparametrization used in the state of the art, providing a common structure to analyze the problem in a unified way.

3 - Unfolding Proximal Networks within Plug and Play algorithms: The Faster, the Better?
Audrey Repetti

Plug-and-play (PnP) algorithms and unfolded networks are two types of methods mixing optimization (proximal) algorithms and data-driven approaches through neural networks (NNs). In this work, we couple PnP and unfolded approaches, building a PnP algorithm where the learned denoiser is an unfolded NN based on proximal splitting techniques. We investigate the impact of the choice of the unrolled algorithm to build the NN, on the stability of the overall PnP algorithm and on its reconstruction quality on an image restoration problem.

■ TB-06

Thursday, 10:45 - 12:00 - 107

SCADO 4 - Semidefinite programming for discrete optimization

Stream: Semidefinite and conic approaches to discrete optimization
Invited session
Chair: *Sven Polak*
Chair: *Daniel Brosch*

1 - A class of new cutting planes for SDP relaxations of stable set and coloring problems
Dunja Pucher, Franz Rendl

A famous semidefinite relaxation for both stable set and coloring problems is the Lovász theta function. We consider tightening of the Lovász theta function which can be achieved by adding valid inequalities into the formulation. We combine the ideas of some of the existing inequalities and derive new cutting planes for both problems. Finally, we investigate the bounds obtained by adding the proposed inequalities. We compare our bounds with existing relaxations and present computational results.

2 - Semidefinite bounds for crossing numbers of K_m,n
Sven Polak, Daniel Brosch

Computing the crossing number of the complete bipartite graph K_m,n is a long-standing open problem, going back to Turán in the 1940s. In this talk, we explain how to use semidefinite programming and representation theory to compute new lower bounds on the crossing number of K_m,n, extending a method from de Klerk et al. We develop a full symmetry reduction and use it to improve bounds on several concrete instances. Some of our bounds are computed using a novel relaxation of the original semidefinite programming bound, by only requiring one small matrix block to be positive semidefinite.

3 - The spherical packing problem in cylindrical spaces
Andreas Spomer

How can we arrange spheres in a way such that they fill out as much space as possible? This age-old mathematical question has a lot of applications. The problem has been studied in many interesting spaces, for example in finite fields, on the sphere and in the Euclidean space. I want to consider this problem in cylindrical spaces. In my talk, I will discuss how to effectively upperbound the problem using semidefinite programming. I will take a look at specific cylindrical spaces, look at dense configurations and verify their optimality.

■ TB-07

Thursday, 10:45 - 12:00 - 108

QCO 3 - Quantum computing and optimization III

Stream: Quantum computing optimization
Invited session
Chair: *Brandon Augustino*

1 - Quantum Semidefinite Programming with Thermal Pure States
Oscar Watts

We propose a modification of the quantized MMW algorithm introduced by Brandao and Svore, replacing the Gibbs sampler with thermal pure quantum (TPQ) states. Our approach relies on Quantum Signal Processing and extending Jaynes Principle to TPQ states. While our methodology incurs an additional problem-dependent error, which reduces as the problem size grows, it avoids the explicit preparation of (purified) Gibbs states and shows a similar quantum speedup. We numerically verify the algorithm for the Hamiltonian learning problem for sizes of up to N=210 variables.

2 - Solving combinatorial optimization problems with Quantum Annealers
Janez Povh, Dunja Pucher

We are well into the second quantum revolution, where the knowledge gained from the advent of quantum theory is now being used to build quantum devices. One of the biggest potential benefits form such an undertaking is a new and better way of computing, which has been termed “quantum computing”. There are two main avenues being developed currently; digital quantum computing, which provides universality in terms of which algorithms can be deployed on such devices; and quantum annealing (QA), which has only one specific type of algorithm available, but is therefore much more developed in terms

3 - Quantum algorithm for approximating partition functions
Arjan Cornelissen

We present a novel quantum algorithm for estimating Gibbs partition functions in sublinear time with respect to the logarithm of the size of the state space. This is the first speed-up of this type to be obtained over the seminal nearly-linear time algorithm of Štefankovic, Vempala and Vigoda [JACM, 2009]. Our result also preserves the quadratic speed-up in precision and spectral gap achieved in previous work by exploiting the properties of quantum Markov chains.

Thursday, 13:15 - 14:15

■ TC-01

Thursday, 13:15 - 14:15 - C V

Europt Fellowship Lecture

Stream: Plenaries
Invited session
Chair: *Giancarlo Bigi*
Chair: *Sonia Cafieri*

1 - Tensor methods for nonconvex optimization
Coralia Cartis

We consider the advantages of having and incorporating higher- (than second-) order derivative information inside regularization frameworks, generating higher-order regularization algorithms that have better complexity, universal properties and can certify higher-order criticality of candidate solutions. We discuss practical implementations of some of these methods, which involve the challenging solution of polynomial subproblems. Theoretical and numerical results for the latter will be presented.

Thursday, 14:30 - 16:10

■ TD-01

Thursday, 14:30 - 16:10 - C V

CPVIE 3 - Copositive optimization and applications

Stream: Complementarity problems, variational inequalities and equilibria
Invited session
Chair: *Immanuel Bomze*

1 - Concave tents: a new tool for optimizing nonlinear convex functions over nonconvex sets
Markus Gabl

In order to make convex hulls of nonconvex sets exploitable for generating upper bounds on nonlinear convex optimization over nonconvex sets, we introduce concave tents, which are concave overestimators of the objective over the convex hull of the feasible set that agree with the objective on that set. We derive characterizations of these concave tents by means of conic optimization, thereby elevating the applicability of copositive optimization. Via conic duality we can derive superderivatives so that first order techniques like Frank-Wolfe methods are applicable to the concave reformulation.

2 - Conic relaxations for quadratic optimization problems with exact sparsity term
Bo Peng, Immanuel Bomze

Mixed-binary quadratic optimization problems (MIQPs) play a significant role in many fields, e.g. interpretable AI, where mixed-binary variables allow us to capture the combinatorial nature of original problems. In this talk, we focus on QPs with an exact sparsity term, the zero-norm, arriving at a significant subclass of MIQP. We present several conic relaxations of this class of problems, and sufficient conditions to ensure exactness. Embedding the relaxation into a Branch-and-Bound (BB) framework, we show that the number of nodes used in the BB is significantly reduced.

3 - Extensions and formulations of the cp-rank in completely positive optimization
Immanuel Bomze, Mirjam Duer, Bo Peng

This is a progress report on two separate research projects, one with Mirjam Duer, and one with Bo Peng. Both include studies on the cp-rank of a completely positive matrix for which lower and upper bounds in terms of the order are known. We will discuss an extension to non-symmetric square matrices and characterize it by a QCQP under conic constraints. As well, we will show by example that the standard Burer relaxation of the quadratic and linear constraints will yield useless bounds, even if no conic constraints are present, going back to the original concept of cp-rank.

4 - Polyhedral Properties of RLT Relaxations of Nonconvex Quadratic Programs and Their Implications on Exact Relaxations
E. Alper Yildirim, Yuzhou Qiu

We study RLT (reformulation-linearization technique) relaxations of nonconvex quadratic programs. We establish various relations between the polyhedral properties of the feasible region of a quadratic program and those of its RLT relaxation. Using these relations, we present necessary and sufficient exactness conditions for RLT relaxations. We then give a thorough discussion of how our results can be converted into simple algorithmic procedures to construct instances of quadratic programs with exact, inexact, or unbounded RLT relaxations.

■ TD-02

Thursday, 14:30 - 16:10 - C VI

FICO

Stream: FICO presentation
Invited session
Chair: *Tibor Illés*

1 - FICO solvers
Imre Polik

Our talk will demonstrate how the FICO Xpress tools let you read data, integrate with your own machine learning model and solvers (or the Xpress Solver) and how they enable collaboration with business users, deploying decision support or automated solutions in the cloud or on premises. Get the overview of the great new features of FICO Xpress Solver, Mosel, Workbench, and Insight including optimization with multiple objectives, mixed-integer-optimization enhancements, infeasibility detection, and a new global optimization solver for mixed-integer nonlinear optimization problems.

■ TD-03

Thursday, 14:30 - 16:10 - 104

OVIUM 4 - Random variational inequaliites

Stream: Optimization, variational inequalities and uncertainty models
Invited session
Chair: *Akhtar Khan*

1 - A new stochastic regularized second-order iterative scheme for optimal control and inverse problems in partial differential equations with random data
Miguel Sama, Akhtar Khan

This talk presents a new stochastic regularized second-order iterative scheme for solving a variational inequality in a stochastic environment where the primary operator is only accessible by employing sampling techniques. The proposed iterative method, which fits within the general framework of the stochastic approximation approach, has its almost sure convergence analysis given in a Hilbert space. We test the feasibility and efficacy of the proposed stochastic approximation approach for an optimal control problem and an inverse problem with random data.

2 - A random variational inequality model of international agricultural supply chain with a vulnerability analysis under disaster scenarios
Mauro Passacantando, Fabio Raciti

We further develop a very recent network equilibrium model of international agricultural trade with capacity constraints on production and on routes. Our contribution is twofold: at first, we treat the exchange rates as random variables, and frame the model within the theory of random variational inequalities; in the second place, we use the mean value of the equilibrium solution to perform a vulnerability analysis of the routes, aimed at identifying the set of routes whose disruption would mostly affect the overall international trade. Finally, some numerical experiments are shown.

3 - Bilevel optimisation for selecting hyperparameters for nonlinear support vector machines
Samuel Ward, Alain Zemkoho

Nonlinear support vector machines are a staple of classification. They require the user to tune specific parameters - the regularisation term and choice of kernel. Traditionally, this tuning has been approximated using a grid search. But this method scales very poorly with the number of hyperparameters. We will introduce bilevel optimisation and use this framework to model the hyperparameter turning problem. From here, we introduce stationarity concepts and constraint qualifications for bilevel programs. We will conclude with our solution method and numerical experiments.

4 - Inverse tensor variational formulation for a general control equilibrium problem
Annamaria Barbagallo

The aim of the talk is to introduce the policymaker's point of view for the oligopolistic market equilibrium problem is introduced (see [1]). More precisely the control equilibrium conditions for the regulatory tax are given and their characterization with a suitable inverse tensor variational inequality is established. Thanks to the inverse variational formulation, some existence and uniqueness results are shown. Furthermore, the well-posedness analysis is investigated. The Tikhonov regularization method is extended to tensor inverse problems to study them when they are ill-posedness.

■ TD-04

Thursday, 14:30 - 16:10 - 105

DFO 2 - Advances in zeroth-order methods

Stream: Derivative-free optimization
Invited session
Chair: *Andrea Cristofari*

1 - A Derivative-Free Trust-Region Method Based on Finite-Difference Gradient Approximations
Dânâ Davar, Geovani Grapiglia

In this work we present a derivative-free trust-region method, based on finite-difference gradient approximations, for smooth convexly constrained optimization problems. We establish a worst-case complexity bound for the number of function evaluations that the method needs to find an approximate stationary point. Notably, the obtained bound depends only linearly on the problem dimension. Illustrative numerical results are also presented.

2 - Learning the right layers: a zeroth-order bi-level optimization strategy for semi-supervised learning on multilayer graphs
Sara Venturini, Andrea Cristofari, Francesco Rinaldi, Francesco Tudisco

Clustering on multilayer graphs poses additional complications with respect to standard graphs as different layers may be characterized by different types of information. In this work, we assume a semi-supervised learning setting, where the class of a small percentage of nodes is initially provided, and we propose a Laplacian-regularized model that learns an optimal nonlinear combination of the different layers from the available input labels. The learning algorithm is based on a zeroth-order Frank-Wolfe optimization scheme, combined with a modified Label Propagation iteration.

3 - Minibatch Stochastic Three Points Method for Unconstrained Smooth Minimization
El Houcine Bergou

In this work, we propose a new zero order optimization method called Minibatch Stochastic Three Points (MiSTP) method in a setting where only an approximation of the objective function evaluation is possible. It is based on the Stochastic Three Points method (STP) proposed by E. Bergou et al. At each iteration, MiSTP generates a random search direction in a similar manner to STP, but chooses the next iterate based on the approximation of the objective function rather than its exact evaluations. We analyzed MiSTP complexity and evaluate its performance on multiple machine learning tasks.

4 - Zeroth order descent with Structured Directions
Silvia Villa, Marco Rando, Cesare Molinari, Lorenzo Rosasco

I will present the Structured Stochastic Zeroth order Descent (S-SZD) algorithm, a finite difference approach which approximates a stochastic gradient on a set of ld orthogonal directions, where d is the dimension of the ambient space. These directions are randomly chosen, and may change at each step. I will illustrate our theoretical findings in numerical simulations where assumptions are satisfied and on the real-world problem of hyper-parameter optimization, observing that S-SZD has very good practical performances.

■ TD-05

Thursday, 14:30 - 16:10 - 106

NNO 6 - Complexity of nonconvex optimization

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Masoud Ahookhosh*

1 - On the Rate of Convergence of the Difference-of-Convex Algorithm (DCA)
Moslem Zamani, Hadi Abbaszadehpeivasti, Etienne De Klerk
The DCA (difference-of-convex algorithm) is a popular algorithm for difference-of-convex (DC) problems. In this talk, we present some non-asymptotic convergence rates for DCA that cover both smooth and non-smooth problems. Moreover, we derive a new linear convergence rate result for the DCA under the assumption of the Polyak-Łojasiewicz inequality. The novel aspect of our analysis is that it employs semidefinite programming performance estimation.

2 - Yet another fast variant of Newton's method for nonconvex optimization
Sadok Jerad, Serge Gratton, Philippe L. Toint
A second-order algorithm is proposed for minimizing smooth nonconvex functions that alternates between regularized Newton and negative curvature steps. In most cases, the Hessian matrix is regularized with the square root of the current gradient and an additional term taking moderate negative curvature into account, a negative curvature step being taken only exceptionally. Worst_case complexity rates are proven for both first and second order criticallity. Initial numerical experiments with two variants of the new method are finally presented.

■ TD-06

Thursday, 14:30 - 16:10 - 107

FOM 2 - First-order methods in convex optimization

Stream: First-order optimization methods
Invited session
Chair: *Radu Ioan Bot*
Chair: *Yura Malitsky*

1 - A First order Primal-dual Method for Solving Constrained Variational Inequalities
Tatjana Chavdarova
Variational Inequalities (VIs) are a framework for analyzing a broad problem class. Due to the lack of a first-order method to solve VIs with general-form constraints, we combine interior-point with a primal-dual approach to derive a new method named "ACVI." We show that ACVI converges when only assuming the associated operator is monotone, with a rate that matches the known lower bound. When the sub-problems of ACVI are solved approximately using a warm-start technique, the convergence rate stays the same, provided that the errors decrease at an appropriate rate.

2 - Extended Convergence Conditions for the Chambolle-Pock Algorithm
Pontus Giselsson
The Chambolle-Pock method is a well-known three-parameter algorithm that solves saddle-point problems with a specific structure. In this work, we substantially ease the constraints on these parameters while ensuring convergence in a primal-dual gap function. Our proof relies on an extended version of a recently proposed automated Lyapunov analysis framework, which builds on the performance estimation methodology. Furthermore, we present tight linear convergence results and demonstrate that the optimal linear convergence factor is achieved when selecting parameters beyond the conventional conve

3 - First-order methods for bi-level optimization
Shimrit Shtern
We suggest a new ITerative Approximation and Level-set EXpansion (ITALEX) approach for bilevel problems with simple norm-like outer functions, which are not required to be either smooth or strongly convex. ITALEX alternates between expanding the level-set of the outer function and approximately optimizing the inner function over this level-set. When optimizing the inner function through known first-order methods, ITALEX obtains a feasibility convergence rate of O(1/k) and an optimality convergence rate O(1/k0.5), thus achieving the best known convergence rates for these problems.

4 - Revisiting High-Resolution ODEs for Faster Convergence
Hoomaan Maskan, Alp Yurtsever, Konstantinos Zygalakis, Armin Eftekhari
In this talk, we analyze first-order accelerated methods for the unconstrained minimization of convex and strongly convex smooth functions from a continuous time perspective. We use high-resolution ordinary differential equations (ODEs) to understand the behavior of Nesterov's accelerated gradient algorithm. We propose a new general first-order acelerated method for strongly convex functions. For convex functions, we exploit the variational perspective on high-resolution ODEs. Our analysis improves on several convergence rates.

■ TD-07

Thursday, 14:30 - 16:10 - 108

OM 3 - Isoperimetric problems and optimization on manifolds

Stream: Optimization on manifolds
Invited session
Chair: *Alexandru Kristaly*

1 - Lower semicontinuity of Kirchhoff-type energy functionals and spectral gaps on (sub)Riemannian manifolds
Csaba Farkas

In this talk, we characterize the sequentially weakly lower semicontinuity of the parameter-depending energy functional associated with the critical Kirchhoff problem in context of (sub)Riemannian manifolds. We also present some spectral gap and convexity results.

2 - Sharp isoperimetric and Sobolev inequalities on CD(0,N) spaces: an optimal mass transport approach
Alexandru Kristaly

By using optimal mass transport theory, we prove a sharp isoperimetric inequality in CD(0,N) metric measure spaces assuming an asymptotic volume growth at infinity. As applications of the isoperimetric inequality, we establish Sobolev and Rayleigh-Faber-Krahn inequalities with explicit sharp constants in Riemannian manifolds with nonnegative Ricci curvature. Talk based on a joint work with Z. Balogh.

3 - Sharp Sobolev inequalities on Finsler manifolds with nonnegative Ricci curvature
Agnes Mester

We establish Sobolev inequalities on n-dimensional Finsler manifolds having nonnegative n-Ricci curvature in the case p>n. For this purpose, we elaborate suitable anisotropic symmetrization arguments by applying the sharp isoperimetric inequality available on these spaces. We also provide the best constants of the given functional inequalities. As application, by using variational arguments, we guarantee the existence & multiplicity of solutions for certain elliptic PDEs involving the Finsler-Laplace operator. Our results are also new in the Riemannian setting.

Friday, 8:30 - 9:30

■ FA-01

Friday, 8:30 - 9:30 - C V

Plenary II

Stream: Plenaries
Invited session
Chair: *Tamás Terlaky*

1 - **Mixed-Integer Semidefinite Programming - a New Perspective**
Renata Sotirov

Mixed-integer semidefinite programming can be viewed as a generalization of Mixed-integer programming where the vector of variables is replaced by mixed-integer positive semidefinite matrix variables. The combination of positive semidefiniteness and integrality allows to formulate various nonlinear optimization problems as (linear) mixed-integer semidefinite programs (MISDPs). In this talk we present new results on MISDPs and resulting continuous relaxations. Finally, we present novel approaches for solving MISDPs.

Friday, 9:40 - 10:55

■ FB-01

Friday, 9:40 - 10:55 - C V

QCO 4 - Quantum computing and optimization IV

Stream: Quantum computing optimization
Invited session
Chair: *Brandon Augustino*

1 - Inexact feasible quantum interior point methods with exponentially improved complexity for linear optimization problems
Tamás Terlaky, *Mohammadhossein Mohammadisiahroudi*, *Ramin Fakhimi*, *Zeguan Wu*

Quantum computing promises to accelerate the solution of optimization problems. We apply Quantum Linear System Algorithms (QLSAs) to Newton systems within IPMs in solving LO problems. Due to their inexact nature, direct use of QLSAs lead to infeasible IPMs. We propose Inexact-Feasible IPMs (IF-IPM) using a novel system to generate inexact but feasible steps. We show that this method enjoys the best iteration complexity. Moreover, we show how an iterative refinement scheme leads to exponential complexity improvement. We investigate the proposed IF-IPM's efficiency using the QISKIT simulator.

2 - New perspectives on quantum interior point methods
Brandon Augustino

Existing quantum interior point methods seek to speedup their classical counterpart by using quantum linear systems algorithms to solve the Newton linear system at each iteration. While this approach yields polynomial speedups in the dimension, it introduces a dependence on a condition number bound which may prohibit any overall advantage. In this talk we present two new approaches to quantizing IPMs. The first approach draws on a recently established relationship between interior point methods and simulated annealing, while the second seeks to derive a quantum central path.

3 - Sublinear time quantum interior point methods for tall linear programs
Sander Gribling, *Simon Apers*

In this work (in progress) we study tall linear programs over full-dimensional polytopes: those with n inequality constraints on d variables and n»d. We show how to approximate, in time O (sqrtn poly(d)), a Newton step of an interior point method based on either the logarithmic-, the volumetric-, or the Lewis-weight barrier. Our main contribution is a quantum algorithm to compute (1 +- eps)-spectral approximations of AT A for a matrix A in Rn times d in time O(sqrtndr/eps+domega) where r is the maximum number of non-zero entries in a row of A.

■ FB-02

Friday, 9:40 - 10:55 - C VI

GO 3 - Advances in global optimization

Stream: Global optimization
Invited session
Chair: *Sonia Cafieri*

1 - A Penalty-based Weighted Tchebycheff Scalarization Algorithm for Designing Polymer Single Screw Extruders
Ana Maria A.C. Rocha, *Antonio Gaspar-Cunha*, *Guilherme Barbosa*, *João Pedro Torres*, *M. Fernanda P. Costa*, *Edite M.G.P. Fernandes*

A key point in polymer single screw extrusion is to optimize the process, i.e., to define the best operating conditions and/or the screw geometrical parameters. For that purpose, a penalty-based weighted Tchebycheff Scalarization algorithm is used to tackle simultaneously six objectives and to generate good approximations to the Pareto front. The choice of the penalty parameter value is a critical issue aiming to balance convergence and diversity of the obtained solutions. The results show that the set of solutions obtained converges well to the Pareto front and have a very good distribution.

2 - A reliable global optimization approach for a covering problem
Sonia Cafieri, *Frédéric Messine*

We consider a covering problem, where a rectangle has to be covered by 6 equal circles whose radius is to be minimized. We present a global optimization approach, that relies on an original mathematical programming formulation for the problem at hand. An interval Branch-and-Bound algortihm provides reliable global exact solutions. This approach enables a numerical proof of a theorem and certifies decimal digits of numerical solutions for the considered problem.

3 - Hybridizing two Linear Relaxation Methods in an Interval Branch-and-Bound Algorithm
Frédéric Messine, *Ignacio Araya*, *Jordan Ninin*, *Gilles Trombettoni*

In deterministic global optimization, linear relaxation techniques of a nonconvex program are used in the lower bounding phase mainly based on the use of reformulation-linearization techniques. However, there also exist two interval-based polyhedral relaxation techniques which provide reliable bounds without adding new auxiliary variables. The purpose of this work is to describe how to hybridize these two distinct interval-based relaxations: the first one is based on affine forms and affine arithmetic and the second one is based on a Taylor expansion of the constraints at the box vertices.

■ FB-03

Friday, 9:40 - 10:55 - 104

CVPIE 4 - Games, equilibria and intertwined optimization problems

Stream: Complementarity problems, variational inequalities and equilibria
Invited session
Chair: *Shunsuke Hayashi*

1 - A Novel Equilibrium Model for Trust and Reputation Systems
Attilio Marcianò, Sofia Giuffre'

Nowadays, few practical methods are available to assess the quality or reliability of resources in the online environment. Trust and Reputation systems (TRs) aim to solve this problem by allowing consumers to properly assess the trustworthiness of resources before using them. The aim of our work is to develop an effective equilibrium model for TRs by means of a variational inequality formulation. In particular, we provide a definition of equilibrium for TRs and we prove that it is equivalent to a variational inequality. Then, we perform a Lagrange analysis and some examples explain the model.

2 - Heterogeneous extension of 2-dimensional Fujita-Ogawa model in spatial economics
Shunsuke Hayashi

In the field of spatial economics, Fujita-Ogawa (FO) model is known to be one of equilibrium models to analyze the agglomeration patterns of cities. In the model, there exist a number of firms and households to maximize their own payoffs, but those economic agents are assumed to be homogeneous. In this study, we consider the heterogenous model in which there exist different kinds of firms. Moreover, we formulate the equilibrium conditions as a large-scale complementarity problem, which reduces to a concave quadratic programming.

3 - On Projected Solutions for Quasi Equilibrium Problems with Non-self Constraint Map
Maede Ramazzanejad

In a normed space setting, this paper studies the conditions under which the projected solutions to a quasi equilibrium problem with non-self constraint map exist. Our approach is based on an iterative scheme which gives rise to a sequence weakly converging to a projected solution. Finally, as a particular case, we discuss the existence of projected solutions to a quasi variational inequality problem.

■ FB-04

Friday, 9:40 - 10:55 - 105

HOMCO - High-order methods in convex optimization

Stream: High-order methods in convex optimization
Invited session
Chair: *Yurii Nesterov*

1 - Efficiency of higher-order algorithms for minimizing composite functions
Ion Necoara

We design a higher-order majorization-minimization algorithmic framework for composite problems (possibly nonconvex/nonsmooth), which covers e.g. minimization of max-type functions, optimization problems with functional constraints and simple composite minimization. Our framework replaces each component in the composite model with a higher-order surrogate such that the corresponding error function has a higher-order Lipschitz continuous derivative. We present convergence and complexity guarantees for our higher-order majorization-minimization algorithms for both nonconvex and convex problems.

2 - Hessian barrier algorithms for non-convex conic optimization
Pavel Dvurechensky

A key problem in mathematical imaging, signal processing and computational statistics is the minimization of non-convex objective functions that may be non-differentiable at the boundary of the feasible set. This work proposes a new family of first- and second-order interior-point methods for non-convex optimization problems with linear and conic constraints, combining logarithmically homogeneous barriers with quadratic and cubic regularization respectively.

3 - Super-Universal Regularized Newton Method
Nikita Doikov

We analyze the performance of a variant of Newton method with quadratic regularization for solving composite convex minimization problems. At each step of our method, we choose regularization parameter proportional to a certain power of the gradient norm at the current point. We present the method with a simple adaptive search procedure allowing an automatic adjustment to the problem class with the best global complexity bounds, without knowing specific parameters of the problem. Global convergence rates are established for the proposed method.

■ FB-05

Friday, 9:40 - 10:55 - 106

NNO 7 - Second-order methods for nonsmooth optimization

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Behzad Azmi*

1 - A second-order gradient sampling method for nonsmooth optimization
Bennet Gebken

In nonsmooth optimization, solution methods with an order of convergence that is better than linear are difficult to construct, as it is not obvious how to obtain higher-order derivative information. In this talk, as a "second-order derivative", we consider the so-called second-order eps-jet, which is a set that contains the coefficients of all existing second-order Taylor expansions in an eps-ball around a point. Based on this concept, we construct a solution method which, according to numerical experiments, is often more efficient (in terms of function evaluations) than comparable methods.

2 - Incremental Quasi-Newton methods for nonsmooth and nonconvex optimization
Gulcin Dinc Yalcin, Frank E. Curtis

We dealt with optimization problems whose objective functions consist of sums of large numbers of component functions. We focused on quasi-Newton methods whose updates are performed incrementally using subgradients of the component functions and the Broyden-Fletcher-Goldfarb-Shanno (BFGS) strategy which can be applied to the problem directly, a difference-of-convex reformulation, smoothed approximation, or (strongly) convex local approximation. Then, we solved semi-supervised machine-learning problems and compared the results with those obtained by a state-of-the-art bundle method.

3 - TIkhonov regularization technique in continuous and discrete time optimization
Mikhail Karapetyants

This talk will address the classical optimization problem of minimizing a proper, convex and lower semicontinuous function via the second order in time dynamics, combining viscous and Hessian-driven damping with a Tikhonov regularization technique. These systems are closely connected to discrete time algorithms. The Tikhonov term allows strong convergence of the trajectories (iterations, in the discrete case) to an element of the minimal norm from the set of all the minimizers of the objective funtion. Alongside this result the fast convergence of function values could also be obtained.

■ FB-06

Friday, 9:40 - 10:55 - 107

FOM 3 - Stochastic methods

Stream: First-order optimization methods
Invited session
Chair: *Radu Ioan Bot*
Chair: *Yura Malitsky*

1 - Asynchronous Parallel Block-Coordinate Forward-Backward Algorithm
Cheik Traoré, Saverio Salzo, Silvia Villa

We present the convergence properties of a randomized block-coordinate descent algorithm for the minimization of a composite convex objective function, where the block- coordinates are updated in parallel, asynchronously and randomly according to an arbitrary probability distribution. In that work, we prove that the iterates generated by the algorithm form a stochastic quasi-Fejér sequence and thus converge almost surely to a minimizer of the objective function. Moreover, we prove a general sublinear rate of convergence in expectation for the function values and a line.

2 - From SGD to Adaptive Methods: Benefits of Adaptive Gradient Techniques
Junchi Yang

The classical analysis of Stochastic Gradient Descent (SGD) requires well-tuned stepsizes based on problem parameters. We show that untuned SGD attains order-optimal convergence rates, but with an unavoidable exponential dependence on the smoothness parameter. We further explore adaptive methods, such as AdaGrad and AMSGrad, which effectively eliminate this exponential dependency without prior knowledge of the smoothness parameter. Our findings offer theoretical support for the benefit of adaptive methods over untuned SGD in alleviating the issue of gradient explosions.

3 - Modern Stochastic Approximation Techniques for Machine Learning
Ya-Ping Hsieh

This talk aims to deliver to the ML researchers certain valuable and concrete messages from the Robbins-Monro (RM) framework of stochastic approximation theory, through its 70+ years of development (Robbins & Monro, 1951). A unique feature of the RM framework is its applicability to generic learning dynamics, which provides a powerful and unified treatment for various complex systems, single- or multi-agent, offline and online alike. Our talk will present important implications of the RM theory in prominent fields such as games, RL, and approximate probabilistic inference.

■ FB-07

Friday, 9:40 - 10:55 - 108

WCA 2 - Lyapunov-based analysis and design of first-order methods

Stream: Worst-case analysis of iterative methods via semidefinite programming and Lyapunov stability
Invited session
Chair: *Pontus Giselsson*

1 - Automated tight Lyapunov analysis for first-order methods
Manu Upadhyaya, Sebastian Banert, Adrien Taylor, Pontus Giselsson

We present a methodology for establishing the existence of quadratic Lyapunov inequalities for a wide range of first-order methods used to solve convex optimization problems. We showcase our methodology on several first-order methods that fit the framework. Most notably, our methodology allows us to significantly extend the region of parameter choices that allow for duality gap convergence in the Chambolle-Pock method when the linear operator is the identity mapping.

2 - Optimizing First-Order Method Parameters via Backpropagation through the Performance Estimation Problem
Anton Åkerman

We investigate the use of gradient-based methods for finding optimal parameters of first-order methods within the context of the Performance Estimation Problem. This approach combines recent methods for differentiating convex optimization problems with the PEP-framework. Although the problem of finding parameters which minimize the worst-case convergence rate generally is non-convex, our implementation performs well,for both the Douglas-Rachford and Davis-Yin operator splitting methods, as well as for some more general parameterizations of first-order methods.

3 - PEPit: a Python package for worst-case analysis of first-order optimization methods and their continuous versions
Céline Moucer, Baptiste Goujaud, François Glineur, Julien Hendrickx, Adrien Taylor, Aymeric Dieuleveut, Francis Bach

In this talk, we present the open source package "PEPit", that provides a computer-assisted access to worst-case analyses of a broad class of first-order methods and ordinary differential equations, and includes about 70 examples. The package relies on the "performance estimation" framework, which casts such worst-case analyses as semidefinite programs (SDP) which we can solve numerically. We propose to begin with a simple continuous example: the gradient flow, which is highly related to gradient descent.

Friday, 11:30 - 12:45

■ FC-01

Friday, 11:30 - 12:45 - C V

OVIUM 5 - Optimization under uncertainty

Stream: Optimization, variational inequalities and uncertainty models
Invited session
Chair: *Annamaria Barbagallo*

1 - Mathematical programming with uncertain data
Chiang Kao

Mathematical programs are difficult to solve when the parameters are uncertain. This paper discusses a case where the uncertain data are expressed in intervals. We formulate the problem as a pair of two-level mathematical programs. To illustrate that the proposed model is applicable in practice, we discuss a branch of mathematical programming, fractional programming, that is widely applied to measure the relative efficiency of a set of production units, and the efficiencies of twenty-four non-life insurance companies in Taiwan are calculated using the developed model.

2 - Necessary optimality conditions in scalar optimization under uncertainty
Christiane Tammer

It is well known that real world problems often contaminated with uncertain data, especially, due to unknown future processing, errors in measurement, or incomplete information in the development of the model. We apply nonlinear scalarization techniques well known in vector optimization for deriving necessary conditions for solutions of robust optimization problems.

3 - Robust solutions to multi-objective optimization problems with one uncertain objective
Fabian Chlumsky-Harttmann, Anita Schöbel

Our work deals with a multi-objective portfolio optimization problem with uncertainty in one objective, namely the volatility. We apply methods from the field of robust multi-objective optimization. In particular, we employ the concepts of minmax robust efficiency and multi-objective regret robustness for which considering the special case of uncertainty in only one objective yields interesting results. Furthermore, we discuss other possible notions of regret robustness for the problem at hand and investigate how these concepts relate to each other.

■ FC-02

Friday, 11:30 - 12:45 - C VI

GT 3 - Computing the nucleolus

Stream: Game theory
Invited session
Chair: *Juan Vidal-Puga*

1 - Computing the nucleolus: misconceptions, efficiency and applications
Márton Benedek

Computing the nucleolus requires finding the unique point in a low-dimensional polytope lexicographically minimising the exponential sized non-increasingly ordered vector of excesses. The mainstream approaches break down the lexmin problem into solving a linear series of exponential sized linear programs (LPs). We introduce the state-of-the-art lexicographical descent method computing the nucleolus as the first algorithm guaranteeing strict lexicographical improvement in every step. The efficiency of the method is demonstrated through computational tests as well as new areas of applications.

2 - Computing the per-capita nucleolus in balanced games: the case of assignment games
Tamás Solymosi

The nucleolus, one of the major point-valued solutions for cooperative games, lexicographically maximizes the nondecreasingly ordered vector of the coalitional satisfactions over the set of imputations. This satisfaction measure, however, does not take into account e.g. the size of the coalitions. We show that if the core of the game is not empty, coalitions which are not anti-essential in the dual game can be ignored in the computation of the per-capita nucleolus. As an application, we present a strongly polynomial algorithm that computes the per-capita nucleolus in assignment games.

3 - TU-games with utility: the u-prenucleolus
Zsófia Dornai, Miklós Pintér

The u-prenucleolus is a generalization of the prenucleolus using utility functions. We prove a generalisation of Kohlberg's theorem to the u-prenucleolus and a generalisation of Katsev and Yanovskaya's theorem, thereby giving a sufficient and necessary condition on the unicity of the u-prenucleolus. We also define the u-essential coalitions which give a characterisation set for the u-prenucleolus. Special cases of this result give a characterisation set for the per-capita prenucleolus on balanced games and a characterisation set for the prenucleolus on certain non-balanced games.

■ FC-03

Friday, 11:30 - 12:45 - 104

QCO 5 - Quantum computing and optimization V

Stream: Quantum computing optimization
Invited session
Chair: *Rodolfo Alexander Quintero Ospina*
Chair: *Brandon Augustino*

1 - Computing graph edit distance on quantum devices
Massimiliano Incudini

Distance measures are important in Machine Learning and Pattern Recognition algorithms, with different types of distance used depending on the data. For graph-shaped data, Graph Edit Distance (GED) is important in measuring the (dis)similarity between two graphs in terms of the operations needed to make them identical. However, GED is NP-hard, so approximate solutions are preferred. We present a QUBO formulation of GED problem, which allows their implementation on quantum annealers and gate-based quantum computers. The study focuses on proof-of-principle tests of their performance.

2 - Quantum Variational Algorithms: Warm Starting, Iteration Complexity, and more
Jakub Marecek

There has been much recent interest in near-term applications of quantum computers. Variational quantum algorithms (VQA), wherein an optimization algorithm implemented on a classical computer evaluates a parametrized quantum circuit as an objective function, are a leading framework in this space. In this talk, present analyses [arXiv:2209.10615] of the iteration complexity of VQA, that is, the number of steps VQA required until the iterates satisfy a surrogate measure of optimality. We also discuss the role of warm starting [arXiv:2009.10095].

3 - Quantum computing and optimization Talk
ZoltÁn ZimborÁs

To be added

■ FC-04

Friday, 11:30 - 12:45 - 105

MO 5 - Multiobjective (mixed-)integer programming

Stream: Multiobjective optimization
Invited session
Chair: *Gabriele Eichfelder*
Chair: *Pierluigi Mansueto*

1 - A new algorithm for detecting the nondominated set of a triobjective integer program
Daniele Patria, *Marianna De Santis*

We present a criterion space algorithm for solving triobjective nonlinear integer programs. The method is guaranteed to determine the complete nondominated set of the problem relying on a specific assumption on the objective functions. More specifically, the distance between points in the image space is assumed to be bounded from below. At every iteration of the algorithm, specific biobjective integer subproblems are defined and solved using a suitable oracle. Numerical results on both linear and nonlinear instances are shown.

2 - An adaptive relaxation refinement scheme for multi-objective mixed-integer nonconvex optimization
Moritz Link, *Gabriele Eichfelder*, *Stefan Volkwein*, *Leo Warnow*

In this talk, we present a novel approach for computing an enclosure of the nondominated set of multi-objective mixed-integer nonconvex problems. Our algorithm uses information from the criterion space to guide adaptive relaxation refinement in the decision space. This procedure allows us to compute an enclosure satisfying a certain quality criterion up to a prescribed accuracy without solving any MINLPs, but only MILPs and convex NLPs. Furthermore, the adaptivity prevents the relaxations from getting unnecessarily complex. We validate the proposed scheme with numerical experiments.

3 - Branch-cut algorithms for multiobjective mixed-integer linear optimization
Akshay Gupte

We talk about some recent progress in branch-and-cut algorithms for solving multiobjective problems with both continuous and integer variables. We will describe the recent work of Adelgren and Gupte (INFORMS J. Computing, 2022) which is for two objectives since it exploits customised methods for checking dominance between bound sets that are efficiently implementable in dimension two. We will identify the challenges in scaling to higher dimensions for mixed-integer problems. To overcome some of these obstacles, we devise several cutting plane techniques, primarily in the objective space.

■ FC-05

Friday, 11:30 - 12:45 - 106

NNO 8 - Nonsmooth optimization algorithms - Part I

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Masoud Ahookhosh*

1 - Adaptive linesearch-free proximal algorithms for convex optimization under local Lipschitz continuity of the gradient
Puya Latafat, Andreas Themelis, Lorenzo Stella, Panagiotis Patrinos

Gradient-based proximal algorithms have traditionally been limited to global Lipschitz differentiability requirements. Attempts to widen their applicability or reduce conservatism typically involve wasteful trial-and-error backtracking routines. Extending recent advancements in the smooth setting, we show how for convex problems it is possible to avoid backtrackings altogether and retrieve stepsizes adaptively without function evaluations. We demonstrate this with an adaptive primal-dual three-term splitting method that includes proximal gradient as a special case.

2 - On the nonmonotone FBS algorithm for a class of infinite-dimensional nonsmooth nonconvex problems
Behzad Azmi, Marco Bernreuther

In this talk, we discuss the convergence and complexity of the nonmonotone forward-backward splitting method for solving a class of nonsmooth composite problems in Hilbert spaces. The objective function is the sum of a Fréchet differentiable (not necessarily convex) function and a lower semicontinuous convex function. These problems appear, for example, frequently in the context of optimization problems governed by nonlinear partial differential equations with nonsmooth sparsity promoting cost functionals. We will also report on numerical experiments justifying our theoretical findings.

3 - Regularized smoothing for solution mappings of convex problems, with applications to two-stage stochastic programming and some hierarchical problems
Mikhail Solodov

Many modern optimization problems involve in the objective function solution mappings or optimal-value functions of other optimization problems. Those solution mappings and value-functions are usually not known explicitly. We present a computationally practical approach to regularize and approximate those objects by combining interior penalty with Tikhonov regularization. Applications are presented to two-stage (possibly nonconvex) stochastic programming, and to a certain class of hierarchical decision problems that can be viewed as single-leader multi-follower games.

■ FC-06

Friday, 11:30 - 12:45 - 107

SCADO 5 - Semidefinite programming for combinatorics and geometry

Stream: Semidefinite and conic approaches to discrete optimization
Invited session
Chair: *Sven Polak*
Chair: *Daniel Brosch*

1 - Solving Max-Cut and QUBO Problems via Low-Rank Methods
Jan Schwiddessen, Valentin Durante

Many combinatorial optimization problems on graphs and any linearly constrained binary quadratic problem can be reformulated as a quadratic unconstrained binary optimization (QUBO) problem or an instance of the related Max-Cut problem. Therefore, finding efficient solution approaches for the latter problems is of great interest. In this talk, we present an exact solver for these problem classes which exploits recent advances in low-rank factorizations for semidefinite programming. We demonstrate that the solver outperforms other existing approaches on dense instances.

2 - The Flag Algebra of Rooted Binary Trees
Daniel Brosch, Diane Puges

While trees are usually considered sparse objects, they turn dense when considering only the leaves to be the "vertices" of a tree. In this setting one defines an (induced) subtree, given by a subset of leaves, to be the smallest tree containing these leaves, where inner vertices of degree 2 are contracted. We can then naturally extend Razborov's flag algebras to this setting, allowing the application of sums-of-squares and moment techniques to extremal questions about trees. We introduce and apply these methods to investigate the inducibility of trees and density profiles of trees.

3 - The Lasserre hierarchy for equiangular lines with a fixed angle
Willem de Muinck Keizer

The study of spherical finite distance codes is of fundamental importance in discrete geometry. It has implications in pure mathematics, e.g. for strongly regular graphs, and applied mathematics, e.g. for compressed sensing. In recent work by De Laat, De Muinck Keizer and Machado, a new bound coming from semidefinite programming is given for such codes by computing higher steps of the Lasserre hierarchy. In this talk, I would like to discuss this result. In particular, I would like to focus on the Fourier analytic methods.

■ FC-07

Friday, 11:30 - 12:45 - 108

WCA 3 - Interpolation constraints for worst-case bound computation

Stream: Worst-case analysis of iterative methods via semidefinite programming and Lyapunov stability
Invited session
Chair: *Sébastien Colla*

1 - Tight representation of classes of non convex non smooth functions
Anne Rubbens

We present a novel approach, algebraic instead of analytical, for the interpolation problem of given function classes: what necessary and sufficient conditions must a set of data satisfy to ensure the existence of a function of the class defined on the whole space and interpolating the data? Using this approach, we provide interpolation conditions for classes of non-smooth non-convex functions, allowing to tightly analyze the performance of first-order methods on these classes using the PEP framework, and to derive optimal parameters for these methods.

2 - Interpolation Conditions for Linear Operators and Applications to Performance Estimation Problems
Nizar Bousselmi, François Glineur, Julien Hendrickx

We develop a Performance Estimation Problem (PEP) representation for linear operators. We consider convex optimization problems involving linear operators, such as those whose objective functions include compositions by a linear operator or featuring linear constraints. Our goal is to identify, thanks to (PEP), the worst-case behavior of methods designed to solve such problems. We demonstrate the scope of our tool by computing several tight worst-case convergence rates, including the gradient method and the Chambolle-Pock method.

3 - Exploiting Agent Symmetries for Automatic Performance Analysis of Distributed Optimization Methods
Sébastien Colla, Julien Hendrickx

We develop a representation of the consensus steps in Performance Estimation Problem (PEP) to be used for computing automatically worst-case performance bounds of a large class of distributed optimization algorithms. These algorithms aim at minimizing the average of local functions that are distributed across a network of agents. In particular, we exploit symmetries between classes of agents to obtain a compact PEP formulation and to describe under which conditions the performance is independent of the network size.

Friday, 14:00 - 15:15

■ FD-01

Friday, 14:00 - 15:15 - C V

DFO 3 - Derivative-free methods for challenging problems

Stream: Derivative-free optimization
Invited session
Chair: *Damiano Zeffiro*

1 - Design of a cooling system for gas turbines - A DFO industrial application
Filippo Marini, Margherita Porcelli, Elisa Riccietti

In this talk we present an industrial application where Derivative Free Optimization (DFO) plays a crucial role. The problem consists in the design optimization of a jet impingement cooling system for a nozzle in a gas turbine with the aim of maximizing its efficiency. We will propose a black-box optimization model for the problem and the main features of the arising objective and constraint functions. Finally, we will show some numerical tests using DFO solvers.

2 - Mixed interior-exterior point method for non-linear black-box optimization
Andrea Brilli, Giampaolo Liuzzi, Stefano Lucidi

We consider constrained optimization problems where both the objective and constraint functions are of the black-box type. For such problems, we propose a new derivative-free optimization method which is based on the use of a merit function that handles inequality constraints by means of a log-barrier approach and equality constraints by means of an exterior penalty approach. We prove convergence of the proposed method to KKT stationary points of the problem under standard assumptions.

3 - Retraction based Direct Search Methods for Derivative Free Riemannian Optimization
Vyacheslav Kungurtsev, Francesco Rinaldi, Damiano Zeffiro

Direct search methods represent a robust and reliable class of algorithms for solving black-box optimization problems. In this talk, we explore the application of those strategies to Riemannian optimization, wherein minimization is to be performed with respect to variables restricted to lie on a manifold. More specifically, we consider classic and line search extrapolated variants of direct search, and, by making use of retractions, we devise tailored strategies for the minimization of both smooth and nonsmooth functions. We present their theoretical and practical convergence performance.

■ FD-02

Friday, 14:00 - 15:15 - C VI

MO 6 - Scalarizations in multiobjective optimization

Stream: Multiobjective optimization
Invited session
Chair: *Gabriele Eichfelder*
Chair: *Firdevs Ulus*

1 - DESDEO: the open source framework for interactive multiobjective optimization - recent advancements and future plans
Giovanni Misitano, Bhupinder Singh Saini, Bekir Afsar, Babooshka Shavazipour, Giomara Lárraga, Kaisa Miettinen

We introduce DESDEO, a modular, open source Python framework for interactive multiobjective optimization, its recent advancements, and future plans. We summarize DESDEO's structure, scalarization-based and evolutionary interactive methods it contains, and modularity advantages. As decision makers and their preferences play a central role in interactive methods, we discuss interactive visualizations and components for building user interfaces. We also exemplify benefits of having multiple methods in the same framework. Post-talk, attendees will have the know-how to apply DESDEO in their work.

2 - Polyhedral approximation of convex sets via homogenizations
Daniel Dörfler

We consider the problem of approximating not necessarily bounded convex sets by polyhedra, which arises, for instance, in the computation of approximate solutions to convex vector optimization problems. First, we formulate a notion of approximation based on a convex cone associated with a convex set called its homogenization. We show that sequences of approximations converge if the approximation error diminishes and investigate polarity relations. Finally, we present an algorithm for the computation of outer and inner polyhedral approximations for the special case of spectrahedral shadows.

3 - Speed up the Sandwiching Algorithm using reduced costs
Ina Lammel, Karl-Heinz Küfer, Philipp Süss

The Sandwiching Algorithm creates an inner and outer approximation of a bounded convex Pareto front. We introduce a method based on reduced costs that decreases the number of linear optimization problems solved to determine the approximation quality. In numerical tests this method reduces the approximation time by up to 87%. We compare the new algorithm with a similar method proposed by Doerfler et al. (2021). For the bicriteria case we show that only two linear programs must be solved in each iteration. Generally, no constant bound on the number of linear programs to be checked can be proven.

■ FD-03

Friday, 14:00 - 15:15 - 104

CONTR 3 - A bit of quantum, a bit of markets

Stream: Contributed talks
Invited session

1 - Hamming-packings vs NISQ devices
Péter Naszvadi, Mátyás Koniorczyk

With the advent of the noisy intermediate-scale quantum era, quadratic unconstrained binary optimization (QUBO) gained further attention being equivalent to the Ising model that quantum annealers can solve. In the present contribution we propose Hamming-packing problems that are well-suited for NISQ devices. These problems bear relevance in telecommunications. We have generated problem instances and compared their MILP model solved using CPLEX with a QUBO formulation solved on classical-quantum hybrid hardware. Our calculations demonstrate that latter heuristics can be useful in this context.

2 - Sustainability Cost on a Multi-periodic Game with Incomplete Information under Cap-and-Trade Policy
Mahnaz Fakhrabadi, Leif Sandal

This paper investigates the impact of Cap and Trade on a supply chain problem. This channel consists of a manufacturer and a retailer playing under the Stackelberg game. In our market, the demand for a perishable commodity is stochastic and dynamic as a function of price with incomplete information. This market does not forget the previous periods' prices and tracks their impact on the next periods' demands with a scaling factor. To increase fairness, our manufacturer offers a non-negative buy-back value at each period for the leftovers. This transfers part of the risk to the manufacturer.

3 - Portfolio Optimization for Genetic Selection
Josh Fogg, Julian Hall

Markowitz' Critical Line Algorithm (1956) was developed to explore the Pareto frontier of continuous, bi-objective optimization problems. The context was constructing financial portfolios, where investors seek to balance risk and return. To this day, CLA remains a cornerstone of contemporary portfolio theory.

We showcase a CLA-like algorithm which solves a similar problem arising in genetics, in the context of selective breeding. There we seek to maximize genetic merit while minimizing inbreeding and its associated risks. The data is high dimensional, sparse, and has exploitable structure.

■ FD-04

Friday, 14:00 - 15:15 - 105

OVIUM 6 - Subdifferential, optimality, and penalization

Stream: Optimization, variational inequalities and uncertainty models
Invited session
Chair: *Marius Durea*

1 - Generalized differentiation and optimality conditions in set optimization
Elena-Andreea Florea, Marius Durea

In this talk, in the framework of set optimization problems, we investigate some solutions concepts as well as a number of associated penalization procedures and optimality conditions. For the latter issue, we discuss several appropriated generalized differentiation concepts on primal and dual spaces from the perspective of calculus rules they enjoy and their compatibility and/or similarities with known constructions widely used in the settings of scalar and vector optimization problems.

2 - Penalisation in vector optimization
Paul Schmölling

Often constrained problems are harder to solve than unconstrained ones. In vector optimisation the fact that the objective function is vector valued can be used for a penalisation approach, which in combination with generalised cone-convexity concepts gives rise to a characterisation of the solutions of the constrained problem in terms of unconstrained ones.

3 - Subdifferential calculus for set-valued mappings with applications in set optimization
Radu Strugariu

We explore some calculus rules for the Frechet and limiting type subdifferentials, constructed for general set-valued mappings, with the aim of formulating optimality conditions in set optimization.

■ FD-05

Friday, 14:00 - 15:15 - 106

NNO 9 - Nonsmooth optimization algorithms - Part II

Stream: Nonsmooth and nonconvex optimization
Invited session
Chair: *Moslem Zamani*

1 - Coordinate descent for SLOPE
Mathurin Massias

Sorted L-One Penalized Estimation (SLOPE) is a generalization of the lasso with appealing statistical properties. Yet, it has not yet reached widespread interest because current SLOPE solvers rely on algorithms that perform poorly in high dimensions. We propose a new fast algorithm to solve the SLOPE optimization problem, which combines proximal gradient descent and proximal coordinate descent steps. We provide new results on the directional derivative of the SLOPE penalty and its related SLOPE thresholding operator, as well as provide convergence guarantees for our proposed solver.

2 - Linearization Algorithms for Fully Composite Optimization
Maria-Luiza Vladarean, Nikita Doikov, Martin Jaggi, Nicolas Flammarion

This paper studies first-order algorithms for solving fully composite optimization problems over convex and compact sets. We leverage the structure of the objective by handling its differentiable and non-differentiable components separately, linearizing only the smooth parts. This provides us with new generalizations of the classical Frank-Wolfe method and the Conditional Gradient Sliding algorithm, that are applicable to a subclass of non-differentiable problems. We prove global complexity bounds for our algorithms that are optimal in several settings.

3 - Operator Splitting Based Newton-type Method for Constrained Optimization
Titus Pinta

We present a super linearly convergent Newton-type method for solving constrained optimization problems. The algorithm is constructed based on operator splitting, by iteratively taking a Newton step for the minimization problem, followed by a Newton-type step for imposing the constrains. Both smooth and semismooth, equality and inequality constrains and smooth and semismooth objectives can be handled. The analysis of the convergence rate is done by employing a general framework, centered around a generalization of semismoothness called Newton differentiability, that can yield convergence rate

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■ FD-06

Friday, 14:00 - 15:15 - 107

SCADO 6 - Semidefinite and conic optimization

Stream: Semidefinite and conic approaches to discrete optimization
Invited session
Chair: *Etienne De Klerk*

1 - Exploiting sparsity in polynomial optimization for water networks.
Olga Kuryatnikova, Bissan Ghaddar

In this work we exploit sparsity in the valve setting problem for water networks. The valve setting problem consists of many small subproblems involving few variables and monomials and connected with sparse linking constraints. Thus the problem exhibits both correlative and term sparsity. We analyze the performance of existing polynomial optimization relaxations and suggest a new simple relaxation that uses both types of sparsity to reach a trade-off between the bound quality and running times. We report numerical results on four water networks ranging in size from 4 to 2000 nodes.

2 - Rational polyhedral outer-approximations of the second-order cone
Burak Kocuk

It is well-known that the second-order cone can be outer-approximated to an arbitrary accuracy by a polyhedral cone of compact size defined by irrational data. In this work, we propose two rational polyhedral outer-approximations of compact size retaining the same guaranteed accuracy with different properties. We also discuss two theoretical applications in which having a rational polyhedral outer-approximation is crucial, and run some experiments which explore the benefits of the formulations proposed in this paper from a computational perspective.

3 - SDP approaches for best polynomial approximation problems
Etienne De Klerk

A classical problem in approximation theory is to find a polynomial of given degree that gives the best uniform approximation to a given function f. It is known that this problem allows a reformulation as a generalized moment problem (GMP). The GMP may in turn be solved using SDP hierarchies as introduced by Lasserre, if f is a polynomial. In this talk we show how this machinery may be used to generalize the univariate Chebyshev polynomials to the multivariate case (in small dimension). This is joint work with Mareike Dressler, Simon Foucart, Mioara Joldes, Jean-Bernard Lasserre, and Yuan Xu.

■ FD-07

Friday, 14:00 - 15:15 - 108

OM 4 - Equilibrium problems on manifolds

Stream: Optimization on manifolds
Invited session
Chair: *Orizon P Ferreira*

1 - A new regularization of equilibrium problems on Hadamard manifolds via Busemann function
João Xavier da Cruz Neto, Glaydston Bento, Italo Melo, Jurandir Oliveira, Pedro Rodrigues

We introduce a new proximal algorithm for equilibrium problems on a genuine Hadamard manifold, using the Busemann function to generate a new regularization. Under the hypothesis of equilibrium bifunction being monotone and convex in the second variable, we show that the generated sequence converges to an equilibrium point, if it exists.

2 - Finding Nash-Stampacchia equilibrium points of Hirschleifer games on Hadamard manifolds using numerical algorithms.
Boróka Oltean-Peter

This paper discusses the problem of finding Nash-Stampacchia equilibrium points of Hirschleifer games on Hadamard manifolds using numerical algorithms. Nash equilibrium points are a subset of Nash-Stampacchia equilibrium points, which can be obtained as solutions of variational inequalities. These inequalities correspond to critical points of the payoff functions. Various numerical algorithms have been studied to find these critical points. The Nelder Mead algorithm is found to be the best option because it does not require gradients. This paper provides a detailed analysis of the results.

3 - Gradient projection method on the sphere, complementarity problems and copositivity
Orizon P Ferreira, Yingchao Gao, Sándor Zoltán Németh, Petra Renáta Rigó

For addressing constrained problems on the sphere in Euclidean spaces, we study the gradient projection method. For a general spherically convex set the convergence analysis of the method is presented. By applying this algorithm, we test copositivity of operators with respect to general cones. This approach can also be used to analyze solvability of nonlinear cone-complementarity problems. Numerical results, including testing such copositivity of operators, with respect to the nonnegative orthant, Lorentz cone and the positive semidefinite cone are presented.

Friday, 15:20 - 16:20

■ FE-01

Friday, 15:20 - 16:20 - C V

Plenary III

Stream: Plenaries
Invited session
Chair: *Tibor Illés*

1 - An Algorithm for Maximizing a Convex Function Based on its Minimum, and Beyond.
Aharon Ben-Tal

The COMAX algorithm for maximizing a convex function over a convex feasible set is proposed. The algorithm consists of two phases: in phase 1 a feasible starting point is obtained that is used in a Gradient Descent algorithm in phase 2. The main contribution of the paper is connected to phase 1; five different methods are used to approximate the original NP-hard problem of maximizing a convex function (MCF) by a tractable convex optimization problem. All the methods use the minimizer of the convex objective function in their construction.

Friday, 16:30 - 17:00

■ FF-01

Friday, 16:30 - 17:00 - C V

Closing

Stream: Plenaries
Invited session
Chair: *Tibor Illés*
Chair: *Tamás Terlaky*
Chair: *Giancarlo Bigi*

Algorithms for nonconvex optimization

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Track(s): 5

Complementarity problems, variational inequalities and equilibria

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Track(s): 1 3

Contributed talks

Track(s): 3 4

Derivative-free optimization

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Track(s): 1 2 4

FICO presentation

Track(s): 2

First-order optimization methods

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Track(s): 1 6

Game theory

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Track(s): 2 4

Global optimization

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Track(s): 2 4

High-order methods in convex optimization

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Track(s): 4

Interior-point algorithms

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Track(s): 1 7

Multiobjective optimization

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Track(s): 2 4

Nonsmooth and nonconvex optimization

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Track(s): 1 5

Optimal and stochastic optimal control and games

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Track(s): 7

Optimization for machine learning

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Track(s): 1 4

Optimization on manifolds

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Track(s): 5 7

Optimization, variational inequalities and uncertainty models

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Track(s): 1 3 4

P-graphs and mixed-integer programming

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Track(s): 6

Plenaries

Track(s): 1

Quantum computing optimization

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Track(s): 1 3 7

Semidefinite and conic approaches to discrete optimization

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Etienne De Klerk
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Track(s): 6

Worst-case analysis of iterative methods via semidefinite programming and Lyapunov stability

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Adrien Taylor
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Track(s): 6 7

Session Chair Index

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