Wednesday, 8:30-10:00

■ WA-01

Wednesday, 8:30-10:00 - Room: Lecture room 16

Opening and Plenary Martin Schmidt

Stream: Plenaries
Plenary session
Chair: *Markus Sinnl*
Chair: *Sophie Parragh*

1 - Nonlinear Flows Meet Bilevel and Robust Optimization
Martin Schmidt

In this talk, we study two network optimization problems with nonlinear flow models.

First, we consider network flow interdiction problems formulated as max-min bilevel programs with a nonlinear, nonconvex follower problem. The leader attacks a limited number of arcs to maximize load shedding, while the follower minimizes it by solving a transport problem on the disrupted network. We develop an exact algorithm based on upper and lower bounding schemes that computes an optimal interdiction, assuming the network remains weakly connected. Numerical results demonstrate the approach on gas networks.

Second, we address network design under demand uncertainty for nonlinear, nonconvex flow models. Using adjustable robust optimization, we compute designs that ensure feasible transport for all demand scenarios within a given uncertainty set. We show that a design is robust feasible if and only if a finite set of worst-case scenarios can be routed through the network. These scenarios are obtained by solving polynomially many nonlinear optimization problems. Embedding this result in an adversarial framework yields an exact algorithm that computes an optimal robust network design in finitely many iterations. We again illustrate the method on gas network applications.

Wednesday, 10:30-12:30

■ WB-01

Wednesday, 10:30-12:30 - Room: Lecture room 16

Recent Developments in Derivative-Free Optimization: Methods and Applications

Stream: Theory and practice of zeroth and first-order methods
Invited session
Chair: *Francesco Rinaldi*

1 - Hybrid Neural-Quadratic Model-Based Derivative-Free Optimization
Stefan M. Wild

Quadratic models are popular choices in model-based DFO because they can capture local nonlinearities while remaining amenable to efficient trust-region subproblem solution. Neural network models, by contrast, excel at capturing more global, higher-order nonlinearity. In this talk we attempt to get the best of both worlds through a new hybrid surrogate framework for expensive DFO that integrates neural network regression and classical quadratic models within a unified trust-region methodology. Key to our framework is adaptive model selection. Numerical results on benchmark test sets show that model switching is essential — different surrogates dominate at different stages — and that their combination yields consistently better performance than any fixed surrogate choice. This is joint work with Pengcheng Xie.

2 - New perspectives on trust-region method with inaccurate gradient information
Zaikun Zhang

We analyse the behaviour of trust-region method with inaccurate gradient information, including its global convergence and convergence rate. We present the admissible region of inaccurate gradients, so that the method behaves essentially the same as if the gradients are accurate. We discuss how the algorithmic parameters affect this region in both deterministic and stochastic cases.

3 - Zeroth Order Proximal-Point Operator
Cesare Molinari

The proximal operator is a fundamental tool in optimization, particularly valuable for developing fixed-point algorithms to minimize composite and non-differentiable functions. Recently, an approximation of the proximal operator — often referred to as the Zero-Order Proximal Operator (ZOPO) — was introduced based on a perturbed Hamilton-Jacobi equation. By construction, ZOPO recovers the exact proximal operator in the limit $delta to 0$ and can be naturally approximated via Monte Carlo sampling. The connection to the exact operator has sparked considerable interest, leading to further research on the approximation properties of ZOPO and the development of methods that leverage the low $delta$ regime. Our study is motivated by the observation that small values of $delta$ result in a significantly more complex target distribution to sample from, rendering the process computationally prohibitive. If $delta$ is too small, Monte Carlo approximations of ZOPO become extremely inaccurate unless an impractically large number of samples is drawn. Because the resulting estimate is a convex combination of samples drawn from $mathcalN(x, lambdadelta I)$, a vanishing $delta$ shrinks the variance of the sampling distribution, severely limiting the exploration of the space and deteriorating the quality of the approximation. In this work, we investigate the high-temperature regime of ZOPO, where the parameter $delta$ is fixed at a constant strictly bounded away from 0.

4 - A Direct Search approach for the Technology Diffusion Problem
Matteo Bergamaschi, Marta Pozzi, Francesco Rinaldi, Laura Sanità

The Technology Diffusion Problem (TDP) is a fundamental optimization problem on graphs, with applications ranging from innovation spread in social networks to information propagation in complex systems. Given its combinatorial nature, TDP poses significant computational challenges, especially on large-scale graphs. Currently, beyond heuristic approaches, IP formulations can provide good approximate solutions, but they often lack scalability. In this talk, we introduce two complementary contributions. First, we propose a new exact IP formulation that strengthens the theoretical modeling of the problem. Second, we present a practical direct search approach designed to efficiently tackle large-scale graphs, producing high-quality approximate solutions within reasonable computational time.

■ WB-02

Wednesday, 10:30-12:30 - Room: Lecture room 15

Advanced topics in optimization and learning 1

Stream: Optimization for Machine Learning and Statistics
Invited session
Chair: *Marco Viola*

1 - Linear convergence of Bregman first-order methods: theoretical insights
Jonathan Chirinos Rodriguez, Christian Daniele, Cédric Févotte, Emmanuel Soubies

Over the past few decades, first-order methods have been central to continuous optimization due to their computational efficiency and high accuracy across a broad class of tasks. From a theoretical standpoint, strong convexity is the standard condition required to guarantee linear convergence rates. However, recent extensions such as Kurdyka–L ojasiewicz-type, or quadratic gradient growth conditions, have proven sufficient to achieve the same results. More recently, it was observed that standard methods do not always exploit the underlying geometry of the objective function. Bregman proximal gradient methods (BPGM) aim to tackle precisely this issue; by carefully choosing a mirror function, one can construct a better-adapted iterative procedure. However, linear convergence rates within this framework remain somewhat underexplored. In this talk, we address the following natural questions: Is there a notion of strong convexity in this setting that ensures linear convergence for BPGMs? Furthermore, can such a condition be relaxed in the same way as in classical proximal gradient methods? To answer this, we introduce a novel notion of strong convexity within the context of BPGM that rigorously establishes linear convergence rates. To conclude, we introduce the utility of our framework within the context of Poisson inverse problems. This presentation is linked to a companion talk given by C. Daniele within the stream 'Theory and practice of zeroth and first-order methods'.

2 - Score matching meets Moreau
Florian Thaler, Thomas Knoll, Andreas Habring, Thomas Pock

In this work we propose and investigate an approach to learning energy based models that combines ideas from from diffusion models and bilevel learning. Whereas diffusion models typically learn time-dependent scores of the data distribution without direct access to an energy, we instead learn a time-independent energy function. Approximating the diffusion equation with the Hamilton-Jacobi equation naturally yields the Moreau envelope. Adapting the well known denoising score matching objective to this setting leads to a bilevel problem, which we tackle using implicit differentation and an unrolling scheme. We provide analytical insights into the method and assess its performance across diverse toy examples, including standard 2D Gaussian mixtures and standard image benchmarks.

3 - Characterizations of inexact proximal operators
Guillaume Lauga, Samuel Vaiter

Proximal operators are now ubiquitous in non-smooth optimization. Since their introduction in the seminal work of Moreau, many papers have shown their effectiveness on a wide variety of problems, culminating in their use to construct convergent deep learning methods. The characterization of these operators for non-convex penalties was completed recently in [Gribonval et al., "A characterization of proximity operators", 2020]. In this presentation, we propose to follow this line of work by characterizing inexact proximal operators, thus providing an answer to what constitutes a good approximation of these operators.

Equipped with these characterizations, we investigate the convergence of proximal point, forward-backward, and Douglas-Rachford algorithms in the presence of errors that may be non-summable and/or non-vanishing, which is a scarcely studied point of view in the inexact literature.

4 - Variable-Metric Proximal Method for Stochastic Optimization
Ilaria Trombini, Nataša Krklec Jerinkić, Federica Porta, Valeria Ruggiero

Many optimization problems arising in machine learning can be formulated as the minimization of the sum of two functions: a smooth term representing the expected risk, typically approximated in practice by the empirical risk, and a second term encoding prior information on the solution. In this framework, proximal gradient techniques provide an effective approach for dealing with composite optimization problems.

In this work, we introduce a variable-metric proximal method for stochastic optimization. The proposed approach combines three main ingredients: a variable metric that adapts the geometry of the search space, a stochastic line search procedure that ensures suitable decrease properties, and an incremental mini-batch strategy based on additional sampling. This combination allows the method to progressively improve the accuracy of the stochastic gradient estimates while maintaining computational efficiency.

We establish convergence results for the proposed scheme under different assumptions on the objective function. In particular, the analysis does not require the differentiable component of the objective to have a Lipschitz continuous gradient. Moreover, we discuss possible strategies for the automatic selection of the algorithmic parameters.

Finally, numerical experiments on binary classification problems illustrate the effectiveness of the proposed method and show competitive performance with respect to several state-of-the-art algorithms.

■ WB-03

Wednesday, 10:30-12:30 - Room: Lecture room 17

Structured nonsmooth optimization 1

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

1 - Nonsmooth Exact Penalty Methods
Maxence Gollier, Youssef Diouane, Dominique Orban

Penalty methods are a well known class of algorithms for constrained optimization. They transform a constrained problem into a sequence of unconstrained penalized problems in the hope that approximate solutions of the latter converge to a solution of the former. If Lagrange multipliers exist, exact penalty methods ensure that the penalty parameter only need increase a finite number of times, but are typically scorned in smooth optimization for the penalized problems are not smooth. This led researchers to consider the implementation of exact penalty methods inconvenient. Recent advances in proximal methods have led to increasingly efficient solvers for nonsmooth optimization. We study a general exact penalty algorithm and use it to show that the exact L2-penalty method for equality-constrained optimization can, in fact, be implemented efficiently by solving the penalized problem using a proximal-type algorithm.

2 - Clustering Large Datasets Using Nonsmooth Optimization: The Clust-Splitter Algorithm
Jenni Lampainen, Kaisa Joki, Napsu Karmitsa, Marko M. Mäkelä

Clustering is a fundamental task in data mining and machine learning, where the aim is to group data points into clusters based on their similarity. The recent growth of data and improvements in computer hardware have made it possible to store and process massive datasets containing millions of data points and attributes. While this development makes large-scale clustering both feasible and essential, it also introduces significant challenges. Many existing algorithms either converge to suboptimal solutions, such as local minima, or require excessive computational resources. Therefore, there is a significant need for clustering methods that can produce accurate results within a reasonable time on very large datasets.

This talk presents a novel incremental clustering method, Clust-Splitter, for large-scale minimum sum-of-squares clustering problems. The method is based on a nonsmooth optimization approach, where the number of variables depends only on the number of clusters and attributes. Especially for large datasets, this is a significant advantage compared to commonly used mixed-integer formulations, where the number of variables also depends on the number of data points. The method also incorporates a new data splitting strategy to generate effective starting points. Numerical results show that Clust-Splitter frequently reaches the best-known solution in reasonable time and is particularly suitable for large-scale datasets.

3 - Duality on DC problems via c-conjugation
Maria Dolores Fajardo, Jose Vidal-Nunez

In this talk we establish the concept of a DC optimzation problem and how they are approached using standard conjugate duality. In the spirit of using a generalized conjugation scheme, we present the class of evenly convex functions and how this broader duality scheme allows us to define characteristic sets to get not only sufficient but also necessary conditions for duality in the case of a primal DC problem and two different duals.

4 - Lagrange duality on DC optimization
Jose Vidal-Nunez, Maria Dolores Fajardo

This talk is a follow-up of the previous talk entitled "Duality on DC problems via c-conjugation". While the former is concentrated on standard Fenchel and Lagrange dualities, this second presentation deals with a different perpective of Lagrange duality reaching to a new dual problem in DC programming. Finally, we present duality results for this new dual problem and a standard DC primal making use of the c-conjugation scheme.

■ WB-04

Wednesday, 10:30-12:30 - Room: Seminar room MZ 003B

Adaptive robust optimization

Stream: Optimization under uncertainty
Invited session
Chair: *Markus Gabl*

1 - Copositive optimization techniques in (adjustable) robust optimization
Markus Gabl, Immanuel Bomze

Copositive Optimization (COP) aims at providing convex conic reformulations of nonconvex all-quadratic optimization problems. Adjustable Robust Optimization (ARO) aims to optimize under uncertainty in a two-stage setting, ensuring that the solution achieves optimal worst-case performance, is feasible under any circumstance, and may partially adapt to the realization of the uncertain data in the second stage. While ARO problems cannot be solved directly and must be tackled via tractable reformulations, many instances exhibit structures that enable the application of COP techniques. In this talk, we review existing approaches, discuss open questions, and present recent advances in this area.

2 - Copositive approach to adjustable robust optimization with inexact decision rules
Johannes Zischg, Markus Gabl

Copositive optimization deals with convex reformulations of non- convex quadratic optimization problems. Adjustable robust optimization (ARO) deals with two-stage optimization problems under uncertainty, where we look for a first-stage decision such that the second-stage response to the realiza- tion optimizes the worst-case performance overall. Xu and Burer exploited a quadratic reformulation of ARO problems with uncertain right-hand sides and provided an exact copositive reformulation, while de Reuter et al. proposed an extension of ARO with inexact decision rule, introducing second-stage uncer- tainty. In this work, we seek to extend the Xu/Burer reformulation to the latter setting, adapting a recently proposed algorithm by Anstreicher and Gabl, which contains a copositivity test as a core component. Potential benefits include the ability to handle a larger family of second-stage uncertainty sets (for example, mixed integer uncertainty sets), since all the difficulty can be deferred to the copositivity test.

3 - Cardinality-Constrained Portfolio Optimization under Estimation Uncertainty
Bo Peng, Immanuel Bomze, Yuan Chen

In large-scale portfolio optimization, covariance matrix estimators are subject to significant estimation error, which degrades out-of-sample performance. We address this issue by formulating the asset allocation problem as a cardinality-constrained mean-variance model. By imposing an exact cardinality constraint ($||w||_0le s$) on the portfolio weights, the model mitigates estimation risk in high-dimensional settings without the need for penalty terms in the objective function.

To solve this NP-hard problem to global optimality, we propose a branch-and-bound algorithm based on a hierarchy of conic relaxations. We reformulate the sparsity constraint using continuous complementarity and apply doubly nonnegative and semidefinite programming (SDP) relaxations to obtain strong lower bounds. To balance bound tightness and computational cost, the algorithm dynamically selects the relaxation at each node: it evaluates the spectral spread of the local objective Hessian and switches to a more scalable, compact SDP approximation when the matrix is ill-conditioned. Additionally, the search employs an adaptive node-selection strategy that alternates between best-bound and best-incumbent rules based on the progress of the upper and lower bounds.

4 - On selecting good robust optimal solutions
Ralf Werner, Korbinian Hirschmüller

In 2014, Iancu and Trichakis introduced the concept of Pareto efficiency in linear robust optimization. In this presentation, we give a fresh look on this concept and some related new ideas. Specifically, we consider the novel related concept of regret efficient solutions of linear robust optimization problems.

■ WB-05

Wednesday, 10:30-12:30 - Room: Seminar room MZ 003A

SDP, SOCP & QP

Stream: Conic Optimization
Invited session
Chair: *Elisabeth Gaar*

1 - Computing cuts in graphs: Homory-Hu tree and the Sparsest Cut problem
Vladimir Kolmogorov

I will consider two classical problems in combinatorial optimization for undirected weighted graphs. The first one is to compute a Gomory-Hu tree, which is a data structure representing minimum s-t cuts for all pairs s,t. I will present a new algorithmic approach based on a reduction to the problem that I call "OrderedCuts". I will discuss its theoretical properties and show some experimental results, which indicate that the new approach is among current state-of-the-art GH tree construction algorithms.

The second problem is to compute the Sparsest Cut, i.e. cut (S,T) that minimizes the ratio $cost(S,T) / min(|S|,|T|)$. The best known algorithm for this NP-hard problem is due to [Sherman'09], which computes $O(sqrtlog n)$-approximation using $O(nvarepsilon)$ maxflow computations. I will present an alternative approach which simplifies Sherman's algorithm and also allows parallelization: it gives the same approximation using $O(polylog(n))$ maxflows on $O(nvarepsilon)$ processors. I will also show that a similar approach works for the minimum Balanced Vertex Separator problem. (The latter is a joint work with Jack Spalding-Jamieson).

2 - A single loop method for quadratic minmax optimization
Stefano Cipolla, Oliver Stein, Alain Zemkoho

We consider a quadratic minmax problem with coupled inner constraints and propose a method to compute a class of stationary points. To motivate the need to compute such stationary points, we first show that they are meaningful, in the sense that they can be locally optimal for our problem under suitable linear independence and second-order conditions. Then, based on a suitable log barrier function, we build an infeasible interior point-type single loop method (which does not explicitly distinguish between the outer and inner problem) and prove that a non-degenerate stationary point is an attraction point as the algorithm moves along the designed central path. We show in particular that our method is polynomial in the special case where the inner feasible set of our constrained minmax problem is independent of the outer variables. Our numerical experiments, on both synthetic data and a class of min cost flow problems, showcase the behaviour of our method and how it outperforms existing algorithms from the literature in terms of the quality of the computed stationary points [1].

[1] S.Cipolla, O. Stein, A. Zemkoho, A single loop method for quadratic minmax optimization, Preprint at Optimization Online: https://optimization-online.org/?p=33225

3 - The bi-objective single-row facility layout problem
Christof Brandstetter, Elisabeth Gaar, Markus Sinnl

In this work, we present a bi-objective extension of the well-known single-row facility layout problem (SRFLP). In the SRFLP, a set of one-dimensional facilities must be arranged in a single row, such that the weighted sum of the center-to-center distances of each distinct pair of facilities is minimized. For our bi-objective extension, we introduce an additional such weighted sum objective and want to obtain the set of Pareto optimal points using the epsilon-constraint method. As it is known that using semi-definite programming (SDP) relaxation is more effective in solving the SRFLP than integer programming (IP), we present a custom SDP-based branch-and-bound algorithm to solve each iteration of the epsilon-constraint method. This is in contrast to many works on the epsilon-constraint method, which use a black-box IP solver to solve each iteration of the epsilon-constraint method. This allows us to propose several enhancement procedures for our epsilon-constraint approach, such as i) multiple branching strategies, including non-binary branching, ii) variable fixing, iii) problem reduction, iv) re-using of branch-and-bound trees, and v) solution pooling.

4 - Tackling Stable Set with a new Exact-Subgraph-Based Hierarchy
Elisabeth Gaar

One of several hierarchies towards the stability number of a graph is the exact subgraph hierarchy (ESH). On the first level it computes the Lovász theta function as semidefinite program (SDP) with a matrix variable of order n+1 and n+m+1 constraints. On the k-th level it adds all exact subgraph constraints for subgraphs of order k to the SDP.

We introduce the compressed ESH (CESH), a variant of the ESH that computes the Lovász theta function through a smaller SDP, which seems favorable. Furthermore, we investiage scaled ESCs (SESCs), which are a more natural way to represent exactness for the CESH. We present both computational and theoretical findings for the CESH and SECSs.

■ WB-06

Wednesday, 10:30-12:30 - Room: Seminar room MZ 201B

Nonsmooth, Weakly Convex, and Variational Optimization

Stream: Difference-of-convex decompositions and structured nonconvex optimization
Invited session
Chair: *Yassine Laguel*

1 - Optimiality conditions beyond KKT in non smooth optimization
Kuntal Som, Joydeep Dutta, D. Thirumulanathan

In this talk, I will introduce the Approximate Karush-Kuhn-Tucker (AKKT) conditions for differentiable optimization problems and explain in detail how they serve as a necessary condition for optimality, even in situations where the well-known constraint qualifications are not satisfied by the constrained optimization problem. I will further introduce the U-condition and discuss its crucial role in establishing a connection between AKKT sequences and standard Karush-Kuhn-Tucker (KKT) points, thereby providing a bridge between two optimality conditions.

In the second part of the talk, I will describe our recent work, where we attempt to generalize the U-condition to non-smooth optimization settings, covering both convex problems and problems involving locally Lipschitz continuous functions. By employing tools from convex analysis and the calculus of Clarke's subdifferential, we rigorously investigate how the known results for the differentiable case can be extended to the non-differentiable setting. Our results provide new insights into optimality conditions for non smooth optimization problems.

2 - Subgradient Splitting Methods for Nonsmooth Fractional Programming with Fixed-Point Constraints

Nimit Nimana, Mootta Prangprakhon

We consider a class of nonsmooth fractional programming problems with fixed-point constraints, where the numerator is convex and the denominator is concave. To solve this problem, we propose splitting algorithms that compute subgradient steps separately for the convex numerator and the concave denominator. These methods offer a straightforward approach by eliminating the need to solve subproblems at each iteration. By leveraging fixed-point constraints, the proposed algorithms are particularly well-suited for problems with complex constraint structures. Under certain assumptions, we establish the convergence of the proposed methods. Furthermore, to address large-scale optimization, we propose an incremental subgradient algorithm for a class of nonsmooth sum-of-ratios fractional programming problems and analyze its convergence. Finally, we present numerical experiments, including comparative analyses of our algorithms with existing methods, to demonstrate the effectiveness and performance of the proposed approach.

3 - An Inexact Line-Search Forward-Backward Method for Weakly Convex Regularizers

Cristiano Parenti, Silvia Bonettini, Marco Prato

In imaging inverse problems, weakly convex regularizers have emerged as a powerful tool to bridge the gap between the expressive power of non-convex models and the theoretical guarantees of convex optimization. However, computing the proximal operator for these regularizers is often intractable and prior knowledge of the data-fidelity term's Lipschitz constant is regularly required. We propose a novel inexact Forward-Backward method equipped with an Armijo-type line search, designed for optimizing the sum of a smooth function and a weakly convex one. By shifting the concave component of the regularizer into the smooth objective part, we evaluate the proximal step via Fenchel duality as a strongly convex dual subproblem. We specifically apply this versatile framework to a Plug-and-Play (PnP) method employing a gradient-step denoiser. In this setting, the gradient of the inner dual subproblem is conveniently evaluated directly through the denoiser itself. Our method allows for unconstrained regularization parameters, handles non-convex data-fidelity terms, and avoids the need to estimate Lipschitz constants. The inner inexactness is adaptively controlled to guarantee descent, ensuring convergence to a stationary point via the Kurdyka-Łojasiewicz property. Experiments on image deblurring with Gaussian and Cauchy noise demonstrate its competitiveness with state-of-the-art PnP algorithms. This is a joint work with Professors Silvia Bonettini and Marco Prato.

4 - Structured Nonconvex Regularization for Inverse Problems: A Star-Geometric Perspective

Oscar Leong

A central question in inverse problems is how to choose regularizers that are both well-matched to the data and amenable to optimization. In this talk, I will discuss a geometric and algorithmic perspective on this question. First, I will describe a framework exploiting star geometry for optimal regularizer selection, in which positively homogeneous regularizers are identified with star bodies and the data distribution induces a "summary statistic" that determines the optimal regularizer. This viewpoint also yields conditions under which the optimal regularizer is convex.

Motivated by the fact that optimal regularizers are often nonconvex, I will then discuss recent work on learning difference-of-convex (DC) regularizers for inverse problems. Our results give geometric conditions under which optimal star-body regularizers admit DC structure, and they lead to convergent algorithms for variational reconstruction that exploit the learned DC structure. I will illustrate these ideas with applications to computed tomography reconstruction

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■ WB-07

Wednesday, 10:30-12:30 - Room: Seminar room MZ 112B

Recent developements in forward-backward algorithms

Stream: Splitting algorithms
Invited session
Chair: *Francisco Javier Aragón Artacho*

1 - Splitting the forward-backward algorithm: A full characterization

Emanuele Naldi, Anton Åkerman, Enis Chenchene, Pontus Giselsson

We introduce a general extension of the forward-backward splitting method for monotone inclusion problems involving sums of multiple maximal monotone operators together with cocoercive operators. Our framework unifies and strictly generalizes many existing minimal-lifting splitting schemes and, crucially, fully characterizes the class of frugal forward-backward-type methods (with minimal lifting and averaged nonexpansiveness). This added flexibility enables distributed implementations over arbitrary network architectures and allows heterogeneous cocoercivity constants, permitting the use of larger, more adaptive local step sizes, that can accelerate convergence. Because such flexibility raises nontrivial tuning questions, we develop both theoretical guidance and systematic heuristics for selecting the involved matrices and parameters, and we validate these choices through experiments. Across centralized and decentralized settings, the resulting methods show competitive and improved performance, while turning the design of frugal, minimal-memory splitting schemes into a principled and practical recipe.

2 - A relaxed and inertial nonlinear forward-backward algorithm

Juan Jose Maulen Muñoz

In this talk, we study inertial and relaxation extensions of the nonlinear forward-backward algorithm, a general splitting framework that encompasses several widely used methods in convex optimization and monotone operator theory. The approach provides a unified perspective that includes classical schemes such as forward-backward, forward-backward-forward, and various primal-dual algorithms as particular cases.

We analyze a relaxed and inertial version of this framework and establish weak convergence results under mild assumptions. In addition, we derive linear convergence guarantees in the presence of strong monotonicity. Our analysis recovers known convergence results for several existing algorithms and extends them to the proposed inertial and relaxed setting.

3 - Forward-backward and backward-forward splitting for nonmonotone problems

Brecht Evens, Puya Latafat, Panagiotis Patrinos

In this talk, we study the relaxed forward-backward splitting method for finding a zero of a sum of two operators, as well as the associated backward-forward method. While classical results require monotonicity of the backward operator and cocoercivity of the forward operator, we establish convergence under significantly weaker, pointwise assumptions. Our framework covers a broader class of operators and, even in settings where convergence is already known, provides novel stepsize guarantees. Notably, our analysis recovers known convergence results for the relaxed proximal point algorithm in the weak Minty setting as a limit case by setting the forward operator to zero.

4 - Projected Gradient Methods with Momentum
Diego Scuppa, Matteo Lapucci, Giampaolo Liuzzi, Stefano Lucidi, Marco Sciandrone

We focus on the optimization problem with smooth, possibly nonconvex objectives and a convex constraint set for which the Euclidean projection operation is practically available. Focusing on this setting, we carry out a general convergence and complexity analysis for algorithmic frameworks. Consequently, we discuss theoretically sound strategies to integrate momentum information within classical projected gradient type algorithms. One of these approaches is then developed in detail, up to the definition of a tailored algorithm with both theoretical guarantees and reasonable per-iteration cost. The proposed method is finally shown to outperform the standard (spectral) projected gradient method in two different experimental benchmarks, indicating that the addition of momentum terms is as beneficial in the constrained setting as it is in the unconstrained scenario. [https://arxiv.org/abs/2601.16683]

■ WB-08

Wednesday, 10:30-12:30 - Room: Seminar room MZ 102A

Topology optimization

Stream: Shape and topology optimization
Invited session
Chair: *Peter Gangl*

1 - Mitigating AC losses in electrical machines with topology optimization
Théodore Cherrière

In high-speed electrical motors, currents induced in the stator conductors cause additional losses known as "AC losses". This issue is critical when using Halbach permanent-magnet rotors in aeronautics.

The induced currents depend strongly on the conductors' cross-sectional shape and location. Thanks to recent advances in additive manufacturing, various conductor shapes can now be considered, but conventional engineering methods based on parametric optimization cannot explore this diversity.

The present work proposes a design optimization approach based on density topology optimization. The distribution of currents within the conductors is computed using a constrained magneto-harmonic model based on Maxwell equations, discretized with the finite element method. Various tricks are used to speed up the computation of the forward model. Then, high-resolution design optimization is performed within a stator slot, using sensitivities computed with the adjoint method.

Several approaches with different levels of freedom are compared within the same global framework: optimization of a homogeneous conductivity over the whole coil, then over each wire independently, and finally full topology optimization of each wire. Results demonstrate a significant decrease in total copper losses with topology optimization compared to the other methods, with no additional computation time.

2 - Towards topology optimization of printed circuit boards
Thomas Gauthey, Théodore Cherrière

This talk proposes a few contributions to the topology optimization of Printed Circuit Boards (PCBs), particularly in trace routing. PCBs are nowadays present in most electronic devices, from small-scale chips with relatively low currents to power electronics carrying hundreds of kilowatts for automotive or aeronautics applications.

The chosen design approach uses the SIMP model for topology optimization, distributing conductive and non-conductive materials across each layer of an academic electrical circuit to minimize Joule losses. The model is based on a 2D electrostatic finite-element analysis, strongly coupled to circuit models more commonly used in electronics. This allows the introduction of linear components, such as resistors, and non-linear ones, such as diodes, into the design.

Several benchmark problems are proposed to optimize the geometry of the copper trace, the components, or both. It ranges from a simple voltage-divider and trace-routing problem across multiple circuit layers and components to more concrete applications in micro- and power-electronics.

3 - Density-based topology optimization of high-temperature superconducting shielding
Zakaria Houta

Superconducting materials exhibit zero electrical resistance; among them, high-temperature superconductors (HTS) can be cooled with liquid nitrogen, which is relatively common and can therefore be used in practical applications.

The behavior of such materials is strongly nonlinear. Below a critical current density that depends on the local flux density, the resistivity is zero (near zero for numerical stability) and increases dramatically once the critical current is reached. The transient magneto-dynamic physics is implemented using an H-formulation model, which is widely used in the literature, and discretized with the finite element toolbox NGSolve, exploiting all available symmetries to reduce computation time.

Then, a density-based topology optimization is performed to optimize a magnetic shield made from an HTS bulk. Because of the very strong nonlinearity of the problem, the material interpolation should be carefully chosen to obtain meaningful results. The sensitivities of the criteria (magnetic field in the protected zone and the volume of the HTS shield) are derived from a backward-in-time adjoint and verified using the complex-step method. The topology optimization is then carried out for three different HTS constitutive laws using the algorithm of moving asymptotes, in 2D and 3D test cases.

Wednesday, 14:00-16:00

■ WC-01

Wednesday, 14:00-16:00 - Room: Lecture room 16

Variational inequalities and adaptive first-order methods

Stream: Theory and practice of zeroth and first-order methods
Invited session
Chair: *Silvia Villa*

1 - Extragradient methods with complexity guarantees for hierarchical variational inequalities
Mathias Staudigl, Pavel Dvurechensky, Shimrit Shtern, Meggie Marschner

In the framework of a real Hilbert space we consider the problem of approaching solutions to a class of hierarchical variational inequality problems, subsuming several other problem classes including certain mathematical programs under equilibrium constraints, constrained min-max problems, hierarchical game problems, optimal control under VI constraints, and simple bilevel optimization problems. For this general problem formulation, we establish rates of convergence in terms of suitably constructed gap functions, measuring feasibility gaps and optimality gaps. We present worst-case iteration complexity results on both levels of the variational problem, as well as weak convergence under a geometric weak sharpness condition on the lower level solution set. Our results match and improve the state of the art in terms of their iteration complexity and the generality of the problem formulation.

2 - AdaGrad-Diff: A New Version of the Adaptive Gradient Algorithm
Saverio Salzo

Vanilla gradient methods are often highly sensitive to the choice of stepsize, which typically requires manual tuning. Adaptive methods alleviate this issue and have therefore become widely used. Among them, AdaGrad has been particularly influential. In this talk, I will present an AdaGrad-style adaptive method in which the adaptation is driven by the cumulative squared norms of successive gradient differences rather than gradient norms themselves. The key idea is that when gradients vary little across iterations, the stepsize is not unnecessarily reduced, while significant gradient fluctuations, reflecting curvature or instability, lead to automatic stepsize damping. For this new algorithm I will show convergence results, and numerical experiments demonstrating that the proposed method is more robust than AdaGrad in several practically relevant settings.

3 - An adaptive linesearch-free method for variational inequalities
Puya Latafat

Modern adaptive stepsize strategies have begun moving beyond traditional linesearch procedures, providing local adaptability without the overhead of backtracking or parameter tuning. However, their extension to monotone inclusion problems remains limited. In this work, we introduce a new adaptive method supported by a novel Lyapunov-based analysis. Our scheme selects the stepsize using only local information and eliminates the need for backtracking. The analysis holds under local Lipschitz continuity and permits significantly larger stepsizes than existing approaches, while ensuring convergence without an a priori upper bound on the stepsize. Numerical experiments illustrate the practical advantages of the proposed method.

4 - Optimization under Heavy-Tailed Noise: Optimal Sample Complexities and the Role of Adaptivity
Florian Hübler

Stochastic optimisation under heavy-tailed noise has recently attracted renewed attention, motivated by large-scale machine learning settings in which the bounded variance assumption may fail. Existing theory often relies on gradient clipping mechanism to handle such noise. However, the resulting guarantees do not match the known lower bound and require prior knowledge of problem-dependent parameters. We show that replacing clipping with normalisation yields optimal sample complexities when problem-dependent parameters are known. In the parameter-agnostic setting, we show that convergence remains possible, although with worse sample complexity. Additionally, we revisit the necessity of adaptivity: we show that vanilla Stochastic Gradient Descent (SGD) attains minimax-optimal rates under an appropriate convergence criterion. In sum, adaptivity enables optimal and parameter-agnostic performance, but is not necessary and SGD remains a rigorous baseline under heavy tailed noise.

■ WC-02

Wednesday, 14:00-16:00 - Room: Lecture room 15

Advanced topics in optimization and learning 2

Stream: Optimization for Machine Learning and Statistics
Invited session
Chair: *Cesare Molinari*

1 - Lower Bounds for Anytime Acceleration of Gradient Descent
Chung-En Tsai

Recent work suggests that the convergence rate of gradient descent (GD) in smooth convex optimization can be significantly improved by selecting a non-constant stepsize schedule. In particular, a partially accelerated convergence rate has been achieved for both function value and squared gradient norm minimization. Typically, such stepsize schedules critically rely on knowledge of the stopping time, and the question of anytime acceleration is more challenging. While a partially accelerated anytime convergence rate was recently established for function value minimization, it remains unclear if these bounds can be further improved to achieve full acceleration.

In this work, we complement these results with lower bounds for the anytime convergence of GD. First, we show that no positive stepsize schedule can achieve full anytime acceleration for function value minimization. Second, for squared gradient norm minimization, we prove that no positive schedule can achieve any partially accelerated anytime rates, thereby establishing the optimality of constant stepsizes.

The key ingredient of our analysis is an integral inequality involving the stepsize distribution. Our results offer the first improvement over the classical lower bound for GD with an arbitrary positive stepsize schedule, and provide a partial answer to a COLT 2024 open problem posed by Kornowski and Shamir.

2 - Spectral stepsizes in incremental gradient methods for l1-regularized optimization problems
Serena Crisci

Composite optimization problems arise naturally in machine learning, signal processing, statistical estimation, and distributed computing. These problems involve minimizing an objective function consisting of a smooth loss term combined with a non-smooth regularization term. The prototypical example is the Lasso problem, where a least-squares loss is regularized by the 1-norm to promote sparsity. In distributed and federated learning settings, the smooth part of the objective often decomposes into a sum of local objectives, each associated with a different data source or computational node. This leads to incremental or cyclic methods that process one component at a time, offering computational advantages over batch methods requiring simultaneous access to all data. The Barzilai-Borwein (BB) method, originally proposed for unconstrained smooth optimization, has gained significant attention due to its remarkable practical performance. Unlike gradient descent with fixed or diminishing step sizes, BB methods adaptively choose step sizes based on secant information, effectively approximating second-order information without computing Hessian matrices. In this talk, we analyze a incremental proximal BB gradient method for distributed composite optimization. Our analysis combines incremental gradient processing with BB-like step size strategies and non-monotone line search. Numerical experiments on real-world problems are presented.

3 - Bias-Optimal Bounds for SGD
Juan Peypouquet

The non-asymptotic analysis of Stochastic Gradient Descent (SGD) typically yields bounds that decompose into a bias term and a variance term. In this work, we focus on the bias component and study the extent to which SGD can match the optimal convergence behavior of deterministic gradient descent. Assuming only (strong) convexity and smoothness of the objective, we derive new bounds that are bias-optimal, in the sense that the bias term coincides with the worst-case rate of gradient descent. Our results hold for the full range of constant step-sizes, including critical and large step-size regimes that were previously unexplored without additional variance assumptions. The bounds are obtained through the construction of a simple Lyapunov energy whose monotonicity yields sharp convergence guarantees. To design the parameters of this energy, we employ the Performance Estimation Problem framework, which we also use to provide numerical evidence for the optimality of the associated variance terms.

4 - A Projected Stochastic Gradient Method for Finite-Sum Problems with Linear Equality Constraints
Mahsa Yousefi, Nataša Krklec Jerinkić, Benedetta Morini

We propose a stochastic projected gradient method for minimizing finite-sum functions subject to deterministic linear constraints. The method employs mini-batch stochastic gradients and allows exact or inexact projections, providing a controlled decay of infeasibility. Theoretical analysis establishes convergence properties for both constant and diminishing step sequences, without requiring convexity of the objective function. Numerical experiments illustrate the practical effectiveness of the method and its behavior under different step-size choices.

■ WC-03

Wednesday, 14:00-16:00 - Room: Lecture room 17

Structured nonsmooth optimization 2

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

1 - Extending Douglas-Rachford Splitting for Convex Optimization
Anton Åkerman, Max Nilsson, Pontus Giselsson

The Douglas-Rachford splitting method is a classical and widely used algorithm for solving monotone inclusions involving the sum of two maximally monotone operators. It was recently shown to be the unique frugal, no-lifting resolvent-splitting method that is unconditionally convergent in the general two-operator setting. In this work, we show that this uniqueness does not hold in the convex optimization case: when the operators are subdifferentials of proper, closed, convex functions, a strictly larger class of frugal, no-lifting resolvent-splitting methods is unconditionally convergent. We provide a complete characterization of all such methods in the convex optimization setting and prove that this characterization is sharp: unconditional convergence holds exactly on the identified parameter regions. These results immediately yield new families of convergent ADMM-type and Chambolle-Pock-type methods obtained through their Douglas-Rachford reformulations.

2 - Combining exact penalty and exchange methods in semi-infinite programming
Riccardo Tomassini, Giancarlo Bigi

Semi-infinite programming provides a natural mathematical framework for problems where an infinite number of constraints is considered, such as those found in robust optimization, equilibrium selection, and functional approximation. A classical approach to tackling such problems relies on exchange methods, in which only a finite subset of constraints is considered and iteratively updated to ensure convergence to a feasible solution. In this talk, we analyze how, under suitable regularity assumptions, exact penalty techniques can be effectively combined with exchange methods. Specifically, we show that there exists a uniform exact penalty parameter for all approximated subproblems, enabling the design of algorithms that converge to stationary points of the original semi-infinite problem. Numerical experiments are reported to analyze the performance of the proposed approach.

3 - Bregman-Moreau Envelope Reformulations for DC Programming
Moslem Zamani

In this paper, we investigate a class of nonsmooth and nonconvex difference-of-convex (DC) programming. Our approach is based on the use of Bregman-Moreau envelopes, which provide a smooth surrogate framework for handling nonsmooth structures. We introduce and study both left and right Bregman-Moreau envelope formulations of DC functions, and we rigorously establish that these envelope-based problems preserve the optimal value of the original DC formulation.

Building on this foundation, we develop a comprehensive theoretical analysis of the relationship between the original DC problem and its envelope counterparts. In particular, we show that stationary points of the envelope formulations correspond to critical points of the original DC problem. In addition, local minimizers are preserved under this transformation, provided that certain conditions are satisfied. These results provide a solid justification for solving the envelope problems as proxies for the original nonsmooth and nonconvex program.

On the algorithmic side, we propose gradient-based methods tailored to the structure of the Bregman-Moreau envelopes. These methods exploit the smoothness properties induced by the envelope while retaining the essential features of the underlying DC problem. Finally, we support our theoretical findings with numerical experiments, which demonstrate the effectiveness of the proposed approaches in solving nonsmooth nonconvex optimization problems.

4 - Primal-Dual Adagrad with Diagonal Adaptation
Karthik Prakhya, Zimeng Wang, Alp Yurtsever

We propose a new primal-dual algorithmic framework for constrained convex optimization problems that uses dual subgradient descent and is inspired by the diagonal-based step-size adaptation of the AdaGrad algorithm (Duchi et al., 2011). We additionally make use of computationally cheap linear minimization oracles, which form the backbone of generalized conditional gradient (GCG)-type methods, to perform the primal update. Since the convergence of convex programming solvers depends heavily on the scaling of the constraints (i.e. condition number of the dual problem), our proposed methods utilize diagonal scaling as part of dual subgradient descent to adapt to the condition number and utilize different step-sizes for different coordinates.

■ WC-04
Wednesday, 14:00-16:00 - Room: Seminar room MZ 003B

Markov decision processes and stochastic games under uncertainty

Stream: Optimization under uncertainty
Invited session
Chair: *V Varagapriya*

1 - Transition Uncertainties in Constrained Markov Decision Models: A Robust Optimization Approach
V Varagapriya

We examine a constrained Markov decision process under uncertain transition probabilities, wherein the uncertainty is modelled as deviations from observed transition probabilities. We construct the uncertainty set associated with the deviations using polyhedral and second-order cone constraints and employ a robust optimization framework. We demonstrate that each inner optimization problem of the robust model can be equivalently transformed into a second-order cone programming (SOCP) problem. Using strong duality arguments, we show that the overall robust problem can be equivalently reformulated into a bilinear-SOCP (B-SOCP) problem. In addition, we derive bounds for the expected discounted costs and subsequently construct SOCP approximations of the robust problem. In the numerical experiments, we study a machine replacement problem and explore potential sources of uncertainty in the transition probabilities. We examine how the optimal values, solutions, and bounds differ as we vary the feasible region of the uncertainty set, considering only polyhedral constraints and a combination of polyhedral and second-order cone constraints. Furthermore, we randomly generate problem instances with uncertain transition probabilities and analyze the impact of the number of states, actions, and variations in the feasible region of the uncertainty set on the optimal values and bounds.

2 - Managing Renewable Energy Communities under Uncertainty: A Distributionally Robust Approach
Santo Saraceno, Giorgia Oggioni, Rossana Riccardi, Elisabetta Allevi, Abdel Lisser

This work presents a chance-constrained model for the management of Renewable Energy Communities (REC), focusing on electricity exchanges and battery storage systems available to some community members. The model aims to minimize the total operating costs of the community while ensuring energy balance and satisfying technical constraints related to local production, energy storage, and electricity exchanges both within the community and with the main grid. Uncertainty in solar photovoltaic generation and electricity demand is addressed through a distributionally robust approach. The model is tested on a prototype REC using data taken from the Italian electricity market.

3 - A Distributionally Robust Framework for Multi-Agency Coordination in Hazmat Emergencies
Ginger Y. Ke, Jiahong Zhao

Effectively managing the risks associated with hazardous materials (hazmat) transportation and processing requires the coordinated deployment of multiple emergency resources, particularly under uncertainty. Despite its practical importance, multi-agency coordination in hazmat emergency logistics has received limited attention in the literature. To address this gap, we propose a novel framework to quantify the coordinative service level by jointly capturing two dimensions of emergency response performance: average response times and inter-agency response disparities, measured by absolute waiting times between emergency teams. To account for distributional ambiguity in emergency demand severity, we develop a distributionally robust optimization (DRO) model that simultaneously determines the location of new facilities, activation and capacity expansion of existing facilities, and allocation of emergency resources across incident sites. An efficient Benders decomposition algorithm with an enhanced in-out cut generation strategy is designed to solve the resulting large-scale problem. The proposed framework is validated using a real-world case study in Shenzhen, China. Extensive numerical experiments demonstrate the computational efficiency of the algorithm and yield managerial insights into improving coordination and resilience in hazmat emergency management.

4 - Linear production games under uncertainty: a robust chance constrained approach
Xuan Vinh Doan, Tri-Dung Nguyen

Linear production games concern the cooperation among players who would face a joint production problem and share benefits/costs together if they agree to cooperate. In this talk, we aim to address a fundamental challenge of incorporating uncertainty into these cooperative games. We introduce a new solution concept of (robust) least chance decisions under uncertainty and distributional ambiguity, which is motivated by the concept of least core solutions for deterministic games. We develop a framework to find those decisions and compute their (robust) least chance dissatisfaction for games under Wasserstein ambiguity. We demonstrate how the framework can be applied to linear production games with detailed numerical results.

■ WC-05

Wednesday, 14:00-16:00 - Room: Seminar room MZ 003A

Bilevel Optimization and Networks

Stream: Bilevel optimization
Invited session
Chair: *Steven Gabriel*

1 - A Mathematical Programming with Equilibrium Constraints Formulation for Optimal Mitigation of Trade Volumes in Illicit Supply Networks
Steven Gabriel, Joaquin de la Barra, Ahti Salo

Illicit supply networks comprise organizations and individuals who produce, transport, store, and distribute illicit goods or services to consumers. These networks engage in a wide range of activities, including drugs and human trafficking, illegal mining, and the distribution of counterfeit goods such as pharmaceuticals, electronic devices, or clothes. Estimating the size of these supply networks in terms of trade volumes is challenging. Yet they pose significant challenges to legal markets, governance, public health, and the environment, thereby negatively impacting societal well-being. This impact has driven efforts by policymakers, such as governments and law enforcement agencies, to quantify illicit trade volumes and to design/implement strategies to reduce them. Several models have been proposed to help these organizations reduce trade volume in illicit supply networks by identifying optimal strategies for monitoring and interdicting illicit transactions. In this paper, we propose a mathematical programming with equilibrium constraints (MPEC) formulation to determine mitigation strategies portfolios that most effectively reduce trade volume in the illicit supply network. This formulation employs a well-founded supply network equilibrium model that accounts for the objectives and constraints of organizations and individuals, along with the classical spatial price equilibrium (SPE), to model participants' economic behavior. The proposal is illustrated with a case study on

2 - Stochastic Bilevel Optimization with Convex User Equilibrium Model: Exact Single-Level Reformulation
Miguel Lejeune

We consider a stochastic bilevel network design optimization problem in which the lower-level problem is a user equilibrium model with a power function objective. We derive a new equivalent, convex, and single-stage reformulation of the problem. The proposed framework is motivated by a transportation infrastructure investment problem with uncertainty due to the rise of the sea level and possible flooding.

3 - A Computational Study for Non-Convex, Bilevel, Spatial Price Equilibrium Problems
Helmi Hankimaa, Seksun Moryadee, Steven Gabriel, Fabricio Oliveira

We study a spatial price equilibrium model of imperfectly competitive oil-derivative markets. In developing economies, these markets are often dominated by a single firm, which we represent as a market leader facing a competitive fringe. However, unlike a classical quantity-based Stackelberg game, in this context, the leader also sets prices strategically at its distribution terminals. This bi-level problem induces a computationally challenging non-convex mixed-integer quadratic program for which we propose alternative formulations, tighter bounds, and valid inequalities.

4 - Unboundedness in Bilevel Optimization
Miguel Anjos, Bárbara Rodrigues, Margarida Carvalho, Nagisa Sugishita

Bilevel optimization has garnered growing interest over the past decade. However, little attention has been paid to detecting and dealing with unboundedness in these problems, with most research assuming a bounded high-point relaxation. In this paper, we address unboundedness in bilevel and multilevel optimization by studying its computational complexity. We show that deciding whether an optimistic linear bilevel problem is unbounded is strongly NP-complete, even without coupling constraints. Furthermore, we extend the hardness result to the linear multilevel case, by showing that for each extra level added, the decision problem of checking unboundedness moves up a level in the polynomial hierarchy. Deciding unboundedness of a mixed-integer multilevel problem is shown to be one level higher in the polynomial complexity hierarchy than the decision problem for linear multilevel problem with the same number of levels. Finally, we introduce two algorithmic approaches to determine whether a linear bilevel problem is unbounded and, if so, return a certificate of unboundedness. This certificate consists of a direction of unboundedness and corresponding bilevel feasible point. We present a proof of concept of these algorithmic approaches on some relevant examples, and provide a brief computational comparison.

■ WC-06

Wednesday, 14:00-16:00 - Room: Seminar room MZ 201B

Methods for Structured Nonconvex Optimization

Stream: Difference-of-convex decompositions and structured nonconvex optimization
Invited session
Chair: *Hoomaan Maskan*

1 - Non-convex Optimization problems with unbounded damping
Mikhail Karapetyants

Non-convex optimization draws a lot of attention from scientists due to the complex nature of the problem of finding a (global) minima of non-convex functions. One way to approach these problems is through a second order dynamical system with variable coefficients. The convergence of the trajectories generated by the dynamical system to a critical point of the objective function is assured, provided a regularization of the objective function satisfies the Kurdyka-Łojasiewicz property - an important property, which helps dealing with non-convex structure of an objective function. The convergence rates for the trajectories generated by the dynamical system, formulated in terms of the Łojasiewicz exponent, are provided and the unbounded damping considered in the dynamical system significantly improves the convergence rates known so far in the literature. This talk will be a brief overview of the existing result [1] as well as its generalization to general coefficients (damping).

[1] Szilard Csaba Laszlo, Solving Nonconvex Optimization Problems via a Second Order Dynamical System with Unbounded Damping, Communications in Optimization Theory, 2026.

2 - Numerical Evaluation of Active-Set Newton-MR Methods for Box-Constrained Optimization
Diaulas Marcondes, Ernesto G. Birgin, Geovani Grapiglia

This work presents a numerical study of active-set strategies combined with the Newton-MR method for nonconvex twice-continuously differentiable functions subject to bound constraints. While traditional second-order methods are generally based on conjugate gradients (CG), our approach uses the minimum residual method (MINRES) to compute approximate Newton directions within the faces of the feasible set for Hessians that may be indefinite. We investigated two approaches for face exit iterations: one based on Spectral Projected Gradient (SPG) steps and another employing a tailored variant of the Cubic Regularization of Newton's method for bound-constrained problems. We present a comparative analysis with established solvers for optimization with bound constraints, specifically Gencan and ASA-CG.

3 - Beyond alternating simplex projections for simplex-constrained matrix factorization
Naomi Graham

Nonnegative matrix factorization (NMF) is a fundamental tool for dimensionality reduction and feature extraction, yielding a more parts-based decomposition than rank-based alternatives. By identifying the rows of the factor matrices with probability distributions via simplex constraints, we eliminate scale invariance and guide the solution toward interpretability by endowing the factors with an encoding that is free of application-specific assumptions. This version of NMF is also called the stochastic matrix factorization (SMF) problem. One typical solves NMF (and likewise also SMF) via an alternating minimization algorithm. Block-convexity of the objective ensures that the algorithm convergences to stationary points that are "block-wise optimal", meaning that one cannot further decrease the objective by modifying a single block at a time. In this sense, stationary points are solutions to a bi-level optimization problem. We do not yet know, however, if such points are saddle points or local minima. We analyze the SMF landscape by comparing it to that of rank-constrained problems and asking: do the simplex constraints create a fundamentally harder problem? And if so, does this inform how one should approach imposing simplex constraints? For example, we prove convergence of a novel combined project-and-rescale strategy, while experiments demonstrate that this approach convergences faster than performing alternating simplex projections.

4 - The Multi-Block DC Function Class: Theory, Algorithms, and Applications
Pouria Fatemi

In this talk, we present the Multi-Block DC (BDC) class, a broad class of structured nonconvex functions that admit a DC ("difference-of-convex") decomposition across parameter blocks. This block structure not only subsumes the usual DC programming, it turns out to be provably more powerful. Specifically, we demonstrate how standard models (e.g., polynomials and tensor factorization) must have DC decompositions of exponential size, while their BDC formulation is polynomial. This separation in complexity also underscores another key aspect: unlike DC formulations, obtaining BDC formulations for problems is vastly easier and constructive. We illustrate this aspect by presenting explicit BDC formulations for modern tasks such as deep ReLU networks, a result with no known equivalent in the DC class. Moreover, we complement the theory by developing algorithms with non-asymptotic convergence theory, including both batch and stochastic settings, and demonstrate the broad applicability of our method through several applications.

■ WC-07

Wednesday, 14:00-16:00 - Room: Seminar room MZ 112B

Splitting algorithms for generalized monotone inclusions

Stream: Splitting algorithms
Invited session
Chair: *Pedro Pérez-Aros*

1 - Graph splitting methods: Fixed points and strong convergence for linear subspaces
Francisco Javier Aragón Artacho, Heinz Bauschke, Rubén Campoy, César López Pastor

In this talk we present a general analysis for the fixed points of the operators defining the recently introduced graph-based splitting methods (which are defined by a connected graph and subgraph). This framework encompasses a wide family of splitting algorithms for finding zeros in the sum of maximally monotone operators. We specialize our analysis to the case where the operators are normal cones of closed linear subspaces, allowing us to derive an explicit formula for the limit points of the graph splitting schemes. We exemplify these results on some particular algorithms, unifying previously derived results while obtaining new ones.

2 - What is the optimal relaxation parameter for graph-based splitting methods?
César López Pastor, Francisco Javier Aragón Artacho

This talk focuses on the performance of the family of graph-based splitting methods specialized to normal cones of linear subspaces. These algorithms are defined by a connected graph and a subgraph, and the family encompasses well-known schemes such as the Douglas-Rachford algorithm. Numerical experiments on the optimal relaxation parameter reveal noteworthy results for the case where the graphs coincide. Specifically, the optimal relaxation parameter is always 1, and the performance is symmetric with respect to this value. We provide a theoretical proof of this fact by introducing the concept of iso-averaged linear operators and their key properties.

3 - Monotone Operator Splitting with Steering Vectors
Max Nilsson, Sebastian Banert, Pontus Giselsson

We consider iterative algorithms for monotone inclusion problems involving the sum of m maximally monotone operators on a Hilbert space. Our main contribution is a framework for deriving such algorithms directly from Lyapunov analysis, thereby opening new possibilities for method design through steering vectors. The key idea is to iteratively simplify a Fejér-monotonic quadratic inequality and represent it via an LDL factorization. This reformulation turns algorithm design into an inertia eigenvalue problem.

4 - Multioperator splitting methods for a class of nonmonotone inclusion problems
Jan Harold Alcantara, Minh Dao, Akiko Takeda

We consider multioperator inclusion problems beyond the classical monotone setting, motivated by applications to structured optimization and multiblock models. Through a product-space reformulation, we analyze Douglas-Rachford-type methods for classes of problems involving generalized monotone and comonotone operators. We present convergence results showing that these methods retain their convergence guarantees in such nonmonotone settings under a suitable choice of stepsize. We also discuss recent progress on other multioperator splitting algorithms for nonmonotone inclusion problems.

■ WC-08

Wednesday, 14:00-16:00 - Room: Seminar room MZ 102A

Multiobjective Optimization: Structural Properties

Stream: Multiobjective optimization
Invited session
Chair: *Gabriela Kovacova*

1 - A strong notion of domination
Hannah Borgmann, Sven Jäger, Sven Krumke

We consider multi-objective minimization problems with convex continuously differentiable objectives over a compact feasible set. Using the standard definition, we say one solution dominates another if it is not larger in any objective and strictly smaller in at least one. We call a solution efficient if it is not dominated by another.

Consider a pair of solutions where one dominates the other. As is well-known, this implies that all directional derivatives at the dominated solution into the direction of the dominating solution will be non-positive. In the opposite direction, however, the directional derivatives at the dominating solution into the direction of the dominated solution do not need to be non-negative. Intuitively speaking, along the straight line from the dominating solution to the dominated solution, an objective can decrease before then increasing again. We therefore say one solution strongly dominates another if it dominates it and all directional derivatives at the dominating solution into the direction of the dominated solution are non-negative.

To show that each non-efficient solution is strongly dominated by an efficient solution turns out to be surprisingly difficult. We give proofs for all convex bi-objective optimization problems, and for strictly convex multi-objective optimization problems over two-dimensional feasible sets.

2 - Tight conic relaxations for multiobjective optimization
Gabriele Eichfelder, Christian Kugelmann, E. Alper Yildirim

For single-objective optimization problems, it is well known that some nonconvex problems can equivalently be reformulated as convex problems over some cone, for instance the cone of completely positive matrices. In this talk, we examine the implications of such tight lifting-and-relaxation schemes on optimization problems with multiple objective functions.

First, we extend the convex reformulations which have been developed for mixed-binary quadratic problems to multiobjective non-convex quadratic problems, following the steps in Burer's work. We show that this approach is no longer useful for two or more objective functions. The reason is that it only allows us to find supported nondominated points, which can, however, already be found by using a weighted-sum scalarization, and by then applying the same lifting strategies.

Next, we apply another tight lifting-and-relaxation-scheme on a scalarized version of a specific multiobjective optimization problem, and study that further. Here, the surprising outcome is that for the considered class of multiobjective problems all nondominated points are supported. These two observations motivate to further examine such lifting-and-relaxation-schemes also for multiobjective optimization problems.

3 - Structural Properties of Multiobjective Quadratic Problems
Christian Kugelmann, Gabriele Eichfelder, E. Alper Yildirim

We investigate hidden convexity properties of quadratic multiobjective optimization and their implications for weighted-sum scalarizations. For two objectives, hidden convexity holds under affine equality constraints but can already fail under linear inequality constraints. Moreover, the existence of an optimal solution to a weighted-sum scalarization can be certified via a positive (semi-)definite convex combination of the Hessian matrices.

4 - Generation of Supported Points via Image Space Transformations
Felix Neussel, Oliver Stein

In this talk, we present new results on the supported points of multiobjective optimization problems, that is, the weakly efficient points that can be obtained via the weighted sum scalarization.

Transformations are commonly applied in multiobjective settings to simplify the original problem, e.g., by normalizing the image set when the objectives are expressed in different units. Conditions under which transformations do not change the set of efficient points are well known.

We introduce new assumptions ensuring that the transformation preserves the supported points as well. This is a highly desirable property if the weighted sum scalarization is to be used in order to solve the transformed problem.

Finally, we consider transformations that can render originally unsupported points supported in the transformed problem. This enables algorithms to find nondominated points by applying the weighted sum scalarization to a transformed problem.

Wednesday, 16:30-18:30

■ WD-01

Wednesday, 16:30-18:30 - Room: Lecture room 16

Algorithm design, analysis, and first-order methods

Stream: Theory and practice of zeroth and first-order methods
Invited session
Chair: *Luca Calatroni*

1 - Perspectives on the analysis and design of optimization algorithms: Lyapunov analyses and counter-examples
Adrien Taylor

Lyapunov analysis is an essential tool for studying simple first-order optimization methods and for obtaining performance guarantees. This talk will cover a few recent constructive approaches to the discovery of such Lyapunov functions and of their structural properties in the context of first-order optimization. In addition, we cover a few constructive approaches to counterexamples for when no such Lyapunov exists.

The talk will be example-based, as many ingredients of those methodologies are already present when analyzing simple optimization algorithms such as gradient descent, the heavy-ball method, or the primal-dual hybrid gradient algorithm (Chambolle-Pock). We further illustrate how simple Lyapunov structure can be studied with existing software for computer-aided analyses (and in particular with PEPit), relying on different formulations of the analysis problem.

This talk is based on joint works with great colleagues, that include Francis Bach, Laurent Lessard, Bryan Van Scoy, Manu Upadhyaya, Sebastian Banert, Pontus Giselsson, Baptiste Goujaud, Daniel Berg Thomsen, Si Yi Meng, and Aymeric Dieuleveut.

2 - A Composite Minimization Framework for Mumford-Shah Problems with Efficient Numerical Solution
Clara Lage, Nelly Pustelnik, Audrey Repetti

This work focuses on composite minimization problem for which the discrete Mumford-Shah function is a particular case. We propose a novel optimization formulation whose solutions are equivalent to those of the Mumford-Shah problem. Under suitable assumptions, we show that this formulation uniquely determines a discontinuity penalization function appearing in the classical three-terms Mumford-Shah formulation. Building on recent developments, we introduce a forward-backward algorithm for composite minimization, tailored to efficiently solve the proposed problem.

We demonstrate the effectiveness of this approach through two applications: boundary detection in imaging and the modulus sampling problem, which aims to reconstruct signals from magnitude-only measurements. These results highlight the potential of the proposed framework as a computationally efficient alternative to classical approaches.

3 - Simplifying Worst-Case Design of Gradient Methods through Bounded-Distance Performance Estimation
Pierre Vernimmen, François Glineur

Gradient descent is one of the simplest algorithms in optimization: at each iteration, we move in the opposite direction of the gradient. The usual choice is to use a constant step size, but it is now well understood that carefully chosen nonconstant step sizes, including some long steps, can lead to better worst-case guarantees.

In this talk, the main question is not whether long steps can help, but how to understand and design them in a simple way. The idea is to look at the proof itself. Instead of using all possible relations between all iterates of the algorithm, we force the proof to be local: each iterate is only compared with nearby iterates. The algorithm is unchanged; only the class of allowed proofs is restricted.

This simple restriction reveals a surprisingly clear structure. With the most local proofs, we obtain an explicit recursive step-size rule and a short Lyapunov-style explanation. Allowing slightly less local proofs gives better schedules, with repeating patterns. More generally, the approach suggests a hierarchy of increasingly powerful local proofs and step-size rules.

The message of the talk is that simplifying the proof can be a useful design principle. It can turn a difficult numerical search for good step sizes into interpretable, reusable, and mathematically explainable gradient descent schedules.

4 - Generalized Stochastic Gradient Descent with Momentum Methods for Smooth Optimization
Zimeng Wang, Alp Yurtsever

Stochastic gradient descent with momentum (SGDM) methods have become fundamental optimization tools in machine learning, combining the computational efficiency of stochastic gradients with the acceleration benefits of momentum. Despite their widespread use in practice, the theoretical understanding of SGDM remains incomplete, with most existing analyses focusing on specific momentum schemes or requiring restrictive assumptions. In this paper, we introduce a generalized SGDM framework that unifies a broad class of momentum-based methods, including SGD with Polyak's momentum, SGD with Nesterov's momentum, and many others. We provide comprehensive convergence analyses for both convex and nonconvex optimization problems under mild smoothness and bounded variance assumptions. For convex problems, we establish general ergodic convergence results with constant parameters and derive improved iterate convergence rates with time-varying parameters. For nonconvex problems, we prove sublinear convergence to stationary points and establish linear convergence to a neighborhood of the optimum under the Polyak-Lojasiewicz condition. Notably, our analysis allows flexible parameter choices and thus provides convergence guarantees for many existing momentum methods as special cases.

■ WD-02

Wednesday, 16:30-18:30 - Room: Lecture room 15

Advanced topics in optimization and learning 3

Stream: Optimization for Machine Learning and Statistics
Invited session
Chair: *Marco Viola*

1 - Margin Optimal Trees for Nonlinear Regression
Virginia Marcelli, Laura Palagi, Ilaria Ciocci, Marta Monaci

Interpretable machine learning models have recently attracted growing interest due to their transparent decision-making process. Among these, decision trees are widely studied thanks to their intuitive structure and inherent interpretability. Recent advances in mixed-integer programming have led to several formulations for building optimal decision trees, offering an alternative to traditional greedy heuristics. In this work, we propose a novel Mixed Integer Quadratic Programming formulation for the Optimal Regression Tree problem. Our model is designed to combine the interpretability of decision trees with the generalization capabilities of Support Vector Regression (SVR), extending ideas originally proposed for classification settings by D'Onofrio et al. (C&OR, 2024). The proposed model, denoted as Margin Optimal Regression Tree, learns oblique decision rules that recursively partition the feature space, while fitting a linear SVR at each leaf to predict continuous outcomes. To address the computational challenges inherent to this problem, the formulation is enhanced with symmetry-breaking constraints to eliminate equivalent solutions and reduce the search space, thereby improving solver efficiency. To evaluate the predictive and optimization performance of our approach, we conduct computational experiments on benchmark datasets, comparing it with baseline optimal tree methods.

2 - Fairness-informed pareto optimization : an efficient bilevel framework
Yassine Laguel, Sofiane Tanji, Samuel Vaiter

Fairness concerns are now central in machine learning-based decision systems, where automated predictions increasingly affect individuals and communities. At the same time, the interplay between fairness and predictive performance is often framed as a trade-off, and many standard approaches can be inefficient when viewed through a Pareto lens over group-wise outcomes. In this talk, we present badr, a bilevel optimization framework that selects, among models that are Pareto-optimal with respect to group-wise losses, the one that minimizes a prescribed fairness metric. To solve this problem, we introduce two algorithms: (i) badr-gd, a single-loop gradient-based method with convergence guarantees under mild assumptions, and (ii) badr-sgd, a stochastic variant designed for large-scale settings. We further provide an open-source Python toolbox implementing these methods, supporting multiple fairness metrics, models, and optimization oracles. Empirical results on real-world datasets show that our approach consistently improves fairness metrics compared to existing baselines, while maintaining predictive performance.

3 - Gradient descent algorithm for lower-level constrained bilevel optimization
Samuel Ward

The bilevel program is a potent structure for studying machine learning hyperparameter tuning. Due to its two-level structure, computing the gradient of the upper-level objective (hypergradient) is difficult. A popular solution to this difficulty is Approximate Implicit Differentiation (AID), which enables descent methods according to an inexact hypergradient. These have been shown to yield reasonable convergence rates. Typically, however, they require strong assumptions about the lower-level problem, such as that it is unconstrained and has a smooth objective. In this work, we show how the theory can be generalised to lower-level problems with constraints and a possibly non-smooth objective function. We prove a similar convergence rate and provide numerical comparisons with the more traditional value-function and KKT-reformulation approaches.

4 - Hard Feature Selection in Nonlinear SVMs via Exact Convex MIQP Reformulation
Ilaria Ciocci, Federico D'Onofrio, Sourour Elloumi, Laura Palagi

We address the training of nonlinear Support Vector Machines (SVMs) with embedded feature selection. The problem is modeled as a Mixed-Integer Nonlinear Programming (MINLP) formulation with a hard cardinality constraint, which explicitly enforces a given level of sparsity in the solution. While this improves interpretability, it also introduces strong nonconvexities that make exact solution approaches computationally demanding. We propose a new equivalent reformulation for SVMs with polynomial kernels, transforming the original MINLP into an equivalent Mixed-Integer Convex Quadratic Program. The reformulation introduces auxiliary variables that capture multilinear interactions between binary and continuous variables arising from the kernel expansion. We show that the resulting objective function is convex and prove the equivalence between the original and the reformulated problems. To further improve computational efficiency, we exploit the inherent symmetry of the reformulation, deriving a symmetry-free model that significantly reduces the number of variables and constraints. The proposed approach naturally extends to polynomial kernels of arbitrary degree. Computational experiments indicate that the resulting MIQP can be effectively solved to global optimality on benchmark datasets, demonstrating the practical viability of our approach compared to the original nonconvex formulation.

■ WD-03

Wednesday, 16:30-18:30 - Room: Lecture room 17

Nonsmooth optimization theory

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

1 - Stronger Versions of Fitzpatrick Inequality
Juan Enrique Martínez-Legaz

Maximally monotone operators on a real Banach space can be represented by convex functions defined on the Cartesian product of the space with its dual. The most important of such convex representations is probably the Fitzpatrick function, which was the first to be introduced and is in fact the smallest convex representation. The Fitzpatrick inequality states that the Fitzpatrick function is above the duality product. Some refinements of this inequality are the strong Fitzpatrick inequality and Carlier's inequality, the latter being valid in a Hilbert space setting. In a recent joint work with Regina Burachik, we have extended Carlier's inequality to reflexive spaces for which a strongly monotone operator having a finite-valued Fitzpatrick function is available; in the particular case when the space is 2-uniformly convex, one can take the duality mapping. Using our arguments, we have also proved an even stronger version of the strong Fitzpatrick inequality.

2 - Minimization of Nonsmooth Functions under Equilibrium Constraints

Helmut Gfrerer, Jiri Outrata

We consider the problem of minimizing a nonsmooth and nonconvex function subject to equilibrium constraints. Under the assumption that the objective is semismooth and the set-valued mapping describing the equilibrium constraint is semismooth*, we will demonstrate how this problem can be solved by means of a bundle algorithm. As an numerical example we consider a shape optimization problem stemming from a contact problem with Coulomb friction.

3 - Proper efficiency results in vector optimisation in real linear-topological spaces based on vectorial penalisation

Paul Schmölling

We consider a constrained vector optimisation problem, where the objective function acts between two real linear-topological spaces, and study relationships between the sets of properly efficient solutions to this constrained problem and two unconstrained problems; one of them containing a penalisation term. We use cone convexity results on the objective function and study the behaviour of Henig dilating cones.

■ WD-04

Wednesday, 16:30-18:30 - Room: Seminar room MZ 003B

Advances in optimization under uncertainty

Stream: Optimization under uncertainty
Invited session
Chair: *Yong-Hong Kuo*

1 - On the Equivalent Formulations of the Appointment Scheduling Problem

Linhui Fu

We study the appointment scheduling problem(ASP), where an optimal schedule of outpatients' appointment intervals is to be decided. We found in Denton and Gupta (2003) a stochastic linear program (SLP) claimed to be equivalent to appointment scheduling problem (ASP) and was used in other following works. We show, however, this equivalence is not correct in general, we provided a counterexample showing the non- equivalence and explains why a trivial LP formulation of the original problem are unlikely to be found. In order to treat the problem, we showed a sufficient and necessary condition under which SLP is equivalent to ASP, we showed that without this condition, the ASP is non-convex. We discussed the condition for equivalence of some other variations of ASP, including no-show patients and unpunctual patients. We also provided a stochastic mixed integer linear program for solving the ASP with general cost vectors. Further, we also provided some analytical and experimental results for ASP in different settings.

2 - Data-driven Inference and Optimization for Imputing Non-observable Human Preferences in Staff Scheduling

Jiangxue Han, Yong-Hong Kuo

In a staff scheduling problem, there exist various challenges that hinder a schedule planner (called an agent in this research) from deciding the optimal solutions. We identify the main challenges and formalize them by three properties: model uncertainty, bounded rationality, and compromised infeasibility. To address them, we first determine the soft constraints and allow them to be broken to overcome the infeasibility. We then develop a data-driven inverse optimization framework to minimize estimation errors. Theoretical findings regarding the existence and uniqueness of the optimal solution, the coefficient sign, the number of solutions required, and the criterion of samples are provided. We conduct a thorough computational experiment exploring the influence of sample size, rationality level, solution similarity, and signal change on the performance of inverse models. Through numerical experiments, we find that optimizing the maximum error generated between two schedules is more effective than minimizing the sum of total errors produced during the entire ranking process.

3 - Dual-channel Competition in Healthcare under Information Asymmetry

Fangyuan Cao, Feng Tian, Yong-Hong Kuo, Jie Wang

Healthcare platforms, such as HealthTap and Dingxiang Doctor, have gained popularity in recent years due to their convenience and flexibility, competing with in-person hospitals within the market for medical consultations. Although platforms can verify the qualifications of physicians, physicians' actual performance remains unknown to the public. We develop a sequential game theory model to study the value of information, the value of mechanism design as well as the impacts of online healthcare on the entire healthcare system.

4 - Distributionally Robust Complex Chance-Constrained Program (3CP)

Raneem Madani, Abdel Lisser, Zeno Toffano, Yong-Hong Kuo

This talk introduces a framework for Chance-Constrained Optimization with Complex Variables (3CP), addressing complex linear programming for both individual and joint probabilistic constraints in the complex domain. We first analyze the 3CP model with density-based under the assumption that the random parameters follow a Complex Elliptically Symmetric (CES) distribution. The framework is then extended to distributionally robust settings, this includes: (i) a moment-based model; (ii) a support-based model where the mean is known and the data is constrained to lie in a norm-bounded set; and (iii) a data-driven model where moments are estimated empirically. In all these scenarios, the individual stochastic constraints are transformed into convex deterministic Second-Order Cone Programming (SOCP). For the joint probability constraints, we employ copula theory to handle dependencies and derive both upper and lower SOCP approximations using piecewise linearization and Taylor expansion. Finally, we demonstrate the proposed framework on the minimum-variance distortionless response (MVDR) beamforming problem in signal processing. We further evaluate empirical out-of-sample rates and show that the observed behavior closely matches the prescribed probabilistic guarantees.

■ WD-05

Wednesday, 16:30-18:30 - Room: Seminar room MZ 003A

Recent Advances in Bilevel Optimisation 1

Stream: Bilevel optimization
Invited session
Chair: *Martin Schmidt*

1 - On local search in bilevel mixed integer optimization
Oleg A. Prokopyev, Eneko Clemente

We focus on bilevel mixed-integer linear programs (bilevel MILPs) in which either the leader's or the follower's decisions (or both) are constrained to be binary. Specifically, we explore what happens when the leader's global optimality conditions are replaced by local optimality under the standard Hamming distance. Finding locally optimal leader's solutions via local search faces two main challenges: (i) as in many combinatorial optimization problems, local search may require an exponential number of improving steps to converge in the worst case; and (ii) evaluating the leader's objective value requires solving the follower's problem, which can itself be computationally difficult. We address these challenges by exploring generalized notions of local optimality that leverage the structural properties of bilevel MILPs.

2 - On solving integer bilevel problems using SOCP-based disjunctive cuts
Markus Sinnl, Elisabeth Gaar, Jon Lee, Ivana Ljubic, Kübra Tanınmış

In this talk, we consider different classes of integer bilevel problems, including problems with second-order cone constraints at the upper-level and a convex-quadratic objective function and linear constraints at the lower-level. We illustrate how to develop solution algorithms for these problems based on the so-called single-level relaxation of integer bilevel problems. This relaxation is combined with disjunctive cuts based on second-order cone programming to separate bilevel-infeasible solutions. We present computational results which show that our approaches outperform state-of-the-art approaches.

3 - On the Complexity of Partitioned-Items Bilevel Optimization Problems
Dorothee Henke

Bilevel optimization problems involve two decision makers, a leader and a follower. The leader takes the first decision and has to anticipate the follower's reaction in order to optimize their own objective. This hierarchical structure can make bilevel problems hard to solve. In terms of computational complexity, combinatorial bilevel optimization problems are typically on the second level of the polynomial hierarchy.

In this talk, we will focus on a class of bilevel combinatorial problems that has gained interest in recent years. In a partitioned-items bilevel problem, the leader and the follower each control a subset of some set of items. From these items, they build a feasible solution of some underlying single-level problem together, while optimizing different objective functions. Underlying single-level problems for which this setting has been studied include the assignment problem, the knapsack problem, the spanning tree problem, and the shortest path problem. We will give an overview of known complexity results for partitioned-items bilevel problems and discuss one of them in more detail.

■ WD-06

Wednesday, 16:30-18:30 - Room: Seminar room MZ 201B

Optimization models in supply chain and energy systems

Stream: Energy applications
Invited session
Chair: *Levan Pavlenishvili*

1 - Ad Valorem Tariffs in Global Supply Chain Networks and Impacts on Labor
Anna Nagurney, Samirasadat Samadi

Global supply chain networks are essential to the production, trade, and consumption of commodities, including agricultural ones. Such networks have been increasingly impacted by trade policies, especially ad valorem tariffs, which are affecting commodity flows, prices, and profits. Furthermore, the labor market plays a critical role in the functioning of supply chain networks. However, the impacts of ad valorem tariffs on labor (and employment) have not yet been quantitatively examined in a competitive global supply chain network framework. This paper constructs an oligopolistic supply chain network equilibrium model that integrates ad valorem tariffs and labor. Firms compete noncooperatively in maximizing their profits by determining their product f lows across multiple production sites. Demand markets can be located in different countries, with production and shipment activities subject to labor upper bounds and wages. The governing Nash equilibrium conditions are formulated as a variational inequality. Through Lagrange analysis, an alternative variational inequality is derived with nice features for computations. Illustrative examples are provided along with a global soybean trade case study. Numerical results reveal how such tariffs shift trade flows, reshape labor allocation, and affect demand prices as well as profits, with labor shortages and cost disruptions further negatively compounding the effects.

2 - Benders Decomposition for Stochastic Generation Expansion with Direct Air Capture and Emissions Uncertainty
Rozhin Ziayeepour, Kristen Schell, Ahmed Abdulla, Amir Hakami

Long-term energy system planning is challenged by the need to develop large-scale optimization models under uncertainty, construct representative scenarios of the future, which are influenced by multiple drivers, and then solve the model to the optimality. In addition, studying emerging technologies' role (such as direct air capture(DAC)) in the energy system is complicated by trade offs in terms of their energy consumption and emissions reduction potential. This study aims to answer at minimum cost; how much could DAC contribute to Canada's net-zero energy transition under uncertainty in sectoral emissions trajectories through 2050. To this end, a multi-period mixed-integer stochastic generation expansion planning model of the Pan-Canadian electricity system is developed. To address computational complexity, a Benders decomposition framework is applied, exploiting the problem's block-angular structure. Optimal solutions are obtained in fewer than 100 iterations, demonstrating the computational effectiveness of the proposed modelling framework and the role of penalized subproblem formulations in supporting tractable net-zero energy system planning. The results analyze key trade-offs between DAC deployment and the required expansion of power generation capacity, highlighting how different decarbonization scenarios influence the balance between emissions reduction and system costs.

3 - Multi-objective Sizing of Residential Distributed Energy Generation Based on Environmental, Economic, and Autonomy Criteria

Paulo Rotella Junior, Arthur Leandro Guerra Pires, Rafael Miranda, Luiz Celio Souza Rocha, Karel Janda

This study proposes a multi-objective model for the optimal sizing of residential distributed generation systems, considering economic (Net Present Value), energy autonomy (self-sufficiency), and environmental (CO-equivalent emissions) criteria. The model employs Response Surface Methodology and the Normal Boundary Intersection method to simultaneously optimize the three objective functions, evaluating configurations with photovoltaic, wind, or hybrid generation, associated with lithium-ion battery storage. A normalized Euclidean distance approach is applied in the post-Pareto stage to select a single compromise solution. A case study is developed in the nine capitals of Northeast Brazil, considering the regulatory changes in the electricity compensation system associated with Brazilian Law No. 14,300/2022. Results indicate that, despite regulatory changes, investments in photovoltaic systems continue to be a viable option. The analysis of a financing line with a more favorable discount rate shows gains in economic viability, simultaneously enabling the reduction of environmental impacts and increased self-sufficiency. Moreover, results suggest that integrating small-scale wind energy can be more efficient than expanding storage capacity, allowing greater self-sufficiency with reduced environmental impact. However, this depends on favorable wind regimes, highlighting the importance of region-specific public policies in designing distributed energy systems.

■ WD-07

Wednesday, 16:30-18:30 - Room: Seminar room MZ 112B

Shape optimization 1

Stream: Shape and topology optimization
Invited session
Chair: *Peter Gangl*

1 - Local constraints in Topology Optimization: A Simultaneous Analysis and Design (SAND) approach

Dries Toebat, Florian Feppon

Many physical design problems include constraints that are local in nature. A simple, yet very common example consists of bounding a physical quality, like temperature or stress, to a certain threshold. Such local constraints pose a classical challenge in Topology Optimization, since they give rise to at least a number of constraints equal to the number of discretization points.

So far, the two common approaches to deal with local constraints are aggregation or Augmented Lagrangian methods. However, aggregation only enforces the constraints approximately and the Augmented Lagrangian method can heavily rely on tuning unphysical hyperparameters. In this work, we revisit an alternative approach based on the Simultaneous Analysis and Design (SAND) reformulation of the problem. In the SAND formulation, instead of solving the Partial Differential Equation (PDE) describing the physics directly, the physical quality is introduced as a design variable and the PDE is added as a constraint to the optimization. The major benefit of this formulation is the introduced sparsity of the Jacobian matrix with respect to the physical quality.

The Null Space Optimizer can take advantage of sparse Jacobian matrices by using sparse quadratic programming solvers to identify descend directions. The combination of the SAND formulation and the Null Space Optimizer therefore shows potential to exactly deal with the numerous constraints associated to local constraints.

2 - Momentum-based non-convex shape optimization via dissipative Hamiltonian flows

Onur Tanil Doganay, Matthias Bolten, Hanno Gottschalk, Kathrin Klamroth

Partial differential equation (PDE)-constrained shape optimization is a well-established field of optimization theory. Using the adjoint method, shape gradients can be computed at the cost of solving one additional PDE, which enables the application of gradient-based optimization methods. However, gradient descent methods —interpretable as discretizations of gradient flows— are prone to getting trapped in local minima when applied to non-convex optimization problems. In contrast, the machine learning community has successfully addressed optimization in non-convex energy landscapes through momentum-based methods, which can be viewed as a transition from gradient flows to dissipative Hamiltonian dynamics. We adopt this strategy for non-convex shape optimization. In particular, we introduce a mechanical shape optimization problem that accounts for reliability, material cost, and installation space restrictions. We then demonstrate how dissipative Hamiltonian flows can be used to solve this problem.

3 - Sensitivity analysis and optimization of centroidal Voronoi tessellations with geometric constraints

Juan S. C. Franco, Ernesto G. Birgin, Antoine Laurain

In this paper, we investigate the optimization of Centroidal Voronoi Tessellations (CVT) under geometric constraints. For this purpose, we minimize a linear combination of the standard CVT energy functional with terms involving geometric attributes such as area and perimeter. The derivative of the objective functional with respect to the position of the generators is computed using techniques of shape calculus and sensitivity analysis of minimization diagrams. Several numerical experiments are presented to explore the geometric constraints of cells with identical areas, cells without small edges, and density-based distributions of cells.

4 - Nanotomography Tailored to Homogeneous Materials

Jan Rolfes, Anuraag Mishra, Andrea Gilch, Benjamin Apeleo-Zubiri, Frauke Liers

In nanotomography, one often faces the challenge of the proper acquisition of projection data, e.g. because of ill-described imaging physics, beam sensitivity of the sample material or specific restrictions on the sample geometry, which may prevent the acquisition an artefact-free 3D reconstruction. In this talk, we aim to reduce the amount of projection data required by complementing a compressed sensing approach with expert knowledge and learned properties of the sample material in case the sample contains only a small number of piecewise constant material phases.

■ WD-08

Wednesday, 16:30-18:30 - Room: Seminar room MZ 102A

Multiobjective Optimization: Numerical Methods

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

1 - Theoretical Results of Local Bound Sets for Multiobjective Approximation Algorithms
Daniel Hoff, Gabriele Eichfelder

Classical and generalized local upper bound sets are widely used bounding concepts in multiobjective optimization algorithms to approximate optimal sets in the image space. A search region is defined as all points in the interior of an initial set that are not dominated by some points in a given point set. The search region shall be covered by a union of simpler sets known as search zones. Each point in the image space induces such a search zone. A local bound set is formed by all image points, so that there are no redundant search zones in the representation of the search region. When the point set and initial set are chosen appropriately, then a given optimal set is contained in the closure of the search region. In this case, the local bound set approximates the given optimal set. In this talk, we introduce generalized local bound sets, which are defined by arbitrary point sets and arbitrary initial sets. This reduces the computational effort required for approximation algorithms and allows us to apply warm-start strategies. We will discuss several properties of these bound sets, such as existence, uniqueness, closedness, and approximation results. For a finite point set and an initial enclosure, we present a correct, finite algorithm for iteratively computing these bound sets as well as some of their additional properties. Thus, we provide a toolbox of theoretical results for local bound sets that simplifes the development of multiobjective approximation algorithms.

2 - An adaptive line-search-free multiobjective gradient method and its iteration-complexity analysis
Max L. N. Gonçalves, Geovani Grapiglia, Jefferson Melo

In this talk, we introduce an Adaptive Line-Search-Free Multiobjective Gradient (AMG) method for solving smooth multiobjective optimization problems. The proposed approach automatically adjusts stepsizes based on steepest descent directions, promoting robustness with respect to stepsize choice while maintaining low computational cost. The method is specifically tailored to the multiobjective setting and does not rely on function evaluations, making it well suited for this scenario. The proposed algorithm admits two variants: (i) a conservative variant, in which the stepsize is monotonically decreasing; and (ii) a flexible variant, which allows occasional increases in the stepsize. From a theoretical standpoint, under standard Lipschitz continuity assumptions on the gradients, we establish iteration-complexity bounds for achieving a Pareto critical point for both variants in the nonconvex setting. In the convex setting, we further derive improved iteration-complexity bounds for the conservative AMG variant. From a practical standpoint, the numerical experiments demonstrate that the flexible AMG performs favorably compared to the steepest descent method with either a fixed stepsize or Armijo line search

3 - An Adaptive Inexact Cubic Regularization Method for Multiobjective Optimization
Jefferson Melo, Max L. N. Gonçalves

In this talk, we present an adaptive Inexact cubic regularization method for solving nonconvex multiobjective optimization problems. The method minimizes a regularized model of each objective, allowing approximate first- and second-order derivatives that adapt dynamically with the regularization parameter through a nonmonotone functional value acceptance criterion. We also discuss finite-difference implementations that make the method practical when derivatives are unavailable. Under mild assumptions, the algorithm achieves a worst-case complexity of order O(eps-3/2) to compute an eps-approximate Pareto critical point and exhibits superlinear or even quadratic convergence when exact derivative information is available.

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

Multi-objective mixed-integer nonconvex optimization poses a variety of theoretical and computational challenges, particularly when aiming for an enclosure of the nondominated set without relying on exhaustive branching. In this talk, we present a novel relax-and-refine algorithm that departs from traditional branch-and-bound frameworks, extending a well-known approach from single-objective optimization to general multi-objective mixed-integer optimization problems.

We'll provide a deep dive into selected core concepts powering our algorithm, e.g., the novel box-based relaxation for nonlinear terms with dynamic bound tightening, adaptive refinement tailored to image-space search zones, and the pseudo-enclosure framework required for handling epsilon-feasible points. Beyond that, we'll overview numerical experiments showcasing the algorithm's strengths and limitations. This includes comparisons with branch-and-bound approaches as well as investigations on effects arising from different problem structures.

Thursday, 9:00-10:00

■ TA-01

Thursday, 9:00-10:00 - Room: Lecture room 16

ÖGOR Plenary Bissan Ghaddar

Stream: Plenaries
Plenary session
Chair: *Sophie Parragh*

1 - **Scalable Polynomial Optimization: Leveraging Structure in Power and Water Networks**
Bissan Ghaddar

Several challenging optimization problems in power and water networks involve both operational decisions and non-linear models of the underlying physics described by the network. While these problems are typically large-scale and NP-hard, they possess an underlying sparse topology that can be exploited through chordal decomposition and partitioning techniques. This talk provides an overview of approaches that combine recent advances in conic relaxations of polynomial optimization with structural decomposition to reformulate these problems into more manageable coupled sub-problems that can be solved efficiently. We also highlight how learning-based methods can be integrated to guide decomposition strategies and improve computational performance across different instances.

Thursday, 10:30-12:30

■ TB-01

Thursday, 10:30-12:30 - Room: Lecture room 16

Stochastic and Derivative-free Optimization

Stream: Theory and practice of zeroth and first-order methods
Invited session
Chair: *Francesco Rinaldi*

1 - Stochastic Three Points Method with an Inexact Oracle and Its Application to Steady-State Optimization
Geovani Grapiglia

We consider unconstrained derivative-free optimization problems in which only inexact function evaluations are available. The oracle returns function values with partially controllable inexactness, whose error is bounded linearly in a user-specified accuracy parameter, with an unknown proportionality constant. This framework captures optimization problems arising from approximate simulations or experimental evaluations with adjustable fidelity. We propose a variant of the Stochastic Three-Point method that adaptively balances oracle accuracy and stepsizes without requiring prior knowledge of the error bound. We derive complexity bounds on the expected number of oracle calls required to obtain approximate stationary points. As an application, we study model-free steady-state optimization in control systems and show that the resulting oracle satisfies the proposed assumptions.

2 - A Direction Adaptation Evaluation Strategy for Noisy Derivative-Free Optimization
Morteza Kimiaei, *Mahsa Yousefi*

In this paper, we propose a direction adaptation evaluation strategy (DAES), a simplified variant of matrix adaptation evolution strategies for high-dimensional, noisy derivative-free optimization (DFO). DAES replaces covariance adaptation with an identity matrix, significantly reducing computational overhead while maintaining strong optimization performance.

The method introduces a set of coordinated improvements across mutation, selection, and recombination. In particular, it employs symmetric sampling in positive and negative directions to mitigate noise, followed by joint sorting of inexact function values and associated directions. The sorted samples are partitioned to construct three recombination points, from which a triangular recombination direction is derived to guide the search toward promising regions. Building on this structure, we propose a novel derivative-free curved line search that operates without directional derivative information.

We establish high-probability complexity bounds for DAES under noisy evaluations for nonconvex, convex, and strongly convex objectives. Empirical results on prince benchmark problems from the BARON collection demonstrate that DAES is competitive with state-of-the-art noisy DFO solvers.

3 - A stochastic differential inclusion for modeling particle swarm optimization and its fluid limit
Yerkin Yesbay, *Pascal Bianchi*, *Radu-Alexandru Dragomir*

Particle Swarm Optimization (PSO) is a zero-order optimization method based on particles driven by individual memory (personal best), interaction (global best) and noise. We propose a continuous-time model for momentum-free PSO. Unlike prior works, where personal best and global best are replaced by a smooth approximation, we keep the original terms based on the exact minimizers along trajectories. We show that the discrete-time algorithm converges, in the small step size limit, to a system of stochastic differential inclusions with discontinuous trajectories.

Using this framework, we establish connections between the dynamics of personal/global best and gradient flow. We prove that the expected movement of the personal best is aligned with the negative gradient. Furthermore, in the small-noise and long-time limit, we conjecture that the global best trajectory approaches gradient flow. We prove this claim for linear objectives and provide experimental evidence in the general case. These properties provide insight into the exploitation mechanism of the algorithm and may be used to derive convergence rates in the finite-particle setting.

4 - Robust Bayesian Optimization with an application to material science
Sebastian Denzler, *Kevin-Martin Aigner*, *Larry Lüer*, *Christoph Brabec*, *Frauke Liers*

We propose a novel online learning framework for the robust Bayesian optimization of uncertain black-box functions. Because standard Bayesian optimization is sensitive to hidden or varying parameters, we formulate a min-max robust counterpart and introduce a practically efficient algorithm: BROVER (Bayesian Robust Optimization via Expected Regret minimization).

BROVER integrates Gaussian process regression with a decomposition approach. It splits the minimax structure into a non-convex online learner—based on the Follow-the-Perturbed-Leader algorithm—and a subsequent minimization step in the decision variables. We establish theoretical regret bounds under mild assumptions, ensuring asymptotic convergence to robust solutions.

Numerical experiments on synthetic data validate these guarantees and demonstrate fast convergence to the robust optimum. Furthermore, we apply BROVER to optimize organic solar cell performance using real-world data featuring natural experimental uncertainty. Results show that the algorithm rapidly identifies highly robust solutions in few iterations, establishing it as a practical method for data-driven black-box optimization under uncertainty.

■ TB-02

Thursday, 10:30-12:30 - Room: Lecture room 15

Advanced topics in optimization and learning 4

Stream: Optimization for Machine Learning and Statistics
Invited session
Chair: *Cesare Molinari*

1 - Mixed Precision Newton's Method for Optimization Problems
Giuseppe Carrino, Elisa Riccietti, Theo Mary, Nicolas Brisebarre

Training large-scale machine learning models demands optimization methods that are both fast and numerically reliable. While second-order methods such as Newton's algorithm offer superior convergence over gradient-based approaches, their adoption in modern ML pipelines has been hindered by prohibitive computational costs. Mixed precision, that is, strategically assigning different floating-point precisions to individual operations based on their sensitivity to rounding errors, offers a principled way to recover this efficiency without sacrificing accuracy. In this talk, we present a general convergence theory for mixed precision Newton methods, providing explicit bounds on problem conditioning and attainable accuracy. The framework extends naturally to practical variants including quasi-Newton and Inexact Newton methods, which are particularly relevant at scale. We validate the approach through numerical experiments on regression problems, highlighting both efficiency gains and robustness to ill-conditioning.

2 - Alternate Training Procedures for Multi-Task Neural Networks
Francesco Della Santa, Stefania Bellavia, Alessandra Papini

This work presents a novel training strategy for Multi-Task Neural Networks (MTNNs) that exploits the hard parameter-sharing architecture typically adopted in these models. The proposed approach addresses key challenges in Multi-Task Learning (MTL), with particular emphasis on mitigating conflicts among task-specific gradients, while also aiming to reduce the overall computational cost of the training process. The method, named Alternate Training through the Epochs (ATE), splits the optimization procedure into two phases by alternating the update of shared parameters and task-specific parameters within each training epoch. This framework is fully compatible with standard optimization algorithms, including Stochastic Gradient (SG) and Adam. For the combination of ATE and SG (ATE-SG), we provide a theoretical convergence analysis. Experimental results for both ATE-SG and ATE-Adam show that the alternating scheme can induce beneficial regularization effects, alongside improvements in computational efficiency.

3 - A First-Order Bi-Level Optimization method for Low-Rank and Sparse Learning
Flavia Esposito, Laura Selicato, Man Shun Andersen Ang

Modern machine learning models often involve nested, bi-level optimization problems with nonconvex and nonsmooth objectives, particularly in sparse and low-rank matrix learning arising in signal processing, regression, and structured learning tasks. To address these challenges, we introduce BINNO, a first-order proximal method for structured bi-level optimization. At each iteration, blockwise proximal-gradient updates are computed separately for each level and then combined through a calibrated convex combination, with weights selected to enforce simultaneous decrease of level-wise surrogate objectives. Using variational analysis, we establish conditions guaranteeing admissible descent directions and monotonic reduction of the global objective, even in the presence of nonconvex and nonsmooth terms.We illustrate the performance of the method on synthetic and real-world datasets, demonstrating improved reconstruction accuracy, sparsity, and signal-to-noise compared to standard approaches. This framework provides a principled and scalable tool for nested optimization problems in modern statistical learning.

4 - QIPM solves a million variable linear optimization problem on a real quantum computer
Tamás Terlaky, Mohammadhossein Mohammadisiahroudi, Adrian Harkness, Pouya Sampourmahani

Quantum computing optimization offers novel challenges and opportunities for optimization. Several variants of Quantum Interior Point Methods (QIPMs) were developed recently. Ultimately, the Iterative Refinement Inexact QIPMs are proved to have clear quantum advantage. Regardless of the major theoretical brak-throughs, due to QC hardware limitations, solving LO and SDO problems on real quantum computers remained out of reach. In this paper we discuss how a million variable linear optimization problem was solved on quantum computer simulators, and on an IBM Quantum Computer.

■ TB-03

Thursday, 10:30-12:30 - Room: Lecture room 17

Derivative-free optimization

Stream: Nonsmooth optimization
Invited session
Chair: *Morteza Rahimi*

1 - A Finite-Difference Trust-Region Method for Convexly Constrained Smooth Optimization
Dânâ Davar, Geovani Grapiglia

We propose a derivative-free trust-region method based on finite-difference gradient approximations for smooth optimization problems with convex constraints. The proposed method does not require computing an approximate stationarity measure. We establish worst-case evaluation complexity bounds with linear dependencies on the number of variables for nonconvex, convex and Polyak-Lojasiewicz functions. Numerical experiments on benchmark problems and a model-fitting application illustrate the method's efficiency relative to state-of-the-art derivative-free solvers for both unconstrained and bound-constrained problems.

2 - Random Subspace Partial Simplex Search for Minimization Over Sparse Symmetric Sets in Machine Learning
Shima Shabani, Morteza Kimiaei, Michael Breuß

We study a class of nonconvex cardinality-constrained optimization problems arising in sparse learning. These problems are NP-hard due to the combinatorial nature of sparsity constraints. We introduce a Random Subspace Partial Simplex Search (RS-PSS) algorithm, a simplex-style method on sparse manifolds that integrates coordinatewise search, symmetry-aware swap-based support updates, and randomized low-dimensional subspace exploration. The proposed method augments classical coordinate and swap moves with sparse-compatible subspace searches constructed from a dynamically maintained reservoir of previously accepted feasible points. A key feature of the approach is a refined reservoir initialization strategy that embeds sparse projection directly into a uniform sampling procedure, preserving geometric diversity within the feasible set. The resulting algorithm is designed to escape poor zero coordinatewise stationary points while maintaining feasibility with respect to both convex and sparse constraints. We further establish that, under mild regularity assumptions, every accumulation point of the RS-PSS iterates is a zero coordinatewise stationary point almost surely. Numerical experiments on a collection of synthetic sparse learning problems demonstrate that RS-PSS achieves improved robustness and solution quality, and is competitive in computational efficiency when compared with the some state of the art methods.

3 - Derivative-Free Proximal Methods for Composite Optimization Problems
Elisa Trasatti, Matteo Lapucci, Marco Sciandrone

We consider the problem of minimizing the sum of a smooth black-box function and a possibly non-smooth function with an efficiently computable proximal operator. We assume that the evaluation of the black-box function is corrupted by the presence of deterministic noise. Classical proximal gradient algorithms are inapplicable when reliable gradient information for the smooth component is unavailable. To overcome this limitation, we propose an algorithmic framework that only relies on zeroth-order information about the smooth part of the objective to update variables before carrying out a proximal step with respect to the non-smooth term. We state theoretical properties of the derivative-free framework under mild regularity assumptions. Numerical experiments demonstrate the effectiveness of the proposed method, extending proximal gradient techniques to a broader class of black-box and noisy optimization problems.

■ TB-04

Thursday, 10:30-12:30 - Room: Seminar room MZ 003B

Risk-averse stochastic optimization problems

Stream: Optimization under uncertainty
Invited session
Chair: *Jia Liu*

1 - Chance constrained conic-segmentation support vector machine with uncertain data and distributional shifts
Shen Peng

Support vector machine (SVM) is one of the well-known supervised machine learning models. The standard SVM models deal with the situation where the exact values of the data points are known. In this talk, to ensure the small probability of misclassification for the uncertain data, we consider a chance constrained conic-segmentation SVM model for multiclass classification. To address the distributional shifts, a stable conic-segmentation SVM with distributionally robust chance constraints is further proposed. For both models, the deterministic reformulations are derived, along with their kernelized counterparts and geometric interpretations. Finally, experimental results are presented to demonstrate the effectiveness and stability of the proposed conic-segmentation SVM.

2 - Why Does Adaptive Zeroth-Order Optimization Work?
Haishan Ye

Zeroth-order (ZO) optimization is popular in real-world applications that accessing the gradient information is expensive or unavailable. Recently, adaptive ZO methods that normalize gradient estimators by the empirical standard deviation of function values have achieved strong practical performance, particularly in fine-tuning the large language model. However, the theoretical understanding of such strategy remains limited. In this work, we show that the empirical standard deviation is, with high probability, closely proportional to the norm of the (stochastic) gradient. Based on this insight, we analyze adaptive ZO methods under the generalized (L_0,L_1)-smoothness condition with respect to the matrix norm. We establish explicit convergence rates and query complexity bounds for both deterministic and stochastic settings, demonstrating that adaptive ZO methods achieve the faster convergence and the improved query efficiency compared to the vanilla ZO methods with fixed-step.

3 - International Portfolio Optimization with Chance Constraints
Jia Liu, Jiaxin Wei

In this talk, we study an international portfolio selection problem, which allocates wealth in different security markets. We built an international portfolio selection model with a chance constraint to guarantee the portfolio performance over a benchmark in a large probability. Stock returns are modeled by a multi-factor structure with Gaussian residuals, while factors, exchange rates and the benchmark follow heavy-tailed marginals coupled by copulas to capture nonlinear dependence. We develop a partial sampling approximation method combined with a sequential convex approximation method to solve the chance constrained international portfolio selection problem. Extensive experiments on developed and emerging markets show the reasonability and superior out-of-sample performance of the proposed international portfolio selection model.

4 - Bilevel optimization under pertubation: from lower Stackelberg equilibria to subgame perfect Nash equilibria
Francesco Caruso, Maria Carmela Ceparano, Jacqueline Morgan

Both pessimistic and optimistic bilevel optimization problems may be not stable under perturbation when the lower-level problem does not admit unique solution, meaning that the limit of sequences of solutions to perturbed bilevel problems is not necessarily a solution of the original problem. In this presentation, we investigate the notion of lower Stackelberg equilibrium, an equilibrium concept arising as a limit point of pessimistic equilibria and of optimistic equilibria of perturbed bilevel problems. First, its connections with pessimistic equilibria and optimistic equilibria are displayed, together with existence and closure results. We then analyze the stability properties of lower Stackelberg equilibria with respect to perturbations. Furthermore, moving to a game theory perspective, we examine the relationship between the set of lower Stackelberg equilibria and the set of subgame perfect Nash equilibrium outcomes of the associated Stackelberg game. These results provide a comprehensive view of different equilibrium concepts in bilevel optimization and Stackelberg games, while also offering a new game-theoretic interpretation of previous limit results concerning pessimistic and optimistic equilibria under perturbations.

■ TB-05

Thursday, 10:30-12:30 - Room: Seminar room MZ 003A

Recent Advances in Bilevel Optimization 2

Stream: Bilevel optimization
Invited session
Chair: *Martin Schmidt*

1 - Mixed-Integer Bilevel Optimization with Nonconvex Lower-Level QPs
Immanuel Bomze, Andreas Horländer, Martin Schmidt

We study bilevel problems with a convex quadratic mixed-integer upper-level, integer linking variables, and a nonconvex quadratic, purely continuous lower-level problem. An iterative lower- and upper-bounding scheme is proposed, which is finite and correct in the sense that it either computes globally optimal points or proves infeasibility of the instance. To this end, we make use of the first-order optimality conditions of the lower-level problem for the lower-bounding step. Integer no-good cuts as well as a simple optimality cut are used to obtain finiteness of the method. Finally, we illustrate the applicability of our approach by the first large-scale numerical experiment for this class of problems in the literature.

2 - True single-level reformulation for pessimistic bilevel optimization
Alain Zemkoho

We discuss a tractable way to write a pessimistic bilevel optimization problem as a single-level optimization problem by means of dual representations for the maximization-based two-level value function. The first step of the analysis is based on the value function reformulation of the lower-level problem. Subsequently, the value function is completely eliminated from the problem. The single-level reformulation proposed here has multiple advantages. In particular, it facilitates the development of optimality conditions and the construction of efficient numerical methods for the pessimistic bilevel optimization problems.

This is joint work with Oliver Stein.

3 - Strong Optimistic Solution for Single-Leader-Multi-Follower Ordinal Games
Shivani Valecha, Didier Aussel, Asrifa Sultana

We study two types of optimistic solutions for Single-Leader-Multi-Follower ordinal games (SLMFOG), namely strong and doubly strong optimistic solutions, where followers' decisions are guided by binary relations. While the classical generalized Nash equilibrium ensures stability against unilateral deviations, it fails to address coordinated deviations among agents (coalitions). To overcome this limitation, the concepts of strong and doubly strong Nash equilibria have been studied in the literature. Based on these notions, we introduce strong and doubly strong optimistic solutions for SLMFOG, providing robustness against joint deviations by follower coalitions. Moreover, unlike classical models based on utility functions, we adopt an ordinal framework where preferences are represented by binary relations on topological vector spaces. We establish existence results for these optimistic solutions by reformulating SLMFOG as an optimization problem with quasi-equilibrium constraints. Our framework is motivated by pollution control problems, where a regulator (leader) commits to a policy and multiple agents (followers) respond strategically. Since coalition formation plays a crucial role in such bilevel problems, our work provides a robust foundation for stable solutions.

4 - Incremental Gradient Methods for Smooth Convex Simple Bilevel Optimization under Quadratic Growth
Sudkobfa Boontawee, Nimit Nimana

In this work, we investigate a simple bilevel optimization problem where both the inner and outer levels are formulated as smooth convex minimization tasks. This framework can be viewed as a constrained convex optimization problem, where the feasible set is restricted to the set of minimizers of the inner-level problem. To solve this in settings where the inner-level objective exhibits a finite-sum structure, we propose an algorithm based on the incremental gradient method. Such incremental schemes are a highly practical choice for training modern machine learning models due to their computational efficiency on large-scale datasets. Without any boundedness assumptions, we analyze our method and establish its convergence rate under a quadratic growth condition. Furthermore, we incorporate variance reduction techniques to mitigate the non-vanishing variance inherent in incremental updates, thereby improving the convergence results.

■ TB-06

Thursday, 10:30-12:30 - Room: Seminar room MZ 201B

Robust, Interval, and Worst-Case Structured Optimization

Stream: Difference-of-convex decompositions and structured nonconvex optimization
Invited session
Chair: *Zimeng Wang*

1 - Beyond Interval Boxes: Generalized Enclosures for Interval Linear Programming
Elif Radová Garajová, Miroslav Rada

Interval linear programming provides a natural framework for modeling optimization problems under data uncertainty, where coefficients are only known within prescribed bounds. A key challenge is the characterization of feasible and optimal solution sets across all admissible realizations. These sets are typically non-convex and may consist of multiple disconnected components, making their exact description difficult. As a result, standard approaches often approximate them by a single interval box, which can lead to substantial overestimation and loss of structural information.

In this talk, we explore alternative approaches for constructing tighter and more informative approximations of such sets. Our focus is on methods that exploit a structured decomposition of the solution space into smaller convex regions, whose union provides a more refined representation. In particular, we consider enumeration-based techniques, including branch-and-bound methods, as well as approaches based on arrangements of hyperplanes induced by extremal realizations of the interval data. Although these methods are computationally more demanding than simple interval enclosures, they offer a significantly improved description of feasible and optimal sets by capturing their geometric complexity, thereby reducing overestimation and enhancing interpretability in interval linear programming.

2 - Measuring solution reliability in multiobjective linear programming via the robustness quotient
Milan Hladík

Traditional robust optimization typically requires explicit knowledge of uncertainty sets to identify solutions that are immune to worst-case scenarios. This talk introduces a different perspective on robustness in multiobjective linear programming by focusing on solution stability under perturbations of cost coefficients.

Our approach introduces the robustness quotient, a novel metric that quantifies the largest admissible variation in cost coefficients that preserves the optimality of a given solution for some (a priori unknown) weighted scalarization. For nondegenerate solutions, we show that this quantity can be computed efficiently via generalized linear fractional programming. In the general case, however, the problem becomes NP-hard. To address this issue, we develop efficiently computable lower and upper bounds based on geometric insights and optimization techniques. Furthermore, we prove that the extreme cases (whether the robustness quotient is zero or infinite) can be determined in polynomial time. Finally, numerical experiments indicate that, while exact methods are limited to small-scale instances, the proposed approximation schemes scale effectively to larger problems.

3 - Minmax Regret Optimization with Benchmarks
Yannick Becker, Pascal Halffmann, Anita Schöbel

The minmax regret concept is a key approach in robust optimization, traditionally defined by minimizing the maximum deviation from the optimal value that could have been achieved if the scenario was known before. While this standard reference point is evaluated over the entire feasible set, in many competitive environments, such as financial markets, this absolute target may be less relevant than the performance of specific reference strategies or market indices.

We present a generalized minmax regret model where the reference point is determined by a predefined benchmark set. This concept serves as a true generalization of classical regret; it recovers the standard model when the benchmark set coincides with the feasible set, while providing the flexibility to restrict the benchmark set to specific competitors.

We provide a systematic investigation of the mathematical and structural properties of this benchmark-based regret. Specifically, we analyze how the representation of the benchmark set influences the properties of the resulting minimax problem. While the decision is still optimized over the full feasible region, the choice of the benchmark set significantly alters the structure of the regret objective. We discuss conditions for tractable reformulations and extend the concept to the multi-objective case. This benchmark regret framework provides a robust approach that aligns closely with competitive decision-making and real-world performance metrics.

4 - The Worst-Case Scenario in Minimum Cost Flows under Interval Capacities: Algorithms and Complexity
Miroslav Rada, Elif Radová Garajová

We investigate minimum cost network flow problems under interval uncertainty in arc capacities, where each capacity can vary independently within given lower and upper bounds. In this talk, we address the question of how bad the optimal solution can get across all feasible realizations, and identify the scenarios which actually attain this worst-case behavior. Understanding this is crucial for evaluating the robustness of network flow solutions under uncertainty.

We show that computing the corresponding worst optimal value is strongly NP-hard, even when restricted to the class of series-parallel graphs, which often simplify complex combinatorial optimization problems. To address this challenge, we propose a mixed-integer linear programming formulation that enables the exact computation of the worst optimal value. In addition, we develop a pseudopolynomial-time algorithm tailored to series-parallel networks, providing an efficient approach for this interesting special case.

Beyond complexity, we also uncover structural properties of worst-case scenarios. In particular, we prove that arcs with non-extremal capacities form a forest, leading to a tight bound on their number and revealing the possibility for an extremal scenario with a sparse structure. These findings allow for development of the quasi-extreme reduction and basis enumeration, known from the interval transportation problem, which can be considered as a special case of our problem.

■ TB-07

Thursday, 10:30-12:30 - Room: Seminar room MZ 112B

Shape optimization 2

Stream: Shape and topology optimization
Invited session
Chair: *Peter Gangl*

1 - Super Resolution Shape Optimization
Stephan Schmidt, Volker Schulz

The aim of this talk is to present a new approach to shape optimization, where a holistic finite element approach is used to describe both PDE solution and shape optimization. In doing so, a dynamic upscaling approach is possible, where a higher resolution shape is created during optimization.

The approach is then couple to a Newton scheme operating on the fully coupled problem.

2 - Shape optimization of electric machines preserving mesh quality
Alessio Cesarano, Martin Siebenborn

In PDE-constrained shape optimization, a lot of computational effort is used to update the geometry at every iteration step. This iterative process can result in loss of element quality and degeneracy of the underlying mesh, which is particularly relevant for applications involving large deformations of some parts of the domain. Degeneration of elements has a negative impact on the convergence of iterative solvers as well as the approximation properties of the discrete solution. It is therefore important to take into account the mesh quality, if remeshing is to be prevented. For these purposes, while a widely used approach to finding a descent direction is based on Hilbert spaces and the solution of an elliptic PDE to find a deformation field, recent trends have involved the use of Lipschitz spaces. Building on previous work in this field, this work deals with the shape optimization of rotating electric machines using PDE-constrained shape optimization algorithms based on Lipschitz transformations. The p-Laplace operator and the alternating direction method of multipliers (ADMM) are used to approximate a descent method for Lipschitz shapes. This approach allows for better mesh quality after large deformations, the creation of new corner points from a smooth initial shape, as well as the smoothening of pre-existing corner points.

3 - Shape Optimization of Spin Patterns for Industrial Spinning Processes
Sebastian Blauth, Christian Leithäuser, Walter Arne

Synthetic fibers are among the most widely produced materials today, with applications in textiles, medical devices, and filtration systems. They are produced by melting polymer granulates and extruding the melt through arrays of fine nozzles arranged in a so-called spinneret. These can contain anywhere from 50 nozzles in research settings to several hundred thousand nozzles in industrial production. As the hot polymer filaments emerge from the nozzles, a directed airflow is applied to cool and solidify them into the final product. However, individual fibers generate aerodynamic slipstreams, which interact with neighboring filaments and lead to non-uniform cooling across the spinneret. As the geometrical arrangement of the nozzles — the so-called spin pattern — directly governs these aerodynamic interactions, it is a key determinant of the overall fiber quality.

In this talk, we present our software SPOT (spin pattern optimization tool), which optimizes spin patterns using techniques from PDE-constrained shape optimization. The air flow around the fiber bundle is modeled with the two-dimensional Navier-Stokes equations, and the nozzle arrangement is treated as design variable. The objective is to achieve a uniform aerodynamic drag across all fibers, ensuring homogeneous cooling conditions and, thus, a uniform fiber quality. We demonstrate the capabilities of SPOT on representative test cases and discuss its potential for improving industrial spinning processes.

■ TB-08

Thursday, 10:30-12:30 - Room: Seminar room MZ 102A

Multiobjective Optimization: Applications

Stream: Multiobjective optimization
Invited session
Chair: *Leo Warnow*

1 - Multi-objective Optimization Data Reduction Approach for Hard-Margin Linear Support Vector Machines
Christian Günther, Marc Steinbach

This talk focuses on the theoretical and algorithmic analysis of hard-margin linear support vector machines (SVMs) in real Hilbert spaces. SVMs are powerful supervised machine learning models primarily used for classification. In the case of binary classification, the goal is to find the optimal linear classifier to separate data points of two different classes in a potentially high-dimensional feature space. Assuming the data points from the two classes can be strictly linearly separated, obtaining a linear classifier based on the maximum-margin hyperplane requires solving a primal or dual quadratic optimization problem. A significant aspect of our work involves applying discrete multi-objective optimization methods, particularly when the goal is to minimize a finite number of conflicting objective functions simultaneously (in the sense of Edgeworth and Pareto) over a finite feasible set. We demonstrate their application to SVMs. Specifically, we explore methods to reduce the number of data points and focus on the most essential ones to obtain an optimal solution in primal/dual SVM problems. A key outcome will be the derivation of a Multi-objective (Vector) Optimization Data Reduction Approach for hard-margin linear SVMs. This approach is particularly useful when the underlying dataset grows over time.

2 - Bayesian multi-objective stochastic control
Gabriela Kovacova, Igor Cialenco

In the last decade, a significant body of work was developed on dynamic programming for multi-objective control problems. One motivating application from finance is the mean-risk approach to portfolio selection, where to identify efficient portfolios we simultaneously maximize mean and minimize risk. The existing dynamic programming results have been derived under an (implicit) assumption of the distribution of underlying stochastic factor – such as asset returns in portfolio selection problem – being known. However, in many situations, including the portfolio selection, distribution of the stochastic factor is not known. This motivates the need for combining multi-objective control with model uncertainty approaches.

In this work, we explore the Bayesian approach to model uncertainty in the context of multi-objective control problem. We build on the existing results for single-objective Bayesian control and aim to establish validity of dynamic programming results for Bayesian multi-objective control.

3 - Multi-Criteria Optimization in Material Modeling
Joris Wenzel, Michael Bortz, Fabian Jirasek, Stefan Ruzika, Hans Hasse

Mathematical modeling of material properties is essential in many areas of engineering. Important model classes in this field are equations of state (EOS) and force-field models for molecular simulations. These models contain parameters that are fitted to experimental data to describe properties of interest accurately. However, improving the description of one property typically deteriorates the description of others. These conflicting objectives naturally motivate the use of MCO. In previous work, we observed characteristic topologies of Pareto sets in MCO problems for fluid material modeling using EOS and force-field models. These Pareto sets have a pronounced "Pareto knee" region with long, nearly linear extensions connecting it to the individual minima [Stöbener et al. 2014, Kulkarni et al. 2022]. This can be explained by the approximately quadratic nature of the objective functions in many practical problems we studied. Such approximations are necessary because evaluating the objective functions, often not available in explicit form, can be computationally expensive. Based on the quadratic approximation the Pareto knee can be identified efficiently. This region is of high interest, as it represents well-balanced compromises. The approximation can then be refined iteratively based on these results. We will discuss the observed Pareto-set topologies, the effectiveness of quadratic approximations of the objective functions, and the advantages of MCO in these problems.

4 - Enhancing Stakeholder Coordination in Food Grain Supply Chains through Platform-Based Collaborative Logistics
Abhay Singh, Aalok Kumar

Food grain supply chains in developing economies like India face inefficiencies due to fragmented logistics, post-harvest losses, weak coordination, and environmental pressures. To address the above problem, this study proposes a platform-enabled collaborative logistics framework that leverages information openness and resource sharing to improve stakeholder coordination. This network includes farmers, collection centres, logistics centres, and processing units. A Multi-Objective Mixed Integer Linear Programming (MOMILP) model is developed to optimize facility location, capacity expansion, and product flows under three objectives: minimizing logistics cost, minimizing carbon emissions, and maximizing employment. The ϵ-constraint method is used to generate Pareto-optimal solutions, enabling trade-off analysis across economic, environmental, and social dimensions. A case study of a grain supply chain in northern India, using a user-generated dataset, demonstrates applicability. Results show that platform-enabled coordination reduces costs and emissions while enhancing rural employment. The study offers a practical decision-support tool for sustainable supply chain design.

Thursday, 14:00-16:00

■ TC-01

Thursday, 14:00-16:00 - Room: Lecture room 16

Methods for Constrained and Structured problems

Stream: Theory and practice of zeroth and first-order methods
Invited session
Chair: *Francesco Rinaldi*

1 - A Support-Set Algorithm for Optimization Problems with Nonnegative and Orthogonal Constraints
Xin Liu

In this paper, we investigate optimization problems with nonnegative and orthogonal constraints, where any feasible matrix of size np exhibits a sparsity pattern such that each row accommodates at most one nonzero entry. Our analysis demonstrates that, by fixing the support set, the global solution of the minimization subproblem for the proximal linearization of the objective function can be computed in closed form with at most n nonzero entries. Exploiting this structural property offers a powerful avenue for dramatically enhancing computational efficiency. Guided by this insight, we propose a support-set algorithm preserving strictly the feasibility of iterates. A central ingredient is a strategically devised update scheme for support sets that adjusts the placement of nonzero entries. We establish the global convergence of the support-set algorithm to a first-order stationary point, and show that its iteration complexity required to reach an -approximate first-order stationary point is O(2). Numerical results are strongly in favor of our algorithm in real-world applications, including nonnegative PCA, clustering, and community detection.

2 - On ADMM, Frank-Wolfe, Cutting plane algorithms for Quantum Entanglement Detection
Liding Xu, Yechao Liu, Sebastian Pokutta

The cone of positive-semidefinite (PSD) matrices is fundamental in convex optimization, and we extend this notion to tensors, defining PSD tensors, which correspond to separable quantum states. We study the convex optimization problem over the PSD tensor cone and its application in quantum entanglement detection. While this convex cone admits a smooth reparameterization through tensor factorizations (analogous to the matrix case), it is not self-dual. Moreover, there are currently no efficient algorithms for projecting onto or testing membership in this cone, and the semidefinite tensor optimization problem, although convex, is NP-hard. To address these challenges, we consider methods for computing lower and upper bounds on the optimal value of the problem. We develop several optimization methods to tackle the problem, including Frank-Wolfe, ADMM, and cutting plane algorithms. In addition, we study the oracle subproblems, which appear to be the common difficulty in the proposed algorithms. Finally, we compare these algorithms on benchmark instances for quantum entanglement anaylsis.

3 - Analysis of a regularized continuous formulation for the maximum s-plex problem
Eleonora Bellesso, Immanuel Bomze, Francesco Rinaldi

Community detection is an important task in social network analysis. In this study, we focus on the s-plex clique relaxation model which allows each member to have at most s1 non-neighbours inside the relaxed structure. In particular, we provide a continuous regularized optimization framework for the maximum s-plex problem, where we consider a broad class of regularization terms that can be included in the Motzkin-Straus continuous formulation. Inspired by previous results and techniques used to provide a regularization framework for the maximum clique problem, we then develop conditions that guarantee the local (and global) equivalence between the continuous regularized problem and the original combinatorial one. We further analyze some regularized functions that meet the detected conditions. Finally, we report preliminary numerical experiments showing the validity of the proposed approach.

4 - The Maximum Clique Problem under Adversarial Uncertainty: a min-max approach
Giovanni Spisso, Immanuel Bomze, Chiara Faccio, Francesco Rinaldi

In this talk, we analyze the problem of identifying large cliques in graphs that are affected by adversarial uncertainty. More specifically, we consider a new formulation, namely the adversarial maximum clique problem, which extends the classical maximum-clique problem to graphs with edges strategically perturbed by an adversary. The proposed mathematical model is thus formulated as a two-player zero-sum game between a clique seeker and an opposing agent. Inspired by regularized continuous reformulations of the maximum-clique problem, we derive a penalized continuous formulation leading to a nonconvex and nonsmooth optimization problem. We further introduce the notion of stable global solutions, namely points remaining optimal under small perturbations of the penalty parameters, and prove an equivalence between stable global solutions of the continuous reformulation and largest cliques that are common to all the adversarially perturbed graphs. In order to solve the given nonsmooth problem, we develop a first-order and projection-free algorithm based on generalized subdifferential calculus inspired by Clarke and Goldstein, and establish global sublinear convergence rates for it. Finally, we report numerical experiments on benchmark instances showing that the proposed method efficiently detects large common cliques.

■ TC-02

Thursday, 14:00-16:00 - Room: Lecture room 15

Advanced topics in optimization and learning 5

Stream: Optimization for Machine Learning and Statistics
Invited session
Chair: *Brendan Ames*

1 - Optimal experimental design under linear constraints: duality, sparsity, and column generation.
Selin Ahipasaoglu, Stefano Cipolla

In this work, we discuss how large instances of the optimal experimental design problem under linear constraints can be solved efficiently by a generalised column generation algorithm that exploits the sparsity of the optimal solution. The method can be used efficiently for the D-optimal and A-optimal criteria as well as their weighted mixtures.

2 - Finding a Hidden Clique via Non-Convex Quadratic Programming
Brendan Ames

Although the maximum clique problem is well-known to be computationally intractable, several recent analyses have established sufficient conditions under which we can expect to identify the largest clique in a graph. We will consider a novel non-convex relaxation scheme for clique and provide sufficient conditions which ensure identification of the maximum clique from the optimal solution of this relaxation. We propose a novel first-order method for solving this relaxation and establish conditions under which the algorithm is guaranteed to converge to the global minima revealing the hidden clique. We will illustrate the effectiveness of the proposed relaxations using randomly generated graphs, as well as real-world social, literary, and biological networks.

3 - Faster algorithms for packing forests in graphs and related problems
Pavel Arkhipov

We consider several problems related to packing forests in graphs. The first one is to find k edge-disjoint forests in a directed graph G of maximal size such that the indegree of each vertex in these forests is at most k. We describe a min-max characterization for this problem and show that it can be solved in almost linear time for fixed k, extending the algorithm of [Gabow, 1995]. Specifically, the complexity is $O(k delta m log n)$, where n, m are the number of vertices and edges in G respectively, and $delta = max1, k - k_G$, where k_G is the edge connectivity of the graph. Using our solution to this problem, we improve complexities for two existing applications:

(1) k-forest problem: find k forests in an undirected graph G maximizing the number of edges in their union. We show how to solve this problem in $O(k3 minkn, m log2 n + k cdotrm MAXFLOW(m, m) log n)$ time, breaking the $O_k(n3/2)$ complexity barrier of previously known approaches.

(2) Directed edge-connectivity augmentation problem: find a smallest set of directed edges whose addition to the given directed graph makes it strongly k-connected. We improve the deterministic complexity for this problem from $O(k delta (m+delta n)log n)$ [Gabow, STOC 1994] to $O(k delta m log n)$. A similar approach with the same complexity also works for the undirected version of the problem.

4 - Optimizing edge weights in the inverse eigenvector centrality problem
Mauro Passacantando, Fabio Raciti

In this paper we study the inverse eigenvector centrality problem on directed graphs: given a prescribed node centrality profile, we seek edge weights that realize it. Since this inverse problem generally admits infinitely many solutions, we explicitly characterize the feasible set of admissible weights and introduce six optimization problems defined over this set, each corresponding to a different weight-selection strategy. These formulations provide representative solutions of the inverse problem and enable a systematic comparison of how different strategies influence the structure of the resulting weighted networks. We illustrate our framework using several real-world social network datasets, showing that different strategies produce different weighted graph structures while preserving the prescribed centrality. The results highlight the flexibility of the proposed approach and its potential applications in network reconstruction, and network design or network manipulation.

■ TC-03

Thursday, 14:00-16:00 - Room: Lecture room 17

First-order methods in nonsmooth optimization

Stream: Nonsmooth optimization
Invited session
Chair: *Morteza Rahimi*

1 - Anderson and Barrier Acceleration of PDHG
Yingxin Zhou, Stefano Cipolla, Vuong Phan

he Primal-Dual Hybrid Gradient (PDHG) method has recently emerged as an attractive first-order alternative to simplex and interior point methods for solving large-scale linear programs (LPs). Its low per-iteration cost and natural suitability for parallelisation make it particularly attractive for large scale LPs. However, PDHG often requires a large number of iterations to reach the high levels of accuracy demanded in LP applications, and its convergence can degrade substantially on ill-conditioned or degenerate instances. In this work, we present two complementary strategies for accelerating the convergence of PDHG in the LP setting. First, we incorporate Anderson acceleration — a nonlinear extrapolation technique for fixed-point iterations — into the PDHG update scheme https://arxiv.org/abs/2508.08062. Second, we introduce a barrier-based acceleration strategy that augments the primal-dual iterations with logarithmic barrier terms, drawing a principled connection between first-order primal-dual methods and interior point methodology. We provide convergence analysis for the resulting schemes and present numerical experiments on a range of benchmark LP instances, demonstrating significant reductions in iteration counts and solution times compared to highly tuned PDHG implementations.

2 - Asynchronous Nonconvex Nonsmooth Stochastic Optimization with Markovian data
Khiem Huynh

Asynchronous stochastic optimization is essential for scaling learning algorithms across multiple workers, yet most theoretical guarantees assume independent and identically distributed (i.i.d.) data. This assumption is often violated in real-world scenarios, where data are generated sequentially by stochastic processes, leading to temporal dependence. We study asynchronous stochastic optimization for nonconvex and nonsmooth objectives with Markovian data. In the smooth i.i.d. setting, asynchronous SGD with delay-adaptive step sizes is known to achieve delay-independent convergence rates and outperform synchronous methods. We show that this result extends to the more challenging setting of nonsmooth, nonconvex optimization with dependent data. We establish convergence rate of asynchronous Proximal SGD with delay-adaptive step size to a near-stationary point, measured by the norm of the gradient of the Moreau envelope, that depends only on the number of workers. Our results recover known guarantees in the i.i.d. regime for asynchronous stochastic weakly convex optimization. We validate our theory with an online nonnegative matrix factorization problem arising in network dictionary learning, where samples correspond to subgraphs extracted from a large network via Markov chain Monte Carlo procedures. Experiments confirm the benefit of asynchronous Proximal SGD, highlighting their practical advantages in the presence of both system heterogeneity and temporal data dependence.

3 - Adaptive scaled gradient methods under local Hölder continuity of gradient
Morteza Rahimi, Susan Ghaderi, Masoud Ahookhosh

This talk presents a convergence analysis of an adaptive scaled gradient method (AdaSGA) for convex optimization problems whose gradients are locally Hölder continuous. The proposed method employs a data-driven scaling strategy that adapts to the local smoothness of the objective function. We establish global convergence of the generated sequence and derive iteration complexity bounds under mild assumptions. Furthermore, by invoking the Kurdyka-Łojasiewicz inequality, we prove linear convergence rates and provide explicit complexity estimates. Preliminary numerical experiments are included to illustrate and support the theoretical findings.

4 - Smoothing Nonsmooth Posteriors via Higher-Order Moreau Envelopes: Applications to Matrix Completion
Susan Ghaderi, Alireza Kabgani, Yves Moreau, Masoud Ahookhosh

Sampling from Bayesian models with nonsmooth composite potentials remains challenging due to the lack of smoothness required by gradient-based methods. In this work, we introduce a higher-order Moreau envelope to smooth objectives of the form $f + g$, where f is smooth and g is nonsmooth or weakly convex. By leveraging a p-order regularization with $p in (1,2]$, the proposed envelope yields a differentiable surrogate that better captures the underlying geometry than classical quadratic smoothing. We combine this construction with a Langevin-type algorithm to enable efficient sampling, and apply the framework to Bayesian matrix completion with sparsity-inducing priors. Numerical results demonstrate improved stability and reconstruction performance compared to standard smoothing approaches.

■ TC-04

Thursday, 14:00-16:00 - Room: Seminar room MZ 003B

Block-coordinate Optimization

Stream: Theory and practice of zeroth and first-order methods
Invited session
Chair: *Luca Calatroni*

1 - From multilevel to block-coordinate optimization: automatic coarse level selection
Elisa Riccietti, Edgar Desainte-Mareville, Nelly Pustelnik, Marion Foare, Paulo Gonçalves

Classical optimization methods used to solve imaging inverse problems do not scale well with the image size. To address this issue, and drawing inspiration from multigrid methods for numerical PDEs solving, multilevel optimization methods have been introduced. They rely on the multiscale decomposition of a signal, using tools such as the wavelet transform, to define auxiliary problems on smaller-scale images whose solutions are used to accelerate the convergence. Multilevel schemes usually target low frequencies at coarse levels, which limits their good performance to contexts where the degradation is strong, but the noise is low. Leveraging the link between multilevel and block-coordinate descent algorithms, we propose a strategy to incorporate high-frequency steps into multilevel algorithms to accelerate convergence and improve the reconstruction quality in all the degradation contexts. Specifically, we propose an automatic rule for block selection, which dynamically adapts to the degradation and noise levels.

2 - Block Coordinate Plug-and-Play Algorithms with Linesearch for Image Restoration
Simone Rebegoldi

Plug-and-Play (PnP) algorithms represent a powerful and innovative paradigm for solving inverse problems in computational imaging. These methods replace the usual explicit regularization step with an implicit step, implemented by means of a denoising algorithm. Recently, a new denoising operator for PnP algorithms has been proposed, defined explicitly as the gradient step of a potential function parametrized by a convolutional neural network. Such denoisers allow for a clearer variational interpretation of PnP methods; however, they are high-memory consuming, as their implementation requires storing large computational graphs.

We propose a novel class of block coordinate PnP methods to address imaging inverse problems. The block coordinate strategy is designed to reduce the high memory consumption arising in PnP methods that rely on Gradient Step denoisers. The proposed methods apply a proximal-gradient step with momentum, followed by an Armijo-like linesearch on a suitable merit function, to one block of variables at a time while keeping all other blocks fixed. We perform the convergence analysis of the methods under the assumption that a suitable merit function satisfies the Kurdyka-Lojasiewicz property on its domain. Numerical experiments on ill-posed imaging problems, including deblurring and super-resolution, demonstrate that the proposed PnP approach achieves state-of-the-art reconstruction quality while substantially reducing GPU memory requirements.

3 - bAdag: a new adaptive block coordinate gradient algorithm
Giovanni Seraghiti

We propose a new Block Coordinate Gradient (BCG) method, dubbed block Adagrad (bAdag) which falls in the class of Objective Function Free Optimization (OFFO) and adaptive gradient methods. bAdag generalizes the Adagrad algorithm to the block coordinate setting where, at each iteration, only a subset of variables is updated using a gradient step while the others remain fixed. BCG methods have been applied in a variety of contexts, especially in applications where the cost of one full gradient computation is higher than that of a single partial derivative. Although adaptive strategies to select the step size are widely popular in first order optimization, they remain relatively unexplored for BCG. Our work contributes to linking these two research fields. BCG methods consist of two key steps: the selection of a block of variables, and the update of these variables based on partial gradient information corresponding to the selected block. In the bAdag algorithm, we consider three widely popular block selection strategies: the Gauss-Southwell rule, uniform random selection, and the cyclic rule. Moreover, we show that an Adagrad-like step size can be derived from the history of the partial gradient available at each iteration. We prove hergodic convergence rates for smooth, nonconvex objective for the three block selection rules considered. We test our algorithm on least squares and logistic regression.

4 - Structured Step-Size Policies for Scalable Worst-Case Optimization Design
Erwan Meunier, Julien Hendrickx

We leverage the Performance Estimation Problems framework (PEP) to numerically design first-order optimization algorithms with respect to worst-case performance. Existing approaches typically optimize time-varying step sizes over N iterations, leading to an N-dimensional search space that quickly becomes computationally prohibitive, even for moderate horizons.

Our main contribution is to instead optimize a low-dimensional set of parameters defining a structured step-size policy, based on the observation that effective step sizes follow simple parametric forms. Although the resulting design problem remains non-convex, restricting the search to this constant-dimensional subspace drastically reduces computational cost while preserving significant improvements in worst-case performance. This formulation directly embeds the fitting of near-optimal step sizes into the design process.

We further investigate the robustness of parameters optimized for a fixed horizon N, showing that they generalize well to different iteration counts while maintaining strong performance guarantees.

In practice, we demonstrate that well-chosen constant step sizes for Online Gradient Descent can outperform the decreasing step-size schedules commonly recommended in the literature.

■ TC-05

Thursday, 14:00-16:00 - Room: Seminar room MZ 003A

Structured Derivative-Free Optimization

Stream: Theory and practice of zeroth and first-order methods
Invited session
Chair: *Silvia Villa*

1 - Complexity guarantees and polling strategies for Riemannian direct-search methods
Bastien Cavarretta, Florentin Goyens, Clément Royer, Florian Yger

Direct-search algorithms are derivative-free optimization techniques that operate by polling the search space along specific directions forming a positive spanning set (PSS). When the variables are constrained to lie in a Riemannian manifold, feasibility dictates these directions to live in tangent spaces. Designing such Riemannian direct-search methods raises a number of questions about their convergence properties and practical efficiency. In this talk, we provide a complexity analysis for a class of Riemannian direct-search schemes, that depends on the quality of directions used. We then investigate two strategies for building PSSs on manifolds. Projected PSSs are defined by projecting an ambiant PSSs at every tangent space, whereas intrinsic PSSs are built by directly operating in the tangent space. Numerical experiments advocate for the use of intrinsic PSSs, especially when the codimension of the manifold is much larger than its intrinsic dimension. Finally, we perform blackbox adversarial attack of classical neural networks using Riemannian direct-search techniques.

2 - Riemannian optimization with finite-difference gradient approximations
Timothé Taminiau, Geovani Grapiglia, Estelle Massart

Derivative-free Riemannian optimization aims to minimize an objective function using only function evaluations, under the constraint that the decision variables lie on a Riemannian manifold. The rapid increase in problem dimensions over the years calls for computationally cheap algorithms, that is, algorithms requiring as few function evaluations and retractions as possible. We propose a novel derivative-free Riemannian optimization method based on finite-difference gradient approximations that relies on an adaptive selection of the finite-difference accuracy and stepsize. When endowed with an intrinsic finite-difference scheme, that measures variations of the objective in tangent directions using retractions, our proposed method requires $O(depsilon-2)$ function evaluations and retractions to find an $epsilon$-critical point, where d is the manifold dimension. We then propose a variant of our method when the search space is a Riemannian submanifold of an n-dimensional Euclidean space. This variant relies on an extrinsic finite-difference scheme, approximating the Riemannian gradient directly in the embedding space, assuming that the objective function can be evaluated outside of the manifold. This approach leads to worst-case complexity bounds of $O(depsilon-2)$ function evaluations and $O(epsilon-2)$ retractions. We also present numerical results showing that the proposed methods achieve superior performance over existing derivative-free methods.

3 - A High-Temperature Perspective on the Zeroth-Order Proximal Operator
Hippolyte Labarrière, Emanuele Naldi, Cesare Molinari, Silvia Villa

Recent works treat global black-box optimization by designing efficient methods relying mostly on sampling. In this regard, the Zeroth Order Proximal Operator (ZOPO) has been an object of interest since it combines the advantage of only needing to evaluate the objective with the ability to approximate a well-known and powerful tool in optimization: the proximal operator. This operator depends on a temperature parameter which, when going to zero, reduces ZOPO to the exact proximal operator.

Although this vanishing-temperature phenomenon has been leveraged in several works to build algorithms and obtain theoretical guarantees, we propose a comprehensive analysis of ZOPO in the high-temperature regime. We demonstrate that the low-temperature limit is computationally unsustainable when using sampling to estimate ZOPO, suffering from severe variance issues. By embracing a high or piecewise-constant temperature, we can overcome these sampling bottlenecks while simultaneously leveraging the operator's natural smoothing properties to navigate complex, non-convex landscapes.

4 - Inexact derivative-free methods for structured bilevel optimization
Gabriele Sanguin, Francesco Rinaldi, Marco Viola, Matteo Pernini

Bilevel Optimization is a powerful framework for addressing complex machine learning challenges such as hyperparameter tuning, meta-learning, data distillation, and adversarial training to name a few. In many relevant applications, the upper-level objective can however only be evaluated through a black-box procedure, making derivative information unavailable, unreliable, or prohibitively expensive to compute. This naturally motivates the use of derivative-free methods, which rely exclusively on function evaluations and are therefore well suited to this bilevel setting. This work investigates the development and application of inexact derivative-free methods for solving structured BO problems with a black-box upper-level objective and the feasible region described as the convex hull of a finite set of atoms. In particular, starting from the inexact direct-search method introduced in [Diouane et al., COAP 2024] for unconstrained setting, we propose a new method for the case of such constrained problems in which we guarantee feasibility by using tailored Frank-Wolfe-like search directions. We discuss the theoretical properties of the proposed algorithm and test its effectiveness on a standard set of instances.

■ TC-06

Thursday, 14:00-16:00 - Room: Seminar room MZ 201B

Financial and demand aspects in energy systems

Stream: Energy applications
Invited session
Chair: *Miguel Anjos*

1 - Computing reward allocations in energy communities
Giancarlo Bigi

A coalitional game with transferable utility arising from the analysis of energy communities is introduced as the Energy Sharing Game (ESG). A veto player is needed beyond the prosumers to manage the community, and the worth of a coalition is its benefit compared to the selfish behaviour of the prosumers. The worth of a coalition in ESG is provided by the optimal value of an optimization problem where prosumers control variables, while their presence in the coalition activates constraints and terms in the objective function. The least core provides those allocations that maximize the margin between the overall reward of any coalition and its worth, so it somehow provides the most stable allocations of the reward between the prosumers and the manager to choose from. The properties of ESG are analysed both in the presence and absence of admission fees. Then, the least core and its value are studied. In particular, an exact formula and computable bounds for the least core value are provided. The computation of the exact formula for the least core value is addressed through suitable families of mixed-integer programs, whose resolution is viable when the underlying optimization problems of the prosumers are linear. Indeed, five different approaches have been developed and tested for problems up to 200 prosumers, and the results show that the fastest is quite efficient.

(based on joint papers with D.Fioriti, A.Frangioni, M.Passacantando, D.Poli)

2 - Dynamic Congestion Pricing in Energy Networks
Ali Nikseresht, Reza Rahimi Baghbadorani, Jehum Cho, Yashar Ghiassi-Farrokhfal

Congestion represents significant challenges in the operation of welfare-based energy networks, often resulting in market inefficiencies and system instability.

This study proposes a novel framework for mitigating network bottlenecks by introducing a dynamic pricing approach for congestion management through the lens of the grid operator. The goal is to determine the optimal price for congested lines, incentivizing a redispatch of resources that minimizes system-wide stress while preserving social welfare.

We reformulate the congestion management problem as specialized mathematical programs, transitioning from a minimax formulation to bilevel optimization structures. To solve these formulations, we implement different algorithmic strategies: (i) convex-concave minimax methods, utilized to handle saddle-point stability, and (ii) difference-of-convex programming, applied to the bilevel model to decompose nonconvex constraints into manageable subproblems.

Numerical experiments assess the effectiveness of the proposed methodology and provide a computational framework for the congestion management problem.

3 - Demand Uncertainty with fuzzy logic in optimal power systems
Aurelio Oliveira, Caroline Cerqueira

This work focuses on optimizing power flow in the electrical system, considering uncertainties in energy demand, minimizing costs and energy losses within the constraints of the physical network. To this end, fuzzy triangular numbers are used to represent power demand. The problems are solved using specialized software that employs interior point methods with logarithmic barrier function for quadratic programming and a surprise function to handle fuzzy numbers. Numerical experiments with IEEE test systems and the actual Brazilian National Interconnected System instances demonstrate good performance regarding solution quality compared to a classical model that does not consider data uncertainty, despite the increased number of iterations and consequently the processing time. A comparison with solutions from a two-stage stochastic programming approach is also performed.

4 - Optimising Power Purchase Agreement Portfolios to Minimise Fiscal Risk: A Case Study of Georgia's Electricity Sector
Levan Pavlenishvili

In this paper, we propose an optimisation formulation to address the backlog of Power Purchase Agreements (PPAs) with the electricity system commercial operator (ESCO) in the Republic of Georgia. The ESCO is a state-owned off-taker of PPAs that, with government guarantees, signs trilateral PPAs with power plant developers. Over the years, ESCO has accumulated a backlog of more than 30 PPA projects that have not been commissioned as planned. Furthermore, according to the International Monetary Fund (IMF), some of these projects were identified as a potential fiscal risk for the government. This fiscal risk arises from the possibility that, due to high PPA prices, ESCO could become insolvent, creating a liability for the government to step in and make unplanned budget payments.

The optimisation formulation proposed in this paper aims to minimise the fiscal risk associated with PPAs. It is a generation expansion planning model incorporating conditional value at risk (CVaR) and additional constraints to prevent the off-taker from becoming insolvent. The model has also been modified to address other government policy priorities, such as improving competition in the power market through generation diversification. The model's solution and sensitivity analysis can also be used to identify conditions for renegotiating PPAs.

■ TC-07

Thursday, 14:00-16:00 - Room: Seminar room MZ 112B

Numerical methods for nonconvex optimization

Stream: Splitting algorithms
Invited session
Chair: *Emanuele Naldi*

1 - The Boosted Double-proximal Subgradient Algorithm
Pedro Pérez-Aros

In this talk, I will present the Boosted Double-proximal Subgradient Algorithm (BDSA), a new splitting method for structured nonsmooth and nonconvex optimization problems involving sums and differences of composite functions. The method combines subgradient information, proximal steps, and a linesearch procedure, and includes several existing algorithms as special cases.

I will discuss its convergence under the Kurdyka-Łojasiewicz property, as well as convergence-rate results. Numerical experiments on challenging test problems with many critical points illustrate the strong practical performance of BDSA, including its ability to avoid non-optimal critical points. I will also present applications to constrained minimum-sum-of-squares clustering and a nonconvex version of Heron's problem.

2 - Nonmonotone subgradient methods based on a local descent lemma
Rubén Campoy, *Francisco Javier Aragón Artacho*, *Pedro Pérez-Aros*, *David Torregrosa-Belén*

In this talk, we extend the context of nonmonotone descent methods to a general class of nonsmooth and nonconvex functions satisfying a nonsmooth and local version of the descent lemma. Under this assumption, we propose a general subgradient method with a nonmonotone linesearch and prove subsequential convergence to stationary points. Our approach applies to a broad class of problems, including those involving forward-backward envelopes and augmented Lagrangians. We also report numerical results illustrating the advantages of the proposed method compared to existing algorithms.

3 - Stochastic proximal subgradient algorithm for a class of nonsmooth nonconvex programs
David Torregrosa-Belén

In this work, we propose a stochastic proximal subgradient algorithm to minimize the sum of a proper, lower semicontinuous function and the expectation of a nonsmooth function that satisfies a generalized version of the descent lemma. This class of problems arises, for instance, in the field of optimal quantization, where the goal is to discretize a continuous probability distribution. Since in practice it is not usually feasible to access the exact value of the expected cost, nor its derivatives, we propose a stochastic approximation scheme that accesses this information through sampling. We analyze the convergence of the proposed scheme and provide global convergence guarantees by leveraging the Polyak-Lojasiewicz-Kurdyka property.

4 - Numerical approaches for regularized linear-quadratic optimization
Alberto De Marchi

Optimization problems with convex quadratic cost and polyhedral constraints are ubiquitous in signal processing, automatic control and decision-making. This talk will consider an enlarged problem class that covers also logical conditions and cardinality constraints, among others. In particular, we focus on situations where parts of the constraints are nonconvex and possibly complicated, but it is practical to compute projections onto this nonconvex set (or to evaluate the proximal mapping of the regularizer). Our approach combines the augmented Lagrangian framework with solver-agnostic subproblem reformulations that exploit the problem structure. While convergence guarantees follow from the former, the proposed reformulations lead to significant improvements in computational performance.

■ TC-08

Thursday, 14:00-16:00 - Room: Seminar room MZ 102A

Optimal control and stochastic optimal control 1

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

1 - Dynamic Programming using Average-Value-at-Risk Criteria
Kerem Ugurlu

We investigate dynamic programming equations on Average-Value-at-Risk (AVaR) using machine learning techniques and demonstrate several simulations. The dynamic programming equation on AVaR is specifically using a so called "state aggregation technique" that makes use of the sufficient statistic of the optimization problem. Via state aggregation, we present the "Markovian" framework and demonstrate several implementations using ML techniques. The risk averseness level alpha on the model is also investigated via several simulations.

2 - Navigating uncertainty Towards a robust pension fund management framework (and related topics)
Gerhard-Wilhelm Weber, *Ioannis Baltas*, *Athanasios Yannacopoulos*, *Emel Savku*

The aim of the present project is to provide a novel, unified framework for the study of the problem of the optimal management of defined contribution pension funds under the effects of risk and model uncertainty. More precisely, we consider a fund manager who is endowed with some initial wealth stemming from pooled contributions of the fund members and his role is to optimally distribute this wealth, among several financial assets, in order for the fund to achieve some desired goal at the end of the trading horizon and to effectively mitigate any unnecessary risks. Furthermore, given the special design and the long-term structure of pension fund schemes, the effects of important external stochastic (market and demographic) factors, such as human mortality, interest rates and inflation, as well as model uncertainty, must be included in the decision-making process. By employing a mixture of robust control theory and dynamic programming techniques, we are able to provide: (i) the optimal investment decisions of the fund manager in closed-form, and a (ii) comprehensive numerical study (using real-world data and a novel machine-learning inspired approach) of the qualitative features of the problem at hand, that provides valuable insights on how the suggested pension fund management approach can be effectively applied in practice.

3 - A Generalized Allocation Rule for Big Boss Games
İsmail Özcan, *Gerhard-Wilhelm Weber*

This study introduces the k-proportional -value as a generalized payoff allocation rule for big boss games by modifying the minimal right vector through a proportionality parameter, k. The proposed specification maintains core feasibility while allowing greater flexibility in the allocation of payoffs. An AI- and OR-motivated case study based on Amazon's personalized recommendation system is used to demonstrate the applicability of the framework in evaluating hierarchical collaboration, incentive alignment, and fair compensation in complex, data-driven organizational environments. The analysis suggests that the proposed approach constitutes a useful and practically relevant tool for studying cooperation and distributive equity in contemporary firms.

4 - Trend-Aware Transshipment in Networked Inventory Systems with Endogenous Diffusion
Jaakko Ahola, Marko M. Mäkelä

We study a inventory transshipment problem on a network where demand evolves through endogenous trend diffusion. Unlike classical models with exogenous or independent demand, we assume that demand at each node is influenced by neighboring nodes, or in case of out of stock demand is diverted to neighboring nodes.

The practical motivation here is finding an optimal dynamic inventory balance in a rapidly evolving smart phone sales network. New phone models dramatically affect sales of older models and trends propagate through the network by default from larger cities to smaller ones.

We propose an influence-aware transshipment framework that enables inventory relocation decisions to anticipate future demand changes before the trend fully reaches a node. The model takes into account network-based diffusion dynamics with inventory decisions, including transshipment and holding, and is formulated as a mixed-integer non-linear program.

We evaluate the inventory model on simulating demands on networks of varying sizes and topologies, including random graphs, small-world networks, and fully connected graphs, to analyze how structural properties influence decision-making. Demand can be also exposed to external effects, e.g. seasonal variation.

The work aims to provide a mathematical programming perspective on integrating network-driven demand dynamics into inventory optimization.

Thursday, 16:30-17:40

■ TD-01

Thursday, 16:30-17:40 - Room: Lecture room 16

EUROPT Fellowship Lecture

Stream: Plenaries
Invited session
Chair: *Giancarlo Bigi*

1 - The Interplay between Approximation Theory and Semidefinite Programming
Etienne De Klerk

Projection onto a convex set is central to both approximation theory and continuous optimization. If the ambient space is the (Euclidean) space of polynomials of fixed degree, then the projection often involves semidefinite programming in a natural way. In this talk we will explore the case where the convex set in question is the cone of sums-of-squares (SoS) of polynomials of fixed degree. We will see how this links to Chebyshev (uniform) approximation, and to the Lasserre hierarchy for polynomial optimization. The key is to understand the projection of a given nonnegative, polynomial (of high degree) onto the SoS cone of fixed degree, when using a suitable norm. Conversely, we will also look at how one may use numerical semidefinite programming to construct polynomial kernels in approximation theory, that are optimal in some sense.

Friday, 9:00-10:00

■ FA-01

Friday, 9:00-10:00 - Room: Lecture room 16

Plenary Ana Luisa Custodio

Stream: Plenaries
Plenary session
Chair: *Immanuel Bomze*

1 - Derivative-Free Optimization for Multiobjective Problems: Methods and Perspectives
Ana Luisa Custodio

Derivative-free optimization provides a framework for addressing continuous optimization problems in which derivative information is unavailable or prohibitively expensive to obtain. Such settings arise naturally in simulation-based optimization and other complex scenarios where function evaluations are costly and may be affected by noise.

This talk focuses on the development of derivative-free methods for multiobjective optimization. In particular, attention is given to algorithmic frameworks that approximate Pareto fronts without relying on aggregation techniques, highlighting the role of direct search methods and their theoretical properties. Extensions incorporating surrogate models, parallel strategies, and approaches for handling constraints will also be discussed.

The presentation aims to provide a coherent perspective on this line of research, emphasizing the interplay between algorithmic design and theoretical analysis. Connections with broader challenges in continuous optimization will be outlined, including scalability and the treatment of increasingly complex problem structures.

Friday, 10:30-12:30

■ FB-01

Friday, 10:30-12:30 - Room: Lecture room 16

Bregman methods, inverse problems, and imaging

Stream: Theory and practice of zeroth and first-order methods
Invited session
Chair: *Silvia Villa*

1 - Path computation for L0 problems via L0 Bregman relaxations.
Mhamed Essafri, *Emmanuel Soubies*, *Luca Calatroni*

Sparse modeling plays a fundamental role in areas such as machine learning, inverse problems in signal and imaging, and computer vision. A common approach to enforce sparsity uses the L0 penalty, leading to optimization problems that balance data fidelity with sparsity.

However, the L0 penalty yields problems that are discontinuous, non-convex, and NP-hard, making them difficult to solve. Recently, we introduced exact continuous relaxations of the L0-regularized objective, called L0 Bregman relaxations. These replace the discontinuous sparsity term with a continuous (though still non-convex) penalty, while preserving global minimizers and removing some local ones, simplifying the optimization landscape.

In this work, we present a regularization path strategy that leverages a key property of these relaxations: local minimizers of the original L0 problem remain local minimizers of the relaxed formulation over a range of parameters. This enables efficient warm-start initialization. Based on this idea, we propose the L0PathBrex algorithm, which computes a path of candidate sparse solutions. Numerical experiments demonstrate its effectiveness compared to state-of-the-art methods, including the L0Learn package.

2 - Fast Langevin-based sampling
Andreas Habring

Within modern machine learning and inverse problems, Langevin based sampling is the most wide-spread method for obtaining samples from general Gibbs distributions. While algorithms are as simple as gradient descent, unfortunately, Langevin sampling suffers from slow convergence, especially in non-convex and high-dimensional settings. In this talk we will introduce Langevin sampling, discuss its relation to optimization in Wasserstein-space, and present two approaches for acceleration: one momentum-based and the other one relying on successive approximation. In addition to theoretical analyses we will consider numerical experiments for low-dimensional toy problems as well as large-scale imaging problems.

3 - Linear Convergence of Bregman First-Order Methods: applications to Poisson Inverse Problems
Christian Daniele, *Jonathan Chirinos Rodriguez*, *Cédric Févotte*, *Emmanuel Soubies*

First-order optimization methods are fundamental techniques for solving a broad class of problems in several applications. From a theoretical standpoint, it is well known that strong convexity is the reference condition for achieving linear convergence in Proximal Gradient methods.

More recently, Bregman Proximal Gradient Methods (BPGM) have been re-examined through the concepts of relative smoothness and relative strong convexity. While linear convergence for BPGM has been established under the latter assumption, such condition is often difficult to satisfy or verify in practice. Thus a natural question arises: Can this condition be relaxed?

In this talk, we introduce a novel notion of relative strong convexity within the BPGM framework that guarantees linear convergence rates in the convex setting. Focusing on Kullback-Leibler minimization—a central problem in Poisson inverse problems—we propose a tailored mirror map and prove that the objective functional satisfies our new condition relative to this choice. Finally, we provide numerical experiments across diverse scenarios to validate the theoretical linear rates and the efficiency of the proposed approach.

This presentation is linked to a companion talk given by Jonathan Chirinos-Rodríguez within the stream 'Optimization for machine learning and statistics'.

4 - Blind image reconstruction: from LMMSE estimators to convergent plug and play regularisation
Luca Calatroni

Blind inverse problems arise in signal/image processing applications where both the image and the forward model are unknown. In this talk, we present two complementary approaches to blind image reconstruction, highlighting the transition from linear to nonlinear estimators. We first analyze Linear Minimum Mean Squared Error (LMMSE) estimators in the blind setting, characterizing their sample complexity and reconstruction error. For image deconvolution problems, we then consider a nonlinear framework based on convergent plug-and-play regularization applied jointly to the image and the unknown kernel, and propose an asymmetric PALM-inspired algorithm with convergence guarantees.

■ FB-02

Friday, 10:30-12:30 - Room: Lecture room 15

Recent advances in weakly convex optimization

Stream: Optimization for Machine Learning and Statistics
Invited session
Chair: *Krzysztof Leśniewski*

1 - Primal-dual algorithm for weakly convex functions under sharpness conditions
The Hung Tran, *Ewa Bednarczuk*, *Monika Syga*

We investigate the convergence of the primal-dual algorithm for composite optimization problems when the objective functions are weakly convex. We introduce a modified gap function, which is a lower bound of the standard duality gap function. Under the sharpness condition of this new modified gap function, the iterates contain a subsequence converging to a global saddle point provided that the initial point is chosen sufficiently close to the set of global saddle points. The convergence rate is linear. We give numerical examples and applications in image denoising and deblurring to demonstrate our results.

2 - Generalized Mangasarian-Fromovitz Condition for Infinite Programming with Degenerate Equality Constraints
Krzysztof Leśniewski

We consider smooth infinite programming problems with equality and infinitely many inequality constraints defined on Banach spaces. A major difficulty in such problems arises when the derivative of the mapping defining the equality constraints is not surjective. This situation appears naturally in applications where constraints are induced by differential equations, leading to degeneracy of the feasible set and failure of classical constraint qualifications.

In this talk we introduce the Generalized Perturbed Mangasarian-Fromovitz Constraint Qualification (GPMFCQ), which extends classical regularity conditions to this degenerate setting. The proposed framework allows one to derive optimality conditions and establish the existence of Lagrange multipliers even when standard assumptions are not satisfied.

We also discuss a characterization of the linearized cone that captures the difference between pointwise and uniform behavior of infinite systems of constraints. This provides additional insight into the geometry of feasible directions.

Finally, we outline potential applications to inverse problems and optimal control, where equality constraints arise from differential models and are non-regular.

3 - On the Projection Problem with Quadratic Lower-Level Set Constraints
Krzysztof Rutkowski, Ewa Bednarczuk

In this presentation, we investigate the problem of projecting a point onto a set defined by quadratic lower-level set constraints. This problem can be formulated as the minimization of a squared norm objective function subject to constraints given by the lower-level sets of quadratic functions. We show necessary conditions for global optimality and discuss sufficient conditions. Furthermore, we examine the relationship between this problem and projection problems involving linear lower-level constraints.

■ FB-03

Friday, 10:30-12:30 - Room: Lecture room 17

Smoothing techniques for nonsmooth optimization

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

1 - A Newton-Kantorovich Inverse Function Theorem in Quasi-Metric Spaces
Titus Pinta

The purpose of this work is to investigate root finding problems defined on (quasi-)metric spaces, and ranging in Euclidean spaces. The motivation for this line of inquiry stems from recent models in biology and phylogenetics, where problems of great practical significance are cast as optimization problems on (quasi-)metric spaces. We investigate a minimal algebraic setup that allows us to study a notion of differentiability suitable for Newton-type methods, called Newton differentiability. This notion of differentiability benefits from calculus rules and is sufficient to prove superlinear convergence of a Newton-type method. Finally, a Newton-Kantorovich-type theorem provides an inverse function result, applicable on (quasi-)metric spaces.

2 - ItsOPT: Inexact Two-Level Smoothing Optimization Framework
Masoud Ahookhosh, Alireza Kabgani

We introduce an inexact two-level optimization framework (ItsOPT) for finding first- or second-order critical points of nonsmooth and nonconvex functions. The framework includes two levels: In the upper level, a smoothing technique (e.g., High-order Moreau envelope, high-order forward-backward envelope, high-order tensor envelope) will be applied to generate a smooth approximation of the objective function with the same minimizers. Then, first- or second-order methods will be introduced for minimizing the smoothing function. In the lower level, the corresponding high-order proximal subproblems (e.g., High-order proximal, forward-backward, and tensor subproblems) will be solved inexactly using subgradient or Bregman proximal methods. This will provide an approximated solution for the subproblems, leading to inexact smoothing information for the upper-level methods. We note that the complexity of solving the considered optimization problems is the multiplication of the complexities of both levels. Applying accelerated first- or second-order methods at the upper level and solving the subproblems with negligible complexity (e.g., logarithmic rate) may lead to the superfast methods attaining complexity better than worst-case complexity bounds. We finally introduce some algorithms and report preliminary numerical results.

3 - Boosted inexact high-order forward-backward methods for nonconvex optimization
Alireza Kabgani, Masoud Ahookhosh

We introduce a new framework that combines first-order majorization-minimization with high-order regularization to design a boosted inexact forward-backward method. The approach builds high-order majorant models while relying on simple first-order steps to approximately solve the resulting subproblems. We show that this interplay leads to improved convergence behavior and can enhance the practical performance of forward-backward schemes, particularly for composite and nonconvex problems. The proposed method also provides a flexible structure where different inexact strategies can be used within the same framework. Numerical experiments illustrate the efficiency of the method compared to classical approaches.

4 - A new numerical method for isolated singular roots of polynomial systems
Jeferson Zapata, Vladimir Kolmogorov, Mikhail Karapetyants

Computing isolated singular roots of polynomial systems is a challenging problem that has received considerable attention in the literature. We focus on the endgame regime, which tracks solutions close to the root. Existing approaches include power series endgames, Cauchy endgames, and various methods that regularize the solution via dual-space-based deflation, which requires computing additional derivatives of the system. We propose a new approach to this problem that, in many cases, exhibits a superlinear convergence rate.

■ FB-04

Friday, 10:30-12:30 - Room: Seminar room MZ 003B

Machine learning in optimization under uncertainty

Stream: Optimization under uncertainty
Invited session
Chair: *Dawen Wu*

1 - Reformulating a Continuous Chance-Constrained Optimization Problem as Neural Network Training
Dawen Wu

Chance-constrained optimization (CCO) problems are stochastic optimization problems with probabilistic constraints defined by a confidence level $alpha$. This paper focuses on a convex CCO problem with a single individual chance constraint, where under an elliptically symmetric distribution the chance constraint admits a second-order-cone reformulation. A common scenario, especially in sensitivity analysis, is to solve such problems efficiently in a series of predefined confidence levels. When dealing with multiple confidence levels, the standard approach treats each confidence level as a separate task. This can be inefficient, particularly when a large number of levels need to be evaluated. To overcome this inefficiency, we propose a warm-start algorithm based on neural networks. First, the CCO problem is modeled by a system of ordinary differential equations (ODEs). Next, we employ a physics-informed neural network to learn the solution trajectory of this ODE system. The warm-start is then implemented by reusing the trained network weights for the next confidence level, requiring only a brief period of retraining. The experimental results show that our algorithm produces high-quality approximations and has significant potential for improving computational efficiency.

2 - Joint chance-constrained optimization governed by multiple PDEs
Heng Zhang, Abdel Lisser, Yong-Hong Kuo

Chance-constrained optimal control problems (CCOCPs) governed by partial differential equations (PDEs) are essential for robust decision-making under uncertainty. However, they remain computationally challenging due to the non-smooth and generally non-convex nature of joint probabilistic constraints. In this talk, we present a unified framework for solving CCOCPs governed by multiple linear PDEs with separable random source terms. We address two distinct stochastic environments: scenarios with mutually independent random sources, and dependent scenarios modeled by Archimedean copulas.

This paper proposes tractable integral-form reformulations of the joint pointwise chance constraints. Using these reformulations, we establish the eventual convexity of the feasible set under both the independent and copula-dependent assumptions. To efficiently solve the resulting optimization problems, we propose a tailored Augmented Lagrangian Method (ALM), which accommodates both independent and Archimedean-copula dependent cases via a novel probability-allocation subproblem. Finally, we will present numerical experiments. The results demonstrate the practical convergence of the proposed ALM approach and its effectiveness in consistently reducing constraint violations.

3 - Physics-informed neural networks for high-dimensional ODE systems to solve optimization and optimal control problems
Ange Valli, Dawen Wu, Abdel Lisser, Sihem Tebbani

In this talk, we present physics-informed neural networks (PINNs) for solving systems of ordinary differential equations (ODEs). We present PINN architectures for solving optimization and optimal control problems, which can be formulated as ODE systems thanks to optimality conditions. We discuss methods to enhance PINN capacity for solving high-dimensional systems. We use Stein's method to approximate gradients and accelerate neural network training while preserving the network's capacity to compute the optimal solution. In our numerical experiments, we study high-dimensional ODE systems derived from the spatial discretization of partial differential equations (PDEs).

4 - An alternating optimization approach for robust mixed-integer optimal control with applications to separation processes
Andrea Gilch, Dominik Cebulla, Jan Rolfes, Christian Kirches, Frauke Liers

Many engineering processes lead to optimization problems governed by partial differential equations (PDEs) that involve both discrete decisions and uncertain parameters. Solving such problems in a robust way typically results in robust mixed-integer optimal control problems (MIOCPs) constrained by PDEs. For this class of problems, computationally tractable algorithms are largely unavailable, which makes the direct solution of the full problem extremely challenging. We focus on a particular problem arising in material design for separation processes.

In this talk, we therefore pursue a decomposition-based algorithmic approach. The key idea is to alternately solve PDE-constrained optimal control problems and distributionally robust optimization problems. This decomposition allows us to circumvent solving the full robust MIOCP directly while still accounting for uncertainty in the optimization.

We demonstrate the proposed methodology using a case study of a particle separation process, a technique widely used to purify, for example, pharmaceutical products. In such systems, small perturbations in operating conditions can significantly affect the separation outcome and may even lead to the loss of the entire product batch. The process dynamics are described by nonlinear transport-dispersion PDEs, while operational decisions introduce discrete choices and uncertain parameters.

■ FB-05

Friday, 10:30-12:30 - Room: Seminar room MZ 003A

New Developments in Bilevel and Hierarchical Optimization

Stream: Bilevel optimization
Invited session
Chair: *Oliver Stein*

1 - Bridging Stochastic and Bilevel Optimization: A Unified Framework for Hierarchical Decisions under Uncertainty
Sebastian Vasquez, Merve Bodur, Bernardo Pagnoncelli

Stochastic programming and bilevel optimization are established frameworks for modeling decision-making under uncertainty and hierarchy. We introduce two-stage bilevel optimization with hierarchical recourse (2SBO-HR), a general framework in which uncertainty is realized after initial decisions and both agents adapt through explicit second-stage optimization problems. 2SBO-HR accommodates both stochastic and robust interpretations of uncertainty while preserving the sequential bilevel structure. We focus on the stochastic instantiation and develop reformulations and decomposition-based algorithms, including an adaptation of the Integer L-shaped method for problems with binary first-stage variables. Computational results on facility location instances demonstrate the effectiveness of the proposed approach relative to existing bilevel optimization methods.

2 - On the complexity of bilevel linear and quadratic programs in fixed dimensions
Sergei Ketkov, Oleg A. Prokopyev

We study bilevel linear programs (BLPs) assuming that one of the decision-makers has a fixed number of variables or constraints. While optimistic BLPs are known to be tractable when the follower has a fixed number of variables, we demonstrate that both optimistic and pessimistic BLPs remain polynomially solvable when the number of follower constraints is fixed. In contrast, we show that the pessimistic BLP with a fixed number of follower variables is strongly NP-hard. Hence, the same instance of a BLP may be polynomially solvable in the optimistic setting, yet strongly NP-hard in the pessimistic case. We further investigate whether the polynomial-time solvability results for BLPs persist when the follower's objective function is generalized from linear to quadratic.

3 - On pairs of optimization problems
Oliver Stein

Many mathematical models base on the coupling of two or more optimization problems. This talk surveys possibilities to couple two optimization problems and discusses how solutions of the different models are interrelated with each other. The considered pairs stem from the fields of standard and generalized Nash equilibrium problems, optimistic and pessimistic bilevel problems, saddle problems, standard and generalized semi-infinite problems, robust optimization, Lagrange duality, bicriteria optimization problems, minimax problems, decomposition, and two-stage stochastic optimization.

4 - Convergence analysis of a splitting-type method for bilevel optimization with a convex-concave fractional inner-level objective function
Tipsuda Arunrat, Nimit Nimana

We study a class of bilevel optimization problems consisting of two nested levels: the outer and the inner. Specifically, we address cases where the outer objective is convex, and the inner objective is fractional, comprising a convex numerator and a concave denominator. In this work, we propose an iterative subgradient-based method designed to handle these specific complexities. Unlike traditional approaches, our method simultaneously addresses challenges arising from both the bilevel and fractional structures. To handle the fractional structure, the stepsize rule is derived from Dinkelbach's algorithm, calculating the values of the fractional components from the previous iterate at each iteration. Meanwhile, to handle feasibility, we adopt a special form of Polyak's stepsize. The main advantage of the proposed method is that it allows all objective functions to be nonsmooth, and processed separately within the same step. Under suitable assumptions, we establish convergence results demonstrating that the generated sequence converges to a solution and provide the corresponding rate of convergence.

■ FB-06

Friday, 10:30-12:30 - Room: Seminar room MZ 201B

Global Optimization

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

1 - A Comparison of Convex Relaxations of Optimization Problems with Hard Cardinality Constraints
E. Alper Yildirim

Sparsity plays a vital role in a wide range of applications such as machine learning, data science, image processing, portfolio management, and sparse regression due to the interpretability, robustness, and ease of implementation of sparse solutions. As such, optimization problems with cardinality constraints arise in a plethora of applications such as interpretable machine learning, portfolio optimization, and principal component analysis.

In this talk, we consider alternative formulations of the NP-hard class of optimization problems with hard cardinality constraints. We introduce various polyhedral and convex conic relaxations of such formulations. We compare the resulting convex relaxations in terms of their strength and computational cost. We present preliminary computational results.

2 - New characterizations for Farkas type lemmas and their applications to optimization
Miguel Goberna

This talk, based on [GDV], deals with the characterization, in terms of closedness of certain sets regarding other sets, of Farkas lemmas determining when the upperlevel set F of a convex function contains the intersection of a given convex subset of some locally convex space X with the inverse image by a continuous linear operator of certain convex subset of a second locally convex space Y. More in detail, each of the mentioned characterizations of Farkas type lemmas consists in the closedness of certain subset of either one of the "primal" spaces X×Y×R and Y×R, or of the "dual" space X×R, regarding some singleton set of the corresponding space. Moreover, we also provide an existence theorem for the feasible set F in terms of the closedness of certain subset of the dual space X×R regarding the singleton set formed by the null element. These results are illustrated with significant applications to optimization. [GDV] M.A. Goberna, N. Dinh, M. Volle. Primal and dual characterizations for Farkas type lemmas in terms of closedness criteria. Set-Valued Var Anal 33 (2025) 31.

3 - Advancing Constrained Global Optimization via Infinity Computing
Dmitri Kvasov, Yaroslav Sergeyev

This contribution presents the application of the grossone-based Infinity Computer framework to constrained global optimization. By enabling direct numerical computations with infinite and infinitesimal quantities, it overcomes limitations of traditional approaches based on symbolic representations. Within this framework, optimization algorithms are reformulated using grossnumbers to enhance precision and robustness, particularly in penalty-based techniques. Theoretical properties are briefly discussed, and preliminary numerical experiments are presented to assess the proposed approach. The results suggest that the Infinity Computer may offer a promising framework for tackling complex constrained optimization problems.

4 - Hyperbolic Lasso: A Regularized Regression Framework Based on the Hyperbolic Penalty Method
Vinicius Layter Xavier, Claudia Jakelline Barbosa Silva

The Lasso regression framework has been extensively investigated due to its inherent capability for simultaneous estimation and variable selection, yielding sparse solutions under an 1-norm constraint. Regularization techniques of this class are well established as effective mechanisms for controlling model complexity and mitigating overfitting. However, the non-differentiability of the 1 penalty introduces challenges for gradient-based optimization methods. In this work, we introduce a differentiable reformulation of the Lasso problem via hyperbolic smoothing and the Hyperbolic Penalty method. This formulation provides a smooth approximation to the 1 norm, thereby enabling the application of continuous optimization techniques. The resulting Hyperbolic Lasso exhibits structural properties that support an efficient and stable search over the regularization parameter space, in contrast to standard pathwise coordinate descent strategies as implemented in widely used software such as glmnet. Due to this property, we propose an efficient recursive parameter search scheme. Model assessment and comparative analysis against glmnet are performed using nested cross-validation, which yields approximately unbiased estimates of generalization error. The computational efficiency and practical applicability of the proposed method are demonstrated through empirical studies on multiple real-world datasets, highlighting its competitiveness in terms of predictive mean squared error.

■ FB-07

Friday, 10:30-12:30 - Room: Seminar room MZ 112B

Applied operator theory and variational analysis

Stream: Splitting algorithms
Invited session
Chair: *Rubén Campoy*

1 - Regularization Methods for Solving Hierarchical Variational Inequalities with Complexity Guarantees
Daniel Cortild, Meggie Marschner, Mathias Staudigl

We consider hierarchical variational inequality problems, or more generally, variational inequalities defined over the set of zeros of a monotone operator. This framework includes convex optimization over equilibrium constraints and equilibrium selection problems. In a real Hilbert space setting, we combine a Tikhonov regularization and a proximal penalization to develop a flexible double-loop method for which we prove asymptotic convergence and provide rate statements in terms of gap functions. Our method is flexible, and effectively accommodates a large class of structured operator splitting formulations for which fixed-point encodings are available.

2 - Recent Advances in Variational Convexity: Characterizations, Calculus Rules, and Applications
Ziyuan Wang, Radu Ioan Bot

Recently introduced by Rockafellar in 2019, variational convexity is a generalized convexity under which stationary points of nonconvex functions are guaranteed to be local minimizers. However, it is often challenging to verify variational convexity.

In this work, we characterize variational convexity through proximal hulls of prox-bounded functions and present several calculus rules of variational convexity, facilitating easy verification of variational convexity. These results provide sufficient conditions for local optimality in nonlinear programming. Furthermore, we show that variational convexity leads to convex-like convergence rates of proximal algorithms in the absence of convexity. A case study on proximal hessian-driven heavy ball method is conducted to illustrate our approach.

3 - Extrapolated Product of Two Relaxed Cutters with Relaxation Parameters Beyond Two
Rafal Zalas

We study the extrapolated product of two relaxed cutters having a common fixed point. We assume that one of the relaxation parameters is greater than two so that the corresponding product is no longer quasi-nonexpansive. We show that if both of the operators are (weakly/linearly) regular, then under certain conditions, the extrapolated product inherits the same type of regularity. We then apply these results to proving convergence in the weak, norm and linear sense of algorithms that employ such operators.

4 - Contractive orbits of set-valued maps and applications to fixed points and optimization
Detelina Kamburova

We study a class of set-valued maps that contract along an orbit to a point that is either a strict fixed point or lies outside the domain of the map. Such mappings arise naturally in variational analysis and optimization. We first introduce the notion of a contractive orbit with respect to the topology of the underlying space. As an application, we derive a sufficient condition ensuring that a function attains a strong minimum in generalized topological settings. We also define a contractive orbit with respect to a generalized distance function and investigate conditions under which the two notions of a contractive orbit coincide. Finally, we present examples of commonly used distance functions that are not true metrics but nevertheless satisfy our assumptions.

Friday, 12:30-13:00

■ FC-01

Friday, 12:30-13:00 - Room: Lecture room 16

Closing session

Stream: Plenaries
Invited session
Chair: *Sophie Parragh*
Chair: *Markus Sinnl*
Chair: *Immanuel Bomze*
Chair: *Giancarlo Bigi*

Bilevel optimization

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Track(s): 5

Conic Optimization

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Track(s): 5

Difference-of-convex decompositions and structured nonconvex optimization

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Track(s): 6

Energy applications

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Track(s): 6

Global Optimization

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Track(s): 6

Multiobjective optimization

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Track(s): 8

Nonsmooth optimization

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Track(s): 3

Optimal control and stochastic optimal control

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Track(s): 8

Optimization for Machine Learning and Statistics

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Track(s): 2

Optimization under uncertainty

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Track(s): 4

Plenaries

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Track(s): 1

Shape and topology optimization

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Track(s): 7 8

Splitting algorithms

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Track(s): 7

Theory and practice of zeroth and first-order methods

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Track(s): 1 4 5

Session Chair Index

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