ALOP International Workshop on Algorithmic Optimization 2025

September 23–26, 2025
Trier University

https://alop.uni-trier.de/event/international-workshop-on-algorithmic-optimization/

Program & Book of Abstract

Scientific Committee: Martin Schmidt & Volker Schulz

Local Organizing Committee: Bianca Schröder & Judith Wahlen & Ellen Zwartenkot

Tuesday, September 23

8:30 – 9:00 9:00 – 9:15	Registration Welcome Ceremony	Foyer, E Building HS 9
9:15 – 10:15	Invited Speaker: Matthias Heinkenschloss	HS 9
10:15 – 10:45	Coffee Break	E 51
10:45 – 11:45	Invited Speaker: Johannes Thürauf	HS 9
11:45 – 12:30	Contributed Talk Session: Branch-and-Cut a) Aloïs Duguet b) Jan Kronqvist	HS 9
12:30 – 14:00	Lunch	Mensa
14:00 – 15:30	Contributed Talk Session: Bilevel Optimization a) Andreas Horländer b) Julius Hoffmann c) Henri Lefebvre	HS 9
16:00 – 18:00	Meet and Greet/Welcome Reception including Elevator Pitch and Poster Session	E 51

Wednesday, September 24

8:30 – 9:15	Late Registration	Foyer, E Building
9:15 – 10:15	Invited Speaker: Marina Leal	HS 9
10:15 – 10:45	Coffee Break	E 51
10:45 – 11:45	Invited Speaker: Michael Hintermüller	HS 9
11:45 – 12:30	Contributed Talk Session: Heuristics a) Luca Nerozzi b) Roger Rios	HS 9
12:30 – 14:00	Lunch	Mensa
14:00 – 15:30	Contributed Talk Session: Applications a) Bhagwat Ram b) Lucas Moschen c) Marc Steinbach	HS 9
15:30 – 16:00	Coffee Break	E 51
16:00 – 16:45	Contributed Talk: Graphs & Combinatorial Optimization a) Kevin Mann b) Fabio Furini	HS 9
19:00	Wine tasting followed by Conference Dinner at “Wirtshaus zur Glocke” Glockenstraße 12, 54290 Trier	

Thursday, September 25

9:15 – 10:15	Invited Speaker: Kathrin Welker	HS 9
10:15 – 10:45	Coffee Break	E 51
10:45 – 11:45	Invited Speaker: Martine Labbé	HS 9
11:45 – 12:30	Contributed Talk: Graphs & Combinatorial Optimization a) Fabio Ciccarelli b) Khandoker Mohammed Mominul Haque	HS 9
12:30 - 14:00	Lunch	Mensa
14:00 – 15:30	Contributed Talk: Robust Optimization a) Komal Muluk b) Simon Stevens c) Christoph Grüne	HS 9
15:30 – 16:00	Coffee Break	E 51
16:00 – 17:30	Contributed Talk Session: Shape Optimization a) Diaraf Seck b) Maximilian Würschmidt c) Stephan Schmidt d) Tim Suchan	HS 9

Friday, September 26

9:15 – 10:15	Invited Speaker: Carina Costa	HS 9
10:15 – 10:45	Coffee Break	E 51
10:45 – 11:45	Invited Speaker: Marianna de Santis	HS 9
11:45 – 12:00	Closing Remarks	HS 9
12:00 - 13:30	Lunch	Mensa

Invited Talks

Adaptive Surrogate Modeling for Trajectory Optimization with Model Inexactness

Matthias Heinkenschloss

Rice University

In many applications, one must compute optimal trajectories from imperfect knowledge of the dynamics. For example, solving trajectory optimization problems for hypersonic vehicles requires computing lift and drag coefficients at many flight configurations. Determining these coefficients over the entire state space would require expensive high-fidelity computations using detailed representations of the hypersonic vehicle at prohibitively many samples.

This talk proposes using computationally inexpensive adaptive kernel regression models constructed from high-fidelity samples to approximate the components of the dynamics that are expensive to evaluate. To reduce the effect of model errors on the optimal trajectory, the current kernel regression model is updated as needed at the cost of evaluating the components of the dynamics at a small number of additional sample points. First, the optimal control problem is solved using the current kernel model to represent the dynamics. Next, a new optimality sensitivity analysis is combined with error estimates of the kernel model to determine whether the kernel regression model needs to be updated and, if so, at which samples the dynamics should be evaluated to update it. This talk outlines our current model refinement procedure and demonstrates its performance on a trajectory optimization problem for a hypersonic vehicle with lift and drag models that are known but expensive to evaluate.

Bilevel and Robust Optimization with Nonlinear Flows

Johannes Thürauf

University of Technology Nuremberg

In this talk, we study two different network optimization problems for a general nonlinear flow model.

On the one hand, we investigate network flow interdiction problems. The resulting model is a max-min bilevel optimization problem, in which the follower's problem is nonlinear and nonconvex. In this game, the leader attacks a limited number of arcs with the goal of maximizing the load shed and the follower aims at minimizing the load shed by solving a transport problem in the interdicted network. We develop an exact algorithm that combines tailored lower- and upper-bounding schemes, enabling the computation of provably optimal interdictions under the assumption that the network remains weakly connected. Our numerical results show the applicability of this exact approach using the example of gas networks.

On the other hand, we study network design problems for nonlinear and nonconvex flow models under demand uncertainties. To this end, we apply the concept of adjustable robust optimization to compute a network design that admits a feasible transport for all, possibly infinitely many, demand scenarios within a given uncertainty set. To solve the corresponding adjustable robust mixed-integer nonlinear optimization problem, we show that a given network design is robust feasible, i.e., it admits a feasible transport for all demand uncertainties, if and only if a finite number of worst-case demand scenarios can be routed through the network. We compute these worst-case scenarios by solving polynomially many nonlinear optimization problems. Embedding this result for robust feasibility in an adversarial approach leads to an exact algorithm that computes an optimal robust network design in a finite number of iterations. We finally demonstrate the applicability of the method by computing robust gas networks that are protected from future demand fluctuations.

Mathematical Optimization for Hierarchical Clustering: An Option or a Necessity in Today's Data-Driven World?

Marina Leal

Universidad Miguel Hernández de Elche

Clustering is a fundamental technique in data analysis, used to identify groups within a dataset and support decision-making across a wide range of applications. Among clustering methods, hierarchical clustering stands out for building a nested structure of clusters, commonly represented by a dendrogram. Traditionally, such dendrograms have been constructed using iterative algorithms without any explicit use of mathematical optimization.

This talk revisits hierarchical clustering from the perspective of optimization, discussing whether optimization is already implicit in classical methods and where it can provide substantial benefits. In particular, we will ask whether there are situations in which optimization is not merely helpful but indispensable; for instance, when feature selection is required, when hierarchical clustering must incorporate labeled data, or when there are many ties in the data that make cluster assignments ambiguous.

Through these questions, and by examining concrete problems, the aim is to reflect on the role of mathematical optimization for hierarchical clustering: an option or a necessity in today's data-driven world?

A neural network approach to learning solutions of a class of elliptic variational inequalities

Michael Hintermüller

Weierstrass Institute for Applied Analysis and Stochastics

We discuss a weak adversarial approach to solving obstacle problems using neural networks. By employing (generalised) regularised gap functions and their properties we rewrite the obstacle problem (which is an elliptic variational inequality) as a minmax problem, providing a natural formulation amenable to learning. Our approach, in contrast to much of the literature, does not require the elliptic operator to be symmetric. We provide an error analysis for suitable discretisations of the continuous problem, estimating in particular the approximation and statistical errors. Parametrising the solution and test function as neural networks, we apply a modified gradient descent ascent algorithm to treat the problem and conclude the talk with various examples and experiments. Our solution algorithm is in particular able to easily handle obstacle problems that feature biactivity (or lack of strict complementarity), a situation that poses difficulty for traditional numerical methods.

Riemannian approaches for PDE constrained shape optimization using inner and outer metrics

Kathrin Welker

Helmut-Schmidt-University / University of the Federal Armed Forces Hamburg, Germany

Shape optimization is concerned with identifying shapes (or subsets of $\mathbb{R}^n$, $n \in \mathbb{N}$) behaving in an optimal way with respect to a given physical system. It has been an active field of research for the past decades and is used for example in engineering. Many relevant problems in the area of shape optimization involve a constraint in the form of a partial differential equation (PDE). Theory and algorithms in shape optimization can be based on techniques from differential geometry, e.g., a Riemannian manifold structure can be used to define the distances of two shapes. Thus, shape spaces are of particular interest in shape optimization. In this talk, we apply the differential-geometric structure of Riemannian shape spaces to the theory of classical PDE-constrained shape optimization. We have a look on inner and outer Riemannian metrics, different Riemannian shape spaces and present algorithms to solve PDE-constrained shape optimization problems.

Solving Chance-Constrained (Mixed Integer) Linear Optimization Problems with Branch-and Cut

Martine Labbé

Université Libre de Bruxelles and INOCS Team, INRIA, Lille

We consider chance-constrained optimization problems (CCOPs), where constraints with random coefficients must hold with probability above a given threshold. Such problems arise frequently in energy applications and are NP-hard. In the linear case with random data of finite support, CCOPs can be reformulated as mixed-integer linear programs using big-M constants. We propose a Branch-and-Cut algorithm for linear CCOPs, introducing new valid inequalities and analyzing their closures. Computational results demonstrate the strength of these inequalities compared to existing ones, confirming the effectiveness of the proposed approach.

This is a joint work with Diego Cattaruzza, Matteo Petris, Marius Roland and Martin Schmidt.

Minimum Sum-of-Squares Clustering: Fuzziness, Robustification and Mixed-Integer Programming Techniques

Carina Costa

State University of Maringá

The Minimum Sum-of-Squares Clustering (MSSC) problem is a very important problem in unsupervised machine learning, whose goal is to find a partitioning of a given data set into groups. There are two main concepts associated with this task: hard clustering, in which each data point belongs to exactly one cluster, and fuzzy clustering, in which each data point can belong to multiple clusters, according to the so-called degree of membership.

In the first part of the talk, we consider both concepts and discuss the issue of finding the true underlying clustering structure when only erroneous data is available.

To tackle this, we apply techniques from robust optimization to hedge the clustering result against unstructured errors in the observed data. To solve the nominal and robustified problems, we propose alternating direction methods to quickly obtain feasible points of good quality. The computational study reveals interesting results. In the second part of the talk, we focus on the classic MSSC problem, which is known to be extremely hard to solve to global optimality even in two dimensions. Therefore, we present several tailored mixed-integer programming techniques to improve the performance of state-of-the-art MINLP solvers when applied to the problem. Among these techniques are cutting planes, propagation techniques, branching rules and primal heuristics. Our numerical study shows that our techniques significantly improve the performance of the open-source MINLP solver SCIP.

Branch-and-bound methods for multi-objective mixed integer quadratic optimization

Marianna-de-Santis

Università degli Studi di Firenze

Multi-objective mixed-integer nonlinear programming (MOMINLP) is a powerful framework for modeling real-world decision problems, as practical applications often involve multiple conflicting objectives and require 0-1 or integer variables to represent logical relationships or discrete quantities. Solving MOMINLPs entails identifying the set of efficient solutions - i.e. solutions for which no objective can be improved without worsening at least one other.

An efficient integer assignment in the context of MOMINLP refers to a fixing of the integer variables such that there exists at least one efficient solution corresponding to that assignment. Depending on the problem instance, solution algorithms with correctness guarantees may need to explore a large number of efficient integer assignments - potentially all integer-feasible ones - making full enumeration sometimes unavoidable. This marks a significant departure from the single-objective case and presents a major challenge for algorithm development.

In this talk, we review essential tools recently proposed in the literature for developing branch-and-bound methods for multi-objective mixed-integer nonlinear optimization and we explore approaches specifically tailored to problems with quadratic objective functions. A key component of the proposed methods is the use of outer approximations of the upper image set, derived from appropriately defined continuous relaxations. Pruning conditions in the context of branch-and-bound methods for MOMINLPs are presented and discussed. Numerical experiments are conducted on instances involving two and three objectives.

Contributed Talks

Contributed Talk Session: Branch-and-Cut

Branch-and-Cut for Mixed-Integer Programming Games

Aloïs Duguet

Trier University

Generalized Nash equilibrium problems with mixed-integer variables form an important class of games in which each player solves a mixed-integer optimization problem with respect to her own variables. Those games are hard to solve as they are more general than both purely continuous games and purely integer games. In particular, most methods for those two classes are not applicable to the mixed-integer case. In this work, we introduce the first branch-and-cut algorithm to compute exact pure Nash equilibria for different classes of mixed-integer games with linear constraints. The main idea is to reformulate the problem of finding Nash equilibria as the problem of solving a suitable bilevel problem based on the Nikaido–Isoda function. The proposed branch-and-cut method is applicable to (generalized) Nash equilibrium problems under reasonable assumptions. Depending on the specific setting, we use tailored equilibrium or intersection cuts. The latter are well-known in mixed-integer linear optimization and we adapt them to the game setting. We prove finite termination of the algorithm and present some first numerical results for knapsack games and capacitated flow games.

Warm-starting for solving sequences of convex MINLP

Jan Kronqvist

KTH Royal Institute of Technology

For certain types of applications, we are faced with a sequence of problems that need to be solved. Solving a sequence of mixed-integer problems is obviously more challenging than solving a single problem. If the problems in the sequence are similar, and the structural difference between two consecutive problems is small, then one intuitively thinks of warm-starting. For certain types of problems, e.g., LP, warm-starting is well developed. But, for problems with integer variables it is not clear how to best perform warm-starting or if it is even possible to perform efficiently. Here we focus on convex MINLP, and we propose two warm-starting techniques that builds upon the outer approximation (OA) concept. We develop some fundamental theory of warm-starting in this setting, and we prove that under certain conditions a simple warm-starting can reduce the computational effort of OA to just a single master iteration (to find the optimal solution and verify optimality). Through numerical experiments, we show that the single iteration is not just theoretical possibility, and that the performance of OA can be greatly improved by warm-starting in this setting. Sequences of convex MINLP arise in several practical applications. Examples include: hybrid model predictive control, solving multiobjective convex MINLP through scalarization, and analyzing the sensitivity of certain model parameters.

Contributed Talk Session: Bilevel Optimization

Mixed-Integer Bilevel Optimization with Nonconvex Quadratic Lower-Level Problems: Complexity and a Solution Method

Andreas Horländer

Technische Universität Nürnberg

We study bilevel problems with a convex quadratic mixed-integer upper-level, integer linking variables, and a nonconvex quadratic, purely continuous lower-level problem. We prove Σ_2^p-hardness of this class of problems, derive an iterative lower- and upper-bounding scheme, and show its finiteness and correctness in the sense that it computes globally optimal points or proves infeasibility of the instance. To this end, we make use of the Karush–Kuhn–Tucker conditions of the lower-level problem for the lower-bounding step, since these conditions are only necessary but not sufficient in our setting. Moreover, 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 a large-scale numerical experiment.

A bilevel model for competitive facility location planning

Julius Hoffmann

Karlsruhe Institute of Technology

The competitive facility location problem (CompFLP) has become an integral part of location theory literature and combines this research area with game theory. In the mentioned problem family, two or more companies compete for the demand of given customers by determining the locations and possibly other properties of their facilities. Many variants of the CompFLP have been studied. One crucial aspect of the problem setting is the chronology of the moves of the competitors. In our work, we study a Leader-Follower (Stackelberg) model where a leader must perform the first move in anticipation of the response of the follower. Another important part of the problem definition are the criteria according to which the customer demand is assigned to the players. For example, the demand of a single customer can be assigned completely to one of the competitors (deterministic utility model) or can be split between the competitors according to attractiveness criteria of the facilities and personal preferences (random utility models). While it is possible in most of the random utility models to attract more customer demand by enhancing the attractiveness of the facilities via investments, we are not aware of this problem configuration for deterministic utility models with the Leader-Follower setting. We address this research gap in our work and consider the Leader-Follower CompFLP in a deterministic utility framework and with facility expansion possibilities (LF-CompFLP-DU-FE). For this problem, we present a mathematical model via bilevel programming. Additionally, we show some appropriate computational methods for solving the problem configuration.

A Dantzig-Wolfe Single-Level Reformulation for Mixed-Integer Bilevel Optimization: Exact and Heuristic Approaches

Henri Lefebvre

Trier University

Bilevel optimization problems arise in numerous real-world applications. While single-level reformulations are a common strategy for solving convex bilevel problems, such approaches usually fail when the follower's problem includes integer variables. In this paper, we present the first single-level reformulation for mixed-integer linear bilevel optimization, which does not rely on the follower's value function. Our approach is based on convexifying the follower's problem via a Dantzig-Wolfe reformulation and exploits strong duality of the reformulated problem. By doing so, we derive a nonlinear single-level problem, which is equivalent to the original bilevel model. Moreover, we show that this problem can be transformed into a mixed-integer linear problem using standard linearization techniques and bounds on the dual variables of the convexified follower's problem. Notably, we show that these bounds can be computed in practice via a polynomial-time-solvable problem, which is purely based on the primal problem's data. This results in a new branch-and-cut approach for mixed-integer linear bilevel optimization. In addition to this exact solution approach, we also present a penalty alternating direction method, which computes high-quality feasible points. Numerical experiments on instances from the BOBILib shows that we are able to improve the best known solution of 427 instances out of a test set of 2216 instances.

Contributed Talk Session: Heuristics

A Heuristic Dynamic Programming Approach for Sustainable Crop Rotation Planning

Luca Nerozzi

University of Siena

A crop rotation planning problem in agriculture is addressed, considering constraints from both public policies (e.g., the European Union's Common Agricultural Policy) and private sustainability initiatives. Given a set of seeding periods over a planning horizon and a set of farmland plots, the goal is to assign crops to each plot and period so that agronomic rotation principles and sustainability requirements are met, while maximizing the farmer's profit. Crop yields and profits depend on the sequence of crops planted, as good rotation practices help reduce production costs and improve soil health. We propose an efficient heuristic algorithm based on Dynamic Programming to tackle this problem. Experimental results on real-world instances demonstrate that our approach consistently finds feasible solutions respecting agronomic, management, and sustainability constraints. Moreover, it significantly reduces computational time compared to exact optimization methods, while maintaining high-quality solutions.

A fast metaheuristic for the p-neighbor k-supplier problem

Roger Rios

Universidad Autonoma de Nuevo Leon (UANL)

The p-neighbor k-supplier problem is a location problem in which, given a set of users and a set of potential facilities, the goal is to select at most k facilities or suppliers such that the maximum distance from a user to its p-th closest open facility is minimized. This problem arises, for instance, in location of emergency units, when the aim is to have a minimum guaranteed response time between a demand point and its supplier by providing backup supplier in case one of them fails to respond to an emergency. We propose a GRASP for this NP-hard problem. The construction phase evaluates the objective function of the k-dispersion problem to provide a feasible solution. We enhanced the time complexity of this heuristic by using tailored-made data structures, called Greedy Dispersion , and adapted it to use a value-based restricted candidate list within GRASP. The constructed solution is then improved, in the next phase, by a local search whose move is a vertex substitution or interchange. We adapted the concept of fast interchange specifically for this problem and called it Fast Vertex Substitution. This local search is significantly faster by exploiting the structure of the objective function, allowing to reuse several expensive computations, leading to outstanding computational speed-up times for all the test cases. Empirical evidence over a wide set of instances shows the effectiveness of the proposed procedure.

Contributed Talk Session: Applications

Sustainable Distribution of Perishable Goods: A Fuzzy Multi-Objective Vehicle Routing Approach

Bhagwat Ram

SRM University AP

Transporting perishable goods like food and medicine presents significant challenges due to their limited shelf life. Effective logistics require flexible strategies to balance spoilage prevention, cost control, and environmental sustainability. This study proposes a multi-objective green vehicle routing model specifically tailored for perishable items. The model aims to simultaneously minimize operational costs, spoilage losses, and carbon emissions while addressing uncertainties in customer demand. To model this uncertainty, two-parameter coherent fuzzy numbers are employed. A simulated annealing algorithm is used to optimize vehicle routing. The model also analyzes the outlook and variability of each customer's uncertain demand. Three different strategies within the SA framework are evaluated: the geometric approach excels in minimizing operational costs, the logarithmic approach is most effective at reducing spoilage and managing demand uncertainty, and the exponential approach performs best in lowering carbon emissions. Overall, the proposed model improves logistical efficiency and promotes a sustainable, cost-effective distribution system for perishable goods.

Combinatorial algorithms for large household allocation problems

Lucas Moschen

Trier University

Microsimulation models are powerful tools for predicting changes in various aspects of society, such as demography and the economy. Within the MikroSim project, a dynamic spatial microsimulation model is being developed for the entire German population. A fundamental stage of this model is the use of geographic statistical information to generate a high-quality allocation of households to dwellings at the municipal level. In this work, the household–dwelling allocation step is formulated as a maximum weight matching problem with side constraints, which is generally too large to be solved by standard optimization methods. We propose a Lagrangian-relaxation-based approach in which approximation algorithms are applied to the Lagrangian relaxations, thereby guaranteeing a certain level of optimality for the final allocation while allowing the design of warm-start procedures that significantly speed up the algorithm. Numerical experiments show that this method produces high-quality allocations using significantly less time and memory than standard solution algorithms, and that it is also competitive with tailored decomposition algorithms that we developed for this problem. This enables both approaches to handle instances with more than one billion variables and to scale to some of the largest German municipalities.

SynGROW: Synthetic Generation of Rigorously Optimized Volumetric Vasculature

Marc Steinbach

Leibniz Universität Hannover

Synthetically generated vascular trees support surgery planning or bio-printed synthetic organs. Vascular growth is believed to be driven by an energy minimization principle, leading to an optimization approach. We present an algorithm that combines NLP techniques for the global geometry of vascular trees with Simulated Annealing for the topology. We demonstrate that its implementation in the software SynGROW is capable of generating multiple non-intersecting realistic trees in organs of complex shape at low computational cost.

Contributed Talk Session: Graphs & Combinatorial Optimization 1

How to reconfiguration Using ILPs in Parameterized Algorithms

Kevin Mann

Trier University

Different variations of alliances in graphs have been introduced into the graph-theoretic literature about twenty years ago. More broadly speaking, they can be interpreted as groups that collaborate to achieve a common goal, for instance, defending themselves against possible attacks from outside. In this talk, we initiate the study of reconfiguring alliances. This means that, with the understanding of having an interconnection map given by a graph, we look at two alliances of the same size k and investigate if there is a reconfiguration sequence (of length at most ℓ) formed by alliances of size (at most) k that transfers one alliance into the other one. We use ILPs to obtain parameterized algorithms with respect to the combined parameter neighborhood diversity together with k or neighborhood diversity together with ℓ.

Hidden Bilevel Structures in Graph Disconnection Problems: Stackelberg Game Models and Exact Algorithms

Fabio Furini

Sapienza University of Rome

Many fundamental graph disconnection problems hide an underlying bilevel structure that can be exploited for stronger formulations and algorithms. In this talk, we reveal and formalize this hidden structure for two key problems: the capacitated vertex separator and the k-vertex cut. Both are modeled as two-phase Stackelberg games, where a leader strategically deletes vertices and a follower reacts by optimizing over the disconnected graph. We present new integer programming formulations naturally capturing this bilevel interaction, supported by families of strengthening valid inequalities and polynomial-time separation procedures. Our computational studies demonstrate that these approaches significantly improve the state-of-the-art, yielding better solutions and faster convergence on benchmark instances. Beyond these two problems, the bilevel perspective opens promising directions for a broader class of graph modification and partitioning problems.

Contributed Talk Session: Graphs & Combinatorial Optimization 2

The Bin Packing Problem with Item-Class Setups

Fabio Ciccarelli

Sapienza University of Rome

We introduce and study a novel generalization of the classical Bin Packing Problem (BPP), termed the Bin Packing Problem with item-class Setups (BPPS). In this setting, items are partitioned into classes, and whenever any item of a given class is packed into a bin, a fixed setup weight and cost associated with that class are incurred. This models a variety of practical scenarios in production, logistics, and cloud computing, where class-based configurations consume both resources and setup time. We first present a compact Integer Linear Programming (ILP) formulation for the BPPS and analyze its linear relaxation. Although the LP relaxation admits a closed-form solution computable in linear time, its worst-case performance can be arbitrarily poor. To address this, we propose a new family of valid inequalities, the Minimum Class-occurrence Inequalities (MCIs), which strengthen the relaxation and restore a worst-case guarantee comparable to that of the classical BPP. On the algorithmic side, we prove that straightforward adaptations of classical BPP heuristics yield unbounded approximation ratios for the BPPS. We then design a two-phase approximation scheme that leverages BPP heuristics at the class level and achieves provable performance guarantees. Finally, we establish a comprehensive benchmark of 480 BPPS instances and conduct extensive computational experiments to assess the impact of MCIs, warm-start strategies, and bin-count upper bounds on the performance of the proposed ILP formulations, as well as the empirical performance ratio of the proposed heuristic algorithms.

Prime cordial labeling of Knödel graph $W_{3,n}$

Khandoker Mohammed Mominul Haque

Shahjalal University of Science and Technology

A graph with vertex set V is said to have a prime cordial labeling if there is a bijection f from V to $\{1, 2, \ldots, |V|\}$ such that if each edge uv is assigned the label 1 for $gcd(f(u), f(v)) = 1$ and 0 for $gcd(f(u), f(v)) > 1$ then the number of edges labeled with 0 and the number of edges labeled with 1 differ by at most 1. In this paper, we show that the Knödel graph $W_{3,n}$ is prime cordial for all n except $W_{3,8}$.

Contributed Talk Session: Robust Optimization

Recoverable Robust Optimization with Commitment

Komal Muluk

TU Dortmund

We propose a model for recoverable robust optimization with commitment. Given a combinatorial optimization problem and uncertainty about elements that may fail, we ask for a robust solution that, after the failing elements are revealed, can be augmented in a limited way. However, we commit to preserve the non-failing elements of the initial solution. We settle the computational complexity of such a robust counterpart of various classical polynomial-time solvable combinatorial optimization problems. We show for the weighted matroid basis problem that an optimal solution to the nominal problem is also optimal for its robust counterpart. In fact, matroids are provably the only structures with this strong property. Robust counterparts of other problems are NP-hard such as the matching problem and the stable set problem, even in bipartite graphs. However, we establish polynomial-time algorithms for the robust counterparts of the unweighted stable set problem in bipartite graphs and the weighted stable set problem in interval graphs, also known as the interval scheduling problem.

A Branch-and-Cut Approach for Decision-Dependent Robust Optimization Problems

Simon Stevens

Trier University

Compared to classic robust optimization, decision-dependent robust optimization (DDRO) models the uncertainties as being dependent on the decision variables, thus enabling some control over these uncertainties within the model. The literature on DDRO is still limited and most of the existing solution techniques rely on reformulations using duality. Hence, they are naturally restricted to uncertainty sets that can be dualized. Recent results by Goerigk et al. show that DDRO problems can be reformulated as bilevel optimization problems, opening up new possibilities for solving this class of problems. First numerical results by Lefebvre et al. indicate that applying general bilevel solvers like MibS to DDRO problems for which the uncertainty set cannot be dualized is possible in general, though not efficient. We present a tailored branch-and-cut approach for solving DDRO problems in which the uncertainty set is given by an interdicted knapsack problem. To this end, we tailor an interdiction-like cutting plane from the bilevel literature, which is incorporated in the branch-and-cut framework. We present numerical results on a set of benchmark instances and compare our approach with the existing general bilevel solver MibS. The results demonstrate that our approach is significantly faster and capable of solving larger DDRO instances.

Completeness in the Polynomial Hierarchy for many natural Problems in Bilevel and Robust Optimization

Christoph Grüne

RWTH Aachen University

In bilevel and robust optimization we are concerned with combinatorial min-max problems, for example from the areas of min-max regret robust optimization, network interdiction, most vital vertex problems, blocker problems, and two-stage adjustable robust optimization. Even though these areas are well-researched for over two decades and one would naturally expect many (if not most) of the problems occurring in these areas to be complete for the classes Σ_2^p or Σ_3^p from the polynomial hierarchy, almost no hardness results in this regime are currently known. However, such complexity insights are important, since they imply that no polynomial-sized integer program for these min-max problems exist, and hence conventional IP-based approaches fail. We address this lack of knowledge by introducing over 70 new Σ_2^p-complete and Σ_3^p-complete problems. The majority of all earlier publications on Σ_2^p- and Σ_3^p-completeness in said areas are special cases of our meta-theorem. Precisely, we introduce a large list of problems for which the meta-theorem is applicable (including clique, vertex cover, knapsack, TSP, facility location and many more). We show that for every single of these problems, the corresponding min-max (i.e. interdiction/regret) variant is Σ_2^p- and the min-max-min (i.e. two-stage) variant is Σ_3^p-complete.

Contributed Talk Session: Shape Optimization

Shape Stability of a Quadrature Surface Problem in Infinite Riemannian Manifolds

Diaraf Seck

Cheikh Anta Diop

We revisit a quadrature surface problem in shape optimization. With tools from infinite-dimensional Riemannian geometry, we give simple control over how an optimal shape can be characterized. The framework of the infinite-dimensional Riemannian manifold is essential in the control of optimal geometric shape. The covariant derivative plays a key role in calculating and analyzing the qualitative properties of the shape hessian. Control only depends on the mean curvature of the domain, which is a minimum or a critical point. In the two-dimensional case, Gauss-Bonnet's theorem gives a control within the framework of the algorithm for the minimum.

Option Pricing via Shape Optimization

Maximilian Würschmidt

Trier University

We propose a computational framework for risk-neutral pricing of perpetual options based on a classical shape optimization approach. Our algorithm adapts classical FEM-based shape optimization techniques to effectively approximate optimal stopping regions – or equivalently optimal shapes – thus we particularly approximate the optimal strategy. The method is designed to apply for problems with unbounded optimal shape. We use a probabilistic representation of the boundary sensitivity of the solution of second order elliptic Dirichlet problems as necessary optimality criterion. Numerical experiments demonstrate the accuracy of our methodology. (Based on joint work with Stephan Schmidt)

Total Generalized Variation (TGV) and Non-Smooth Optimization for Shapes

Stephan Schmidt

Trier University

The talk discusses how to use a total variation semi-norm on shapes as a prior. The idea is to concentrate curvature changes to edges, which is of great help when non-smooth shapes are to be reconstructed in inverse problems. Unsurprisingly, classical total variation keeps all typical downsides such as stair-casing when applied to manifolds. To this end, the concept of total generalized variation (TGV) by Bredies/Kunisch/Pock is extended to shapes. For didactical reasons, TGV is presented as a variable splitting technique similar to infimal convolution. To implement TGV for shapes, the required separation of the linear component of a geometric variables necessitates non-standard finite elements on the tangent space of manifolds. In addition to discussing optimization strategies for TGV-regularized problems, custom function spaces in FEniCS are therefore also briefly mentioned. The methodology is exemplified with applications stemming from geo-electric impedance tomography and mesh inpainting as well as texture denoising.

Fracture propagation by using shape optimization techniques based on outer Riemannian metrics

Tim Suchan

Helmut Schmidt University/University of the Federal Armed Forces Hamburg

In this presentation, we describe a novel approach for the simulation of two-dimensional, brittle, quasi-static fracture problems based on a shape optimization approach. In contrast to the commonly-used phase-field approach, this proposed approach for investigating fracture paths does not require a specified 'length-scale' parameter defining the diffuse interface region nor a level set function. Instead, it interprets the fracture as part of the boundary of the domain and uses shape optimization algorithms to minimize the energy in the system and therefore describes the fracture propagation directly. Embedding the problem of energy minimization in a Riemannian manifold framework formulated on a suitable shape space, together with the choice of an outer Riemannian metric, yields both advantages from an analytical as well as an applied perspective. Furthermore, an eigenvalue decomposition of the strain tensor is used to produce more realistic fracture paths (the so-called strain splitting), which only allows fracture growth from tensile loads. Numerical results for the commonly considered single-edge notch tension and shear test are presented.

Poster Session

Aloïs Duguet
Branch-and-Cut for Mixed-Integer Generalized Nash Equilibrium Problems

Debraj Ghosh
tba

Henri Lefebvre
Mixed-Integer Linear Bilevel Optimization: A New Single-Level Reformulation

Tam Linke
Incorporating Airway and Functional Data in Lung Radiation Therapy Planning

Arun Pankajakshan
Challenges of gradient descent in constraint-adaptive active learning: Application to pharmaceutical particle size characterization

Owais Saleem
On an optimization framework for damage localization in structures