SIGOPT INTERNATIONAL CONFERENCE ON OPTIMIZATION 2025

Siegen, Germany
March 4-6, 2025

Universität Siegen

GOR

DFG Deutsche Forschungsgemeinschaft

Welcome to the SIGOPT International Conference on Optimization 2025

Dear Participants,

on behalf of the whole organizing committee, I would like to welcome you to the SIGOPT International Conference on Optimization 2025 in Siegen. The scientific program comprises 48 presentations, as well as five invited talks. The social program with a guided tour through the old town of Siegen and a conference dinner will provide additional opportunities for scientific exchange and networking. We would like to thank all the presenters who submitted their work and we hope that this conference will lead to many fruitful collaborations. We are grateful to the Deutsche Forschungsgemeinschaft DFG and the Gesellschaft für Operations Research GOR e. V. for their kind support of the conference.

Ulf Lorenz

Contact Information

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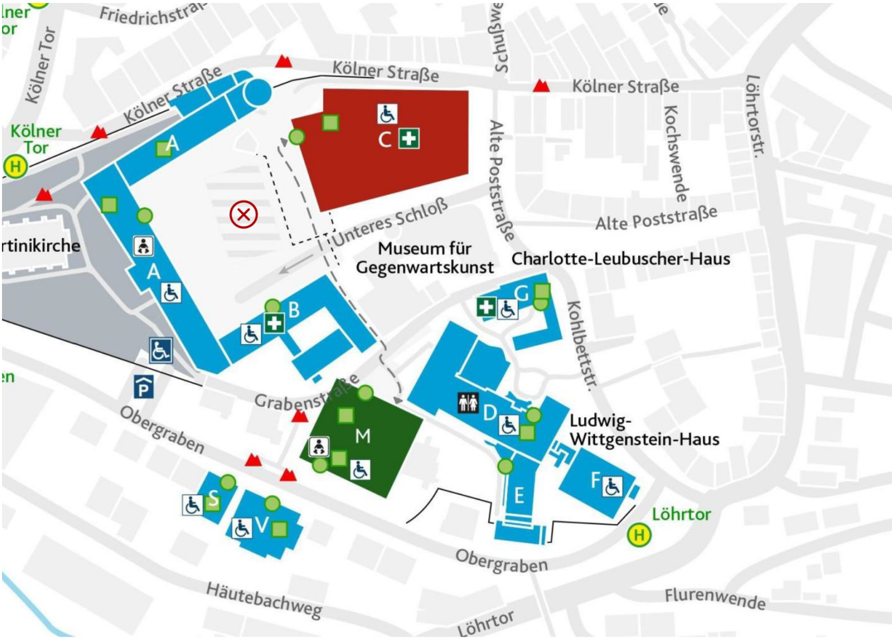
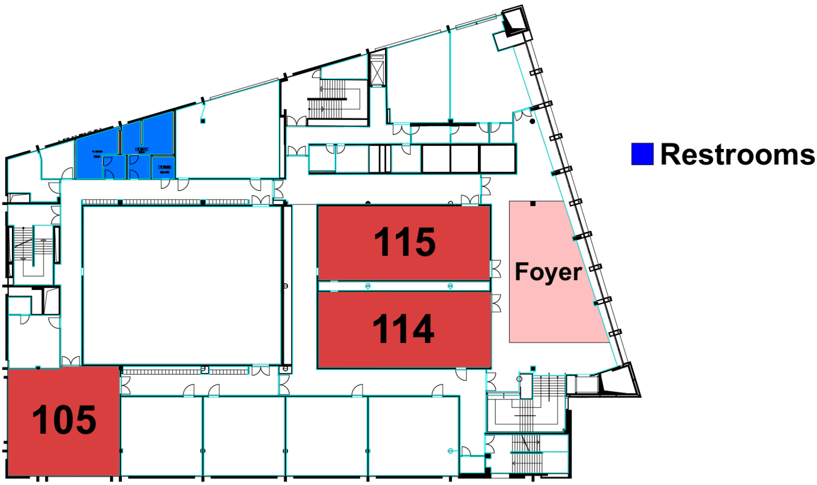
Map of the Campus



Map of the Unteres Schloss (US) Campus area. The conference takes place in the C-Building (red). The university canteen (Mensa) is located in the M-Building (green). Meals are served from 11:00 to 14:30. The meeting point for the excursion is placed in front of the US-C building (marked by the red cross).

Map of the Conference Building (US-C)



Tuesday, March 4th

08:00 - 08:30	Registration	
08:30 - 09:00	Welcome	
09:00 - 10:00	US-C 114, Chair Erwin Pesch	
	Danny Segev The joint replenishment problem: Classical results and some recent progress	
10:00 - 10:30	**Coffee Break**	
Session 1	US-C 114	US-C 115
	Technical Operations Research I Chair Julius Breuer	Stochastic and Mathematical Programming Chair Melinda Hagedorn
10:30 - 11:00	**The Location Problem for Compressor Stations in Pipeline Networks** Michael Schuster	**Optimized convergence of stochastic gradient descent by weighted averaging** Melinda Hagedorn
11:00 - 11:30	**Advancing the Optimization of Ventilation System Planning with Improved Life-Cycle Cost and Acoustic Considerations** Julius Breuer	**A Stochastic Conjugate Gradient with Variance Reduction in Non-smooth Setting** Mahmoud Yahaya
11:30 - 12:00	**Advanced Search and Rescue Operations for Drowning Swimmers using Autonomous Unmanned Aircraft Systems: Location Optimization, Flight Trajectory Planning and Image-Based Localization** Sascha Zell	**A linear programming approach for the elementary shortest path problem** Regina Schmidt
12:00 - 12:30	**Green Constraints in Manufacturing: Modeling and Optimizing Production for Renewable Energy Integration** Om Parkash	**Optimal inventory decisions for growing items** Mohammed Abdulaziz Darwish
12:30 - 13:30	**Lunch**	

Tuesday, March 4th

Session 2	US-C 114	US-C 115
	Theory of Optimization I Chair Marc C. Steinbach	Technical Operations Research II Chair Julian Mrochen
13:30 - 14:00	**Data driven elasticity in function space** Marc C. Steinbach	**Optimal Packing of Irregular Objects Composed by Generalized Spheres** Andreas Fischer
14:00 - 14:30	**Spectral Galerkin Approximation of Impulsive Optimal Control in Volterra Equations** Rayane Oum Essaoud	**Structural Optimization of Trusses for Additive Manufacturing in Bending Applications** Julian Mrochen
14:30 - 15:00	**Analyzing the speed of convergence in nonsmooth optimization via the Goldstein ε-subdifferential** Bennet Gebken	**Cooperative Demand Fulfillment in a Market-Based Multi-Agent Control System** Tobias Meck
15:00 - 15:30	**Gauss ranges and properties of the closed convex sets which are preserved under addition and intersection** Cornel Sebastian Pintea	**Distillation column optimization: A formal method using stage-to-stage computations and distributed streams** Tobias Seidel
15:30 - 16:00	**Coffee break**	
Session 3	US-C 114	US-C 115
	Machine Learning in Optimization Chair John Alasdair Warwicker	Quantum and physics-based Optimization Chair Ali Shahid
16:00 - 16:30	**A Mixed-Integer Linear Programming Framework for the Adversarial Training of Neural Networks** John Alasdair Warwicker	**Minimization of Gibbs free energy for a Poisson-Boltzmann Problem** Ali Shahid
16:30 - 17:00	**Error Analysis and Fine-Tuning of an Artificial Neural Network for the 1D Bin Packing Problem** Corinne Pretz	**QUBO Formulations and Quantum Computing Based Methods to Solve the 0/1 Multi-Dimensional Knapsack Problem** Evren Güney
17:00 - 17:30	**Incremental Subgradient Method for Multiple Instance Learning in Skin Segmentation** Narges Araboljadidi	**Optimizing Employee Transportation: A Novel Approach Combining Reinforcement Learning and Genetic Algorithms** Anouar Lahmdani
17:30 - 17:45	**Break**	
17:45 - 18:45	US-C 114, Chair Ulf Lorenz	
	Mirjam Dür Recent developments in conic optimizarion	

Wednesday, March 5th

08:30 - 09:30	US-C 114, Chair Ulf Lorenz	
	Anita Schöbel **Sustainable public transport**	
09:30 - 09:45	**Coffee Break**	
Session 1	US-C 114	US-C 115
	Theory of Optimization II Chair Patrick Mehlitz	Duality and Set-valued Optimization Chair Felix Neussel
09:45 - 10:15	**On critical multipliers in generalized nonlinear programming** Patrick Mehlitz	**Local Duality Theory** Felix Neussel
10:15 - 10:45	**The metric projection over a polyhedral set through the relative interiors of its faces** Valerian Alin Fodor	**Stability results for set-valued optimization problems in Geoffrey space** James Larrouy
10:45 - 11:15	**On Inner Independence Systems** Sven de Vries	**Bishop-Phelps Type Scalarization for Vector Optimization in Real Topological-Linear spaces** Christian Günther
11:15 - 11:45	**Coffee Break**	

Wednesday, March 5th

11:45 - 12:45	US-C 114, Chair Alfred Müller	
	Nicole Bäuerle On optimality criteria for dynamic investment and their connections	
12:45 - 13:45	**Lunch**	
Session 2	US-C 114	US-C 115
	Iterative Methods for Stochastic Optimization Chair Simon Weißmann	Robust and Discrete Optimization Chair Michael Hartisch
13:45 - 14:15	**Almost sure convergence rates for stochastic gradient methods** Simon Weißmann	**Counter Example Guided Abstraction Refinement for Multistage Robust Discrete Linear Programs** Michael Hartisch
14:15 - 14:45	**Averaged stochastic gradient methods and training of artificial neural networks** Adrian Riekert	**The robust selection problem with information discovery** Marc Goerigk
14:45 - 15:15	**Polyak's Heavy Ball Method accelerates under Polyak-Lojasiewicz Inequality** Sebastian Kassing	**On Two-Stage Robust Selection Problems with Budgeted Uncertainty** Dorothee Henke
15:15 - 15:45	**Derivative-free stochastic bilevel optimization for inverse problems** Mathias Staudigl	**Advancements in the domain of LLM Reinforcement Learning through DeepSeek`s Approach** Florian Breda
16:00 - 17:30	**Excursion**	
18:30 - 22:00	**Conference Dinner**	

Thursday, March 6th

08:30 - 09:30	US-C 114 - Chair: Ulf Lorenz	
	Marc Pfetsch Combinatorial Aspects of Physical Networks	
09:30 - 09:45	**Coffee**	
Session 1	US-C 114	US-C 115
	Multi objective Optimization Chair Maryam Roudneshin	Mixed Integer Programming Chair Thomas Hirschmüller
09:45 - 10:15	**Smoothing Function for Solving Non-Smooth Multi-Objective Environmental and Economic Dispatch Problems** Mohamed Tifroute	**Constructing Low-Discrepancy Point Sets by Mathematical Programming** Kathrin Klamroth
10:15 - 10:45	**On some nonlinear conjugate gradient methods for multiobjective optimization** Jamilu Yahaya	**Investigating Mixed-Integer Programming Formulations of the p-Second-Center Problem** Sara Joosten
10:45 - 11:15	**A novel approch to optimise biorefinry supply chain design** Maryam Roudneshin	**Improved Linear Programming Bounds for Multiply Constant-Weight Codes** Thomas Hirschmüller
11:15 - 11:45	**Coffee Break**	

Thursday, March 6th

Session 2	US-C 114	US-C 115
	Layout planning Chair Lennard Hansmann	Applications Chair Johannes Schmidt
11:45 - 12:15	**The Single Row Facility Layout Problem with Product Paths** Anja Fischer	**Optimal configurations for modular systems at the example of crane bridges** Maren Beck
12:15 - 12:45	**The Undirected Circular Facility Layout Problem** Louisa Schroeder	**Sports League Scheduling with Minitournaments** Johannes Schmidt
12:45 - 13:15	**The Template-Based Newspaper Layout Problem** Lennard Hansmann	**A dynamic programming algorithm for order picking in robotic mobile fulfillment centers** Jan-Erik Justkowiak
13:15 - 13:30	Final Meeting and Closing	
13:30 - 14:30	**Lunch**	

Invited Speakers

Danny Segev

Danny Segev is a professor at Tel Aviv University's School of Mathematical Sciences and Coller School of Management. He holds a PhD from Tel Aviv University and has held visiting positions at Carnegie Mellon and MIT. His research focuses on algorithms for optimization under uncertainty, including dynamic programming, submodular functions, and graph theory, applied to problems in computational revenue management, e-commerce, and business operations. Segev is an associate editor for Operations Research and Management Science.

US-C 114 09:00-10:00

The joint replanishment problem: Classical results and some recent progress

Dating back to the mid-60's, with indirect investigations surfacing even earlier, the joint replenishment problem has been playing an instrumental role in developing the theoretical foundations of inventory management as well as in boosting the practical appeal of this academic field. While joint replenishment settings have been studied in various forms and shapes, they are all inherently concerned with the lot-sizing of multiple commodities over a given planning horizon, aiming to efficiently synchronize numerous Economic Order Quantity (EOQ) models. What makes such synchronization particularly challenging is the interplay between different commodities via joint ordering costs, incurred whenever an order is placed. I will discuss a number of classical results in this context along with some recent developments.

Mirjam Dür

Mirjam Dür was born in Vienna, Austria, where she received a M.Sc. degree in Mathematics from the University of Vienna in 1996. She received a PhD in applied mathematics from University of Trier in 1999. After that, she worked as an assistant professor at Vienna University of Economics and Business Administration, as a junior professor at TU Darmstadt, as an Universitair Docent at the University of Groningen (NL) and as a professor of Nonlinear Optimization in Trier. Since October 2017, she is a professor of Mathematical Optimization at the University of Augsburg. Her research interests include global optimization, quadratic and combinatorial optimization, conic optimization and matrix theory.

US-C 114 17:45-18:45

Recent developments in conic optimizarion

A conic optimization problem is a problem involving a constraint that the optimization variable be in some closed convex cone. Linear optimization is a prominent example, where the nonnegativity constraint can be interpreted as requiring that the variable should be in the cone of nonnegative vectors. Other examples are second order cone problems (SOCP) where the variable is constrained to be in the second order cone, and semidefinite programming (SDP) where the matrix variable is required to be in the cone of positive semidefinite matrices. More general cones like the cones of copositive or completely positive matrices appear especially modelling quadratic or combinatorial optimization problems. In this talk, we will review recent progres made in this field. We will discuss both theoretical progress and algorithmic issues.

Anita Schöbel

Anita Schöbel is professor for Applied Mathematics at the RPTU University of Kaiserslautern-Landau and she is head of the Fraunhofer Institute for Industrial Mathematics ITWM. The ITWM has 550 employees dealing with industrial research projects in applied mathematics. At Fraunhofer, Anita coordinates the research areas Next Generation Computing and Quantum Computing. Anita was president of the German Operations Research Society (GOR) in 2019/20 and president of EURO (Association of European Operational Research Societies) in 2023/24, currently still being on the board. She is member of the senate of the national research data infrastructure (NFDI), AI pilot for mobility of Rhineland-Palatinate (RLP), and member of many advisory boards, e.g., of Munich Quantum Valley, HLRS, council for technology of RLP, and also a member of acatech. Her research interests are discrete optimization, public transport, robust multiobjective optimization, location theory and NGC. Anita is author of 180 refereed research articles and 9 books.

US-C 114 08:30-09:30

Sustainable public transport

Moving travelers efficiently, with low costs, and respecting environmental goals like CO2 emissions is one of the challenging problems our society faces today. In this talk we sketch how optimization can help to provide sustainable public transport. A first goal is to make public transport more attractive compared to nun-sustainable modes. There are numerous papers dealing with optimizing lines, timetables,vehicle schedules and other planning stages. We introduce some of these stages and then discuss how integrated optimization of these stages can help to further improve efficiency of public transport. Another goal is to make public transport modes themselves more energy-efficient. In this context, we present models for designing energy-efficient, but passenger-friendly lines and for optimizing train timetables that allow the usage of regenerative energy. Finally, for providing sustainable transport within a region, we need also look at other modes of transport besides regular bus or metro transportation including demand-responsive transport and individual cars. We sketch a model in which such different transport modes are optimized simultaneously.

Nicole Bäuerle

Nicole Bäuerle received the PhD degree in mathematics from Ulm University, Ulm, Germany, in 1996. Since 2005, she has been a Professor of probability with the Karlsruhe Institute of Technology, Karlsruhe, Germany. From 2002 to 2005, she was a Professor of insurance mathematics with the University of Hannover, Hannover, Germany. She has authored or coauthored more than 90 papers and a book jointly with Ulrich Rieder on Markov Decision Processes with Applications to Finance. Her research interests include stochastic processes and control with applications to finance, insurance, and stochastic networks. Dr. Bäuerle is a Deputy Editor in Chief of the Journal of Applied Probability since 2019.

US-C 114 11:45-12:45

On optimality criteria for dynamic investment and their connections

On optimality criteria for dynamic investment and their connections In this presentation, we will explore various optimization criteria for portfolio investment problems and discuss their properties. A pivotal role is played by the risk-sensitive objective which is linked to Mean-Variance problems and risk measures. We show how to solve multi-stage risk-sensitive problems and discuss the impact of the risk-sensitivity parameter on the optimal policy. These kind of criteria typically lead to time-inconsistent optimal investment strategies. Using a Mean-Variance example we explain how this issue can be resolved by using a new interpretation. In the end we consider problems with risk-measures and if time allows discuss parameter uncertainty in these problems and propose methods to manage it. The talk is based on joint works with Anna Jaśkiewicz, Antje Mahayni, Marcin Pitera, Ulrich Rieder and Łukasz Stettner.

Marc Pfetsch

Marc Pfetsch studied mathematics at the University of Heidelberg from 1992 to 1997, earning a diploma. He then completed a master's degree in Operations Research at Cornell University with a Fulbright scholarship. In 2002, he obtained his PhD in discrete geometry from TU Berlin. From 2002 to 2008, he conducted research at the Zuse Institute Berlin (ZIB), where he led the "Integer Programming and Discrete Structures" group. After his habilitation at TU Berlin, he became a professor of Mathematical Optimization at TU Braunschweig in 2008 and a professor of Discrete Optimization at TU Darmstadt in 2012. There, he led the Optimization research group and held various faculty leadership roles, including Dean (2022–2024). In 2016, he received the EURO Excellence in Practice Award.

US-C 114 08:30-09:30

Combinatorial Aspects of Physical Networks

This talk considers combinatorial properties of physical networks like water, gas, heat, and electrical networks. One common model is given by potential-based flows, for which, in general, the corresponding flows depend in a nonlinear way on potentials (e.g., pressures) and are unique. The talk will review three different topics. The first is how the fact that flows in physical networks are acyclic can be used to strengthen mixed-integer optimization formulations and to derive combinatorial models. The second concerns the recovery of the structure of the network, given only information at the entries and exits. The talk will demonstrate positive and negative results in this direction. The third deals with topology optimization of such networks. Here, valid inequalities on the binary decision variables are derived using the nonlinear behavior of the network.

US-C 114 10:30 - 11:00

The Location Problem for Compressor Stations in Pipeline Networks

Michael Schuster

In the operation of pipeline networks, compressors play a crucial role in ensuring the network's functionality for various scenarios. In this contribution we address the important question of finding the optimal location of the compressors. That results in non-convex mixed integer stochastic optimization problems with probabilistic constraints. Using a steady state model for the gas flow in pipeline networks including compressor control and uncertain loads given by certain probability distributions, the problem of finding the optimal location for the control on the network, s.t. the control cost is minimal and the gas pressure stays within given bounds, is considered. In the deterministic setting, explicit bounds for the pipe length and the inlet pressure, s.t. a unique optimal compressor location with minimal control cost exists, are presented. In the probabilistic setting, an existence result for the optimal compressor location is presented and the uniqueness of the solution is discussed depending on the probability distribution. Further the problem of finding the optimal compressor locations on networks including the number of compressor stations as variable is considered. Results for the existence of optimal locations on a graph in both, the deterministic and the probabilistic setting, are presented. The paper concludes with an illustrative example on a diamond graph demonstrating that the minimal number of compressor stations is not necessarily equal to the optimal number.

US-C 115 10:30 - 11:00

Optimized convergence of stochastic gradient descent by weighted averaging

Melinda Hagedorn, Florian Jarre

Under mild assumptions stochastic gradient methods asymptotically achieve an optimal rate of convergence if the arithmetic mean of all iterates is returned as an approximate optimal solution. However, in the absence of stochastic noise, the arithmetic mean of all iterates converges considerably slower to the optimal solution than the iterates themselves. And also in the presence of noise, when a termination of the stochastic gradient method after a finite number of steps is considered, the arithmetic mean is not necessarily the best possible approximation to the unknown optimal solution. This paper aims at identifying optimal strategies in a particularly simple case, the minimization of a strongly convex function with i.i.d. noise terms and termination after a finite number of steps. Explicit formulas for the stochastic error and the optimality error are derived in dependence of certain parameters of the SGD method. The aim was to choose parameters such that both stochastic error and optimality error are reduced compared to arithmetic averaging. This aim could not be achieved; however, by allowing a slight increase of the stochastic error it was possible to select the parameters such that a significant reduction of the optimality error could be achieved. This reduction of the optimality error has a strong effect on the approximate solution generated by the stochastic gradient method in case that only a moderate number of iterations is used or when the initial error is large. The numerical examples confirm the theoretical results and suggest that a generalization to non-quadratic objective functions may be possible.

US-C 114 11:00 - 11:30

Advancing the Optimization of Ventilation System Planning with Improved Life-Cycle Cost and Acoustic Considerations

Julius Breuer, Peter F. Pelz

The efficiency of ventilation systems is increasingly challenged by EU climate targets, necessitating reduced energy consumption while maintaining comfort. Consequently, the focus has shifted from minimising investment costs to optimising life-cycle costs. This growing complexity requires discrete optimisation techniques. A two-stage stochastic optimisation model that accounts for both planning and operation has been shown to yield globally minimal life-cycle cost solutions. However, conventional planning approaches remain highly sequential—fans are placed first, and noise constraints are evaluated only afterwards. Recent research suggests that this leads to suboptimal designs compared to holistic planning, where airflow and acoustics are optimised jointly. Previous studies have been limited to small case-study buildings. In this work, we investigate a significantly larger system, with 15 times more rooms and demands. The existing methodology does not scale efficiently, resulting in prohibitive computation times. To address this, we refine the approach by exploiting the problem's inherent structure, reducing graph complexity, and simplifying fan models. With these enhancements, solutions can now be obtained in a reasonable timeframe, demonstrating that holistic planning significantly improves system efficiency. These findings highlight the necessity of integrated, scalable optimisation methods for the design of energy-efficient ventilation systems.

US-C 115 11:00 - 11:30

A Stochastic Conjugate Gradient with Variance Reduction in Non-smooth Setting

Mahmoud Yahaya, Poom Kumam

There has been some interest in stochastic conjugate gradient (SCG), for smooth objective functions, but what is considerably not well-known is SCG for non-smooth objective functions. In this presentation, we introduced a proximal stochastic conjugate gradient (ProxSCG). It is a stochastic algorithm that incorporates important properties such as mini-batching and variance reduction for objective functions that are a sum of two terms smooth finite sum loss functions and a non-smooth component term. In ProxSCG - we formulated a stable stochastic conjugate gradient direction and the result generalizes the existing SCG approaches. Moreover, we present the convergence analysis and discuss the convergence rates and complexity of ProxSCG for strongly and non-strongly convex setup of the objective function respectively. We also perform some numerical experiments to showcase the algorithm's capabilities in comparison to other algorithms on some machine learning models. We verify that ProxSCG demonstrates a stronger potential for adaptation than the existing approaches.

US-C 114 11:30 - 12:00

Advanced Search and Rescue Operations for Drowning Swimmers using Autonomous Unmanned Aircraft Systems: Location Optimization, Flight Trajectory Planning and Image-Based Localization

Sascha Zell, Toni Schneidereit, Armin Fügenschuh, Michael Breuß

Drowning is among the most prevalent causes of death from unintentional injuries worldwide. Because of the time-sensitive nature of swimming accidents and the shortage of lifeguard staff resulting in unsupervised swimming areas, interest in supportive rescue methods increases. In this paper, we propose an autonomous Unmanned Aircraft System (UAS) usable by Emergency Medical Service (EMS) providers in swimmer rescue scenarios additionally to Standard Rescue Operation (SRO) equipment. The UAS consists of Unmanned Aerial Vehicles (UAVs) and purpose-built hangars located near the swimming area to store the UAVs. When receiving an alert, the UAVs autonomously navigate to the emergency site to conduct a Search and Rescue (S&R) operation for the drowning person. We introduce a Mixed-Integer Linear Programming (MILP) model to address the Facility Location Problem (FLP), assisting with identification of accessibility-optimal UAV hangar placements near the swimming area. Additionally, we present a MILP model to optimize the UAV flight trajectories in advance of the operation, allowing for efficient coordination of a heterogeneous UAV fleet. We apply the presented MILP models to a real-world scenario in the Lusatian Lake District using the state-of-the-art commercial solver CPLEX to solve the instances. Furthermore, we present a method for automated image-based swimmer localization using the state-of-the-art neural network You Only Look Once (YOLO). Finally, we use a Discrete-Event Simulation (DES) approach to quantify how much time is saved by using additional resources.

US-C 115 11:30 - 12:00

A linear programming approach for the elementary shortest path problem

Regina Schmidt

The Elementary Shortest Path Problem (ESPP) is the problem of finding an elementary minimum-cost path between two nodes in a directed graph in such a way that each node on the path is visited exactly once. If negative arc costs are allowed, then the problem is NP-hard. We study an exact integer programming formulation for the ESPP and we discuss its LP relaxations. We present a solution approach based on these relaxations.

US-C 114 12:00 - 12:30

Green Constraints in Manufacturing: Modeling and Optimizing Production for Renewable Energy Integration

Om Parkash, Rainer Drath

Optimization of production processes is an established approach to reducing costs, saving time, minimizing waste, enhancing efficiency, while optimizing production schedules. Manufacturing companies increasingly face the challenge of aligning their production with renewable energy supply and minimizing environmental impact while maintaining product quality and availability. In future, regenerative energy will be available in variable amounts, and pricing and optimal green production has to take this into account to reduce carbon emissions and energy costs. Those constraints are today mostly not in consideration. The systematic integration of renewable energy into manufacturing is unsolved.

A critical component of this optimization are new constraints inherent in such systems, which dictate the extent to which processes, resources, and energy systems can be adjusted. The present research introduces the core ideas of such a green production and proposes a concept to systematically identify, categorize, and model the green constraints associated with the production components. These constraints are comparatively formalized by, e.g. OCL or SHACL, to ensure their representation in machine-readable formats for seamless integration into optimization frameworks. The resulting constraint models serve as input for subsequent automatic optimization of production processes, allowing manufacturers to dynamically adjust operations to energy availability and demand. In addition, this study explores advanced modeling approaches to represent constraints and their interdependencies in both graphical and expressive collaborative formats.

US-C 115 12:00 - 12:30

Optimal inventory decisions for growing items

Mohammed Abdulaziz Darwish

The Economic Order Quantity (EOQ) model is widely used for inventory control but assumes constant item quantity, which is unrealistic for growing products like birds, sheep, and cows. These products gain weight as they are fed, requiring companies to optimize purchasing, feeding, and holding strategies. This study develops an inventory model that minimizes total costs by determining the optimal number of growing items to purchase at the start of each cycle. Unlike existing models, it incorporates multiple end-product weight categories, reflecting industry practices such as offering frozen chicken in different weights (e.g., 1000g, 1200g). This approach aligns more closely with real-world scenarios, providing a practical and cost-effective solution for managing growing inventory items. We developed a mathematical model and determined the optimal solution to the problem.

Acknowledgments: The author is grateful to Kuwait University for its support.

US-C 114 13:30 -14:00

Data driven elasticity in function space

Marc C. Steinbach

Data-Driven Computational Mechanics (DDCM) is a recent paradigm in continuum mechanics where the empirical material law that describes elasticity is replaced by a minimum-distance requirement with respect to raw measured data. We present a discrete-continuous QP formulation in Hilbert space and analyze its regularity as well as the existence, uniqueness and structure of solutions. We also discuss a finite-element discretization, propose a structure-exploiting operator splitting method, and present computational results.

US-C 115 13:30 - 14:00

Optimal Packing of Irregular Objects Composed by Generalized Spheres

Andreas Fischer

For modeling the optimal packing of objects composed by generalized spheres, we present non-overlapping and containment conditions. A new composition condition enables translations, rotations and reflections of the irregular objects. The modeling is applicable to special problems, like balance, homothetic, or sparse packing. Different geometrical shapes can be created and treated in the same way through selecting a suitable norm, possibly obtained by the composition of norms. Illustrations for small probems demonstrate the potential of the approach. The talk is based on joint work Igor Litvinchev, Tetyana Romanova, and Petro Stetsyuk.

US-C 114 14:00 - 14:30

Spectral galerkin approximation of impulsive optimal control in volterra equations

Rayane Oum Essaoud

Volterra integral equations find applications in many fields of economies (including the evolution of capital stock under an investment strategy), science and engineering, population dynamics, the spread of epidemics, semi-conductor devices, etc. While optimal control theory was developed mostly for differential equations, controlled Volterra integral equations are also an important category of controlled systems, however, little is known about them compared to most classes of control systems. Spectral approach is also weakly implemented for this class of control problems.
In this work we apply spectral Galerkin approximation to impulsive optimal control problems governed by volterra integral equations.

US-C 115 14:00 - 14:30

Structural Optimization of Trusses for Additive Manufacturing in Bending Applications

Julian Mrochen

Manufacturing paradigms are shifting from mass production to flexible and scalable systems to accommodate increased product diversity and small batch sizes within modular systems. This work presents a case study on the bending process, highlighting the critical need to design and optimize load-bearing structures to meet technical requirements effectively. The focus is on developing a truss system capable of efficiently handling the loads intrinsic to the bending process. Central to this approach is the precise calculation of compliances, ensuring the structural integrity and performance of the system. By integrating established Operations Research (OR) methodologies with engineering principles, the study establishes a robust framework for optimizing truss structures. A distinctive aspect is the emphasis on additive manufacturing, enabling the optimization framework to address the unique challenges and opportunities presented by this advanced manufacturing technique.

US-C 114 14:30 - 15:00

Analyzing the speed of convergence in nonsmooth optimization via the Goldstein ϵ-subdifferential

Bennet Gebken

In smooth optimization, Taylor expansion is a powerful tool when analyzing the speed of convergence of solution methods. In nonsmooth optimization, this tool cannot be applied anymore, as there is no suitable generalization of Taylor expansion for a nonsmooth function. As a result, while many different solution methods for nonsmooth problems have been proposed, the speeds of convergence of these methods are rarely analyzed. In this talk, I will present a novel approach based on the Goldstein ε-subdifferential for analyzing convergence behavior in nonsmooth optimization. More precisely, given a converging sequence and upper bounds for the distance of the ε-subdifferential to zero for vanishing ε, we derive an estimate for the distance of said sequence to the minimum. The assumptions we require for this are polynomial growth around the minimum and, depending on the order of growth, a higher-order generalization of semismoothness. After giving an overview of the assumptions and the theoretical results, I will show how these results lead to a better understanding of the behavior of gradient sampling methods.

US-C 115 14:30 - 15:00

Cooperative Demand Fulfillment in a Market-Based Multi-Agent Control System

Tobias Meck, Peter F. Pelz

Controlling fluid systems is becoming an increasingly challenging task, facing expectations beyond efficiency and resilience. For example, modularisation concepts in the process industry require a high degree of adaptability of the methods. Furthermore, the underlying logic of the algorithms needs to be transparent to achieve acceptance and application in practice. Prior work identified the application of economic concepts to technical systems as a promising approach to tackling these challenges. Here, the active components, i.e., pumps or valves, trade volumetric flow rate guarantees on a common market. While the pumps act as producers, supplying a flow by adjusting their rotational speed, the valves correspond to consumers with an assigned flow demand. As a first step, a purely distributed auction concept was developed, where each pump tries to fulfil the sold guarantees individually. This concept requires only minimal system knowledge. However, additional system knowledge, such as the topology, is usually readily available and can be leveraged to optimise the flow supply. In this work, we extend the state-of-the-art auction concept by enabling temporary cooperation among the pump agents. This allows for the calculation of optimal rotational speeds, which minimise the total power consumption of the agent team. We show that this extension not only improves the electrical efficiency but also enhances the demand fulfilment of the whole system.

US-C 114 15:00 - 15:30

Gauss ranges and properties of the closed convex sets which are preserved under addition and intersection

Cornel Sebastian Pintea

We characterize the closed convex subsets of $\mathbb{R}^n$ which have open or closed Gauss ranges. Some special attention is paid to epigraphs of lower semicontinuous convex functions. We apply these characterizations to show that some classes of closed convex sets are closed with respect to the Minkowski sum and the intersection.

US-C 115 15:00 - 15:30

Distillation column optimization: A formal method using stage-to-stage computations and distributed streams

Tobias Seidel, Lorenz T. Biegler

Distillation in distillation columns is a widely used process to separate liquid mixtures and plays a key role in the energy-intensive sector of chemical processes. To minimize the required energy for separation, an optimal design and optimal operation are needed. Using the MESH (mass, equilibrium, summation, heat) equations in an equilibrium stage model results in a highly nonlinear description with hundreds to thousands of optimization variables and equality constraints. Including the design in the optimization introduces discrete degrees of freedom related to the number of stages, further complicating the problem as a nonlinear mixed-integer optimization problem.

To simplify the problem, we employ distributed streams, eliminating discrete degrees and replacing them with continuous ones. To avoid sophisticated initialization procedures, we combine this smooth formulation with stage-to-stage calculations that presolve most of the nonlinear equations, reducing the problem to maintaining only the MESH equations for a single stage. For this nonlinear reduction, we can prove the existence and uniqueness of solutions, ensuring a well-defined formulation and equivalence of the optimization problems.

Our numerical experiments demonstrate the efficiency and stability of solving the proposed optimization problem in various scenarios, including single and multiple distillation columns.

US-C 114 16:00 - 16:30

A Mixed-Integer Linear Programming Framework for the Adversarial Training

John Alasdair Warwicker, Samuel Roths, Steffen Rebennack

The training of neural networks (NNs) is a necessary task to improve their generalisation ability, measured by their performance on unseen inputs. However, even trained NNs can be vulnerable to adversarial inputs, which are minimally perturbed versions of standard inputs that are incorrectly labelled by the NN. The adversarial training of NNs can help to increase their robustness and guard against adversarial attacks. Recently, mixed-integer linear programming (MILP) models have been presented which are used to model the process of classification through trained NNs. One prominent application of such models is the ability to generate adversarial examples through providing constraints on the target input while minimising the level of perturbation. MILP models have also been presented for training NNs, showcasing comparable accuracy to traditional stochastic gradient descent approaches. In this work, we use recent advances in the field of MILP to present the adversarial learning of NNs as an optimisation problem. We present a number of settings for the presented framework which allow for training against various settings of adversarially generated inputs, including non norm-based attacks, with the goal of increased robustness at minimal cost to performance. Experimental results on the MNIST data set of handwritten digits evaluate the performance of the proposed approach, and we discuss how the framework fits within the state-of-the-art.

US-C 115 16:00 - 16:30

Minimization of Gibbs free energy for a Poisson-Boltzmann Problem

Ali Shahid, Klemen Bohinc, Ángeles Martínez, Stefano Maset

The study of the electrostatic interactions between charged structures and ions is crucial in understanding the behavior of soft matter, in particular living matter. Biological systems typically consist of a multitude of charged structures. Membranes, cellular components, globular proteins, polyelectrolytes, DNA, and polystyrene sulfonate are examples of biopolymers having charges and, consequently, an electrical behavior. These charged structures are placed in biological media (for example blood) containing free ions in addition to water molecules. In this work, we consider an ionic solution containing several types of spherical ions between two uniformly charged parallel planes. Each ion in the solution is moving with a molecular motion influenced by the electric forces of the charged planes and the other ions. It is of interest to determine the ions concentration at the electrostatic and thermal equilibrium (*Poisson-Boltzmann problem*). The ions concentration at the equilibrium are the concentrations minimizing the *Gibbs free energy* of the system. The corresponding minimization problem is infinite-dimensional and so it is discretized into a finite-dimensional constrained nonlinear programming problem, which is then solved using a standard optimization solver. A convergence analysis of the discrete minimum to the continuous minimum is performed.

US-C 114 16:30 - 17:00

Error Analysis and Fine-Tuning of an Artificial Neural Network for the 1D

Corinne Pretz

This talk explores the combination of artificial neural networks (ANNs) with mathematical optimization models to solve the 1D Bin Packing Problem (BPP). A Mixed-Integer Linear Program (MILP) is developed to combine the internal computations of a feedforward ANN with the mathematical formulation of the 1D BPP. The objective is to improve the efficiency of ANNs while ensuring a performance guarantee for their predictions. The used ANN predicts the required number of bins for a given 1D BPP instance. The MILP then identifies instances where the prediction of the ANN deviates maximally from the optimal solution (prediction of more bins than actually needed). These critical instances are then trained into the ANN through fine-tuning, iteratively improving its prediction accuracy. Experimental results show that, for multiple fine-tuning approaches, a performance guarantee can be provided within a time limit for small instances and networks. However, numerical difficulties arise when solving the MILP for larger networks and instances. These findings highlight the potential of this hybrid approach, particularly for smaller problem instances. Future research should focus on optimizing MILP parameters and exploring more complex machine learning models and a two-stage MILP to enhance practical usage.

US-C 115 16:30 - 17:00

QUBO Formulations and Quantum Computing Based Methods to Solve the 0/1 Multi-Dimensional Knapsack Problem

Evren Güney, Joachim Ehrenthal, Thomas Hanne

The Multi-Dimensional Knapsack Problem (MDKP) is a well-established combinatorial optimization problem. Due to its NP-hard nature, solving MDKP efficiently remains challenging. Recent advances in quantum computing have enabled the exploration of Quantum Unconstrained Binary Optimization (QUBO) formulations for optimization problems. Therefore, we develop and analyze QUBO formulations for MDKP, focusing on the encoding of multi-constraint structures and the characterization of penalty parameters. To evaluate the performance of quantum optimization methods on MDKP, we conduct classical simulations of the Quantum Approximate Optimization Algorithm (QAOA) and quantum annealing. QAOA is implemented using Qiskit and IonQ simulators, while quantum annealing is examined through D-Wave's simulated annealing. Our experiments analyze the impact of penalty parameter magnitudes on solution quality, e.g. optimality gaps and computation time, across the different quantum simulators and compared to state-of-the-art classical solving as baseline. Our comparative analysis sheds light on the strengths and limitations of quantum approaches for solving constrained combinatorial problems like MDKP. Specifically, our results provide insights into the trade-offs between penalty parameter tuning and solution quality. Finally, we provide insights into the applicability of quantum optimization to multi-constrained problems and inform future research directions.

US-C 114 17:00 - 17:30

Incremental Subgradient Method for Multiple Instance Learning in Skin Segmentation

Narges Araboljadidi, Valentina De Simone

Multiple Instance Learning (MIL) has emerged as one of the strong paradigms in dealing with weakly supervised learning problems, especially on image classification ones. In this research, we propose a customized incremental subgradient descent method (ISM) to solve the MIL problems. ISM is an optimization technique for non-smooth convex problems, where the objective function is convex but may not be differentiable at all points. It is very suitable for large-scale problems because of its low computational complexity and ability to handle sparse updates. In the case of MIL, it processes the training bags in a sequence and updates the model parameters using the subgradients of the loss function. This approach uses the problem structure for efficiently computing subgradients for each bag, hence incrementally updating the model. We demonstrate the efficiency of the ISM on the UCI skin segmentation dataset and compare its performance with that of the state-of-the-art method, which combines Sequential Minimal Optimization (SMO) with the Support Vector Machine (SVM) model. The experimental results, obtained using 5-fold crossvalidation, indicate a remarkable accuracy of 79.25% and significant computational efficiency, given an average runtime of about 99.3 seconds. In contrast, the SMO-based SVM approach yields with more accuracy, 79.44the average time of execution, 247.9 seconds. These results clearly indicate that ISM is highly effective in reducing runtime significantly for MIL on skin segmentation tasks, while remaining competitive in terms of accuracy.

US-C 115 17:00 - 17:30

Smoothing Function for Solving Non- Smooth Multi-Objective Environmental and Economic Dispatch Problems

Anouar Lahmdani, Mohamed Tifroute

The Environmental and Economic Dispatch problem (EEDP) is a nonlinear Multiobjective Optimization Problem (MOP) which simultaneously satisfies multiple contradictory criteria, and it's a nonsmooth problem when valvepoint effects, multi-fuel effects and prohibited operating zones have been considered. It is an important optimization task in fossil fuel fired power plant operation for allocating generation among the committed units such that fuel cost and pollution (emission level) are optimized simultaneously while satisfying all operational constraints. The purpose of this paper is to use smoothing functions with the gradient consistency property to approximate the nonsmooth EEDP. Our approach based on the smoothing functions, where a sequence of smooth multiobjective subproblems that progressively approximate the nonsmooth multiobjective problem is presented. We show that any accumulation point of a selected subsequence of the iteration sequence generated by the smoothing MOO algorithm is a Clarke stationary point. So the Pareto optimal solutions (stationary points) of the approximate problems converge to a Pareto optimal solution (stationary point) of the original multiobjective programming problem. In this paper, The formulation of EEDP include absolute value function. The constrained nonsmooth multiobjective problem is transformed into a set of single-objective subproblems using the -constraint method . For both method, the objective function of the subproblems are smoothed by the smoothing method and the subproblems are solved by the Interior point barrier method.

US-C 114 9:45 - 10:15

On critical multipliers in generalized nonlinear programming

Patrick Mehlitz, Matúš Benko

For twice continuously differentiable mappings $f\colon \mathbb{R}^n \to \mathbb{R}$ and $F\colon \mathbb{R}^n \to \mathbb{R}^m$ as well as a merely lower semicontinuous function $g\colon \mathbb{R}^m \to \mathbb{R} \cup \{\infty\}$, we are concerned with the composite optimization problem

$$\min_x \; f(x) + g(F(x)) \quad \text{subject to} \quad x \in \mathbb{R}^n$$

which has been named a *generalized nonlinear program* by Rockafellar. In order to solve it numerically, several different methods have been suggested in the literature. Exemplary, problem-tailored augmented Lagrangian or sequential quadratic programming methods have been developed, potentially requiring additional structural properties of g. Primal-dual fast convergence of the sequence of iterates to a primal-dual stationary pair can be proven in the presence of a certain primal-dual error bound which is closely related to so-called *noncriticality* of the associated multiplier. In the talk, we present two types of results. First, we characterize the situation where, given a stationary point of the problem, all associated multipliers are noncritical. Second, we are concerned with the aforementioned error bound which can be characterized in terms of noncriticality of the particular multiplier under consideration. Both results require additional mild calmness-type properties of the multiplier mapping associated with the composite problem, and the talk presents verifiable sufficient conditions for their validity.

US-C 115 9:45 - 10:15

Local Duality Theory

Felix Neussel

Dual concepts play a central role in the fields of linear and convex programming. However, for nonconvex problems, the utility of duality is limited because there usually is a duality gap between the original problem and its dual. Local duality theory enables the use of dual concepts for general nonlinear problems. The vanishing of the local duality gap requires weaker assumptions than convexity, which can be satisfied for most problems by different equivalent reformulations.

A classical reformulation leads to the augmented Lagrangian method while in a more recent approach, the objective and constraints are raised to a sufficiently large natural power. In this talk, a new derivation of the local dual problem and a local optimization algorithm based on local duality are presented. Additionally, it will be demonstrated how the weighted sum scalarization in multiobjective optimization benefits from a combination of conventional and local duality theory.

US-C 114 10:15 - 10:45

The metric projection over a polyhedral set through the relative interiors of its faces

Valerian Alin Fodor, Cornel Sebastian Pintea

We characterize the region of the n-dimensional Euclidean space for which two optimization problems with the square distance function as common objective function, but different constraints, are equivalent. The affine hull of a certain face of a closed convex set $C \subseteq \mathbb{R}^n$ is the constraint associated to one problem and the whole closed convex set C is the constraint associated to the other problem. Such optimization problems are best approximation problems which can be reformulated in terms of the metric projection. Using the language of the metric projection, we characterize the region of $\mathbb{R}^n$ which is metrically projected over a face of C in the same way that it is projected over the affine hull of the face itself. The metric projection over such a face is the one associated to the entire closed convex set, and the metric projection over the affine hull of such a face is the one associated to the affine hull. It turns out that this region is the closure of the inverse image, through the metric projection over the entire closed convex set, of the relative interior of the face. We also characterize analytically the closure of the regions of $\mathbb{R}^n$ that are projected over the relative interiors of the faces of a polyhedral set, through the metric projection of the polyhedral set itself. We show that these regions are polyhedral convex sets by explicitly characterizing them through systems of linear inequalities.

US-C 115 10:15 - 10:45

Stability results for set-valued optimization problems in Geoffrey space

James Larrouy

During this talk, we study the external and internal stability of minimal solutions to set-valued optimization problems in a new functional framework that we call Geoffroy spaces. We consider perturbations on both the objective function and the admissible domain. To address these problems, we introduce two variational convergences for sequences of set-valued maps, namely the Gammacone convergence and the sequential Gamma-cone convergence. The upper and the lower convergence of strong level sets are also studied.

US-C 114 10:45 - 11:15

On Inner Independence Systems

Sven de Vries, Stephen Raach, Rakesh V. Vohra

A classic result of Korte and Hausmann and Jenkyns bounds the quality of the greedy solution to the problem of finding a maximum value basis of an independence system $(E,\mathcal{I})$ in terms of the rank-quotient. We extend this result in two ways.

First, we apply the greedy algorithm to an inner independence system contained in $\mathcal{I}$. Additionally, following an idea of Milgrom , we incorporate exogenously given prior information about the set of likely candidates for an optimal basis in terms of a set $\mathcal{O} \subseteq \mathcal{I}$. We provide a generalization of the rank-quotient that yields a tight bound on the worst-case performance of the greedy algorithm applied to the inner independence system relative to the optimal solution in $\mathcal{O}$. Furthermore, we show that for a worst-case objective, the inner independence system approximation may outperform not only the standard greedy algorithm but also the inner matroid approximation proposed by Milgrom.

Second, we generalize the inner approximation framework of independence systems to inner approximations of packing instances in $\mathbf{Z}^n_{\geq 0}$ by inner polymatroids and inner packing instances in $\mathbf{Z}^n_{\geq 0}$. We consider the problem of maximizing a separable discrete concave function and show that our inner approximation can be better than the greedy algorithm applied to the original packing instance. Our result provides a lower bound to the generalized rank-quotient of a greedy algorithm to the optimal solution in this more general setting and subsumes Malinov and Kovalyov .

US-C 115 10:45 - 11:15

Bishop-Phelps Type Scalarization for Vector Optimization in Real Topological- Linear spaces

Christian Günther, Bahareh Khazayel, Radu Strugariu, Christiane Tammer

It is well-known that scalarization techniques (e.g., in the sense of Gerstewitz; Kasimbeyli; Pascoletti and Serafini; Zaffaroni) are useful for generating (weakly, properly) efficient solutions of vector optimization problems. One recognized approach is the conic scalarization method in vector optimization in real normed spaces proposed by Kasimbeyli (SIAM J Optim, 20(3), 2010), which is based on augmented dual cones and Bishop-Phelps type (norm-linear) scalarizing functions.

In this talk, we present a Bishop-Phelps type scalarization method for vector optimization problems in real topological-linear spaces, which is based on Bishop-Phelps type cone representing functions (e.g., seminorm-linear functions). This method can be seen as an extension of Kasimbeyli's conic scalarization method in real normed spaces. Within this framework, we derive new Bishop-Phelps type scalarization results for the concepts of weak efficiency and different types of proper efficiency.

US-C 114 13:45 - 14:15

Almost sure convergence rates for stochastic gradient methods

Simon Weißmann

In this talk, we present recent advances in establishing almost sure convergence rates for stochastic gradient methods. Stochastic gradient methods are among the most important algorithms in training machine learning problems. While classical assumptions such as strong convexity allow a simple analysis, they are rarely satisfied in applications. In recent years, global and local gradient domination properties have shown to be a more realistic replacement of strong convexity. They were proved to hold in diverse settings such as (simple) policy gradient methods in reinforcement learning and training of deep neural networks with analytic activation functions.

We prove almost sure convergence rates

$$f(X_n) - f^* \in o\left(n^{-\frac{1}{4\beta-1}+\epsilon}\right)$$

of the last iterate for stochastic gradient descent (with and without momentum) under global and local β-gradient domination assumptions. The almost sure rates get arbitrarily close to recent rates in expectation. Finally, we demonstrate how to apply our results to the training task in both supervised and reinforcement learning.

US-C 115 13:45 - 14:15

Counter Example Guided Abstraction Refinement for Multistage Robust Discrete Linear Programs

Michael Hartisch, Leroy Chew

In robust discrete optimization, solution approaches often rely on scenario generation that utilizes the solution of the so-called adversary problem. These approaches often require the use of dualization techniques to obtain a compact reformulation, or, if no such formulation exists, they rely on domain-specific algorithms. For multistage problems that exceed two decision stages, general solution frameworks are rare. We propose an approach based on counterexample-guided abstraction refinement, originally rooted in satisfiability checking of quantified Boolean formulas. We extend this methodology to address multistage robust discrete problems with linear constraints, incorporating optimization capabilities to enhance its applicability.

US-C 114 14:15 - 14:14

Almost sure convergence rates for stochastic gradient methods

Adrian Riekert

We study the situation of optimizing deep artificial neural networks (ANNs) via gradient flows, the continuous-time analogue of gradient descent. Under certain structural assumptions on the considered supervised learning problem, we prove that every non-divergent gradient flow trajectory converges with a polynomial rate of convergence to a critical point. The proof relies on a generalized Kurdyka-Lojasiewicz inequality for the risk function. Furthermore, we apply averaged variants of stochastic gradient methods to the training of ANNs and show empirically that for several different scientific computing problems, these variants outperform standard stochastic gradient based optimizers.

US-C 115 14:15 - 14:45

The robust selection problem with information discovery

Marc Goerigk, Xiaoyu Chen, Michael Poss

We explore a multiple-stage variant of the min-max robust selection problem with budgeted uncertainty that includes queries. First, one queries a subset of items and gets the exact values of their uncertain parameters. Given this information, one can then choose the set of items to be selected, still facing uncertainty on the unobserved parameters. We study two specific variants of this problem. The first variant considers objective uncertainty and focuses on selecting a single item. The second variant considers constraint uncertainty instead, which means that some selected items may fail. While both problems are NP-hard in general, we identify special cases that can still be solved in polynomial time.

US-C 114 14:45 - 15:15

Polyak's Heavy Ball Method accelerates under Polyak-Lojasiewicz Inequality

Sebastian Kassing

In this talk, we consider the convergence of Polyak's heavy ball method, both in continuous and discrete time, on a non-convex objective function. We recover the convergence rates derived in [Polyak, U.S.S.R. Comput. Math. and Math. Phys., 1964] for strongly convex objective functions, assuming only validity of the Polyak-Lojasiewicz inequality. Our approach 1 leverages a new differential geometric perspective of the Polyak-Lojasiewicz inequality proposed in [Rebjock and Boumal, Math. Program., 2024].

US-C 115 14:45 - 15:15

On Two-Stage Robust Selection Problems with Budgeted Uncertainty

Dorothee Henke, Marc Goerigk, Lasse Wulf

A standard type of uncertainty set in robust optimization is budgeted uncertainty, where an interval of possible values for each parameter is given and the total deviation from their lower bounds is bounded. In the two-stage setting, discrete and continuous budgeted uncertainty have to be distinguished. While two-stage robust selection problems with discrete budgeted uncertainty have been shown to be NP-hard, the complexity of the corresponding problems with continuous budgeted uncertainty has still been open. Only for an alternative version of continuous budgeted uncertainty, where the total absolute deviation of all parameters is bounded instead of the sum of all relative deviations, the two-stage robust selection problem has been shown to be solvable in polynomial time. We close a gap in the knowledge about the complexity of these problems by showing that the two-stage robust representative selection problem with the more common version of continuous budgeted uncertainty is solvable in polynomial time. After applying standard dualization techniques to reformulate the problem as a mixed-integer linear program, we present a combinatorial algorithm to solve the latter. Moreover, we provide new hardness results related to the two-stage robust selection problem with continuous budgeted uncertainty. This is joint work with Marc Goerigk and Lasse Wulf

US-C 114 15:15 - 15:45

Derivative-free stochastic bilevel optimization for inverse problems

Matthias Staudigl

Inverse problems are key issues in several scientific areas, including signal processing and medical imaging. Data-driven approaches for inverse problems aim for learning model and regularization parameters from observed data samples, and investigate their generalization properties when confronted with unseen data. This approach dictates a statistical approach to inverse problems, calling for stochastic optimization methods. In order to learn model and regularisation parameters simultaneously, we develop in this paper a stochastic bilevel optimization approach in which the lower level problem represents a variational reconstruction method formulated as a convex non-smooth optimization problem, depending on the observed sample. The upper level problem represents the learning task of the regularisation parameters. Combining the lower level and the upper level problem leads to a stochastic non-smooth and non-convex optimization problem, for which standard gradient-based methods are not straightforward to implement. Instead, we develop a unified and flexible methodology, building on a derivative-free approach, which allows us to solve the bilevel optimization problem only with samples of the objective function values. We perform a complete complexity analysis of this scheme. Numerical results on signal denoising and experimental design demonstrate the computational efficiency and the generalization properties of our method.

US-C 115 15:15 - 15:45

Advancements in the domain of LLM Reinforcement Learning through DeepSeek‘s Approach

Florian R. Breda

Large Language Models (LLMs) have the potential to assist humans in solving complex problems objectively and efficiently, even when users lack formal knowledge of mathematical optimization. A reinforcement learning environment provides rewards based on the quality of generated answers, guiding the learning process. The quality is assessed based on factors such as solvability and the clarity of the formulation’s explanation. This talk gives an insight in newest LLM developments and closes with a research idea, as small, specialized learning environments could be particularly useful for tackling specific problem domains. For instance, LLMs do not yet possess an inherent understanding of linear programs (LPs). Enabling LLMs to autonomously derive LPs from textual problem descriptions requires a structured learning approach

US-C 114 9:45 - 10:15

Smoothing Function for Solving Non- Smooth Multi-Objective Environmental and Economic Dispatch Problems

Mohamed Tifroute, Anouar Lahmdani

The Environmental and Economic Dispatch problem (EEDP) is a nonlinear Multiobjective Optimization Problem (MOP) which simultaneously satisfies multiple contradictory criteria, and it's a nonsmooth problem when valvepoint effects, multi-fuel effects and prohibited operating zones have been considered. It is an important optimization task in fossil fuel fired power plant operation for allocating generation among the committed units such that fuel cost and pollution (emission level) are optimized simultaneously while satisfying all operational constraints. The purpose of this paper is to use smoothing functions with the gradient consistency property to approximate the nonsmooth EEDP. Our approach based on the smoothing functions, where a sequence of smooth multiobjective subproblems that progressively approximate the nonsmooth multiobjective problem is presented. We show that any accumulation point of a selected subsequence of the iteration sequence generated by the smoothing MOO algorithm is a Clarke stationary point. So the Pareto optimal solutions (stationary points) of the approximate problems converge to a Pareto optimal solution (stationary point) of the original multiobjective programming problem. In this paper, The formulation of EEDP include absolute value function. The constrained nonsmooth multiobjective problem is transformed into a set of single-objective subproblems using the -constraint method . For both method, the objective function of the subproblems are smoothed by the smoothing method and the subproblems are solved by the Interior point barrier method.

US-C 115 9:45 - 10:15

Constructing Low-Discrepancy Point Sets by Mathematical Programming

Kathrin Klamroth, François Clément, Carola Doerr, Luís Paquete

Uniformly distributed point sets of low discrepancy are heavily used in experimental design and across a very wide range of applications such as numerical integration, computer vision, and finance. We present a novel approach to construct optimal, or close to optimal, $L\infty$ star discrepancy point sets in two and higher dimension that is based on mixed-integer nonlinear programming (MINLP). Two structurally different MINLP formulations are presented and analyzed with respect to symmetries and stronger constraint formulations. Moreover, by separating the construction of low-discrepancy point sets into (i) the relative position of the points, and (ii) the optimal placement respecting these relationships, we obtain a heuristic approach that significantly improves over known constructions. Using tailored permutations, we construct point sets that are of 20% smaller discrepancy on average than the previously best known sets. In terms of inverse discrepancy, our sets reduce the number of points in dimension 2 needed to obtain a discrepancy of 0.005 from more than 500 points to less than 350. For applications where the sets are used to query time-consuming models, this is a significant reduction.

US-C 114 10:15 -10:45

On some nonlinear conjugate gradient methods for multiobjective optimization

Jamilu Yahaya, Poom Kuman

Conjugate gradient (CG) methods have demonstrated significant potential in solving unconstrained optimization problems. While traditional CG methods, such as those based on the Polak–Ribiére–Polyak (PRP), Hestenes–Stiefel (HS), and Liu–Storey parameters, have been extended to vector-valued settings, their search directions often fail to guarantee sufficient descent conditions, even in single-objective optimization cases. In contrast, parameters like Dai-Yuan (DY) and Conjugate descent exhibit robust convergence properties, ensuring descent directions when paired with Wolfe line search. In this study, we introduce two novel CG methods designed to identify Pareto critical points of vector-valued functions. Specifically, we propose a modified HS method and a hybrid approach that combines PRP and DY parameters. These methods satisfy the sufficient descent condition without relying on line search techniques. Global convergence is achieved using Wolfe line search, eliminating the need for regular restarts or convexity assumptions on the objective functions. Through comprehensive numerical experiments, we validate the efficacy of our proposed methods, demonstrating their practical implementation and comparing their performance with recent related works. The results indicate that our methods exhibit promising performance.

US-C 115 10:15 - 10:45

Investigating Mixed-Integer Programming Formulations of the p-Second- Center Problem

Sarah Joosten, Elisabeth Gaar, Markus Sinnl

We study a recently emerged variant of the well-known p-center problem, the p-second-center problem. In this problem, we are given a set of customer demand points, a set of possible facility locations, distances between each customer demand point and each possible facility location, as well as an integer p. The goal of the p-second-center-problem is to open a facility at p of the possible facility locations such that the maximum 2-distance of all customers is minimized. The 2-distance of a customer is defined as the sum of the distances from the customer to its two closest open facilities. So far, only a heuristic has been proposed in the literature for this problem, namely a variable neighborhood search. In this talk, we present several new mixed-integer programming formulations of the p-second-center problem, which allow us to solve it exactly. We compare the strength of these formulations and derive valid inequalities. Furthermore, we provide computational results on instances from the literature.

US-C 114 10:45 - 11:15

A novel approch to optimise biorefinry supply chain design

Maryam Roudneshin

In alignment with the United Nations' Sustainable Development Goals, particularly the objective to secure clean, affordable, and sustainable energy" for all, this study embarks on a crucial exploration of alternative energy solutions amidst the global push for energy diversification and climate change mitigation. The utilisation of seaweed and agricultural waste as a bioenergy source stands out as a strategic opportunity to enhance environmental sustainability and foster renewable energy production within the framework of a circular bioeconomy. The core of this initiative's success hinges on informed decision-making in designing supply chains that are robust, efficient, and sustainable. This research introduces an innovative decision-making framework aimed at optimising the supply chain network for seaweeds and agricultural waste-tobioenergy conversion, with a particular focus on the decision analysis for selecting biorefinery locations. Employing an integrated approach that combines Geographic Information System (GIS) with Multi-Criteria Decision Making (MCDM), the study delineates optimal sites for biorefineries. This decision-making process meticulously considers both economic and environmental factors to propose a model that aligns with the principles of sustainability. Through this approach, the study seeks to influence stakeholders and investors by demonstrating the feasibility and attractiveness of bioenergy projects, thereby advancing the goals of the circular bioeconomy and contributing to the broader agenda of the sustainable energy transition.

US-C 115 10:45 - 11:15

Improved Linear Programming Bounds for Multiply Constant-Weight Codes

Thomas Hirschmüller

In coding theory a binary code is a subset of the set $\{0,1\}^n$ for a natural number n. The elements of a code are called codewords and the distance of two codewords is the number of indices where their entries are different. If every pair of different codewords of a code has at least distance d, the code can detect up to $d-1$ and correct up to $\lfloor (d-1)/2 \rfloor$ errors that may occur when a codeword is sent through a noisy channel. An interesting problem in coding theory is to find the maximum number $A(n,d)$ of codewords a code can have for a fixed length n while still being able to correct up to $\lfloor (d-1)/2 \rfloor$ errors. Because $A(n,d)$ is generally hard to calculate researchers have been studying optimization problems that provide upper bounds for $A(n,d)$, for example the LP of Delsarte(1973) or the SDP of Schrijver(2005). Recently there has been a lot of interest in codes of a specific class, the so called multiply constant-weight codes. In this talk I am going to present improved linear programming bounds for the maximum size of error correcting codes of this class.

US-C 114 11:45 - 12:15

The Single Row Facility Layout Problem with Product Paths

Anja Fischer

In the Single Row Facility Layout Problem (SRFLP) one is given a set of departments, their lengths and pairwise transport weights between them. One looks for an arrangement of the departments in one line minimizing the sum of the weighted distances. But especially in job shop production systems, there are several departments which could process the same job. So we assume that we are given a set of products and for each of them a task list and information on which of the departments a task could be processed. Then we look simultaneously for an assignment of the single tasks to the departments such that the capacity of these is not exceeded and for an SRFLP layout minimizing the sum of the transport lengths of all the products. This new problem can be modeled as a mixed-integer non-linear optimization problem, which can be linearized appropriately. We present three (mixed-) integer linear models for it. Some are based on the well-known betweenness model. Apart from this, we use connections to bin packing and multi-dimensional knapsack problems. We present first computational results comparing the three models. Additionally, we show the potential of improvement in comparison to a 2-step approach where one assigns the jobs to the departments first and determines an optimal order afterwards.

US-C 115 11:45 - 12:15

Optimal configurations for modular systems at the example of crane bridges

Maren Beck

Modular Systems are widely used in practical applications as in the automotive sector. The aim is to optimize modular systems that cover the construction of products that can be assembled on a modular basis. Increasing the number of different variants of individual components on the one hand decreases the cost of oversizing the assembled product, while on the other hand, the cost of maintaining the modular system increases. For the minimization of the overall cost, a mixed-integer model is derived. However, this model cannot simply be passed to a solver for mixed-integer optimization since certain dependency structures of the variables occur. We propose a general solution approach for this complicating structure using binary variables to transform the problem into a mixed-integer optimization problem, which can be solved deterministically. In a further step, since the general solution approach requires a lot of solution time even for small instances of modular systems, we use the special problem structure and derive a decomposition-like solution approach. In all steps mentioned above we look at different examples for modular systems.

US-C 114 12:15 - 12:45

The Undirected Circular Facility Layout Problem

Louisa Schroeder, Anja Fischer

In the Directed Circular Facility Layout Problem (DCFLP) one has given a set of departments, their lengths and pairwise weights between the departments. In contrast to the Single Row Facility Layout Problem (SRFLP), where departments are arranged along one side of a path without overlapping, the DCFLP looks for an arrangement on a circle such that the sum of the weighted center-to-center distances measured in clockwise direction is minimized.
In this talk, we present a new facility layout problem, the Undirected Circular Facility Layout Problem (UDCFLP). For each pair of departments we consider here the shortest distance along the circle, either traveling in clockwise or in counter-clockwise direction.
We present two new mixed-integer linear programming models for the UDCFLP, whereby one model is an adaptation of a well-known model for the DCFLP and the other model is based on the well-known betweenness model for the SRFLP. We develop symmetry-breaking constraints and study the structure of the associated polytopes. Our models, which are strengthened by our new cutting planes, allow us to solve instances with up to 16 departments to optimality within a time limit of one hour. For larger instances we derive strong lower bounds exploiting the connections to some parallel machine scheduling problem.

US-C 115 12:15 - 12:45

Sports League Scheduling with Minitournaments

Johannes Schmidt, Armin Fügenschuh, Moritz Böschow

In sport scheduling for leagues with professional teams, game days with single matches are necessary to achieve fairness, which is a fundamental criterion. Thereby, the resulting high number of required game days is accepted and the length of a season not important. In amateur or youth sports leagues, these priorities change since the teams play all matches during their leisure time. A schedule with a smaller number of game days is preferred and the teams are willing to partly renounce on the fairness for this. Thus, the idea of minitournaments arised. In this format, multiple teams meet at one home team, which is one of them, and play against each other. The travel times of all teams now depend on their assignment to the respective minitourmanets and the choice of the home team. We consider in this talk a league with minitournaments of three teams at each game day and two legs, requiring each team to play against each other team exactly twice. These legs have not to be separated, i.e., the second match against any team can take place before all first encounters are complete. Furthermore, the home field advantages should be divided as evenly as possible during the season to minimize the fairness loss. We present a combinatorial optimization model to compute a feasible league schedule with minimal total traveling distances for all teams, discuss its computational efficiency, and evaluate existing schedules for amateur basketball leagues in the State of Brandenburg.

US-C 114 12:45 - 13:15

The Template-Based Newspaper Layout Problem

Lennard Hansmann

Despite ongoing digitalization and shifts in media consumption patterns, daily newspapers, both in print and digital formats, remain vital sources of information. While print circulation in Germany has experienced a significant decline, digital editions have shown consistent growth, reflecting the changing preferences of readers. Effective layout decisions, encompassing visual hierarchy, article placement, and overall design, are critical for both print and digital production. The process of selecting the optimal layout is complex and involves a multi-stage decision-making framework, requiring substantial effort from editorial teams. Editors are tasked with making a series of intricate decisions regarding the arrangement of content and layout, taking into account various constraints. This process is inherently time-consuming and demands careful coordination to ensure consistency and high-quality outcomes. This research presents a mixed-integer nonlinear programming (MINLP) model for the template-based newspaper layout problem (TBNLP) to optimize layout configurations and article placement, trying to improve production efficiency.

US-C 115 12:45 - 13:15

A dynamic programming algorithm for order picking in robotic mobile fulfillment centers

Jan-Erik Justkowiak, Erwin Pesch, Mikhail Y. Kovalyov

Order picking in robotic mobile fulfillment centers (a semiautomatic warehouse) requires the synchronization of incoming storage racks (supplying items) at a picking station with an outbound stream of customer orders (requesting items) to efficiently operate the station and to increase the systems throughput performance. The movable storage racks are delivered to the picking station by automated guided vehicles that are equipped with a lifting mechanism to hoist and transport racks. A warehouse employee retrieves requested items from the incoming racks to process customer orders on a workbench of limited capacity. We present a dynamic programming algorithm to coordinate the sequence of storage racks with the processing intervals of customer orders at the workbench. The objective is to minimize the number of rack deliveries. Despite monolithic mixed-integer linear programming formulations, our approach appears to be the first combinatorial solution method for the problem in literature. We also determine lower bounds to prune suboptimal states and to accelerate the algorithm. A computational study and a comparison with the strongest model formulation from literature demonstrates the effectiveness of the dynamic programming algorithm.

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