Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

TUM

Welcome to

RAMOO 2025

12th Workshop on Recent Advances in Multi-Objective Optimization

11-12 September, 2025

Organizing Committee:

Clemens Thielen (TUM)
Alina Wittmann (TUM)
Levin Nemesch (RPTU Kaiserslautern-Landau)

Administrative support:

Alexandra Hering (TUM)

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

TUM

Program

Thursday 11 September:

08:30 – 09:00	**Registration**
09:00 – 10:15	**Welcome and Keynote 1**

	09:00 – 09:15	Welcome
	09:15 – 10:15	Oliver Stein (Karlsruhe Institute of Technology) **Branch-and-bound in multiobjective mixed-integer nonlinear optimization**

10:15 – 10:45	**Coffee Break**
10:45 – 12:15	**Scientific Program – Session 1**

	10:45 – 11:15	Daniel Hoff (TU Ilmenau) **An enclosure algorithm for nonconvex multiobjective optimization**
	11:15 – 11:45	Marianna De Santis (University of Florence) **Quadratic convex reformulations for multi-objective binary quadratic programming**
	11:45 – 12:15	Felix Neussel (Karlsruhe Institute of Technology) **On image space transformations in multiobjective optimization**

12:15 – 13:30	**Lunch at the Mensa**
13:30 – 15:00	**Scientific Program – Session 2**

	13:30 – 14:00	Özlem Karsu (Bilkent University) **Weight space decomposition for multiobjective linear programming in the context of equitable optimization**
	14:00 – 14:30	Andreas Löhne (Friedrich Schiller University Jena) **Computing all Nash equilibria of low-rank bi-matrix games**
	14:30 – 15:00	Mark Lyngesen (Aarhus University) **Additively-separable multi-objective optimization problems**

15:00 – 15:30	**Coffee Break and Group Photo**

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

15:30 – 17:00	Scientific Program – Session 3	
	15:30 – 16:00	Maren Manzke (RPTU Kaiserslautern-Landau) **Challenges in multi-objective online optimization**
	16:00 – 16:30	Thibaut Lust (Sorbonne University) **Optimizing a linear function over the Lorenz-efficient set of multi-objective combinatorial optimization problems**
	16:30 – 17:00	Matthias Ehrgott (Lancaster University) **Assigning supervisors to walking school busses**
17:00 – 18:00	Optional: Walk through the Historic City Center to Hotel Wenisch	
18:30	Conference Dinner at Restaurant TONI's by Wenisch	

Friday 12 September:

09:00 – 10:00	Keynote 2	
	09:00 – 10:00	Sophie Parragh (JKU Linz) **Tailored and generic algorithms for integer and mixed-integer multi-objective optimization**
10:00 – 10:30	Coffee Break	
10:30 – 12:00	Scientific Program – Session 4	
	10:30 – 11:00	Xavier Gandibleux (Nantes Université) **Software for modeling and solving multi-objective optimization problems in 2025**
	11:00 – 11:30	Thomas Stidsen (Technical University of Denmark) **Generating hypervolume-maximizing k-nondominated sets for bi-objective mixed integer programming problems**
	11:30 – 12:00	Renée Lamsfuß (University of Wuppertal) **Representations for multiobjective optimization problems based on low discrepancy point sets**
12:00	Lunch at the Mensa	

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

TUM

Venue

Location of the Workshop:

Technical University of Munich
Campus Straubing for Biotechnology and
Sustainability

Lecture Hall U7-b (Roomcode 3505.EG.021)
Ground Floor
Uferstraße 53
94315 Straubing

Location of the Conference Dinner:

Restaurant TONI's by Wenisch
Innere Passauer Str. 59
94315 Straubing

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

TUM
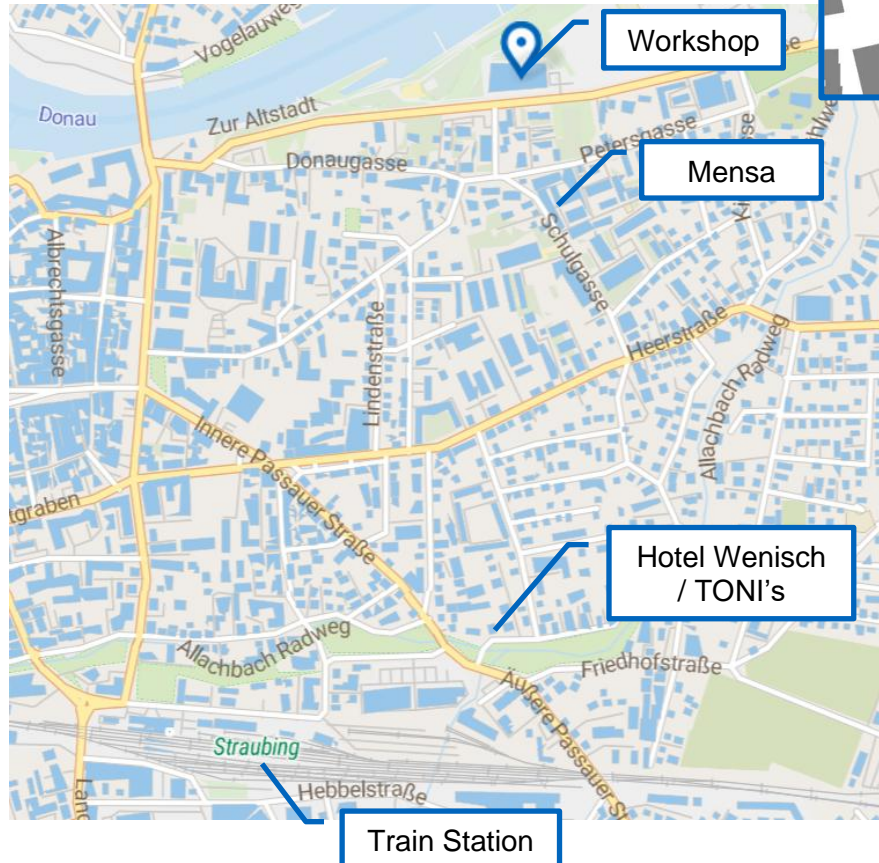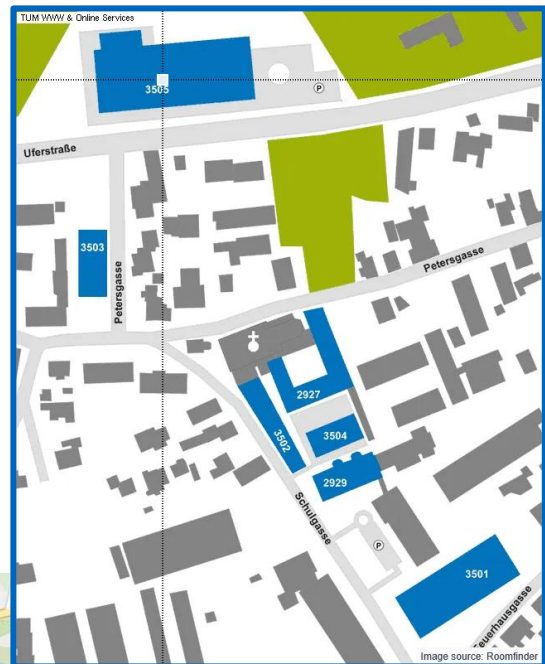
Abstracts

Keynote Talks:

Oliver Stein (Karlsruhe Institute of Technology)

Branch-and-bound in multiobjective mixed-integer nonlinear optimization

The talk explains a recently developed general framework for branch-and-bound methods in multiobjective optimization. It may be applied to continuous as well as to mixed-integer convex and nonconvex multiobjective problems and actually yields the first deterministic method for the mixed-integer nonconvex case. After providing summaries of some main ideas in branch-and-bound and in multiobjective optimization, the talk focuses on natural generalizations of notions and techniques from the single objective to the multiobjective case, such as upper and lower bounds, discarding tests, node selection and, most importantly, a gap-based termination criterion. As a central tool we discuss convergent enclosures for the set of nondominated points and their limiting behavior. Numerical results for two and three objective functions illustrate this approach.

Sophie Parragh (JKU Linz)

Tailored and generic algorithms for integer and mixed-integer multi-objective optimization

Many real-world problems in logistics involve multiple conflicting objectives. For instance, in passenger transport, both system costs and user convenience must be considered, while in strategic supply chain network design, cost, environmental impact, and service level are key factors. These problems are often modeled as (mixed-) integer linear programs. In this talk, we present both tailored and generic approaches to solve such problems effectively. Specifically, we model and solve the bi-objective dial-a-ride problem with electric vehicles, which arises in ride-pooling applications. We develop a tailored algorithm and compare it to existing generic exact approaches. The latter rely on straightforward mixed-integer programming (MIP) formulations as well as on an existing branch-and-price algorithm. Additionally, we address a bi-objective sustainable supply chain network design problem, which involves a more complex trade-off due to the presence of continuous variables. For this problem, we extend a previously developed primal heuristic to handle the bi-objective mixed-integer case. Finally, we present proof-of-concept results for a generic method designed to tackle the general multi-objective mixed-integer case.

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

TUM

Thursday 11 September:

Daniel Hoff (TU Ilmenau)

An enclosure algorithm for nonconvex multiobjective optimization

We deal with nonconvex multiobjective optimization problems for which the nonconvexity results from nonconvex objective or inequality constraint functions. Since in multiobjective optimization conflicting objectives are minimized simultaneously, the set of optimal values, the nondominated set, is generally infinite. One aim in multiobjective optimization is to approximate the nondominated set by a union of boxes. Such a set is called enclosure, and the vertices of the boxes define bounding sets of the enclosure. For these bounding sets, a possible approach is to consider local lower and upper bound sets derived from update point sets. In this talk, we present a branch-and-bound method that iteratively computes new update points by using an easy computable convergent bounding procedure for a class of nonconvex singleobjective subproblems. This routine is applied until the width of the resulting enclosure is small enough. We compare our global enclosure algorithm in numerical tests with some existing enclosure algorithms from the literature.

Marianna De Santis (University of Florence)

Quadratic convex reformulations for multi-objective binary quadratic programming

Multiobjective binary quadratic programming refers to optimization problems involving multiple quadratic – potentially non-convex – objective functions and a feasible set that includes binary constraints on the variables. We extend the well-established Quadratic Convex Reformulation technique, originally developed for single-objective binary quadratic programs, to the multiobjective setting. We propose a branch-and-bound algorithm where lower bound sets are derived from properly defined quadratic convex subproblems. Computational experiments on multiobjective k-item Quadratic Knapsack and multiobjective Max-Cut instances demonstrate the effectiveness of our approach.

Felix Neussel (Karlsruhe Institute of Technology)

On image space transformations in multiobjective optimization

It is well known that one can apply a strictly increasing function to the objective function of any standard single-objective optimization problem without altering the set of optimal points. This can be helpful in generating properties like smoothness or convexity of the objective.

As a generalization to multiobjective optimization, we consider monotone transformations of the objective space that leave the set of efficient points invariant. Under mild assumptions, for the standard ordering cone, we show that such transformations must be component-wise transformations, which means that a univariate strictly increasing function is applied to each of the objectives.

The same class of transformations also leaves the sets of weakly and of Geoffrion properly efficient points invariant. In addition, our approach allows us to specify trade-off bounds of properly efficient points after the transformation. We apply our results to prove some previously unknown properties of the compromise approach.

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

TUM

Özlem Karsu (Bilkent University)

Weight space decomposition for multiobjective linear programming in the context of equitable optimization

We consider equitable linear optimization problems (ELOP), which are multiobjective optimization problems, with each objective representing the benefit that one entity receives. In such problems, the concept of dominance is replaced by equitable dominance. The aim is to find the set of equitably nondominated points, which can be done by solving ordered weighted averaging (OWA) scalarization. Each solution corresponds to a different set of weights that make the solution optimal, hence a different degree of inequity aversion. We discuss a novel use of the parametric simplex algorithm to address ELOP. The algorithm not only provides the set of equitably nondominated solutions but also yields the corresponding weight space decomposition. We also propose an alternative method based on geometric duality to compute the weight space decomposition given the set of nondominated solutions.

Andreas Löhne (Friedrich Schiller University Jena)

Computing all Nash equilibria of low-rank bi-matrix games

Low-rank bi-matrix games are transformed into typically smaller bi-matrix games, where the constraints for both players are arbitrary polytopes rather than simplices. These constrained bi-matrix games, also called polytope games, are studied, in particular, all Nash equilibria are computed using bensolve, a solver for multi-objective linear programs. The connection between the Nash equilibria of the original game and the smaller polytope game is investigated.

Mark Lyngesen (Aarhus University)

Additively-separable multi-objective optimization problems

In this talk we consider additively-separable multi-objective optimization problems, where the global problem is decomposable into subproblems – each containing a subset of the decision variables. Such problems arise when a set of decoupled decision problems influence the same objectives in an additive manner. The global problem can be solved bottom–up by first finding the nondominated set of each subproblem and then finding all nondominated combinations of these – each combination consists of one solution for each of the subproblems. The bottom-up approach has proven effective as most of the computational effort is used on solving the simpler subproblems. As we will see however, it is often the case that some nondominated solutions of subproblems appear in no nondominated combination. We characterise properties of such redundant nondominated solutions of subproblems and propose bound sets which exclude regions containing these. Based on this, we propose a coordination scheme that uses objective space branch-and-bound methods to solve each subproblem. The search tree of each subproblem is pruned using tighter bound sets derived from information shared across subproblems. We implemented the algorithm for the bi-objective case and present preliminary results comparing different choices of objective space search strategies.

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

TUM

Maren Manzke (RPTU Kaiserslautern-Landau)

Challenges in multi-objective online optimization

We combine concepts of multi-objective optimization and online optimization to a general framework for modelling multi-objective request-answer systems with multiple objective functions. In single-objective online optimization, competitive analysis has become a standard tool for measuring the quality of online algorithms. The transfer to the multi-objective case presents quite a few obstacles, resulting in various definitions of "competitiveness" in this case. We simplify the condition for strong competitiveness for multi-objective online problems from the literature and introduce a more comfortable definition of the competitive ratio. In addition, we provide an insightful geometrical interpretation of strict competitive analysis. We apply the concepts to the ski rental problem where we are able to determine all pareto-optimal online algorithms.

Thibaut Lust (Sorbonne University)

Optimizing a linear function over the Lorenz-efficient set of multi-objective combinatorial optimization problems

In this talk we address multi-objective combinatorial optimization problems, where all objectives need to be effectively balanced. For this purpose, we use the Lorenz dominance, an enhancement of Pareto dominance introduced in economics to assess income distribution inequalities. Moreover, in addition to the search for a balanced solution, we are looking for a solution optimizing an additional linear function, allowing to model the preferences of the decision-maker and to select the most suitable solution among all Lorenz-efficient solutions. We propose two new exact methods to solve this problem, and apply it to the assignment and knapsack problems. Results show that the new methods are much more efficient than a method based on a complete enumeration of all Lorenz efficient solutions.

Matthias Ehrgott (Lancaster University)

The Generation of Duty Rosters for Walking School Bus Supervisors

In this paper we discuss the allocation of duties to supervisors of the walking school bus. We assume that a sufficiently big number of supervisors has signed up to perform this service and that a number of walking school bus routes has been generated to cover the demand for walking school busses. We also assume that each of the potential supervisors has reported their availability i.e. the number of (and which) days they are available. Further to this, we assume that each supervisor has left a note of his experience. We then perform column generation on the list of duties that are encountered for a precise route such as the number of and which stops the route covers as well as the number of kids joining the route at which stop. This provides the input data for the roster generation. At the end of the process, we will have the supervisors assigned to a roue to perform on each day they have elected to work.

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

Friday 12 September:

Xavier Gandibleux (Nantes Université)

Software for modeling and solving multi-objective optimization problems in 2025

Over the last ten years, we have observed an evolution in the functionalities of MILP solvers to model and solve multi-objective optimization problems. This trend was initiated earlier by open-source software (such as BenSolve or again Inner), followed later by commercial software (from Gurobi and CPLEX in 2016, to Hexaly recently). All of these software have in common that they are all-in-one standalone solvers. None of them is designed to be extended by the user, for example by adding a new algorithm. Furthermore, the features of commercial solvers are mainly limited to naive solving methods (for example, the lexicographic method, the hierarchical method, or again the weighted sum method), all of them sharing the fact that they summarise the multi-objective problem to a single-objective one, where only one solution is computed. In the first part of this talk, a state-of-the art is presented in focusing on the modeling and solving abilities of each of the solvers found. In the second part, the recent advances on JuMP.jl and MultiObjectiveAlgorithms.jl, two open-source packages among the collection of registered packages available in julia programming language, will be presented. These packages aim respectively to model and to solve multi-objective optimization problems, but also provide all the required methods for plugging new algorithms provided by users.

Thomas Stidsen (Technical University of Denmark)

Generating hypervolume-maximizing k-nondominated sets for bi-objective mixed integer programming problems

Most real-world optimization problems are inherently multi-objective. Over the last decade, a number of more practically useful algorithms for multi-objective optimization have been proposed and are now available as open source code in Julia/JuMP. These algorithms can be applied to discrete multi-objective problems with up to six objectives.

Despite this success, multi-objective approaches still yield computational challenges: The computation requirements can be immense since often NP-hard problems have to be solved many times. Moreover, the nondominated set is often extremely large, making the selection of the most appropriate point from the complete nondominated set difficult or even impossible for a decision maker. This provides a strong motivation for computing a small-cardinality subset of the nondominated set that is optimal with respect to some quality indicator and can be evaluated more easily by a decision maker.

In this talk, we present a novel column generation algorithm that, given a desired number k of points, computes a k-element subset of the nondominated set (a *k-nondominated set*) of a bi-objective mixed integer programming problem that maximizes the dominated hypervolume, which is the most-studied quality indicator for solution sets of multi-objective optimization problems in the literature.

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

TUM

Renée Lamsfuß (University of Wuppertal)

Representations for multiobjective optimization problems based on low discrepancy point sets

In this talk, we present an approach for constructing representations for multiobjective optimization problems using low discrepancy point sets. We focus on the $L\infty$ star discrepancy and, in particular, on the concept of extreme discrepancy as a more generalized discrepancy measure. We construct low discrepancy point sets to obtain uniformly distributed points in the objective space. These points are then used in an ε-constraint method to define representations of the non-dominated set for multiobjective optimization problems. We evaluate the quality of these representations with respect to different metrics and test the approach on various test problems.

Notes

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

11

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

12

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

13

Professorship of Optimization and Sustainable Decision Making
TUM Campus Straubing for Biotechnology and Sustainability
Technical University of Munich

14