GOR Gesellschaft für Operations Research e.V.

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GOR-AG: Praxis der Mathematischen Optimierung
Dr. Jens Schulz

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Herewith, we invite you to the 108th meeting of the GOR working group "Practice of Mathematical Optimization". This meeting is planned to be held in person (or virtually if circumstances require) with the topic

The World of Cutting, Packing and Placing

The workshop takes place in the physics center Bad Honnef (DPG – Deutsche Physikalische Gesellschaft) on **Thursday and Friday, April 11 & 12**.
The working language will be English to be inclusive for a non-German speaking audience.

Note that the participation in a GOR-AG-Workshop for non-members is subject to a registration fee, unless you are a speaker or a host. Given the uncertainty of Covid, travel restrictions, and company policies, we strongly advise you to book your stay and travel accordingly. Cancellation of the on-site event may occur on short notice, and the organizers will waive the registration fee but will not refund any other cost.

Participation in the workshop is subject to a minor registration fee of 30 Euro for GOR members and 150 Euro for non-GOR members. Bachelor and master students can participate at zero charge for GOR student members and 50 Euro for non-GOR student members.

For accommodation and food/drinks, a service charge needs to be paid at physics center on Thursday or Friday (breakfast included when staying overnight):

- Staying from Wednesday to Friday: 253 Euro
- Staying from Wednesday to Thursday: 164 Euro
- Staying from Thursday to Friday:180 Euro
- Participation only on Friday (no overnight): 56 Euro

Please, register via www.redseat.de/pmo108 no later than March 20th.

The latest information on the meeting is available on the homepage of the GOR (http://www.gor-ev.de/arbeitsgruppen/praxis-der-mathematischen-optimierung/real-world-optimization).

Yours sincerely,

Jens Schulz, Julia Kallrath, Josef Kallrath

(GOR AG)

The World of Cutting, Packing and Placing

Specific aims

Cutting, packing and placing problems have been extensively studied for many years because of the vast amount of real-world applications they encompass. Application areas include logistics, manufacturing, clothing and material industries. Based on their dimensionality they can be solved in (pseudo-)polynomial time or maybe be NP-hard. One-dimensional problems include such as knapsack, bin packing, and cutting stock Two-dimensional problems include packing of certain shapes such as circles, rectangles or general polygons, e.g., trim loss and strip packing problems. Three-dimensional geometric problems find applications in pallet or container loading, warehouse management etc. Most variants are NP-hard based on a reduction from knapsack or from bin packing. Here, a vast amount of heuristics and approximation algorithms have been developed to tackle real-world instances.

With the rise of CO2-awareness finding a best packing or minimizing resource consumption, such as in trim loss problems, have become standard considerations when designing logistics operations. A need for efficient transportation, such as considered in packing and loading problems for warehouses or container ships, has led to a variety of solution algorithms and techniques explored – from theoretical standpoint and also from a computational perspective. Besides (math-)heuristics, column generation and Benders decomposition are widely applied techniques to solve such real world problems.

The core of this 1.5-day workshop will consist of an attractive schedule of talks covering a broad range of mathematical techniques, theoretical considerations and real world applications around cutting, packing and placement problems. As usual, we will reserve plenty of time for informal exchange and networking.
In talks of 15+5min, 25+5min or 40+5min duration, experts from practice and research will address problems and solutions.

If you would like to contribute a talk, please feel free to contact any of the organizers.

Jens Schulz (schulz-gor ‘at’ gmx.net)
Julia Kallrath (julia.kallrath ‘at’ h-da.de)

The venue & accommodation

Venue

Deutsche Physikalische Gesellschaft (DPG)
https://www.dpg-physik.de/ueber-uns/physikzentrum-bad-honnef/kontakt-anfahrt
Physikzentrum Bad Honnef
Hauptstraße 5
53604 Bad Honnef

How to get there?
Bad Honnef has good train connection from Cologne, and a 10 minutes walk from the station to the venue.

Conference dinner

The conference dinner will take place in physics center on Thursday evening.

Accommodation

The physics center offers accommodation for up to 30 participants. You can choose to stay in a hotel nearby. Please, select the appropriate option during registration.

Excursion

An excursion to Konrad-Adenauer Haus in Bad Honnef is planned at no extra charge with a capacity for 40 visitors.
Adenauerhaus Rhöndorf - Führung durch Wohnhaus und Garten
Konrad-Adenauer-Straße 8c
16:30-17:30Uhr

The following speakers are confirmed:

Stefan Hougardy
The Bottom-Left Algorithm for the Strip Packing Problem

Hedi Kiraly
Combining computational geometry and operations research in order to solve two-dimensional irregular strip packing problems

Klaus Jansen
Algorithms for monotone moldable job scheduling

Tanya Romanova (Leeds Uk, & Charkiw university)
The phi-function technique for Packing and Cutting

Guido Sand (Hochschule Pforzheim)
Hyperparameter Optimization of Matheuristics for Hoist Scheduling

Abstracts and CVs

Stefan Hougardy (Uni Bonn)
The Bottom-Left Algorithm for the Strip Packing Problem

The bottom-left algorithm is a simple heuristic for the Strip Packing Problem. It places the rectangles in the given order at the lowest free position in the strip, using the left most position in case of ties. Despite its simplicity, the exact approximation ratio of the bottom-left algorithm remains unknown. We will improve the more-than-40-year-old value for the lower bound from 5/4 to 4/3. Additionally, we will show that this lower bound holds even in the special case of squares, where the previously known lower bound was 12/11. These lower bounds apply regardless of the ordering of the rectangles. When squares are arranged in the worst possible order, we establish a 3.17 lower bound for the approximation ratio of the bottom-left algorithm. Finally, we show that the approximation ratio of a local search algorithm based on permuting rectangles in the ordering of the bottom-left algorithm is at least 2 and that such an algorithm may need an exponential number of improvement steps to reach a local optimum.

Stefan Hougardy received his Ph.D. in computer science in 1995 and completed his habilitation in 2004 at Humboldt-Universität zu Berlin. From 2002 to 2007, he served as a project leader at the DFG Research Center Matheon. During 2004-2006, he held positions as a visiting professor at Technische Universität Berlin and Humboldt-Universität zu Berlin. Since 2007, he is professor at the Research Institute for Discrete Mathematics at the University of Bonn. He specializes in combinatorial optimization, focusing on approximation and exact algorithms. For over 15 years, he has been involved in an applied project on chip design in close collaboration with IBM. Within this project, various types of (rectangle) packing problems need to be solved.

Hedi Kiraly (University Duisburg-Essen)
Combining computational geometry and operations research in order to solve two-dimensional irregular strip packing problems

In the realm of two-dimensional strip packing problems, both regularly and irregularly shaped polygons are arranged on a large material of fixed width and unlimited length, ensuring that the polygons do not overlap. The primary goal is to minimize the required length of the large material without exceeding its specified width. While heuristic-based nesting methods are often used in the literature to solve these problems, exact model formulations have also been presented in recent decades, which have been solved with commercial solvers. Most linear Mixed Integer Programming (MIP) models are based on the well-known No-Fit Polygons (NFPs). Until 2022, only two linear MIP models based on direct trigonometry had been introduced. By integrating geometrical insights into a mathematical model, we have developed another MIP model formulation that can handle industry-relevant aspects for the first time in the literature. In addition, the concept of "critical vertices" is explained and it is shown how this simplifies the calculations to avoid overlaps.

Hedi Kiraly is a PhD student at the Chair of Logistics and Operations Research, Mercator School of Management, University of Duisburg-Essen. Her research focuses on cutting and packing problems, in particular on two-dimensional irregular strip packaging problems. She considers both convex and non-convex items with or without holes and a limited number of rotation possibilities. She obtained her BSc in Economics from the University of Vienna and her MSc in Economics with a specialization in Supply Chain Management and Logistics from the University of Duisburg-Essen.

Klaus Jansen (University of Kiel)
Algorithms for monotone moldable job scheduling

A moldable job is a job that can be executed on an arbitrary number of processors, and whose processing time depends on the number of processors allotted to it. A moldable job is monotone if its work doesn't decrease for an increasing number of allotted processors. We consider the problem of scheduling monotone moldable jobs to minimize the makespan.
We argue that for certain compact input encodings a polynomial algorithm has a running time polynomial in n and log m, where n is the number of jobs and m is the number of machines. We describe how monotony of jobs can be used to counteract the increased problem complexity that arises from compact encodings, and give tight bounds on the approximability of the problem with compact encoding: it is NP-hard to solve optimally, but admits a PTAS. The main focus of this work are efficient approximation algorithms. We describe different techniques to exploit the monotony of the jobs for better running times, and present a (3/2 + epsilon)-approximate algorithm whose running time is polynomial in log m and 1/epsilon and only linear in the number n of jobs.
This is joint work with my students Kilian Grage, Felix Land and Felix Ohnesorge.

Klaus Jansen is Professor in Algorithms and Complexity of the Department of Computer Science at the University of Kiel. His research focuses on scheduling and packing problems, in particular 2D and 3D packing problems and related scheduling problems with tasks that use several processors or resources in parallel. He obtained his Diploma in Computer Science at the RWTH Aachen and PhD and Habitation in Mathematics at the University of Trier.

Tetyana Romanova (University of Leeds, Leeds, UK; Institute of Mechanical Engineering Problems of the National Academy of Sciences of Ukraine, Kharkiv, Ukraine)
The phi-function technique for Packing and Cutting

Cutting and Packing (C&P) problems have many and diverse applications including: additive manufacturing, biology, nanotechnology, medicine, robotics, logistics, materials science, space engineering. The phi-function technique provides an analytical description of the placement constraints (e.g., non-overlapping, containment, distance constraints) to solve C&P problems. It deals with arbitrary shaped 2D & 3D objects (these include disconnected objects, non-convex objects, regions with holes and cavities, oblique objects), which can be free translated and continuously rotated subject to homothetic and stretching transformations. It may take into account variable metric characteristics of objects and target domains. Using the phi-function technique reduces C&P problem to a mathematical programming model (Nonlinear Programming or Mixed Integer Nonlinear Programming). Mathematical models, solution strategies and computational results are discussed for several classes of C&P problems (such as sparse packing, quasi packing, ratio packing, packing soft objects, packing clusters of objects, balance packing) motivated by actual applications. Some future research areas are identified.

Tetyana Romanova (Professor) received her M.Sc. degree in Applied Mathematics from Kharkiv National University of Radio Electronics (KNURE), Ukraine; Ph.D. and Dr.Sci. (Habilitation) in Mathematical Modeling and Computational Methods from the Institute of Cybernetics of the National Academy of Sciences of Ukraine, Kyiv. She is a leading scientist of the Institute for Mechanical Engineering Problems of the National Academy of Sciences of Ukraine and visiting professor of the University of Leeds. She is an author of numerous research papers focused on the development of geometric tools, mathematical models and optimization algorithms for solving packing, cutting, layout and covering problems.