Book of abstracts

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Memory-based ruin-and-recreate heuristics for the fixed charge transportation problem

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Abstract

The fixed charge transportation problem (FCTP) extends on the classical transportation problem. They focus on finding the optimal way to allocate units along arcs connecting a set of supply vertices (origins) to a set of demand vertices (destinations). The network is thus represented as a complete directed bipartite graph, where each arc in the FCTP has an associated variable cost for every unit transported as well as a fixed charge if the arc is opened. The goal is to minimise the overall cost while ensuring that all supplied units flow from the origins and all demanded units flow to the destinations. The literature shows that the arcs in an FCTP corresponding to the basic variables in a basic feasible solution form a spanning tree.

There are several gaps in the literature concerning the development of heuristics, specifically ruin-and-recreate (R&R) heuristics, for the FCTP. These heuristics could take advantage of the bipartite network structure and the tree-like nature of basic feasible solutions, which differ from the network and solution structures typically encountered in the vehicle routing problem, where R&R heuristics are commonly applied. A summary of the standard R&R heuristic for the FCTP (presented at EURO 2024 in Copenhagen, Denmark) will be provided at the beginning of this presentation. In short, it implements one of four novel ruin methods, namely arcs removal, vertices removal, multipath removal and subtree removal. A well-known constructive heuristic, such as the least cost, Vogel's approximation or Russell's approximation method, may be used as the recreate method. Lastly, the simplex algorithm may be executed in each iteration as a local improvement method to further improve a solution after which threshold acceptance is used to accept or reject the resulting solution.

The main focus of this presentation is on expanding the heuristics to incorporate memory and elements of stochasticity. Firstly, the ruin methods are adjusted to increase the likelihood of selecting an arc for ruining if it has a higher per-unit cost. This encourages the heuristics to replace costly arcs with more economical alternatives. Secondly, simulated annealing is tested as a stochastic alternative to threshold acceptance. Lastly, several learning

and forgetting functions, such as those found in the field of psychology, are devised with an optimisation method to respectively learn arcs that have been ruined and forget arcs that are left untouched. This approach attempts to avoid ruining the same arc or subset of arcs repeatedly, similar as in tabu search.

Parameter calibration, convergence graphs, algorithmic comparisons and statistical hypothesis testing are shown in the results. It is concluded that the memory-based R&R heuristic with subtree removal as the ruin method, the least cost method as the recreate method, simulated annealing as the acceptance method and no local improvements being executed, returns the best results overall.

On Integration of the Extended Mathematical Programming Formulations for the Travelling Salesman and Vehicle Routing Problems

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Abstract

This study considers two major approaches to formulate the Travelling Salesman and many variants of the Vehicle Routing problems. Namely, one is based on the label setting approach of Miller, Tucker and Zemlin (1960), and the other one is based on the one-commodity network flow idea introduced by Gavish and Graves (1978). Contrary to many existing studies comparing and contrasting these approaches, this study aims to integrate them into a combined approach with superior properties. We demonstrate that the proposed integration idea allows to obtain new mixed integer linear programming formulations for the Asymmetric TSP (including the case of TSP with Time Windows constraints), Asymmetric Capacitated VRP and its generalization to the routing problem with a Heterogeneous fleet, just to name a few problems. Results of a computational study demonstrate the quality of linear programming relaxations of the proposed formulations in comparison to linear programming relaxations of the original formulations for the corresponding problems.

RNA 3D structure inference powered by graphs

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Abstract

Predicting the 3D structures of biomolecules from sequence data is a central challenge at the intersection of OR, IT, and biological sciences. This task requires processing and interpreting imprecise, often incomplete biological data, and developing efficient methods to navigate vast conformational spaces. Although the problem was defined over 50 years ago, it has recently been solved for proteins, with the 2024 Nobel Prize in Chemistry awarded to the creators of two leading computational approaches. For RNA, however, this challenge persists, motivating global efforts to develop novel computational solutions.
In this presentation, we introduce a novel graph neural network (GNN)-based model for RNA 3D structure prediction, utilizing the graph-like nature of RNA molecules. The approach encodes RNA structures as graphs, with nodes representing nucleotides and edges capturing base-pairing and spatial relationships. The GNN is trained to predict spatial coordinates while maintaining structural constraints. Optimization techniques further refine coarse-grained predictions into atomistic models, ensuring physical plausibility and consistency with experimental data. We will showcase the model's effectiveness on benchmark datasets, achieving results competitive with state-of-the-art methods. This work underscores the potential of graph-based learning and optimization in solving complex spatial modeling problems and offers a scalable framework for RNA 3D structure prediction.

A column generation approach for the routing of electricity technicians

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Abstract

The maintenance of an electricity distribution network involves numerous daily technical interventions. In this problem, we are given a set of interventions each with associated time windows, location, necessary skills and duration, as well as a set of team s of technicians with associated set of skills. We need to find feasible routes on the interventions for each team, considering the time windows and skills, and ensure that each team returns to its departure depot before the end of the day. The primary objective is to maximize the total duration of completed interventions and as a secondary objective, we aim to minimize the overall routing cost. This problem can be formulated as a capacitated vehicle routing problem with time windows. Due to the large number of teams and interventions, this results in a large scale optimization problem, and its operational nature limits the time available for exact solving. Here, we propose a column generation approach where one subproblem per vehicle has to be solved and each potential route of a vehicle is considered a s a new column in the master problem. To generate these routes, we rely on dynamic programming. Real world instances from EDF (Electricité de France) of historical technicians' interventions will be used to evaluate the effectiveness of the proposed methods.

Do UEFA and FIFA minimize travel distances? An optimization approach to schedule their main tournaments

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Abstract

The UEFA European Football Championship and the FIFA World Cup are arguably some of the most important international sports tournaments worldwide. When it comes to schedule the games of these tournaments, the organizers have publicly stated to be concerned about the distances travelled by teams and fans. For example, in the official bid for the 2026 FIFA World Cup, the United Bid committee claimed to have developed a match scheduling software with special algorithms that calculate shortest travel distances. Likewise, for the Euro 2024 recently held in Germany, UEFA authorities pointed out that fairness and environmental impact and fairness were the priorities in determining the tournament match schedule. This paper investigates whether the travel distances of these tournaments have really been minimized or not. To this aim, we adopt an integer programming approach, which is a well-established methodology in the sports scheduling literature. By running different variants of an optimization model which minimizes a distance function subject to different criteria, this talk will show schedules that outperform the actual schedules released by FIFA and UEFA.
Besides addressing these two specific cases, the aim of this paper is to define a more general problem which could serve as a real-world case well-known to everyone in the research community. In contrast, most of the previous literature on football scheduling has addressed local competitions. Moreover, with the current trend of FIFA and UEFA to expand not only the number of participating teams but also the number of host countries, minimizing travel distances will likely remain a relevant problem in future editions of these competitions.

Approximating the strength of higher level RLT inequalities in the first level RLT space for polynomial 0-1 programs

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Abstract

The reformulation-linearization technique (RLT), due to Sherali and Adams, is a general framework for constructing hierarchies of linear programming (LP) relaxations of various optimization problems. It was first developed for 0-1 polynomial programs, but was soon adapted to continuous polynomial programs, and then extended to mixed 0-1 polynomial programs. Since then, it has been further extended and adapted, to cover a wide range of integer programming and global optimization problems. As one moves up the levels of the RLT hierarchy, the LP relaxations grow stronger, but the number of variables increases exponentially. In practice, therefore, one can hope to solve the relaxations only at very low levels of the hierarchy. In fact, even solving the relaxation at the first level can be challenging.

In this talk, we present a framework which enables one to strengthen RLT level 1 relaxations by adding cutting planes, instead of additional variables. Our framework allows to generate cutting planes at any given higher level of the hierarchy and optimally project them in the space of the RLT level hierarchy. The framework is applicable to mixed 0-1 polynomial programs with bounded continuous variables. Indeed, it was shown in 2015 that such a transition from higher levels to lower levels RLT space is possible by sequentially moving from higher levels to the desired space level. In our procedure, we show that it is possible to obtain stronger cuts without having to transit through all the intermediary space levels.

In order to explore the potential of these new cutting planes, we will present some computational results, using the quadratic knapsack problem (QKP) as an example. It turns out that, for the difficult sparse QKP instances, our cutting planes close around 40% of the gap between the upper bound from the standard first-level relaxation and the optimum.

Balancing Environmental and Economic Goals in Intermodal Network Design: Insights from a Variable Neighborhood Search

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Abstract

The increasing demand for efficient transportation networks in a globalized world has brought sustainability to the forefront of transportation planning. As a significant source of greenhouse gas emissions, road transportation has driven the transition toward intermodal transportation (IT), which offers a more environmentally friendly alternative. A critical aspect of developing sustainable IT systems is the strategic location of intermodal terminals, which must balance economic efficiency and environmental objectives. This paper addresses the Sustainable Intermodal Terminal Location Problem (SITLP) on incomplete networks, incorporating an emissions budget to constrain rail and road transportation links. The problem is formulated as a mixed integer linear program (MILP) to capture the complexities of network constraints, incomplete connectivity, and multimodal transport options. To efficiently solve medium and large-scale instances, we propose a Variable Neighborhood Search (VNS) algorithm. This metaheuristic method systematically explores the solution space by employing dynamic neighborhood changes to escape local optima and enhance solution quality.
Comprehensive computational experiments validate the effectiveness of the proposed VNS algorithm. For small and medium-scale instances, the VNS approach delivers solutions comparable to exact results obtained via the CPLEX solver. For large-scale instances, the VNS outperforms existing heuristics in the literature, offering high-quality solutions within practical computational times. These findings show the potential of the VNS algorithm for optimizing sustainable intermodal transportation networks under realistic constraints, contributing to environmentally conscious and economically efficient transportation planning.

Optimizing RNA 3D Structure Assessment with Graph Neural Networks

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Abstract

Accurate quality assessment and comparison of RNA 3D structures are essential for addressing the limitations of in silico predicted models and evaluating their applicability in biochemical experiments. While numerous computational methods exist for predicting RNA tertiary structures, benchmarking their predictions typically relies on comparisons with native structures. However, there is a significant gap in reliable tools for assessing the quality of RNA 3D models when no reference structure is available.

We introduce a graph neural network (GNN)-based approach optimized for modeling both local nucleotide interactions and global structural context. This novel method provides a reference-free evaluation of the quality of predicted RNA 3D structures. To ensure robust training, we curated a diverse dataset of experimentally determined RNA 3D structures from a non-redundant repository. Predicted models, generated by state-of-the-art RNA structure prediction tools, were analyzed by scoring local 3D motifs in terms of their compatibility with native counterparts.

Our findings demonstrated that GNNs can effectively rank RNA 3D structures by their native-likeness, capturing the degree of resemblance to experimentally determined native folds. The method operates at the nucleotide level, employing a complex feature set to evaluate local 3D motifs and adapt to varying structure sizes. This optimization-focused design makes our approach particularly suited for assessing novel RNA structural predictions, filling a critical gap in computational RNA analysis.

Scheduling on parallel dedicated machines to maximize the weighted number of Just-In-Time jobs with system level total rejection cost

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Abstract

This study is focused on scheduling problems on parallel dedicated machines, implying that the jobs belong to different classes, and each class must be processed on its dedicated machine. We assume that each job has a due date and a job-dependent penalty for a job completed prior to or after its due date, and the scheduling measure is the weighted number of jobs completed either early or tardy. Furthermore, we consider the option of job rejection, with job-dependent rejection cost, such that all m share a common total job rejection cost. Four variants of the basic scheduling problem are studied (i) minimizing the total integrated cost of the scheduling measure and the total rejection cost; (ii) minimizing the scheduling measure, subject to an upper bound on the system-level total rejection cost; (iii) minimizing the total rejection cost, given an upper bound on the scheduling measure; and (iv) identifying the complete set of Pareto-optimal solutions. For the first problem, we introduce a polynomial dynamic programming (DP) algorithm. All the other problems are known to be ordinary NP-hard, even in the single-machine setting, and thus, our aim is to provide adequate pseudo-polynomial DP algorithms. For all suggested algorithms, we carry out an extensive experimental study.

Stochastic Quay Partitioning Problem

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Abstract

We consider dividing a quay of a maritime container terminal into berth segments so that quality of service for future ship arrivals is as good as possible. This problem will be referred to as a stochastic quay partitioning problem (SQPP). SQPP is defined by a ship traffic model (STM), arrival intensity, quay length and a set of admissible berth lengths. An STM is a stochastic process which generates an arrival scenario which is a sequence of quadruplets: arrival time, vessel length, service time and service weight, defining vessel arrivals. Alternative quay partitions are evaluated on various arrival scenarios generated for certain arrival intensity from a stochastic traffic model (the STM). Evaluation of an SQPP solution on one scenario is a problem of scheduling the arriving vessels on the berths of a partition, which is a classic berth allocation problem (BAP). In SQPP the sizes of BAP instances which must be solved by far exceed capabilities of the methods presented in the existing literature. Therefore, tailored portfolios of algorithms capable of solving very large BAP instances under limited runtime are used. Features of SQPP solutions are studied experimentally. We demonstrate, that partitioning a quay into equal length berths is not always the best approach. A set of algorithms to partition a quay is proposed and evaluated.

Comparative Study of Routing Methods in Internet Networks with QoS

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Abstract

The issue addressed is routing in Internet networks by comparing several resolution approaches. Our work focused on a routing problem that takes into account the Quality of Service (QoS). We considered the network's resources by selecting routing paths that optimize a QoS criterion, while calculating weights that limit these paths to the unique shortest paths. In this way, the routing plan becomes much more controllable by the network administrator. The problem of routing according to unique shortest paths has been solved in different ways:
— Using a linear program with mixed integer variables. We decomposed it into a master problem and a subproblem. In the master problem, we search for an optimal single-path routing where the objective function maximizes the minimal remaining bandwidth. And for the subproblem, we seek a metric that maps the single-path routing obtained in the master problem to a routing of unique shortest paths.
— To improve the first solution, which was implemented using a Branch & Bound (B&B) approach, we adopt a polyhedral approach by considering valid separation cuts primarily based on suboptimality. This solution using a Branch & Cut (B&C) method indeed allowed us to obtain significantly better results than those obtained with B&B and to solve larger examples.
— Using simulated annealing, we exploit the solution provided by the heuristic considering it as a lower bound for the optimal solution.
— Using a multi-agent system based on reinforcement learning. This approach, quite different from the others, allows the introduction of machine learning in our routing problem to make "intelligent" routing.
This last approach opens up another dimension for solving these unique shortest path routing problems, which remain NP-complete problems.

Enumerating Valid RNA Pseudoknot Order Assignments: A Constraint Programming Approach

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Abstract

RNA pseudoknots are complex structural elements found in RNA molecules, and they pose significant challenges in computational structural biology. In our previous work, we developed a mixed-integer linear programming (MILP) model that effectively identified optimal assignments of pseudoknot orders. This model minimized the maximum pseudoknot order while balancing the distribution of nucleotides across different pseudoknot levels. Building on these findings, we now tackle the fundamental problem of enumerating all valid pseudoknot order assignments, regardless of their scoring.

We formalize this enumeration problem as a specialized graph coloring task. In this context, we represent groups of nucleotides involved in pseudoknot interactions as vertices, and their relationships create edges in a constraint graph. A valid coloring of this graph corresponds to a feasible assignment of pseudoknot orders, with each color signifying a distinct pseudoknot level.

We have developed a model capable of systematically enumerating all valid configurations by adapting the core constraints from our previous MILP formulation into a constraint programming framework. This adaptability ensures that our model can be integrated into various computational frameworks, enhancing its versatility and applicability. This enumeration is significant for RNA 3D structure prediction, particularly in fragment assembly approaches, as different pseudoknot order assignments can lead to various structural outcomes. Our work establishes a new computational framework for exploring the complete space of valid pseudoknot configurations, which complements existing optimization methods and has the potential to enhance the accuracy of RNA 3D structure prediction techniques.

Analysis and classification of multiple junctions in RNA structures

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Abstract

Nowadays, it is known that RNA plays a key role in regulating cellular processes. Despite its importance, many aspects of RNA structure remain unexplored, predicting its structural shape a complex challenge. Advancing our biostructural knowledge directly enhances our understanding of RNA functionality. Architectural components are essential for predicting their three-dimensional conformation. Our research focuses on the analysis and optimization of multiloops detection and classification. In particular, 3- and 4-way junctions are formed by three and four helices in the tertiary structure. These motifs, which are the most common junctions in RNA, have been categorized into different families based on helical arrangement and coaxial stacking information. Accurately identifying these junctions is crucial due to their powerful impact on the quality of the potential 3D RNA modeling process. Currently, computational methods do not incorporate these classification rules in their calculations due to the lack of widely available tools. We present a method that implements multiloop classification according to family concepts. The system automatically predicts junction topology using only secondary structure as input.

A Distributionally Robust Optimization Approach for Multi-Level and Multi-Period Disassembly Planning Under Lead Time Uncertainty

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Abstract

In the context of the circular economy, disassembly planning has emerged as a pivotal component of sustainable supply chain management. This paper addresses the problem of multi-level and multi-period disassembly planning under uncertainty in lead times. The objective is to determine the optimal timing and quantities for disassembly operations in order to meet dynamic component demands while minimizing setup costs, inventory holding costs, and stockout penalties. The complexity of the problem is heightened by the hierarchical structure of products, capacity constraints on disassembly operations, and uncertain lead times that impact material availability.
To tackle this challenge, we propose a novel Distributionally Robust Optimization (DRO) framework that incorporates Wasserstein distance-based ambiguity sets to model lead time uncertainty. Unlike traditional stochastic programming approaches, which rely on precise probability distributions, our DRO framework considers a range of plausible distributions within a defined Wasserstein distance from a nominal distribution. This ensures robust performance across a variety of scenarios, providing a more resilient and practical solution.
The proposed model captures the disassembly process's multi-level structure, linking parent and child components through predefined disassembly quantities. It also accounts for dynamic, time-dependent demands for components over the planning horizon. Capacity constraints are integrated to ensure feasibility, and auxiliary variables are employed to linearize non-linear terms, facilitating efficient solution methods. The DRO approach explicitly balances the trade-off between conservatism and cost-effectiveness by adjusting the Wasserstein distance parameter, which governs the size of the ambiguity set.
Our numerical experiments, based on real-world-inspired datasets, demonstrate the efficacy of the proposed DRO approach. The results highlight its superiority in mitigating the risks associated with lead time uncertainty compared to both deterministic and stochastic optimization

methods. Furthermore, sensitivity analyses illustrate the impact of key parameters, such as ambiguity set size and demand variability, on the solution's robustness and cost.
To the best of our knowledge, this work is the first to develop a Distributionally Robust Optimization framework for disassembly planning under lead time uncertainty. This novel contribution lays the groundwork for more resilient and sustainable disassembly operations, aligning with the goals of a circular economy. The insights gained from this study are expected to benefit both academia and industry by offering a robust decision-making tool for complex disassembly systems.
Keywords: Distributionally Robust Optimization, Disassembly Planning, Lead Time Uncertainty, Multi-Level BOM, Multi-Period Planning.

Shapley-Based Stackelberg Leadership Formation in Networks

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Abstract

The dynamics of leadership in networks are central to understanding influence and decision-making processes in social and organizational systems. This study explores the competition between a leader and a follower within networks using a Shapley-based Stackelberg framework, merging game theory and network science. The proposed methodology identifies the most influential nodes through the Shapley value, a game-theoretic centrality measure, and models their strategic interactions using the principles of Stackelberg competition. This sequential decision-making model elucidates how network modifications, such as establishing new links, alter leadership structures.

The research introduces a novel algorithm that computes Shapley values in polynomial time, facilitating the identification of leaders and followers in networks of varying topology. The interaction dynamics are formalized through a structured process that ensures any new connections enhance the Shapley values of both participants, thereby fostering leadership equilibrium. The model's robustness is demonstrated using two scenarios: a symmetric mixed-topology network and a real-world co-authorship network from the Norwegian School of Economics.

Empirical results showcase the mechanism's capability to optimize leadership positions through sequential, rational decisions, providing insights into the formation and evolution of influence hierarchies. This work offers a significant contribution to the fields of socio-economic network analysis and strategic decision-making, with potential applications in organizational design, marketing strategies, and digital platform optimization.

Characteristics of a generous maximum matching

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Abstract

This research deals with a preference-based matching variant known as the generous maximum matching. Preference-based matching refers to the process of pairing applicants to posts based on the preferences of the applicants over the posts. Such matching arises in various applications, including the house allocation problem and the assignment of students to projects.

A variety of objective functions have been explored in the literature to address preference-based matching problems, each aiming to achieve a specific notion of optimality or fairness. One widely studied approach is a profile-based matching method known as rank-maximal matching. This approach maximizes the number of applicants matched to their best-ranked posts, subject to that it maximizes the number of applicants matched to their second-best posts, and so on. At the other end of the spectrum is an approach that minimizes the number of applicants matched to their worst-ranked posts, subject to that it minimizes the number of applicants matched to their second-worst posts, and so on. This approach is known as generous maximum matching, also referred to as fair matching.

Here we focus on characteristics of a generous maximum matching assuming that each applicant has a full preference list without ties. We show that in an optimal generous maximum matching, at most one applicant will receive a post ranked worst. In addition, at least one applicant will get their most preferred post. This result is true for any Pareto optimal maximum matching. We generalize these results and obtain a bound on the amount of applicants who receive undesirable posts. More precisely, in a Pareto optimal matching at most k applicants will receive a post ranked in one of their k worst preferences.

We also show that for an applicant to receive their worst-ranked post, it is necessary that all applicants rank this post last in their preference list. We generalize this result and show that if k applicants receive posts from the last k posts, then those posts will appear in the last k places in the

preference lists of all the other applicants.

Regarding strategy-proofness of the generous maximum matching, we describe a manipulation ensuring that a manipulator will not receive the post ranked last in the manipulator’s preference list. A more complicated manipulation ensures an even higher ranked post for the manipulator.

Q-Learning Enhanced Particle Swarm Optimization for Dynamic Parameter Adaptation: Application to the Multidimensional Knapsack Problem

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Abstract

Particle Swarm Optimization (PSO) is one of the most widely used bio-inspired algorithms [1]. In this algorithm, each particle moves through the search space based on three key parameters: inertia weight, cognitive and social acceleration coefficients. However, the main challenge lies in the difficulty of defining fixed parameters that effectively solve a wide range of problems with PSO.

To address this limitation, we propose an innovative approach based on Q-learning, where each particle in the PSO algorithm is equipped with a learning agent. This agent is responsible for dynamically determining the optimal parameters for the particle's optimization, treating the PSO parameters as possible actions. The agent's states are defined based on the distances between the particle's current position, the best local position, and the best global position.

Each agent learns autonomously from its initial position and updates its Q-table accordingly. This approach not only adapts the optimization algorithm to the specific problem but also differentiates the individual behaviors of the particles based on the context. For example, an agent trapped in a local optimum will adjust its Q-table to encourage exploration of more distant regions. Similarly, an agent located in a steep slope area will be incentivized to accelerate its convergence toward a local or global minimum.

To evaluate the performance of this new approach and demonstrate its effectiveness, we applied it to the multidimensional knapsack problem, an NP-hard optimization problem [2]. Finding an exact solution to this problem often proves computationally expensive, justifying the use of innovative metaheuristic methods like the one we propose. The results confirm the

relevance of our approach for solving complex problems while optimizing resource utilization. We benchmarked our algorithm against the approach presented by Rodrigo Olivares [3] to demonstrate its advantages.

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Polynomial-time approximation schemes for locally checkable problems on planar graphs

1. **Carolina Gonzalez** []

Abstract

A polynomial-time approximation scheme (PTAS) for a minimization (resp. maximization) problem P is an algorithm that, given an instance I of P and a positive number r, computes an approximate solution for P on the instance I whose value is at most 1+r (resp. at least 1-r) times the optimal. Additionally, the complexity of this algorithm must be polynomial in the size of I for every fixed r.

The renowned Baker's technique is a method for designing PTASs for optimization problems on planar graphs, which has been applied to numerous problems. Traditionally, this technique has been employed on a case-by-case basis, thus requiring problem-specific adaptations.

In this work, we present a unified approach to applying Baker's technique to a broad class of problems. Our focus is on locally checkable problems, which are vertex partitioning problems for which a solution has to satisfy some local property for each vertex (i.e. a property that involves only the solution restricted to the vertex and its neighbors). This is the case of several variants of minimum dominating set and maximum independent set, among others.

Using the framework introduced by Bonomo-Braberman and G. (2022), we identify general conditions under which Baker's technique can be applied to locally checkable problems. As a result, we obtain PTASs on planar graphs for all problems meeting these conditions. Notable examples of such problems include: [k]-Roman domination, Grundy domination and k-Maximum Happy Vertices.

Towards a Sustainable Textile Industry: An Optimization Model for Integrated Supply Chains

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Abstract

The textile and apparel industry is one of the most resource-intensive and polluting sectors globally, contributing significantly to water consumption, carbon emissions, and waste generation. The fast fashion model, characterized by rapid production cycles and short product lifespans, has exacerbated the environmental burden, leading to an urgent need for sustainable alternatives. In response, researchers and policymakers are increasingly focusing on circular economy principles to minimize waste, optimize resource use, and promote textile recycling. However, implementing efficient and cost-effective recycling strategies remains a complex challenge due to logistical, technological, and economic constraints.

Textile waste is primarily classified into two major categories: pre-consumer waste and post-consumer waste. Industrial textile waste, such as spinning and winding residues or fabric scraps from weaving and knitting, is often recycled within textile factories and reintegrated into the production chain. In contrast, recycling post-consumer waste—discarded textiles that have reached the end of their useful life—is significantly more challenging. The reuse and recycling of post-consumer textiles have become crucial due to resource conservation, environmental impact reduction, economic benefits, social advantages, and regulatory compliance.

While numerous studies have focused on technological advancements in textile recycling, there remains a critical gap in evaluating the life cycle, socio-economic, and environmental impacts of textile waste management. To address this gap, this study proposes an integrated approach combining the Direct logistics supply chain, which spans raw material sourcing to end-customer delivery, and the Reverse logistics supply chain, which includes the recovery and valorization of pre- and post-consumer textile products. In this context, we present a mixed-integer nonlinear programming (MINLP) model designed for strategic and tactical planning, aiming to minimize total costs.

Additionally, a benchmarking framework has been introduced, and preliminary experiments have been conducted to assess the model's complexity and computational limits. The findings from this study will contribute to the development of more sustainable and cost-effective textile waste management strategies, supporting the transition towards a circular economy in the textile industry.

Maximizing Phylogenetic Diversity under Time Pressure: Planning with Imminent Extinctions

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Abstract

Phylogenetic Diversity (PD) is a well-established measure of the overall biodiversity of a set of present-day species within a phylogenetic tree. In Maximize Phylogenetic Diversity (MPD) one is asked to find a set of species (of bounded size/cost) for which this measure is maximized. MPD is a relevant problem in conservation planning, where there are not enough resources to preserve all taxa, and minimizing the overall loss of biodiversity is critical. Fortunately, MPD can be solved with a greedy algorithm [Steel, Systematic Biology, 2005; Pardi and Goldman, PLoS Genetics, 2005].

Motivated by real-world concerns, we consider extensions of this problem, in which rescue teams are to be coordinated, and species not only require a certain amount of time to be saved but also have an extinction time after which they can no longer be saved. It is asked for a set of species maximizing the phylogenetic diversity, for which additionally a schedule for the available teams can be defined; we consider two variants of the problem based on whether teams are allowed to collaborate on the species simultaneously. These problem variants have much in common with machine scheduling problems, where the weighted throughput is to be maximized. The biology-inspired generalization of the job value presents an interesting extension of the objective function.

Our time-sensitive problem variants are, in contrast to the original MPD, NP-hard, even in very restricted cases. We provide several algorithms and intractability results. The problems are fixed-parameter tractable (FPT) when parameterized by the threshold of phylogenetic diversity, or by the total available time of the teams. Further, the problem where teams are allowed to collaborate is FPT when parameterized with the acceptable loss of diversity. This variant can be solved with an O^*(2^n)-time algorithm, which, assuming the strong exponential time hypothesis, is unlikely to be improved significantly.

Hyperparameter Optimization for Machine Learning in Python

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Abstract

For machine learning models, hyperparameter optimisation (HPO) is a key step in delivering the best performance results. However, it can easily become a computationally expensive problem. Manual hyperparameter optimisation is time-inefficient, making the computational power of machines crucial to leverage. Python Bayesian-based libraries such as Hyperopt, Optuna and Skopt are popular choices for performing this task. From the class of meta-heuristic libraries, the Python library DEAP is selected. However, additional libraries need exploration.
This paper discovers MEALPY and PyGMO libraries for HPO of machine learning models and provides computational experiments. Multiple problems with different classes are solved. One of the tested datasets explores the Czech energy sector. Weather and other factors are used to predict energy variation.
Furthermore, a variety of metaheuristic algorithms are explored to identify hyperparameters using various exploration strategies.

GrassSV – hybrid method to detect structural variants

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   Poznan University of Technology
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Abstract

Genetic diversity in genomes is crucial for populations to adapt and survive in dynamic environments. This diversity arises from genetic mutations, which manifest in the genome as structural variants (SVs). Several types of structural variants exist: deletions, duplications, insertions, inversions and translocations, but not all are equally easy to detect. Current SV detection tools tend to specialize in certain SV types, limiting their overall utility. While some methods excel at identifying position of SV, they often struggle with accurately classifying variant types. Detection precision also varies depending on data quality and the sequencing technology used. At present, the majority of available data in genomic databases comes from high-quality short reads, which remains the most affordable sequencing technology.

We introduce GrassSV, a program that identifies potential SV breakpoints and performs de novo assembly of reads in these regions. Through in-depth analysis of contig mapping patterns, GrassSV can accurately annotate the specific types of SV. The method's robustness was demonstrated on the human Genome in a Bottle dataset, as well as on synthetic data derived from the yeast genome to assess both precision and recall. GrassSV was the only method capable of detecting all SV types while minimizing false positive results.

Mathematical Formulation for Bicycle Sharing Systems with Heterogeneous Rebalancing Vehicles

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Abstract

Vehicle Sharing (VS) is a type of short-term car rental that lets consumers rent a car for an hour or less. Users can reserve an automobile using this method and use it for a limited time; however, they are still responsible for having the vehicle picked up and delivered. Vehicle sharing systems (VSS) facilitate the sharing of a fleet of small to medium-sized cars among various customers. Bicycle Sharing Systems (BSSs) are VSSs that allow the use of bicycles. This study initially discusses the basic features and historical evolution of BSSs. When planning BSSs, numerous operational, tactical, and strategic challenges arise. The rebalancing problem, the focus of this research, is the most significant issue. An operator-based static complete rebalancing problem for a BSS is examined in this work. A model of a bicycle sharing system with heterogeneous rebalancing vehicles is developed, based on a mathematical formulation that is already known from the literature. A computational analysis is made between the model's output for each of the 25 data sets. All of the problems are solved with IBM ILOG CPLEX Optimization Studio version 22.1.0, the mixed integer linear programming models are coded in OPL. CPLEX uses an Intel(R) Xeon Phi(TM) 7290 @ 1.50 GHz with 384 GB RAM to solve the data sets. It does this by altering the settings for the 7200 seconds time limit, the 16 GB available memory limit, the 16 cores, and the writing of the node file in compressed format to the hard drive. The results of each model are obtained and compared for two different fleet sizes in 25 different data sets. The model with Heterogeneous Rebalancing Vehicles, the optimal solutions are obtained for 56% of the problem set.

Formulation for the Traveling Salesman Problem with Time Windows: Solving Most of the Symmetric Test Instances to Optimality with an Optimizer

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Abstract

The Traveling Salesman Problem (TSP), which lies at the heart of routing problems, is one of the most attractive combinatorial optimization problems. Most widely applied variant of TSP is called "Traveling Salesman Problem with Time Windows (TSPTW)". A time window for a city is an interval defined by the earliest and the latest time that this city can be visited. TSPTW and its variants may arise in many real-life problems such as school bus routing, transportation of perishables goods, postal deliveries, industrial refuse collection, military operations, scheduling problems in manufacturing, etc. When we omit the time windows of the problem, TSPTW reduces to TSP. Therefore, TSPTW is an NP-hard problem.
To the best of our knowledge, there is a mathematical formulation for the TSPTW that can be used with alternative objective function in the literature. The formulation has O(n2) binary variables and O(n2) constraints where n is the number of the nodes of the underlying graph. Benchmark instances up to 40 nodes in the literature are solved to optimality with the mathematical formulation.
Since the existing formulation for TSPTW is capable to solve up to small size symmetric problems, there is a need to have faster formulations that can be used for solving symmetric and asymmetric problems directly with an optimizer. This is the main motivation of this paper. We propose a new integer linear programming formulation with O(n2) binary variables and O(n2) constraints for TSPTW that can be used both symmetric and asymmetric problems.
To explore the computational performances of the new and existing formulations, we conduct a computational analysis by solving symmetric benchmark instances from the literature. All of the problems are solved with CPLEX 22.1.0.0 using an Intel Core i7-3630QM CPU 2.40 GHz and 16 GB RAM computer. The upper time limit is 7200 seconds for all computations. We observe that, proposed formulation extremely faster than existing formulation for the test problems solved both formulations. Existing formulation solved instances up to 100 nodes with 20-time window width.

Proposed formulation solved most of the symmetric test instances up to 200 nodes having 300 unit or less time windows range optimaly within seconds. Our contributions may be summarized as follows: A new approach for subtour elimination constraints for routing problem is presented. A new formulation for TSPTW proposed which is extremely faster than then the previous formulations.
Our proposed formulation can be used to solve small and modereate size real life TSPTW to optimally with an optimizer. It can also be used the see the performance of newly proposed heuristics. Computational analysis for the asymmetric test instance is on going.

From Simulation to Reality: Safe and Efficient Urban Air Mobility Operations for Istanbul City

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Abstract

Urban growth has strained transportation infrastructure in metropolitan areas, causing congestion, delays, and complex traffic conditions. To ensure safe and efficient travel, innovative mobility solutions are required. Urban Air Mobility (UAM) is considered as a solution to traffic congestion, and in this context, it is intended to use small, autonomous, low-altitude aircraft to transport passengers or cargo in urban and suburban areas soon. However, the implementation of new urban air transport concepts faces numerous obstacles in terms of safety and security, which are essential for aviation. As flights increase, existing airspace capacity will be exceeded, so a safe and reliable optimization process is essential to minimize delays, reduce fuel consumption, and meet future demand. The effort to balance demand and capacity is known as Air Traffic Flow Management (ATFM). The overall purpose of ATFM initiatives is to find a compromise solution between all stakeholders, usually based on some criteria of fairness. Although drones are expected to be equipped with collision avoidance capabilities, the complexity of operating in congested U-spaces requires multi-layered safety control to minimize potential accidents. Therefore, path planning algorithms should also consider collision avoidance, which significantly will increase the complexity of path planning in UAM operations.
In this work, we aim to develop a four-dimensional (space-time) urban airspace management concept for UATFM that considers dynamic flow structure, congestion, operational efficiency, and safety. First, we will develop a 3D UAM route network model of the U-space for the city of Istanbul to identify possible routes for each origin-destination (OD) pair in each flight request. In the second stage, we will perform congestion-free demand-capacity optimization for flight demands and determine feasible flight plans. Our model will be based on underutilized paradigms in this field, such as metaheuristics. These algorithms will also cover specific emergency and contingency protocols and conflict-free path planning for security plans. The proposed algorithms will be verified and validated using a simulation tool (Pybullet) that considers six-degrees-of-freedom flight dynamics models and can adapt to different synthetically generated UAM scenarios. Then, to see the applicability of the model to real-life scenarios,

the proposed algorithms will also be tested on mini drones (Crazyflie), considering that UAM systems are not yet operational. In extensive experiments, we will analyze the impact of different parameters such as congestion rate, distribution of obstacles and restricted areas on the map, separation, and different speeds on the safety of UTM operations. For contingency planning, a set of rules and actions will be entered into the UATFM module, considering various unforeseen events, and the resilience of the system in the face of a real crisis will also be tested.

The wildfire safety paths problem

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Abstract

We consider the determination of a pair of shortest disjoint paths in a network with arcs that become inaccessible after a specific time.
The problem arises in the context of wildfire scenarios, where the network represents a landscape with areas that may become inaccessible or hazardous after a specific time. We assume the travel time associated with each network arc is known. Furthermore, we presume the time when each arc becomes unavailable can be estimated.
Our objective is to identify two paths connecting a given origin to a given destination within this network, in such a way that the total travel time is minimized while maintaining a safe distance from affected areas. We require these paths to be disjoint to enhance reliability, increasing the chances that at least one of them remains viable if the fire's spread deviates from predictions.
The problem is formulated as a particular shortest pair of disjoint paths problem based on a time-extended network. We present an algorithm for the problem, which computes augmenting paths in a residual network of that time-extended network, and provide computational experiment results.

Variable fixation on an extension of the vertex cover problem

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Abstract

In some contexts, we can model the relationship between locations and their connections using some extensions of the vertex cover problem. In this talk, we revisit some of these extensions and provide preliminary results regarding variable fixations that can be used for solutions methods. We present preliminary computational results from a decomposition algorithm in which we show the applicability of our proposals.

An Open-Source Heuristic for the 2D Irregular Strip Packing Problem: Reproducible, Robust & Resounding Performance

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2. Tony Wauters []
   Computer Science, KU Leuven

Abstract

In the 2D irregular strip packing problem, a set of irregularly shaped items must be placed within a fixed-height rectangular bin, while minimizing its width.
This is one of the most challenging problems in the field of Cutting & Packing due to the geometric complexity of the shapes and the combinatorial challenge of creating compact arrangements of items.

Numerous algorithms have been proposed to address this problem, ranging from simple constructive heuristics to complex methods leveraging exotic meta-heuristics.
While the simple algorithms can be reproduced, they often yield subpar solution quality and are very sensitive to parameters and the specific instance.
Meanwhile, the state-of-the-art approaches are complex, lack a publicly available codebase, and are therefore practically impossible to reproduce.
This creates an unhealthy situation where the community is forced to compete with these `methods' without being able to verify or build upon them.

Another key issue is the reliance on No-Fit Polygons (NFPs) to prevent item overlap.
While NFPs can be an elegant solution in scenarios with limited rotation of items, designing a general and robust generator for them is notoriously difficult.
Critically, we are not aware of any publicly available NFP generator is able to handle non-convex shapes in a robust manner.
Although academic benchmarks from the ESICUP website include pre-generated NFPs, real-world instances do not.
So even if the algorithms were open source, the lack of an NFP generator limits their applicability to a few benchmark instances.

We address these two obstacles by introducing an open-source heuristic

aimed at rivaling the state-of-the-art in terms of solution quality.
Our approach avoids the need for NFPs by using `jagua-rs', a trigonometry-based collision detection engine, enabling broad applicability.
We also emphasize consistent performance, both across runs and across different instances, without requiring instance-specific parameter tuning.

We believe that combining a detailed research paper with an openly available codebase creates a resource more valuable than the sum of its parts. Enabling reproducibility and fostering further advancements in this challenging optimization problem.

Cutting Planes, Column Generation and Decomposition with Interior Point Methods

1. **Jacek Gondzio** []
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Abstract

Advantages of interior point methods (IPMs) applied in the context of nondifferentiable optimization arising in applications such as cutting planes/column generation and various decomposition schemes (Benders, Dantzig-Wolfe) will be discussed. Some of the many false views of the combinatorial optimization community on interior point methods applied in this context will be addressed and corrected. For example, IPMs deliver a natural stabilization when restricted master problems are solved and guarantee fast convergence, measured with merely a few master iterations needed to localize the solution. When applied in the context of decomposition, IPMs deliver epsilon-subgradients and are well-suited to handle the oracles with on-demand accuracy.

Various such techniques have been discussed in the recent survey on IPMs (EURO J. on Computational Optimization, 2025). An approach which combines column generation with IPMs has been successfully used to solve a plethora of applications which include, (robust) vehicle routing problems with time windows, multiple kernel learning problems, truss geometry and topology optimization problems or discrete optimal transport problems, to mention just a few.

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MILP and Branch and Bound Approaches to the Load-Dependent Hazardous Materials Vehicle Routing Problem

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Abstract

Unlike typical vehicle routing problems that primarily aim to minimize cost, Hazardous Materials (HazMat) routing also necessitates minimizing risk exposure based on the route taken. The risk exposure depends on the HazMat load in the vehicle, influencing the sequence of customer visits and deliveries. This paper analyzes the dynamic calculation of route risk as a function of the HazMat load, relating it to the area of exposure. The network is simplified into a complete graph comprising only the depot and customer nodes. Detailed analysis of the trade-offs between cost and risk is conducted. The complication in the problem is that the risk at any stage is a function of the HazMat load on the vehicle, which in turn depends on the customer deliveries that have already been made. Two approaches are developed to circumvent this difficulty. The first is a branch-and-bound approach which is directly able to take into account the loads that have been dropped off and its impact on risk. The second is an MILP approach which uses a suitable approximations for the risk exposure as a function of vehicle load. The results from these two optimization methods are compared with those from a generalized greedy approach. The solution methods are tested on various instance sizes to evaluate feasibility in real-world scenarios. A case study is performed to route multiple delivery vehicles to customers in the Buffalo-Niagara region.

A Branch-and-Cut Algorithm for the Quadratic Knapsack Problem

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Operations and Decision Systems, Université Laval
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Abstract

The Quadratic Knapsack Problem (QKP) is a fundamental combinatorial optimization problem that arises in various applications, including portfolio optimization and resource allocation. It extends the classical knapsack problem by incorporating quadratic interactions between selected items, significantly increasing its complexity. The nonlinearity of the objective function weakens standard linear relaxation techniques, making it more difficult to obtain strong bounds and efficiently solve the problem. Consequently, the development of exact algorithms that effectively address the quadratic nature of the problem is essential.

In this work, we propose a branch-and-cut algorithm that strengthens the formulation of the QKP by introducing lifted cover inequalities over quadratic variables. While lifted cover inequalities have been widely employed in knapsack-type problems to enhance the quality of linear relaxations, their extension to quadratic variables remains largely unexplored. To address this gap, we leverage Binary Decision Diagrams (BDDs) in combination with a Dynamic Programming (DP) formulation to construct a compact representation of the solution space. This hybrid approach allows us to derive strong valid inequalities that significantly improve the problem’s linear relaxation.

Our methodology relies on a DP formulation tailored to the quadratic variables of the QKP. By exploiting the flexibility of the BDD representation, we develop a computational framework for generating valid cover inequalities specifically for these variables. Furthermore, by embedding the cover inequalities within a BDD structure, we systematically lift them, thereby strengthening their effectiveness in the branch-and-cut framework. This process enables a more refined tightening of the relaxation, reducing the solution space without compromising feasibility.

To assess the performance of our proposed approach, we conduct extensive computational experiments on benchmark instances of the QKP. The results demonstrate that integrating lifted cover inequalities over quadratic variables into a branch-and-cut algorithm significantly enhances computational efficiency. Compared to the traditional branch-and-bound method, which remains the only dominant exact solution approach for the QKP, our method achieves a substantial reduction in the number of explored nodes, leading to faster convergence to optimal solutions.

The contributions of this work offer new insights into the design of cutting-plane algorithms for nonlinear combinatorial optimization. By integrating lifted cover inequalities over the nonlinear variables into a branch-and-cut framework, we present an innovative approach that improves exact solution techniques for the QKP. Furthermore, this research highlights the potential of BDDs as a powerful tool for generating strong cutting planes, paving the way for future advancements in quadratic programming and combinatorial optimization.

Optimal charging station placement and network expansion within European low-voltage distribution networks

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Abstract

The rapid adoption of electric vehicles is creating significant challenges for European low-voltage distribution networks,
leading to increased network congestion, voltage stability issues, and potential overloading of existing infrastructure.
We address these challenges by developing an optimal placement strategy for electric vehicle charging stations while considering strategic network expansion possibilities.
We present a novel bi-objective optimization approach that simultaneously minimizes voltage deviations and
total infrastructure costs. The methodology allows for strategic network reconfiguration through the addition of new cables from substations to buses,
effectively creating new feeder networks that can better accommodate charging station loads. We formulate this as a mixed-integer linear programming problem
and solve it using the augmented ϵ-constraint method to generate Pareto-optimal solutions.
The model employs linearized power flow equations and integer decision variables to determine both the optimal locations for charging stations and the necessary network expansions while maintaining computational tractability.
The resulting Pareto front provides policy makers with a comprehensive set of trade-off solutions between infrastructure costs and network stability, facilitating strategic planning decisions.
This integrated approach enables distribution system operators to simultaneously optimize charging station placement and
plan strategic network expansions,

ensuring both long-term grid reliability and adequate public charging infrastructure for the growing number of electric vehicles.

OPTIMAL DESIGN OF WATER DISTRIBUTION NETWORKS USING EVOLUTIONARY COMPUTATION-BASED ALGORITHM

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Abstract

Water is an essential element for life and the demand on this vital resource continues to increase day after day due to continued demographic and industrial growth, in this context the design of the drinking water supply network has prompted great interest from researchers to provide solutions that allow water needs to be met at lower cost
The objective of this study is to develop a program for optimizing the cost of pipes using a new metaheuristic method which has never been applied for the design of drinking water network. In this article the evolutionary computation-based algorithm was applied on three examples of drinking water network references known in the literature which are: Two-Loop network, New York network and GoYang network

A Branch-Price-and-Cut Algorithm for the Kidney Exchange Problem

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Abstract

In this paper, we study a Kidney Exchange Problem (KEP) with altruistic donors and incompatible patient-donor pairs.Kidney exchanges can be modelled in a directed graph as circuits starting and ending in an incompatible pair or as paths starting at an altruistic donor.
For medical reasons, circuits and paths are of limited length and are associated with a medical benefit to perform the transplants.
The aim of the KEP is to determine a set of disjoint kidney exchanges of maximal medical benefit or maximal cardinality.
We consider a set packing formulation for the KEP with exponentially-many variables associated with circuits and paths, and develop a Branch-Price-and-Cut algorithm (BPC) to solve it. We decompose the pricing problem into a subproblem to price out the path variables and several subproblems to price out the circuit variables. We strengthen the linear relaxation via the inclusion of a family of non-robust inequalities.
We perform extensive computational experiments to assess the performance of the BPC algorithm on three sets of instances from the literature and on a newly generated set of challenging instances. On the easiest instances, it yields comparable results with the literature, while on the other sets it clearly outperforms the previous results. Hence, contrary to the existing literature, the BPC algorithm is the only exact approach able to effectively solve various and difficult instances with both objective functions and long chains and cycles.

Sequential Voting and the Condorcet Jury Theorem

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Abstract

Marquis de Condorcet (1785) analyzed a jury of n odd-numbered jurors deciding by majority vote between two equiprobable states of nature, A and B. Each juror independently receives a signal favouring A or B with probability p ($1/2 < p < 1$) of being correct, where p represents the juror's ability. Condorcet's Jury Theorem (CJT) states that as n approaches infinity, the probability of a correct majority decision (known as reliability) converges to 1.

This paper examines sequential and honest voting, where jurors vote in turn with knowledge of prior votes and vote for the alternative most likely given their signal and previous votes, and compares its reliability to the simultaneous voting framework of CJT.

For large juries with homogeneous ability (p constant across jurors), unlike in CJT, herding effects prevent reliability from reaching 1 as n increases. Instead, reliability converges to a limiting value strictly below 1.

For small juries of size three, we analyse the effect of heterogeneous abilities. With honest sequential voting, reliability is maximized when the most capable juror votes second. The reliability of such a voting is at least as large as that of simultaneous voting and strictly larger if the jury is sufficiently heterogeneous in ability. These conclusions extend to expected reliability when abilities are drawn uniformly from [1/2,1].

This is joint work with Steve Alpern.

Multi-Objective Optimisation of Electric Ground Support Equipment Assignment with Partial Charging: Applied Case Study

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Abstract

Ground handling service providers at major airports seek to enhance operational efficiency and sustainability through advanced optimisation techniques beyond the capabilities of traditional human planning approaches. We address the complex problem of electric ground support equipment assignment for push operations, belt loading, cargo loading, and passenger stairs at Charles de Gaulle Airport as part of the European Olga Project. This research frames the challenge as a ground handling problem and Electric Vehicle Routing Problem (EVRP) with partial recharges, focusing on the optimal distribution of tasks across a heterogeneous fleet of electric vehicles. We develop a three-objective optimisation approach that simultaneously minimises the required fleet size, maximises equity in task distribution among vehicles, and reduces peak electricity demand across charging depots. Our solution methodology relies on a reduced Variable Neighbourhood Search (rVNS) metaheuristic with cooperative multistart strategies and specialised heuristics, yielding solutions within one minute of computational time. We leverage previous internal data, statistical analysis on vehicle consumption and recharge profiles, from real concrete data and actual flight plannings. Computational experiments using real operational data from CDG Airport demonstrate significant improvements over current practices. Results show we can reduce peak electricity consumption by more than 30%, thus reducing the infrastructure need by the same amount, while maintaining near-optimal fleet size and equity in task distribution. Additionally, we will demonstrate how our approach enables real-time reassignment of delayed tasks, providing operational flexibility. This approach offers ground handling companies a powerful decision support

tool for daily operations while supporting broader sustainability goals and reducing operational costs through intelligent charging management.

A branch-and-bound procedure for maximizing the projects net present value under fixed earliness penalties

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Abstract

We extend the analysis of the financial aspects of a project beyond the net present value of cash flows associated with the start or completion of activities. In particular, we consider fixed earliness penalties that occur when activities are completed before their due dates. These fixed earliness penalties may arise, for example, when finished goods have to be transported to an alternative storage facility prior to the due date because of insufficient local storage space. The objective is to maximize the sum of the discounted cash flows reduced by the sum of discounted fixed earliness penalties. It is important to note, that the fixed earliness penalties lead to jump points at the due dates in the objective function and its derivative. The problem is subjected to general temporal constraints.

We present a branch-and-bound procedure for the problem. In the root node, we determine an optimal schedule for the given problem without the fixed earliness penalties. This is achieved using an existing and efficient steepest ascent algorithm for the net present value problem with only cash flows. Then, we enumerate all activities that are scheduled before their due date and decide whether to postpone them to their respective due dates. Postponing an activity to its due date is realized by inserting an arc from the project start to the corresponding activity in the project network with a respective arc weight. This sets the earliest start of this activity to its due date. Then, the steepest ascent algorithm is run again to determine an optimal solution for the updated project network, again only considering cash flows.
To improve the performance of the procedure, we present a presolve to identify activities for which delaying to the due date either always or never improves the project's net present value (regardless of other activities being delayed). We also discuss the challenge of finding an enumeration order for the early activities and determining upper and lower bounds.

Robust Multi-Objective Optimization for Bicycle Rebalancing in Shared Mobility Systems

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4. Sergio Nesmachnow []
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Abstract

Shared bicycle systems play a crucial role in promoting sustainable urban mobility by reducing carbon emissions, alleviating traffic congestion, and providing affordable transport options. However, their efficiency heavily depends on the availability of bicycles at high-demand stations and empty docks at return locations. Due to fluctuating demand patterns, bicycle rebalancing is necessary to redistribute bicycles across docking stations, ensuring service reliability. Traditionally, optimization approaches have been applied to enhance the redistribution process, minimizing distance or operational costs. However, most strategies do not consider the robustness of the rebalancing plans when faced with deviations from predicted demand patterns.

This study introduces a robust rebalancing framework incorporating multi-objective optimization to balance both operational efficiency and route stability under uncertain demand conditions. Unlike conventional approaches that solely minimize travel distance or rebalancing costs, our model integrates a secondary objective: resilience, measured by the sensitivity of rebalancing plans to deviations in station occupancy predictions. By incorporating stochastic demand variations into the optimization techniques, the model aims to generate rebalancing strategies that require minimal real-time adjustments when demand changes unexpectedly.

We propose an evolutionary multi-objective optimization approach, leveraging NSGA-II (Non-dominated Sorting Genetic Algorithm II) and MOEA/D (Multi-Objective Evolutionary Algorithm based on Decomposition) to identify Pareto-optimal solutions that optimize both efficiency and robustness. The algorithms will be tested on several instances, evaluating their performance under different demand fluctuation scenarios. The

proposed system contributes to both the optimization of shared mobility logistics and the development of resilient urban transportation networks, ensuring sustainable and efficient rebalancing operations.

A Multi-population Hybrid Genetic Algorithm for the Capacitated Location Routing Problem

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Abstract

We present a multi-population hybrid genetic algorithm for solving the capacitated location-routing problem (CLRP). The CLRP requires the selection of a subset of capacitated depots in order to schedule a fleet of capacitated vehicles to depart from and terminate at the selected depots to serve a set of customers. The objective is to minimize a cost function that includes the cost of opening the selected depots, the fixed utilization cost per vehicle used, and the total cost (distance) of the vehicles routes. The proposed algorithm uses an original multi-population scheme to organize the population into multiple subpopulations according to the depot configurations being explored. The algorithm also includes a multi-depot edge assembly crossover to generate promising offspring from the perspective of both depot location and route edge assembly, a neighborhood-based local search to optimize the routes of each offspring solution, and a diversification-oriented mutation. Extensive experiments on four sets of 281 benchmark instances from the literature show that the algorithm performs remarkably well, finding 103 new best results (improved upper bounds). Additional experiments are presented to gain insight into the role of the key elements of the algorithm.

Solving a domestic waste collection problem using a 2-commodity flow relocation model

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Abstract

In domestic waste collection problem, we have waste bins located over a territory, and their location are known. Each bin has a daily filling rate which could be predicted or estimated after the collection is done. To collect waste, we manage a fleet of limited number of trucks with their capacity. The difficulty of this problem comes from the optimization of the vehicle routing subject to the constraints to maintain the inventories at a certain level regarding the demands of the clients. Furthermore, at the daily operational decision this problem could be seen as a Capacitated Vehicle Routing Problem (CVRP) if we consider the average daily filling rate for each bin. However, it is interesting to build more or less balanced length of routes for the fleet of trucks in order to balance the daily work load for the collection agents as well.

The 2-commodity flow relocation model in a time expended network has been proven to be effective on the management of a shared mobility systems [2] in terms of the control of the length of routes. This allows to have more or less balanced collection tours, which is an important feature to get a feasible global solution regarding the collection time and the fairness in the working time between collection agents. Another advantage of this method is that we can obtain as well the optimality gap of the solution when the optimality of the solution is not reached in short computational time runs. An adapted version of this model for the Capacitated Vehicle Routing Problem (CVRP) on medium has been carried out but only tested on small size data instances and never on a real-life case study with medium size instance (hundreds of points).

In this work, we propose to try this model on a real-life case study from the semi-urban area from the south of France with around 300 collection points. We will compare the results regarding the length of the routes, the solution quality and the computational time, with the one obtained by human experts from the collection organization and those obtained by two other classical methods: the Clarke and Write algorithm [1] and the MILP with subtour elimination constraints using Miller-Tucker-Zemlin formulation [3]. We will discuss as well some perspectives of this work.

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Mathematical Formulations for the Robust Bin Packing Problem with Fragile Objects

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Abstract

In the Bin Packing Problem with Fragility Objects (BPPFO), we are given a set items, each item with a weight and fragility, and a large number of uncapacitated bins. The problem consists in packing all items into the minimum number of bins, ensuring that the total weight packed in any bin does not exceed the smallest fragility among the set of items assigned to the bin. This problem appears, for example, in the telecommunication field, where each call is characterized by a noise and a noise tolerance. Therefore, the assignment of calls to available channels cannot exceed the noise acceptance limit of the fragilest call in the channel. Considering the fact that the noise of the calls is not exactly known in advance, but typically belongs to a given interval, we address a variant of the BPPFO designed to represent data uncertainties affecting the weights. The resulting Robust Bin Packing Problem with Fragility Objects (RBPPFO) generalizes the well-known BPPFO by incorporating a budgeted uncertainty set to model data uncertainties. To solve the RBPPFO, we propose three formulations: a compact mixed-integer linear programming formulation, an arc-flow formulation, and a constraint programming formulation. Additionally, we introduce heuristic techniques to initialize these formulations and enhance their convergence. To evaluate the efficiency of our models and compare their performance, we tested them on a set of instances adapted from the literature. Our results demonstrate the effectiveness of the proposed arc-flow formulation in solving the RBPPFO, highlighting its potential for application beyond the RBPPFO to other packing problems where handling uncertainty is crucial.

Optimal Design of Hybrid Multigeneration Systems via Stochastic Programming

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Abstract

In this talk, we present a stochastic programming approach for the optimal design of hybrid multigeneration energy systems that integrate renewable-based technologies, storage solutions and devices powered with green fuel. The model considers the inherent uncertainty in key variables involved in the decision process, such as energy demand, renewable energy generation, and market prices, employing a two-stage approach that combines strategic decisions on system configuration and capacity with operational decisions relate to daily system operation.
A Sample Average Approximation method is used to handle the computational complexity of the resulting large-scale mixed-integer nonlinear deterministic equivalent reformulation.
The proposed approach is tested on a real case study of a residential complex in Turin, Italy. The results show that the stochastic design outperforms conventional deterministic approaches, providing cost-effective and resilient energy solutions that support global goals for carbon neutrality.

A Benders Decomposition approach for the} clustered hierarchical hub location problem

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Abstract

The Clustered Hierarchical Hub Location Problem (CHHLP) aims to find the locations of two types of hubs in a transportation network: local and global, and directing traffic through these hubs between each pair of customers at minimum cost. A key feature of CHHLP is the clustering of nodes, where inter-cluster connectivity is exclusively provided by global hubs. A practical application of this problem can be observed in transatlantic transportation systems, where continents function as clusters and seaports serve as global hubs. In this study, we propose a mixed-integer linear programming (MILP) formulation to address the CHHLP. The problem becomes computationally challenging for large-scale instances. To tackle this, we employ a Branch-and-Cut method, where cuts are generated using Benders Decomposition to enhance computational efficiency. Additionally, we explore heuristic approaches to provide near-optimal solutions for larger instances, ensuring a balance between solution quality and computational tractability. We also explore the application of Branch-and-Price techniques to solve various instances of the CHHLP. The results aim to demonstrate the effectiveness and scalability of the proposed methods.

An exact algorithm for the vehicle routing problem with private fleet and common carrier

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Abstract

The Vehicle Routing Problem with Private Fleet and Common Carrier (VRPPC) is a generalization of the classical Vehicle Routing Problem in which the owner of a private fleet can either visit a customer with one of his vehicles or outsource the customer to a common carrier. The latter case occurs if the demand exceeds the total capacity of the private fleet or if it is more economically
convenient to do so. The owner's objective is to minimize the variable and fixed costs for operating his fleet plus the total cost charged by the common carrier. This family of problems has many practical applications, particularly in the design of last mile distribution services, and has received some attention in the literature. In this paper, we extend the VRPPC by considering a more realistic cost structures that account for quantity discounts on outsourcing costs. We model and solve the resulting problem using techniques from the integer programming literature. We present an exact approach based on Benders decomposition. In the master problem of the benders decomposition we include variables related to outsourcing. The subproblem of the benders decomposition is a routing problem that we solve using a column generation based algorithm. The master problem of the column generation is a set partitioningproblem and the pricing subproblem is an elementary shortest problem with resource constraints that is solved by dynamic programming. We test the proposed algorithm on instances from the literature.

Highly Effective Exact Algorithms for Solving Two-Dimensional Packing Problems

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Abstract

This paper investigates a broad class of two-dimensional packing problems, focusing on three key variations: the Two-Dimensional Bin-Packing Problem (2BPP), the Two-Dimensional Knapsack Problem (2KP) (with and without item conflicts), and the Orthogonal Packing Problem (2OPP). These problems have many practical applications in manufacturing and logistics. The 2BPP extends the classical Bin-Packing Problem (BPP), minimizing the number of rectangular bins needed to pack items without overlaps. The 2KP extends the Knapsack Problem (KP), selecting a subset of items that maximizes profit while fitting within a rectangular bin. The 2OPP determines whether all items can be packed under non-overlapping constraints. The primary contribution of this paper is a novel branch-price-and-cut (BPC) algorithm for solving the 2BPP. This exact algorithm leverages advanced row and column generation techniques, incorporating subset-row and valid-bound cuts, which were applied for the first time to this problem. It also introduces tailored strategies to handle the complexities of two-dimensional packing. The pricing problem in the column generation phase requires solving a generalized 2KP, leading to the development of an exact solution framework that is also highly effective for the 2KP and 2OPP. A key innovation in this framework is the combinatorial Benders decomposition, enhanced by additional master cuts and logic-based decompositions. Additionally, a set of heuristic algorithms complements the exact method, further improving efficiency. The framework achieves state-of-the-art results, solving large-scale 2BPP instances with up to 500 items, including previously unsolved cases that remained open for over three decades. It also establishes new benchmark results for 2KP and 2OPP.