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Book of Abstracts

THE ASSOCIATION OF EUROPEAN OPERATIONAL RESEARCH SOCIETIES

ECCO COMBINATORIAL OPTIMIZATION

CO CONFERENCES since 1977

Contents

1 Preface

Dear Participant at the ECCO-CO 2022 conference:

ECCO (European Chapter on Combinatorial Optimization) is a working group of EURO (Association of European Operational Research Societies), which provides an excellent opportunity to discuss recent and important issues in Combinatorial Optimization and its applications. The ECCO meetings are held on a regular basis (once a year during Spring) and nicely combine scientific work and the exchange of new ideas with an exciting environment.

CO series of biennial symposia, The Combinatorial Optimization Conferences, started in the UK in 1977 with meeting venues alternated between the UK and continental Europe.

ECCO-CO 2022 is the joint conference of the 35th Conference of the European Chapter on Combinatorial Optimization (ECCO XXXV) and the Combinatorial Optimization Conference 2022 (CO 2022), which takes place online during June 9–11, 2022. Initially, ECCO XXXV-CO 2022 was planned to take place in St. Petersburg, Russia. Due to the war situation, it has been decided to move the conference online. This online edition includes three plenary lectures and 100 oral communications with more than 170 attendees.

Topics of interest for the conference are as follows:

- Theory and applications of combinatorial optimization
- Exact solution algorithms, approximation algorithms, heuristics, and metaheuristics for combinatorial optimization problems
- Integer programming, global optimization, stochastic integer programming, multi-objective programming, graph theory and network flows
- Application areas include logistics and supply chain optimization, manufacturing, energy production and distribution, land consolidation, telecommunications, bioinformatics, finance, discrete tomography, discrete and hybrid dynamical systems, and other fields

A special issue of the *Journal of Combinatorial Optimization* will be dedicated to contributions presented at the conference. All articles will be refereed according to the high standards of the journal. The Guest Editors will be Bo Chen, Alexander S. Kulikov, and Silvano Martello.

Bo Chen
Alexander S. Kulikov
Silvano Martello

2 Committees

2.1 Program Committee

- Jacek Blazewicz
- Bo Chen
- Van-Dat Cung
- Alain Hertz
- Alexander S. Kulikov (chair)
- Silvano Martello
- Paolo Toth

2.2 Organizing Committee

- Tatiana Belova
- Alexander S. Kulikov (chair)
- Maksim Nikolaev
- Nikita Slezkin

3 Plenary Speakers

3.1 Andrea Lodi (Jacobs Technion-Cornell Institute at Cornell Tech and Technion)

Mathematical Programming Games: motivation, algorithms and challenges

In many decision-making settings, a selfish agent seeks to optimize its benefit given some situational constraints. Mathematically, the decision-maker's task is often formulated as an optimization problem whose solution provides a prescriptive recommendation on the best decision. However, decision-making is rarely an individual task: each selfish decision-maker often interacts with other similarly self-interested decision-makers. We explore the opportunities offered by the interplay of Mathematical Optimization and Algorithmic Game Theory by analyzing them through the lenses of a unified framework capable of integrating elements of the two disciplines. We introduce the taxonomy of Mathematical Programming Games (MPGs), simultaneous games where each agent decision problem is an optimization problem expressing a heterogeneous and possibly complex set of constraints. On the one hand, MPGs offer a rigorous and powerful mathematical framework for extending the broad family of problems involving the solution of combinatorial optimization problems – to name a few, logistics, scheduling, tactical decision-making – to a multi-agent setting. On the other hand, MPGs offer a novel perspective capturing the dynamics of strategic decision-making involving multiple agents solving optimization problems and help embed fairness paradigms into the decision-making process. We present a few motivating examples and applications of MPGs, and we overview the challenges and opportunities associated with this promising stream of research offers. (Joint work with M. Carvalho, G. Dragotto and S. Sankaranarayanan.)

3.2 Nikolaos Matsatsinis (Technical University of Crete)

Evolutionary and Swarm Intelligence Algorithms for Combinatorial Optimization Problems

In the last thirty years, a breakthrough was obtained with the introduction of metaheuristics, such as Simulated Annealing, Tabu Search, Genetic Algorithms and Differential Evolution. These algorithms have the possibility to find their way out of local optima. Also, the development and utilization of nature inspired approaches in advanced information systems became increasingly popular. The most popular nature inspired methods are those representing successful animal and micro-organism team behavior, i.e. birds flocks or fish schools inspired Particle Swarm Optimization, the imitation of biological immune systems led to the Artificial Immune Systems, the ants foraging behaviors gave rise to Ant Colony Optimization, the optimized performance of bees inspired Honey Bees Mating Optimization algorithm and Bumble Bees Mating Optimization algorithm, etc. We present a collection of different metaheuristic and nature inspired algorithms, we analyze and compare them based on their results when applied to some classic combinatorial optimization problems, like vehicle routing problem. Each metaheuristic and nature inspired method is presented not only in its classic form but also the most known variants of each method are presented and used in the comparisons. Thus, the methods presented are Genetic Algorithms and their variants, Differential Evolution and Particle Swarm Optimization and its variants. Genetic Algorithms (GAs) are randomized search techniques that simulate some of the processes observed in natural evolution and they offer a particularly attractive approach for many kinds of problems since they are generally quite effective in solving large-scale problems and for rapid global search of large, non-linear and poorly understood spaces. Differential Evolution (DE) is a stochastic, population-based algorithm. Although Differential Evolution is an evolutionary algorithm and, thus, it shares the basic characteristic of the evolutionary algorithms, it has a number of differences compared to them. Particle Swarm Optimization (PSO) is a population-based swarm intelligence algorithm that uses the physical movements of the individuals in the swarm. The advantages and disadvantages of these and other nature inspired methods are presented based on the results of the algorithms in classic combinatorial optimization problems.

3.3 Ulrich Pferschy (University of Graz)

Fairness and Conflicts: Allocating Items and Resources

Fairness issues have received widespread attention in combinatorial optimization. In this talk we will consider fair allocation problems related to subset sum and partitioning problems.

In the first part we consider the allocation of a bounded resource among several agents. For each agent the obtained share of the resource serves as a capacity bound for a subset sum problem with the agent's item set. If a central decision maker maximizes the total sum of item weights, this may result in a highly un- balanced allocation of the resource to the agents and hence be perceived as unfair. On the other hand, more balanced allocations may be far from the overall optimum. Therefore, we will discuss the resulting price of fairness, based on maximin, Kalai–Smorodinski and proportional fairness.

In the second part items cannot be selected by the agents themselves but are allocated by the central decision maker from a common ground set. However, agents can express their preferences by setting a profit value for every item. The decider wants to assign each item to an agent such that the satisfaction, i.e. sum of profits, guaranteed for each of the agents gets as high as possible. This maximin problem is known as the so-called Santa Claus problem. We extend this problem by introducing an incompatibility relation between pairs of items described in terms of a conflict graph. Every subset of items assigned to one agent has to form an independent set in this graph. Thus, the allocation of items to the agents corresponds to a partial coloring of the conflict graph. For this setting we present complexity and algorithmic results depending on the properties of the given conflict graph.

To allow a more flexible approach of expressing preferences we also introduce a new satisfaction measure based on a directed preference graph of each agent. We measure the dissatisfaction of an agent by means of the number of non-assigned items for which no more preferred item is given to the agent. From a fairness perspective we want to allocate the items to the agents in a way that minimizes the maximum dissatisfaction among the agents. Again we obtain NP-hardness results as well as polynomial algorithms with respect to different underlying graph structures, such as trees, stars, paths, and matchings.

4 Abstracts

Comparison of Scalarization Methods on Multi-objective Carpooling Problem

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(*joint work with* Zeliha Ergul Aydın, Zeynep İdil Erzurum Cicek)

Abstract

Carpooling is an efficient way to reduce traffic congestion, air pollution, and transportation costs. In the carpooling literature, optimization studies generally deal with a single objective as total distance traveled, the number of vehicles, and similar economic objectives. But in real life, there may be more than a single objective that users want to achieve in carpooling systems. In long-term carpooling problems, in addition to minimizing the total distance traveled, different objectives such as preventing the wear and tear of the vehicles or the fatigue that the driver will experience due to driving for consecutive days. For this reason, a multi-objective model for long-term carpooling problems is considered in this study. For the solution of the proposed model, Pareto solutions were tried to be obtained with the different scalarization methods as weighted sum scalarization, Pascoletti-Serafini scalarization, Benson's scalarization, and conic scalarization.

Keywords: Multi-objective optimization, carpooling problem, scalarization methods.

A Parallel Algorithm to solve Bi-Objective Knapsack Problem

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Abstract

The combinatorial optimization (OC) problem has received tremendous attention over the past few decades, and many real-world applications are modeled as OC, especially the knapsack problem. Research in this area tends to combine metaheuristics with other precise optimization methods. On the other hand, the parallel design of multi-objective evolutionary algorithm (MOEA) greatly improves the efficiency and effectiveness. In this work, we propose a hybrid multi-objective parallel evolutionary algorithm for the multi-objective knapsack problem (MOKP). The proposed method can be viewed as an extended parallel variant of the two-step approach, where the intermediate step uses the solution found in the first step to reduce the problem size.

Key words Two-phase method, Parallel Multiobjective Evolutionary Algorithms, Reduction Strategy, Multiobjective Knapsack Problem,Integer Linear Programming, Combinatorial Optimization.

Acknowledgements: The authors would like to thank the Director of LIFORCE Laboratory for his help and encouragement during the preparation of this paper.

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Biogeography based heuristic for the traveling repairman problem with time windows

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(*joint work with* İmdat Kara, Berna Dengiz)

Abstract

Traveling Repairman Problem (TRP), which is also known as the cumulative traveling salesman problem, the delivery man problem or the minimum latency problem, is a special variant of Traveling Salesman Problem (TSP). In contrast to the minimization of completion time (or cost or distance) of the tour objective of TSP, the desired objective of TRP is to minimize the cumulative latency (waiting time or delay time) of all customers. Latency of a customer is defined as the time passed until servicing of a customer. Most widely variant of TRP is the Traveling Repairman Problem with Time Windows (TRPTW), which is a combinatorial optimization problem. In this paper, we propose a biogeography-based optimization algorithm (BBOA) as a metaheuristic approach to solve large size TRPTW problems. Detailed computational analysis is conducted by solving symmetric and asymmetric instances given in the literature. The proposed metaheuristic is analyzed in terms of solution quality, coefficient of variation as well as computation time. It is observed that, proposed heuristic has better performance than the existing heuristic developed for TRPTW. The efficiency of the proposed solution methodology is demonstrated by solving instances up to 400 customers within seconds. Main contributions of this paper may be briefly stated as: to define and present a biogeography-based optimization algorithm (BBOA) as a metaheuristic approach to solve large size symmetric and asymmetric TRPTW problems.

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A knapsack problem for rectangles under the gravity center constraints

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(*joint work with* Yuriy Kochetov)

Abstract

We consider a two-dimensional knapsack problem for rectangular items with a gravity center constraint. We have a set of rectangles with pre-defined widths, lengths, and masses and a knapsack with known width and length. Our goal is to select a subset of items and find their packing into the knapsack without overlapping so to minimize an empty space in the knapsack and the total gravity center of such items deviates from the geometric center of the knapsack at most a constant in both axes. We build a mixed- integer linear programming model for this problem and test Gurobi solver for it. This approach allows us find optimal or near optimal solutions for instances with up to 50 rectangles. For large scale instances, we develop a local search algorithm, which uses the item permutations to represent the solutions and the skyline heuristic [1] as a decoding procedure. The gravity center constraint is relaxed and included into the objective function with a penalty. To find the best permutation, we apply the simulated annealing algorithm with swap neighborhood and random starting permutation. Computational results for different classes of test instances are discussed.

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Pareto optimization of two-agent scheduling on mixed batch machines

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(*joint work with* Jun-Qiang Wang)

Abstract

This work is motivated by the assignment of different orders in a vacuum heat treatment workshop. Vacuum heat treatment furnace is widely used in heat treatment of tools, molds and precision coupling parts. Heat treatment of workpieces in vacuum can prevent oxidation and decarburization, and hence helps maintain original luster and desirable surface properties. It also has degassing effect, which is beneficial to improve certain mechanical properties of workpieces. After vacuum heat treatment, workpieces have little distortion, high quality, and long service life. The vacuum heat treatment furnace is modeled as *mixed batch*[1]. The operations on mixed batch machines have longer processing time compared to that on single item machines. Thus, the mixed batch machines are often structural bottlenecks compared to single item machines. There is intensive competition among different orders over limited capacity of mixed batch machines. This work assign jobs to mixed batch machines in order to balance the benefits of different orders.

This work study a Pareto optimization problem of scheduling jobs of two competing agents on mixed batch machines. The processing of a mixed batch is the weighted sum of the maximum processing time and the total processing time of the jobs in the batch. The jobs have different processing times and non-identical job sizes. The objective is to find Pareto optimality and the corresponding schedules for minimizing both agents' makespans. We identify a region covering all the Pareto optimal points, and thus reduces the search space. And an approximate Pareto region is then obtained such that all the obtained points are 5-approximate Pareto optimal. We propose an integrated algorithm to find the approximate Pareto optimal points. Specifically, the integrated algorithm transforms the Pareto optimization problem into two constrained optimization problems based on ε-constraints method, and then proposes a reserved-space heuristic and a feasibility test heuristic to solve these constrained optimization problems. Our computational study shows that the proposed algorithm outperforms the widely used non-dominated sorting genetic algorithm (NSGA-II). Further, our obtained set of approximate Pareto optimal points is very close to the set of all Pareto optimal points.

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A Weighted-based heuristic for Lifetime Maximization in Wireless Sensor Networks

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Abstract

Lifetime extension plays a crucial issue in wireless sensor network applications. An effective mechanism to extend and maximize the lifetime is to partition the deployed sensors into disjoint subsets of sensors (sensor covers) such that each subset covers all targets completely and works alternatively. Finding the optimum number of disjoint sensor covers is formulated as the set k-cover problem, which has been proved to be NP-complete. This paper presents a novel greedy-based heuristic algorithm to address this problem. It comprises two parts: the first one greedily constructs set covers based on the well-known similarity measure Jaccard factor, and the second one ensures that each set cover will not contain redundant sensors. The proposed heuristic was evaluated on common 1000 benchmark instances and compared to other greedy-based approaches from the literature. Simulation results show its effectiveness in generating good solutions in reasonable computation time and scalability for large problem instances.

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On two-stage binary quadratic modeling under uncertainty for Cross-Dock Design

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Abstract

Given a network with a set of supplying (i.e., origin) nodes and a set of receiver (i.e, destination) nodes of those products, a cross-dock entity may serve as a product consolidation point. The origin nodes can deliver the products at the cross-dock, so that, after being classified by type and destination, the products it can be transported (usually, in smaller quantities) to the destination nodes. A cross-docks has a number of receiving doors, so-named strip ones, and a number of exiting ones, so-named stack doors, each of them with a capacity for product pallets handling during a given time period. The assignment of origin / destination nodes to strip / stack doors is a difficult binary quadratic combinatorial problem. A two-stage stochastic binary quadratic optimization model is presented in this work for the cross-dock infrastructure design planning, where the strip and stack doors as well as the related capacity levels must be decided. The uncertainty lies in the set of origin nodes, the set of destination ones, and the door capacity diminishing due to disruptions; it is represented by a finite set of scenarios. A Linearized mixed Integer Programming Problem (LIP) that is mathematically equivalent to the quadratic one is introduced by using the Sherali-Adams Reformulation Linearization Technique RLT1 when the circumstances allow it and otherwise, by using the Fortet (also known as the McCormick) inequalities. A Lagrangean decomposition (LD) is instrumented for model's decomposition in cluster scenario submodels. For that purpose, a dualization of the first-stage variable splitting constraints (where the cross dock building is considered) helps to obtain a (hopefully, strong) lower bound to the LIP solution value by exploiting the GAPs in the cross-dock representation. yation.onstructure. A lazy heuristic scheme is introduced for obtaining feasible solutions for the original model, based on the first stage LD solutions and also exploiting the cross-dock structure.

Acknowledgements: This research has been partially supported by the research projects RTI2018-094269-B-I00 (L.F. Escudero), and PID2019-104933GB-I00 from the Spanish Ministry of Science and Innovation (M.A. Garín), and Grupo de Investigación EOPT (IT-1252-19) from the Basque Government, GIU20/054 from University of the Basque Country (UPV/EHU).

Artificial Neural Network Time Series Model with Multi Objective Optimization for Renewable Energy Developments

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(*joint work with* Chaabane Djamal, Amarouche Khalid , Bachari Nour El Islam)

Abstract

The growing interest and demand for energy and clean energy has led to an acceleration of research related to the evaluation and prediction of the energy source. On the other hand, the world has industrialized and the need for renewable energy is growing exponentially, especially solar, in order to provide energy in the future without harming the environment. One of the forecasting approaches followed recently is the technique of artificial intelligence by artificial neural networks based on numerical forecasting of time series especially in the field of renewable energy and arouses a growing interest among the meteorological communities. The development of Artificial Neural Networks (ANN) models for daily forecasts of weather data time series for most regions of the globe is difficult and rarely documented. Until now, the most difficult problem is to obtain the adequate architecture of the network such as the number of neurons in the hidden layer. To address this problem, a new approach is introduced by the present web application to develop a multi-objective strategy of ANN models that lie at or near the Pareto front in order to allow the user to find a set of ANN with the best architectures, corresponding to optimal trade-off solutions between model simplicity and accuracy. For the evaluation of the performance of the developed ANN models, a test application of two ANN models of daily solar radiation prediction were developed and validated for a station in the city of Oran in northwest Africa which is a coastal area characterized by a semi-arid Mediterranean climate. In one of the ANN models, we considered seasonality during training by developing four independent neural networks for each season and in the other, seasonality was not considered. The ANN training is based on long-term reanalysis data MEERA2 (The Modern-Era Retrospective Analysis for Research and Applications, Version 2) from NASA, which allows to train the models even in areas where no radiation measurements are available or cover a short period of time, as is the case. On the other hand, a data set of thirty-nine years between 1980 and 2018 has been used for the training and implementation of the model, and the test is carried out with respect to the year 2019. The results obtained show that the models developed and optimized using this web application has a good performance. Thus, taking into account the seasonality slightly improves the accuracy of forecasts. The Root Means Square Error (RMSE) obtained for 348 days, is 3.112 $Mj/(m^2d)$. A value that reflects a good accuracy of the ANN model developed by

A fuzzy linguistic preferences based method for solving bi-level programming problems

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(*joint work with* Zainab Asim, Syed Mohd Muneeb)

Abstract

Bi-level programming problems are a special case of multi-level programming problems, where the model consists of only two objective functions. The two objective functions, often conflicting in nature, are generally formulated as decentralized hierarchical decision making system. First objective function at the upper level of hierarchy is controlled by the decision makers we call as leader. Whereas, the objective function at the lower level of hierarchy is controlled by the decision makers we call follower. Mathematically, bi-level programming problems are considered as NP hard problems, which make it a complex optimization problem. In this article, we have proposed an alternative approach to solve the bi-level programming problems. In the proposed method we have used the concept of fuzzy logic, by developing membership functions for the decision-variables and the objective functions. For developing the membership function for the decision variables, fuzzy linguistic preferences are used as modelled by Hashmi et al. (2019). Three types of membership functions viz. linear, exponential, and parabolic are developed and the results obtained were compared. The efficiency of the proposed model is tested on numerical examples taken from the literature. The model can further be applied on various application fields of bi-level programming problems such as supply chain management (Jalil et al., 2018), advertising allocation (Munneb et al., 2018), vendor selection problem (Adhami et al., 2017) etc.

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Scheduling data gathering with background communications and a processing stage

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(*joint work with* Baruch Mor)

Abstract

We analyze scheduling in data gathering networks with background communications. The network consists of many worker nodes and a single base station. Each worker holds a dataset that has to be sent to the base station, and then processed by it. At most one worker can transfer data at a time, and hence, the network works in a flow shop mode. The speed of each communication link may change in time because of various processes using the network. Thus, a link is considered either free or loaded at a given time. Communication and computation preemptions are possible. The objective is to minimize the time required to gather and process all data.

We prove that the problem is strongly NP-hard and indicate several polynomially solvable cases. In particular, an optimum schedule can be found in polynomial time if all links are loaded in the same intervals and certain relations between their communication speeds and the computation speed hold.

Designing exact algorithms for the analyzed problem is challenging because there exist instances where constructing an optimum schedule requires preempting a dataset transfer at a time when no link speed changes. Thus, it is not known which moments should be taken into account as possible communication preemption points. Therefore, we propose heuristic algorithms and test them using computational experiments. On the basis of the obtained results, we give recommendations about the algorithms that should be used for solving the problem in different types of networks.

On Disjoint Maximum and Maximal independent sets in graphs and Inverse Independence number

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Abstract

In this paper, we are interested in the existence of disjoint maximum and maximal independent set (disjoit MMI) in graphs. Note that not all graphs contain disjoint MMI, as an example, graphs with isolated vertex does not contain any disjoint MMI. We give a class of graphs that do not admit a disjoint MMI.

The concept of inverse independence was intoduced by P.G.Bhat and S.R. Bhat in [2]. Let A be a α-set in G. An independent set $D \subset V(G) - A$ is called an inverse independent set with respect to A. The inverse independent number $\alpha^{-1}(G)$ is the size of the largest inverse independent set in G. P.G.Bhat and S.R. Bhat gave few bounds on independence number of a graph, we continue the study by giving some new bounds and exacte value for particular case: spider tree, the rooted product and cartesian product of two particular graphs.

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RNA World - stability of ODE model with limited resources

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(*joint work with* Agnieszka Rybarczyk, Jacek Blazewicz)

Abstract

RNA World Hypothesis posits that at the very beginning, RNA performed all necessary biological functions, it could act both as an enzyme and an information carrier. Modeling such systems presents many challenges, since mechanisms and conditions which had existed in RNA World had been changed by billions years of biological evolution and geological processes. Despite the impossibility of taking any direct measurements, scientists try to create different models based on the laws of chemistry and physics, which would explain how RNA molecules could have emerged and form a population capable of survival and natural selection. One of such approaches are multi-agent systems used by the authors to check different scenarios and experiment with parameters to infer the general laws governing the evolution of RNA World. The results were proven analytically using differential equations as a continuous approximation of the aforementioned simulations. The main conclusion is that despite limited resources, imperfect replication and presence of parasites (RNA molecules unable to act as replicators themselves, but utilizing other molecules to propagate), the survival and stability of the system are possible.

Developing An Efficient Sustainable Grey Bi-level Model for Healthcare Waste Management

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(*joint work with* Syed Mohd Muneeb, Syed Aqib Jalil)

Abstract

Due to outbreak of Pandemic the world faces a very serious issue of handling the healthcare waste management (HWM). The disposal of HWM is posing a challenging issue in current scenario [Saadat et al. (2020)]. To put a check on spread of covid-19 virus, it is imperative to have a proper waste management [Nzediegwu and Chang (2020)]. This paper formulates a decision-making model to optimally allocate medical waste, considering the total cost and carbon footprint generated during transportation and the opportunities created through medical waste management. The paper uses grey linear programming and fuzzy set theory to reach the compromise solution for Bi-Level Multiobjective problem. The problem is first solved using grey linear programming (GLP). Membership functions are then created and used for controlling factors using maximum allowable tolerance values as well as for the goals of both the levels [Asim et al (2021)]. To validate the feasibility and applicability of the proposed model, it is further investigated by taking a case study from Aligarh, India.

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A matheuristic approach for the supplementary school timetabling problem

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(*joint work with* Alexander Lyapin)

Abstract

We consider a new timetabling problem that arises in a real-life application. A school, which provides an additional educational service, improving English language knowledge, aims to enroll an educational process. At first, the school collects the applications from potential students. Each of them indicates the set of time windows he(she) is able to attend the lessons in and take a part in a trial lesson to define their level of knowledge. When a reasonable number of applications is received the school runs the schedule construction process. Students are united into small groups if they have similar ages, the same level of knowledge, and shareable time windows. The size of a group is limited. Students who do not fit the current schedule, are kept on the waiting list until some more applications arrive. The process then is repeated, additional groups and lessons are added to the previous schedule. The objective of the school is two-fold: maximize the number of students attending while keeping a high number of students in a group on average. In this research, we provide a mathematical model for the described problem in terms of integer linear programming. We propose a hybrid algorithm combining a MIP solver for a simplified version of the problem and a constructive heuristic to solve the entire problem. Computational results carried on real and artificially generated instances show that the proposed approach is able to find solutions close to optimal.

Computing quantile-based Makespan risk in Interval Valued Activity Networks

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Abstract

Temporal activity networks are extensively adopted in various domains to model planning and scheduling problems with analysis and optimization purposes. In this work we consider the case in which a temporal activity network resulting from a prior optimization process is given and the decision maker wants to assess some risk measures since the produced schedule may be affected by uncertainties on the activity durations. More specifically, we consider the case in which for each uncertain activity only the interval for its integer valued duration is assumed to be known in advance to the scheduler. In these contexts, considering both the possible sources of uncertainty and the decision maker attitude with respect to risk, it is of interest to evaluate of the quantile (value-at-risk) and the superquantile (conditional value-at-risk or expected shortfall) of a selected performance index to control both its expected value and its variability.

This talk proposes a set of new heuristics devoted to the evaluation of quantile-based risk measures for the makespan given an interval valued temporal activity network affected by uncertainties related to the activity durations representing the schedule. These risk measures are of interest as risk indicators in various real-world applications [1,2]. To this aim we propose and test a set of novel heuristics to determine rapid and accurate numerical estimations [1]. An extensive experimental campaign on project scheduling benchmark instances computationally shows the validity of the proposed algorithms and their promising performance compared to the state-of-the-art approaches.

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Alternative solving methods for Configuration Space Search Problem

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Abstract

The configuration parameter settings play a crucial step in tuning the performance of the wide range of algorithms available today. Finding the best configuration of these parameters for a specific algorithm is a time-consuming and challenging task in practice. Most algorithms have many configurable parameters, and a methodology that automates this process can be extremely useful. It is the case for some companies that need to run the same algorithm several times during a day but change only a subset of the problem's input data.

In [1-3], this problem, known as Algorithm Configuration Problem (ACP), is formulated as an optimization problem. The constraints define the feasible configurations, and the objective optimizes the performance function. The methodology has two phases: In the first phase, the Machine Learning predictor is trained to estimate the performance of a given algorithm with a set of configurations. For this, Support Vector Regression (SVR) using Gaussian kernel is used to help handle data with many dimensions in an efficient way. Then, the performance of this learned approximation is used in a mathematical problem formulation.

In this work, we focus on the second phase, the recommendation phase of the method. Formally, we find the configuration settings for a given instance that optimize the performance approximation, also called Configuration Set Search Problem (CSSP). This problem is a nonconvex Mixed-Integer Non-Linear Programming (MINLP) problem since the SVR function learned via a Gaussian kernel is nonconvex. This work focuses on the solution of CSSP via alternative methods to find a good tradeoff between CPU time and the quality of the provided solution.

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RNAsolo: a structural study-aimed RNA database

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Abstract

Consider the problem of comparative analysis of algorithms that model or predict 3D RNA structures. To conduct such an analysis and evaluate the accuracy and reliability of the algorithms, one needs the appropriate benchmark sets. The latter should be large enough and free of redundancy. So far, there have been no ready-made online collections with such characteristics or tools to create them automatically.

We present RNAsolo [1], a new database system to support training, testing, and benchmarking algorithms dedicated to RNA structural bioinformatics. It collects all experimentally determined RNA-containing structures deposited in the Protein Data Bank [2], cleans them from non-RNA chains, and organizes them into equivalence classes according to the BGSU nonredundant datasets [3]. The system provides users with clear structure visualizations, statistics of database contents, and user-friendly search functions. RNAsolo is a self-updating resource that synchronizes with up-mentioned databases every week. It offers 192 archives with RNA 3D structures (mmCIF, PDB) or sequence data (FASTA), grouped by molecule classification, redundancy, and resolution cutoffs. Any of these subsets can be downloaded using a one-click operation. The database is freely available at https://rnasolo.cs.put.poznan.pl

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Annihilator graph of the ring $C_F(X)$

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(*joint work with* Sudip Kumar Acharyya, Atasi Deb Ray)

Abstract

The annihilator graph of a commutative ring was first introduced by Badawi. Consider X as a completely regular Hausdorff space with finitely many isolated points. $C_F(X)$ is the socle of the ring $C(X)$ of all real-valued continuous functions on X, which consists precisely all continuous functions which vanish everywhere except on a finite number of points of X. In this article, we discussed about the annihilator graph $AG(C_F(X))$ of the ring $C_F(X)$. We find out that, $AG(C_F(X))$ is an infinite connected graph with diameter 2. We also show that, $AG(C_F(X))$ is always triangulated. It is also proven that $AG(C_F(X))$ is uniquely complimented if and only if X has at most three isolated points. Beside being an infinite graph with diameter 2, we showed that $AG(C_F(X))$ can be colored by using only finitely many colors.

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Effective Generation of The Alternative Optima Set for Integer Programming

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Abstract

Optimization problems consist of finding a solution, in a predefined set, that achieves the best evaluation according to an objective function. However, in practical studies, there may be un-modeled aspects or qualitative constraints. Hence, the decision-making process may require the so-called alternative optima. The existence of these solutions offers options to the decision-maker without being forced to deteriorate the decisions quality. In this paper, we present an effective algorithm for generating the set of all optimal alternative solutions. The suggested algorithm is fully adapted for integer programs with binary variables. The generation process consists of solving a minimal series of integer programs, where each is designed to target a new alternative solution with a different predefined characteristic.

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A two-stage heuristic for the trailers waiting time optimization with uncertain arrival times

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Abstract

We present a new loading/unloading trailer scheduling problem for a logistics company. There is a building with several warehouses. Each warehouse stores pallets of different types of products in rooms for loading into trailers. Also, each warehouse has two gates. One gate is for the trailers, another one is for two forklifts from the central zone. At most one forklift can work in each warehouse at a time. The central zone is a production line. It produces some products which must be placed in the warehouses by the no wait rule. We know how the central zone is working during each day, i.e. when each pallet becomes available for putting away. Outbound trailers come to pick up some pallets of a product. Inbound trailers come to put away some pallets of a product. We assume that the arrival time for each trailer is uncertain. Our goal is to assign all trailers to warehouses and find scheduling for service all the trailers with the maximum stability radius, taking into account that the total waiting time for the trailers cannot exceed the given threshold [2]. For this NP-hard problem, we design a two-stage heuristic. First of all, we solve the simplified model using the Gurobi solver. Later on, the VNS algorithm [1] is used to return the solution to the feasible region taking into account detailed information about pallets in each warehouse. Computational results for 6 warehouses, 18 types of products, and 90 trailers are discussed.

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Cost Minimization of Slab Bridges by means of Pattern Search

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Abstract

Slab bridges are a type of bridge with costs similar to those of precast girder bridges. The optimization of different design variables of slab bridges can be a competitive aspect when opting for this type of construction. We have considered the economic cost of the deck as the parameter to be minimized. The optimization of a slab deck can involve the maximization or minimization of several objectives, such as price minimization, safety coefficient maximization (structural resistance), prestress minimization, and weight minimization, among others. All these functions exhibit different behaviors, so that, for example, a design change that decreases the price may probably decrease the safety level of the structure or, in order to maintain it, require an increase in the prestressing force. Therefore, this problem could be approached as a multiobjective optimization problem. However, all of these functions can also be considered as constraints to the problem, for example, by setting a maximum price, a minimum safety coefficient, etc.

On the other hand, the price of the deck can be approached as a linear combination of the quantity of the different materials that are part of it, being the coefficients of that combination the unit prices of each material. In order to find an optimal combination of the design parameters that produces a minimum deck price, avoiding approximate or manual calculation methods, we propose the use of a single-objective optimization metaheuristic: pattern search. This technique has provided accurate results in reasonable computing times.

A VNS Algorithm for Solving Quadratic Assignment Problem

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Abstract

Quadratic Assignment Problem (QAP) is a hard combinatorial optimization problem. Due to solving QAP with exact methods is extremely hard, several meta-heuristics have been proposed. Variable neighbourhood search is a meta-heuristic algorithm that explores distant neighborhoods of the current incumbent solution, and moves from there to a new one if and only if an improvement was made. In this study, we propose a VNS with different neighborhoods and wise shacking mechanisms. The performance of the proposed algorithm is shown and reported on literature instances.

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Matheuristics and Local Search for the Quadratic Multiple Knapsack Problem

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(*joint work with* Silvano Martello, Carlos Rey, Paolo Toth)

Abstract

In the *Quadratic Multiple Knapsack Problem* (QMKP), we have m knapsacks and n items. The ith knapsack has a capacity c_i. The jth item has a profit p_j and a weight w_j. Moreover, if two items j, k are assigned to the same knapsack they produce a *pairwise* profit p_{jk}. The objective is to assign m disjoint subsets of items to the knapsacks with maximum total profit, such that the total weight of the items assigned to any given knapsack does not exceed the capacity of that knapsack.

The QMKP generalizes simultaneously the well-known Quadratic Knapsack Problem (QKP) and the Multiple Knapsack Problem (MKP), which are both strongly $\mathcal{NP}$-hard. Despite its thoeretical intractability, the problem has applications in several real-world situations like project management, capital budgeting, product-distribution system design.

Research on its exact solution started quite recently with Bergman (2019), who proposed column generation techniques and tested them on a set of small-sized benchmark instances. More recently, Galli et al. (2021) presented polynomial-size formulations and relaxations of the problem, while Fleszar (2022) proposed a branch-and-bound algorithm which is currently the best performing exact approach for the QMKP. In this study, we propose the first matheuristic approach for the QMKP relying on the strength of the Lagrangian relaxation for the natural quadratic formulation of the QMKP, which can be exploited to generate "high quality" subsets of items to be packed into the knapsacks. The matheuristic is combined with effective postoptimization local search procedures that are embedded in the final framework. Experimental studies show that our method is competitive with the branch-and-bound algorithm by Fleszar.

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On the arboreal jump number of a poset

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Abstract

An arboreal extension of a poset is a generalization of a linear extension, in which the relative order of each pair of elements in the poset is preserved and the extension has an arboreal structure. A jump is a pair of consecutive elements in the extension which is incomparable in the original poset. The arboreal jump number is an NP-hard problem that aims to find an arboreal extension of a given poset with minimum number of jumps.

This work reveals a relation between the number of jumps of an arboreal order extension and the size of a partition of its elements that satisfy some structural properties of the covering graph. This relation is presented as a characterization of the instances of the problem that admit an extension with a certain number of jumps.

Then, we propose two integer programming models to solve the problem. One of them is a flow based model of polynomial size and the other has an exponential number of cut-set constraints. Finally, we provide a heuristic that is built on an algorithm from the literature to find a minimal arboreal extension.

In this work, we introduce the first benchmark set of instances for the arboreal jump number problem. Our computational results show that we are able to exactly solve instances with up to 100 elements with execution time limited to 30 minutes. Furthermore, our heuristic seems to be a suitable method to find good feasible solutions in a short amount of time.

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A new hybrid genetic algorithm to minimize cycle time for the Simple Assembly Line Balancing Problem

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Abstract

The Simple Assembly Line Balancing Problem is concerned with the assignment of tasks to different workstations of an assembly line, with the objective of maximizing its efficiency. This is usually achieved by either minimizing the number of workstations given a cycle time, or by minimizing the cycle time for a given number of workstations. Our work focuses on the resolution of the latter, which is known in the literature as SALBP-2, by means of a hybrid genetic algorithm.

The proposed algorithm uses a novel encoding system which encodes individuals of the genetic algorithm as instances of a modified problem (specifically, a problem which includes incompatibilities between tasks, SALBP-IBT). This problem contains, by definition, only a subset of the solutions of the original instance. Then, a dynamic programming based method with novel bounds is used to decode the individuals and test their fitness.

The computational experiments show that the algorithm is able to find several new best-known solutions in the reference set of benchmark instances used in the literature.

Dynamic Optimization Algorithms for Same-Day Delivery Problems

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(*joint work with* Jean-François Côté, Thiago Alves de Queiroz, Manuel Iori)

Abstract

In recent years, online purchases have become more and more a common practice to request services or goods at home, changing the habit in which many traditional markets operate. A huge number of e-commerce sellers appeared on the web, and many companies changed their focus to direct-to-consumer deliveries to expand their business. As a consequence, the delivery of online purchases has become a crucial logistic activity. Historically, this type of problem has been addressed in the field of stochastic dynamic vehicle routing problems. In the problem we face, the requests arrive dynamically during the day and must be served within a strict time window. The aim is to use a fleet of vehicles to maximize the number of served requests and minimize the traveled distance. This problem is known in the literature as the *Same-Day Delivery problem* (SDDP). We solve the SDDP by proposing efficient solution algorithms, ranging from a simple reoptimization heuristic to a sophisticated branch-and-regret (B&R) heuristic in which sampled scenarios are used to anticipate future events. All algorithms adopt a tailored adaptive large neighborhood search to optimize the routing plans. We also present two new consensus functions to select routing plans for implementation, and propose strategies for determining the number and size of the sampled scenarios. The algorithms are also adapted to solve the problem variant where vehicles are allowed to perform preemptive returns to the depot. Extensive computational experiments on a large variety of instances prove the outstanding performance of the B&R, also in comparison with recent literature ([1] and [2]), in terms of served requests, traveled distance, and computing time.

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A Kernel Search Heuristic for a Fair Facility Location Problem

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Abstract

We consider an uncapacitated location problem where p facilities have to be located in order to serve a given set of customers, and we assume that a customer requesting a service has to reach a facility at his/her own cost. In this setting, a central issue is that of not discriminating among customers for the accessibility to the service provided. Every choice regarding the location of facilities corresponds to a distance distribution of customers to reach an open facility. Minimizing the average of this distribution would lead to a p-median problem, where system efficiency is optimized but the fair treatment of users is neglected. Minimizing the maximum distance over the customers would lead to a p-center problem, where the unfair treatment of users is mitigated but system efficiency is neglected. To compromise between these two extremes, we minimize the conditional β-mean, i.e., the average distance traveled by the given percentage β of customers that have to travel the longest distance from a facility. We call Fair Facility Location Problem (FFLP(β)) the resulting optimization problem, which is formulated as a Mixed Integer linear Program (MIP) with a proven integrality property. We propose a heuristic framework to produce a set of representative solutions to the FFLP(β). The framework is based on Kernel Search, a heuristic scheme that has been shown to obtain high-quality solutions for a number of MIPs. Computational experiments are reported to validate the quality of the solutions found by the proposed solution algorithm, and to provide some general guidelines regarding the trade-off between average and worst-case optimization. Finally, we report on a case study stemming from the screening activities related to the pandemic triggered by the SARS-CoV-2 virus. The case study concerns the optimal location of a number of drive-thru temporary testing sites for collecting swab specimens.

Knapsack problems
An Overview of Recent Advances

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(*joint work with* Valentina Cacchiani, Manuel Iori, and Silvano Martello)

Abstract

A systematic research on the knapsack problem and its many variants started in the Fifties. It produced, over the next fifty years, an impressive number of scientific results, making this field a very relevant area of combinatorial optimization. The two seminal books devoted to this area, by Martello and Toth in 1990 and by Kellerer, Pferschy, and Pisinger in 2004, include in total about 700 bibliographic entries. In this presentation, structured in two parts, we cover the developments appeared in this field after the publication of the latter volume, until Summer 2021.

Part I is devoted to problems whose goal is to optimally assign items to a single knapsack. Besides the classical knapsack problems (binary, subset sum, bounded, unbounded, change-making), we review problems with special constraints (setups, multiple-choice, conflicts, precedence, sharing, compartments) as well as relatively recent fields of investigation, like robust and bilevel problems. *Part II* covers multiple, multidimensional (vector and geometric), and quadratic knapsack problems, but also presents a succinct treatment of online and multiobjective knapsack problems.

The two parts are based on over 450 different papers, mostly appeared after 2004, the publication year of the latter of the two classical books specifically dedicated to these topics. Recent research has produced a good number of new exact algorithms, but there is still room for improvement on many problem variants. The publication dates of most reviewed articles (over 70% of the articles in the bibliography appeared in the last decade) indicate that all the main variants and generalizations of these problems still undergo intensive analysis and hence are attractive research areas to researchers interested in pursuing investigations in this fascinating area.

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Cellular Network Rollout Scheduling

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Abstract

Cellular Network Rollout Scheduling is a process of building new base stations which should meet a large variety of constraints and business requirements. To build new base station specialists need to complete a chain of tasks using equipment and non-renewable materials. Specialists have different skills, costs of work, qualification, and they work in different companies (contractors). From mathematical point of view this process can be modeled as a generalization of Resource Constraint Project Scheduling Problem. This classical scheduling problem is known to be NP-hard in a strong sense (see [1]). In considered statement task release times are 0 and deadlines are equal to the end of planning horizon. Renewable resources are replaced by more complex specialists assignment requirements. The schedule should satisfy non-renewable resource constraints, where resources are located on several warehouses, and should satisfy precedence relation constraints with time lags.

The objective is to minimize the penalty function consists of the following components:

- makespan;
- cost of work;
- tasks distribution fairness.

We propose an approach to find optimal solution for industrial cases in a few minutes. It is based on the decomposition of the problem in two parts without loss of any feasible solution on the first stage. MILP/CP are used to solve the volume-calendar planning part and greedy heuristic is used for solving task assignment part in an optimal way. Numerical experiments on industrial large-scaled data instances proved the efficiency of the proposed approach.

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New Mixed Integer Nonlinear Optimization Models for the Clustering Problem

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(*joint work with* Marcella Braga, Renan Pinto)

Abstract

A new approach to the clustering problem is presented. Mixed Integer Nonlinear Optimization models are proposed. The distinguishing feature of the new models is that they are developed in a way that avoids the problem of non-differentiability and non-convexity in their continuous relaxation. And the relevance of these new approaches is consolidated through the computational results obtained for small and median size examples.

The Restricted Inverse Optimal Value Problem on Minimum Spanning Tree under Weighted l_∞ Norm

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Abstract

In this paper, we consider the restricted inverse optimal value problem on minimum spanning tree under weighted l_∞ norm. In a connected undirected network $G = (V, E, \mathbf{w})$, we are given a spanning tree T^0, a weight vector $\mathbf{w}$, a lower bound vector $\mathbf{l}$, an upper bound vector $\mathbf{u}$, a cost vector $\mathbf{c}$ and a constant K. We aim to obtain a new weight vector $\mathbf{w^*}$ satisfying the lower and upper bounds such that T^0 is a minimum spanning tree under the vector $\mathbf{w^*}$ with weight K. The objective is to minimize the modification cost $\max_{e_i \in E} c_i |w_i^* - w_i|$ under weighted l_∞ norm. We first analyze some properties of feasible and optimal solutions of the problem and develop a strongly polynomial time algorithm with running time $O(m^2 n)$, where $m = |E|, n = |V|$. Then we reduce the time complexity to $O(m^2 \log n)$ by devising a more complex algorithm using a binary search method. Thirdly, we apply the first algorithm to the restricted inverse optimal value problem under unit l_∞ norm, where $c_i = 1$, and obtain an $O(mn)$ time algorithm. Finally, we give some examples to demonstrate the algorithms and present some numerical experiments to show the effectiveness of these algorithms.

Acknowledgements: The work of X.C. Guan was supported by National Natural Science Foundation of China (11471073).

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Combining Reinforcement Learning and Adaptive Large Neighborhood Search for the Capacitated Vehicle Routing Problem

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(*joint work with* Zhibin Chen)

Abstract

Combinatorial optimization has found applications in transportation, management and other fields, and the solution of example problems has important theoretical significance and practical value. Recently, Deep Reinforcement Learning (DRL) has shown its promise for designing good heuristics dedicated to solving NP-hard routing problems. However, current approaches have three shortcomings: (1) Methods based on single DRL are still not as good as traditional methods, and (2) The performance of the current model needs to be improved. It is limited by the size of the instance, especially in the large scale of routing problems, and (3) DRL models only provide a solution with no systematic ways. To close this performance gap, we creatively propose a hybrid approach, based on DRL and Adaptive Large Neighborhood Search (ALNS), for solving Capacitated Vehicle Routing Problem (CVRP). The core of our model is based on an ALNS formulation, that DRL is a bridge between CVRP and ALNS. In addition, the combination of DRL and graph neural networks enhances the information representation of the neural network for CVRP. This method improves the training efficiency of the model. The experimental results show that the optimization of our model on CVRP surpasses current DRL methods and some traditional algorithms. Moreover, our model can generalize well to different problem sizes and even real-world datasets.

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An Iterated local search for Solving the Total weighted earliness tardiness Blocking Flowshop scheduling problem

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(*joint work with* Younes Boujelbene)

Abstract

Nowadays, the idea of punctual delivery in many industries arise. Therefore, customers need a fixed date in time to receive their commands. Indeed, this due date could be replaced by an space of time to be more feasible than a point of time. In this paper, the flowshop scheduling problem with blocking constraint is introduced aiming to minimize the total weighted earliness tardiness from the due date window. A few works in the literature have considered this problem and have proven that it is NP-hard. Therefore, we propose in this work two methods based on iterated local search in order to solve the problem. A benchmark of 110 instances is used to test the efficiency of our proposed proposal which is compared with a set of 4 competing methods well selected from the scheduling literature. All procedures are re-implemented and calibrated in order to give maximum effectiveness. This result has allowed us to affirm the performance of our proposal.

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Branch-and-cut for the distributed no-wait flowshop scheduling problem

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(*joint work with* Mualla Gonca Avci, Alper Hamzadayı)

Abstract

The no-wait flowshop scheduling problem (NWFSP) is one of the most studied variants of the the classical flowhop scheduling problem where the jobs need to be processed without any interruption between their operations. The distributed no-wait flowshop scheduling problem (DNWFSP) generalizes the NWFSP by considering multiple identical factories working in parallel. The DNWFSP contains two types of decisions, allocating jobs to the factories and sequencing the set of jobs allocating to the same factory. In this study, we develop a branch-and-cut algorithm to solve the DNWFSP. In the developed algorithm, a heuristic is incorporated into the branch-and-cut framework to obtain good upper bounds. In addition, we use a set of symmetry breaking inequalities to tighten the formulation. The performance of our approach has been tested on a set of benchmark instances available in the DNWFSP literature. The computational results underline the good performance of our algorithm.

Optimizing VF Placement in UAVs for 5G Network and Service Provisioning

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(*joint work with* Giorgia Maria Cappello, Patrizia Daniele, Laura Galluccio, Christian Grasso, Giovanni Schembra, Laura Scrimali)

Abstract

In the last few years, 5G technologies have become an essential part of our daily life and their impact is revolutionizing all economic and social sectors. This talk deals with the use of Unmanned Aerial Vehicles (UAVs), equipped with Computing Elements, combined with 5G technology, that has emerged as a powerful tool to extend and improve the capability of 5G networks. We present a system architecture based on the use of UAVs organized as a Flying Ad Hoc Network (FANET) to provide remote areas with a 5G softwarized network where running service chains of Virtual Functions (VFs) with strict requirements in terms of maximum tolerated delays. We introduce two VF placement and chaining strategies, named *MemoryLess Placement* (MLP) and *With-Memory Placement* (WMP), aimed at minimizing the overall energy consumption while maximizing the overall packet rate that is served. The proposed optimization model takes into account the processing capabilities available on board each UAV, and the transmission rate of the communications links between UAVs. Furthermore, we propose a numerical analysis to compare MLP and WMP with a standard strategy, the No-Share Placement (NoShP), which does not share VFs among different flows and does not take into account the packet-rate and bit-rate input/output modifications caused by each VF.

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Hosoya index of caterpillar graphs

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Abstract

The Hosoya index equals to total number of matchings for a graph G [1]. It was shown that the Hosoya index of caterpillar graphs equals to Euler's continuant polynomial [2]. In this study, we obtain a new computation of the Hosoya index of caterpillar graphs by matrix factorization method. We obtain some new equations by this method.

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A branch-and-price algorithm for a Dengue control routing problem

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(*joint work with* Carlos Araújo, Fábio Usberti, Rafael Arakaki)

Abstract

Up to March of 2022[1], Brazil accounted for 77.4% of the world, and 82.46% of South America Dengue reported cases, with a total of 167602 cases. Of these 53574 were confirmed, 97 were classified as severe, and 30 resulted in death. Dengue outbreaks are major public health problems, which place immense pressure on health care and management systems worldwide, sometimes leading to the deaths of the most vulnerable population. To deal with dengue outbreaks, authorities focus their efforts on contingency policies. One effective activity for dengue control is insecticide spraying on targeted street blocks. To this end, spraying vehicles are used, due to their far range and expedite. Our work investigates the routing of spraying vehicles, which is formulated as an arc routing problem with covering constraints. Our methodology is grounded on branch-and-price, where the shortest path with resource constraint is used as slave problem. Computational experiments were conducted over a set of districts, from the city of Campinas, São Paulo. The results show that the methodology was effective to find high-quality solutions in reasonable computational times.

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A $(2+\epsilon)$-approximation Algorithm for Scheduling Moldable Tasks on Hybrid Platforms

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Abstract

The problem of scheduling moldable tasks on hybrid platforms has been recently studied in the scheduling literature. In some settings, hybrid platforms consist of two different platforms, such as CPU-CPU computing systems, where each platform contains a set of processors. One platform admits a task to be scheduled on more than one processor in parallel using the moldable task model: the number of processors assigned to a task can be determined before execution and the processing time of a task is a function of that number. In contrast, another platform only admits a task to be scheduled on a single processor, which is known as a traditional one-job-on-one-processor pattern. In this paper, we generalize the problem to the setting with N identical platforms admitting task parallelization and one platform admitting the one-job-on-one-processor pattern where N is a fixed value. We develop a $(2+\epsilon)$-approximation algorithm for any $\epsilon > 0$. This algorithm is the first polynomial-time algorithm when $N \geq 2$ and reaches the same approximation ratio as previous work when $N = 1$. Furthermore, we extend this result to the case of a contiguous schedule, in which each task can only be executed by contiguous numbered processors.

Keywords: scheduling; moldable task; approximation algorithm; hybrid platforms

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EPTAS for the Dual Splittable Bin Packing Problem with Cardinality Constraints

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Abstract

The problem considered is the splittable bin packing with cardinality constraint. It is a variant of the bin packing problem where items are allowed to be split into parts but the number of parts in each bin is at most a given upper bound. Two versions of the splittable bin packing with cardinality constraint have been studied in the literature. The two versions are referred to as the primal problem and the dual problem. We consider the dual problem where the objective is to minimize the maximum bin size while packing (may be fractional) the items to a given set of bins. We exhibit an EPTAS for the dual problem when the cardinality upper bound is part of the input. This result answers an open question raised by Epstein, Levin, and van Stee [1].

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Algorithms for Finding Fixed-Length Cycles in Edge-Weighted Graphs

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Abstract

In this talk we consider the problem of finding fixed-length cycles in edge-weighted graphs. The problem is formally defined as follows. Let $G = (V, E)$ be a simple edge-weighted graph, k define a desired length, and $w(u, v)$ denote the weight (length) of each edge $\{u, v\} \in E$. The *k-cycle problem* involves identifying a cycle $C = (u_1, u_2, \ldots, u_l = u_1)$ whose length $L(C) = \sum_{i=1}^{l-1} w(u_i, u_{i+1})$ minimises $\|k - L(C)\|$.

An alternative version of this problem involves also specifying a source vertex $s \in V$. The objective is to then identify a cycle $C = (s = u_1, u_2, \ldots, u_l = s)$ that minimises $\|k - L(C)\|$. This second variant has several practical applications including planning jogging routes and cycling tours, or determining a round trip that allows us to complete our daily quota of steps as determined by our fitness tracker.

Little work seems to have been conducted on the problem of finding fixed-length cycles in edge-weighted graphs. Relevant complexity results are known, however. The shortest cycle in a graph can be computed in polynomial time; however, computing longest cycles is $\mathcal{NP}$-hard, both for weighted and unweighted graphs. As a generalisation of the longest cycle problem, the k-cycle problem is also $\mathcal{NP}$-hard. The problem of counting the number of cycles in a graph is also known to be $\#\mathcal{P}$-complete.

In this talk we introduce several exact and heuristic algorithms for the k-cycle problem. Our exact algorithms are based on Yen's algorithm and integer programming, with the latter showing reasonably favourable scaling-up characteristics. Our current work is concerned with developing methods based on local search. We are also considering differing graph topologies and methods of problem decomposition. Results on these features will also be discussed.

Multi-stage Stochastic Optimization for a Biorefinery Supply Chain in Spain

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Abstract

Nowadays, biofuels are evolving as renewable and sustainable energy sources, especially on developed countries, due to the neutral CO_2 emissions within their complete cycle.

Regarding this topic, a biorefinery is considered to be set in Northern Spain. The problem considers uncertainty in biomass prices and availability, therefore, a stochastic optimization approach is needed to reduce the risks of the project. The optimization is represented as a three-stage scenario tree, composed of strategic and tactical nodes. The former refers to location of the biorefinery, while the latter refers to the rent of different warehouses. Additionally, operational nodes are rooted to the strategic and tactical nodes forming two-stage operational scenario trees. In these operational nodes, decisions related to the biomass acquisition are made.

Meaningful insights are obtained from the application of stochastic optimization at all levels: strategic (the facility location problem), tactical (warehouses strategy) and operational (biomass purchases), highlighting a superior performance than the deterministic equivalent model.

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A combinatorial optimization approach for the infectious waste location-routing problem

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Abstract

This work develops a multi-objective location-routing model to mitigate the environmental risk of spreading harmful microorganisms during the transportation of infectious medical waste. Considering the continuously increasing waste volume, the proposed model aims to simultaneously optimize the facility location and multi-depot vehicle-routing decisions. Based on the infectious virus' environmental propagation characteristics, we propose a three-dimensional risk measure, in which the surrounding residents of the network are regarded as the risk receptors. Applying edge flow accumulation constraints, a bi-objective location-routing model simultaneously minimizing total cost and risk is constructed with the efforts of integrating the urban transportation network with the emergency response system.

In line with the model complexity and objective robustness, a solution procedure based on the Minimum Envelope Clustering Analysis and NSGA-II is designed and tested with problem instances with different scales. It can be shown that even the largest instance can be solved by the improved algorithm within 307 seconds, while keeping high computational stability among various problem sizes. The procedure can reduce the CPU time by 79.53% but provide better location-routing plans.

Finally, the real-life problem in Wuhan during the original outbreak of coronavirus is utilized to conduct a series of numerical experiments. Our computational results show that, within approximately 200s, the proposed solution method can provide a set of efficient plans, and the optimization model is sensitive to the vehicle's maximum load, average driving speed, positive rate, and average wind speed. The obtained optimal plan can provide a reduction of 50%, 57.87%, and 75.46% respectively in the over-working load, transportation cost, and system risk. Compared to traditional risk assessments, our approach can melt of the transportation cost by 10.08% with only a 3.75% increase in CPU time.

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A Facility Location Problem to support Helicopter Emergency Medical Services

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Abstract

Locating helipads in strategic positions, especially in mountain areas, is a crucial decision to reduce transport time of injured people to hospitals. The problem has been largely studied in the literature (see, e.g., [1], [2]). Many researches focus on identifying the optimal set of locations to cover a given population percentage by implementing a maximal covering location problem, while other studies aim to minimize the average response time over the entire population or minimize the total rescue time. This work originates from the need of the Parma Helicopter Emergency Medical Service (PHEMS) to identify which existing helipads should be equipped with modern infrastructures for night landing and, if necessary, where to build new helipads. PHEMS provided us with the historical data referring to the rescue interventions carried out in the last years in the province of Parma. We used this large data set to build two different bi-objective optimization models: the first minimizes the cost of equipped helipads and the total rescue time; whereas the second minimizes the cost of equipped helipads and the total delay with respect to given target due-dates identified on the basis of the injured urgency levels. Both models have been solved via an epsilon-constrained method and tested on the PHEMS case. The resulting solutions are characterized by relevant improvements with respect to the existing real-world solutions, both in terms of total rescue time and total delay.

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Vertex quickest 1-center location problem on trees and its inverse problem under weighted l_∞ norm

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Abstract

In view of some shortcomings of traditional vertex 1-center (V1C), we introduce the vertex quickest 1-center (VQ1C) problem on a tree, which aims at finding a vertex such that the maximum transmission time to transmit σ units data is minimum. We first characterize some intrinsic properties of VQ1C and design a binary search algorithm in $O(n \log n)$ time based on the relationship between V1C and VQ1C, where n is the number of vertices. Furthermore, we investigate the inverse VQ1C problem under weighted l_∞ norm, which modifies the given capacities in an optimal way such that a prespecified vertex becomes the vertex quickest 1-center. We discuss the inverse problem from two aspects. We introduce two notions of effective modification and provide some optimality conditions for the optimal solutions, respectively. Then we propose an $O(n^2 \log n)$ time algorithm. Finally, we show some numerical experiments to verify the efficiency of the algorithms.

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Two-Stage robust optimization problems with two-stage uncertainty

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(*joint work with* Marc Goerigk, Lasse Wulf)

Abstract

We consider two-stage robust optimization problems, which can be seen as games between a decision maker and an adversary. After the decision maker fixes part of the solution, the adversary chooses a scenario from a specified uncertainty set. Afterwards, the decision maker can react to this scenario by completing the partial first-stage solution to a full solution.

We extend this classic setting by adding another adversary stage after the second decision-maker stage, which results in min-max-min-max problems, thus pushing two-stage settings further towards more general multi-stage problems. We focus on budgeted uncertainty sets and consider both the continuous and discrete case. For the former, we show that a wide range of robust combinatorial optimization problems can be decomposed into polynomially many subproblems, which can be solved in polynomial time for example in the case of (representative) selection. For the latter, we prove NP-hardness for a wide range of problems, but note that the special case where first- and second-stage adversarial costs are equal can remain solvable in polynomial time.

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A Novel Backtracking Algorithm for Solving List Coloring

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Abstract

The class of NP-hard problems is a class of problems for which there may not exist polynomial-time algorithms and, even if they did, to date they are not known by humanity [1]. One problem in this class is the list coloring problem, which is a generalization of the vertex coloring problem and is an NP-hard problem even for interval graphs [2]. In list coloring, each vertex of a graph must be assigned a color such that no adjacent nodes are assigned the same color and such that the color assigned to each vertex is among those of a predefined list of valid options for that node, using the minimum number of colors.

An approach that one may take when trying to solve NP-hard problems is to design backtracking algorithms. In [3], backtracking is defined as “a systematic way to iterate through all the possible configurations of a search space”. Given that exploring all possible configurations would lead to a great computational effort, sometimes one can prevent this by pruning, a technique which allows the algorithm to rule out a partial solution when it cannot be extended into a full solution better than the best found up to that point. The efficiency of a backtracking algorithm also relies heavily on the way in which solutions are extended at each step.

In this work we propose a novel backtracking algorithm which employs intelligent ways of exploring the search space for solving the problem of list coloring for general graphs and present the computational results we obtained.

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The Distributed No-Idle Flowshop Scheduling Problem with Due Windows

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Abstract

In this study, we address an extension of the Distributed Permutation Flowshop Scheduling Problem [1] with no-idle and due window constraints. The Distributed No-idle Flowshop Scheduling Problem with Due Windows (DNIFSPDW) involves two types of decisions: (1) Assigning jobs to the factories, and (2) sequencing the set of jobs assigned to the same factory. In the DNIFSPDW, machine setup costs are so significant that shutting down and reactivating the machines is not cost-effective. Therefore, idle times between the processing of any consecutive jobs on each machine are prohibited. In addition, each job is associated with a due window indicating the earliest and latest delivery times. The objective function of the DNIFSPDW is to minimize the total weighted earliness and tardiness (TWET). We developed two mixed-integer linear programming models for the DNIFSPDW and compared their performances. Moreover, we developed an iterated greedy algorithm (IG) to solve the DNIFSPDW. We tested the performance of our IG on a set of problem instances. The results of the computational study indicate the effectiveness of the proposed IG.

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Lower bounds for online bin stretching and related problems

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Abstract

We aim to find lower bounds for the online bin stretching problem, introduced by Azar and Regev [1]. In this problem, somewhat similar to bin packing, several items of different sizes arrive one by one - hence the name online - and must be packed into some bins to minimize the load of the largest bin. Moreover, we're given an extra piece of information beforehand: we know the value that an optimal offline algorithm would give on the items that will be sent.
We try to find lower bounds on the performance of online algorithms compared to offline ones. Works have already been done to find lower bounds by modelling the problem as a two-player game, and then using computer searches, as in [2] and [3]. We propose here new ideas to speed up such searches to find better bounds.
Moreover, we also explore the relationships between the different classes of problems when the information known beforehand changes - what if, instead of knowing exactly the optimal value of an optimal offline algorithm, we only know an upper bound? What if we only know the sum of the sizes of the items that will be sent? We try to extend our results to those problems.

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Some formulations for the capacitated dispersion problem

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Abstract

We study the capacitated dispersion problem [1] in which, given a set V of n nodes, a positive capacity c_i for each node i, a nonnegative distance d_{ij} between any pair of distinct nodes i and j, and a positive demand B to cover, we would like to find a subset V' of nodes such that the sum of capacities of nodes in this subset is large enough to cover the demand, i.e., $\sum_{i \in V'} c_i \geq B$ and the nodes in V' are as distant as possible from one another, i.e., $\min_{i,j \in V': i \neq j} d_{ij}$, is maximum. This problem arises, for instance, when we would like to locate facilities to cover the demand for a service, and we would like the facilities to be as distant as possible to decrease the risk of damage from accidents at other facilities.

In this talk we focus on several mathematical formulations for the problem in different spaces using variables associated with nodes, edges and costs. These formulations are then strengthened with families of valid inequalities and variable fixing procedures. Several sets of computational experiments are conducted to illustrate the usefulness of the findings, as well as the aptness of the formulations for different types of instances.

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On the simultaneous metric dimension of graphs

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(*joint work with* Iztok Peterin, Eunjeong Yi)

Abstract

A set of vertices W of a graph $G = (V, E)$ is a *resolving set* of G if, for any two distinct vertices $x, y \in V$, there exists a $w \in W$ such that $d(w, x) \neq d(w, y)$, where $d(u, v)$ denotes the minimum number of edges in a path linking vertices u and v in G. The *metric dimension* of G is the minimum cardinality among all resolving sets of G. A set $S \subseteq V$ is a *simultaneous resolving set* for a finite collection $\mathcal{C}$ of graphs on a common vertex set V if S is a resolving set for every graph in $\mathcal{C}$; the minimum among the cardinalities of all such S is called the *simultaneous metric dimension* of $\mathcal{C}$, denoted by $\mathrm{Sd}(\mathcal{C})$. In this talk, we focus on the simultaneous metric dimension of graphs G and their complements $\overline{G}$. We characterize graphs G satisfying $\mathrm{Sd}(G, \overline{G}) = 1$ and $\mathrm{Sd}(G, \overline{G}) = |V| - 1$, respectively. We show that $\{\mathrm{diam}(G), \mathrm{diam}(\overline{G})\} \neq \{3\}$ implies $\mathrm{Sd}(G, \overline{G}) = \max\{\dim(G), \dim(\overline{G})\}$. We construct a family of self-complementary split graphs G of diameter 3 satisfying $\mathrm{Sd}(G, \overline{G}) > \max\{\dim(G), \dim(\overline{G})\}$. We determine $\mathrm{Sd}(G, \overline{G})$ when G is a tree or a unicyclic graph. Time permitting, we will also look at the fractionalization of this notion.

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A Cybersecurity Investment Portfolio of Security Safeguards for Military and Nonmilitary Cases

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Abstract

This research deals with optimization of cybersecurity investment using a new concept of safeguard cybersecurity value. First, a simple transformation procedure is developed to transform general nonlinear stochastic combinatorial optimization model into equivalent stochastic mixed integer linear program. The resulting computationally efficient linear optimization model is capable of selecting optimal portfolio of security safeguards to minimize cybersecurity investment and expected cost of losses from security breaches. Then, a number of propositions is formulated to provide additional insights into the properties of the obtained stochastic mixed integer program and optimal safeguard portfolio. Finally, drawing upon the theoretical results, a knapsack model is proposed, next transformed into an unconstrained binary program, leading to a simple formula for an immediate selection of security safeguard portfolio to optimize cybersecurity investment. This study shows that portfolio of security safeguards with maximum total cybersecurity value mitigates the impact of cyber risk and reduces the cybersecurity investment. This approach can be applied for military and nonmilitary cases. Practical examples are presented.

Keywords: Cyber Risk, Cybersecurity Investment, Information Systems, IT Policy and Management, Military and Nonmilitary Case Studies.

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Efficient Algorithms for the Routing Open Shop with Unrelated Travel Times on Cacti

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(*joint work with* Ilya Chernykh)

Abstract

We consider the routing open shop problem being a generalization of the metric Traveling Salesman Problem and the Open shop scheduling problem. This problem was introduced in [1,2] and can be described as follows. There is a transportation network represented by an undirected edge-weighted graph. Nodes represent some locations and weight of an edge represents a distance between corresponding nodes. There is a number of jobs distributed among all the nodes and the number of machines initially located at the given node referred to as the depot. Each machine has to visit each node, to process each job and to return back to the depot. The makespan of a schedule is the time moment returning of the last machine to the depot after processing all the operations. The goal is to minimize the makespan. The routing open shop problem is known to be NP-hard even in the simplest two-machine case with the transportation network consisting of just two nodes (including the depot).

We consider a certain generalization of this problem, in which travel times are individual for both two machines and the structure of the transportation network is an arbitrary cactus. An approximation algorithm for such generalization was described in [3], it has a tight performance ratio guarantee for some special cases. This paper considers the generalization of this result to the transportation network with asymmetric distances and presents new polynomially solvable cases.

Acknowledgements: This research was supported by the Russian Foundation for Basic Research, project 20-01-00045

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An adaptive large neighborhood search heuristic for the robust rig routing problem with drilling time uncertainty

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Abstract

In the oil and gas industry, there is a need for constructing auxiliary maintenance and storage buildings nearby exploration sites. As the initial stage for such constructing purposes, it is necessary to drill wells for construction piles. Therefore, there is a fleet of mobile drilling rigs traveling from one exploration site to another, performing the work on drilling wells. For each site, we have a time window for completing all the work on drilling. To complete all the work among all the exploration sites in time it may be necessary to allow several drilling rigs to perform work at the same site.

Yet, in the real world, unforeseen circumstances can affect drilling time, and that, if disregarded, can lead to a disruption of the work plan. Thus, in this problem, we maximize possible deviations of drilling times from expected values when there is still a feasible solution to perform all well-drilling requests in time. At the same time, total traveling costs must be no more than a given threshold. It is a so-called threshold robustness approach.

This research proposes a MILP model for the DRRP with uncertainties and an Adaptive Large Neighborhood Search (ALNS) algorithm to solve it. The destruction operators used in the algorithm are working either at the route, customer, or visit level. The reconstruction operators consider the possibility of changing the work partition. Computational results for the algorithm and Gurobi solver show the dominance of the ALNS scheme for the medium-size instances. Experiments also show the factors that allow one to increase the robustness of a solution.

Time consistent stochastic dominance risk strategies induced by multistage quadratic mixed-integer stochastic optimization

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(*joint work with* Unai Aldasoro, Gloria Pérez)

Abstract

Multistage stochastic optimization is one of the most powerful tools for decision-making under uncertainty. The so-called Risk Neutral (RN) strategy has been conventionally considered. Optimization is performed in average in RN approaches, i.e., the setting does not hedge against the occurrence of low probability high-consequence events. Alternatively, a concerned decision-maker about non-desired scenarios may consider risk-averse strategies for the optimization problem.

From a modelling perspective, two multistage time consistent risk averse measures are introduced, the Coupled Stochastic Dominance (CSD) and the Decoupled Stochastic Dominance (DSD), that can be included in the class of Expected Conditional Risk Measures.The two novel risk averse strategies induced by multistage quadratic stochastic optimization are presented here, they consider the risk control over the the expected linear and quadratic terms. Consequently, CSD and DSD models are both formulated as a multistage stochastic mixed-integer quadratically constrained quadratic programming problems.

Mixed-Integer Quadratic Programming (MIQP) problems significantly impact in the theory and practice of mathematical optimization. As is well-known MIQP are in NP. Decomposition algorithms can exploit the nice structure of models based on scenario analysis and convexity. From an algorithmic perspective, a matheuristic decomposition algorithm is introduced for solving multistage stochastic quadratically constrained quadratic 0-1 problems with semicontinuous variables, based on a Branch-and-Fix Coordination scenario cluster primal decomposition scheme.

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2-Summing problem and NP-hardness of proportionate routing open shop

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Abstract

We introduce the `2-Summing` decision problem as follows. Given a set of positive integers A with total sum W and a positive B such that $W \geqslant 2B$, are there two disjoint (possibly empty) subsets of A with total sums W_1 and W_2 respectively, such that $W_1 + 2W_2 = B$? This problem has some similarity with the classical `Subset Sum` problem. We prove that `2-Summing` is NP-complete and believe that it can be a useful tool for proving NP-hardness of some scheduling problems. To illustrate this, we reduce it to a very restricted special case of a two-machine routing open shop problem [1], described below.

In the routing open problem, mobile machines have to traverse the transportation network to process immovable jobs, located at the nodes of the network, processing times for each operation are given in advance. The order of operations' processing for each job and for each machine is arbitrary. Machines start at the same predefined node and have to return there after completing the processing. The goal is to minimize the finish time. The problem is known to be NP-hard even for the simplest case of two machines on a link [2].

In this paper we use the `2-Summing` problem to prove, that this simplest case remains NP-hard even in more restricted setting with so-called *proportionate* jobs. That means, that for each job its processing times are equal.

Acknowledgements: This research is supported by the Russian Foundation for Basic Research, project 20-01-00045

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The near exact bin covering problem

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Abstract

We present a new generalization of the bin covering problem that is known to be a strongly NP-hard problem. In our generalization there is a positive constant Δ, and we are given a set of items each of which has a positive size. We would like to find a partition of the items into bins. We say that a bin is near exact covered if the total size of items packed into the bin is between 1 and $1 + \Delta$. Our goal is to maximize the number of near exact covered bins. If $\Delta = 0$ or $\Delta > 0$ is given as part of the input, our problem is shown here to have no approximation algorithm with a bounded asymptotic approximation ratio (assuming that $P \neq NP$). However, for the case where $\Delta > 0$ is seen as a constant, we present an asymptotic fully polynomial time approximation scheme (AFPTAS) that is our main contribution.

Mathematical Models and Metaheuristic Approaches for the Order Consolidation Scheduling Problem

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Abstract

In this study, we investigate a time-critical freight logistics problem where the order requests of the customers have to be provided by third party logistics companies (3PL) in a very short time as any delay may result in serious potential loss of productivity and may affect customer service.

The 3PL companies receive urgent order requests and they have to offer a competitive quote in a short time around 10-15 minutes. The study is based on the 3PL company does not own its vehicles and relies on freight provider companies throughout Europe. Historically, the 3PL company serves each customer in a direct route using separate vans or trucks. Though they decided to explore the possibility of order consolidation but insisted that no more than a maximum of three requests can be explored due to their reputation and fear of affecting customer service. Here, each request has a collection point, a destination point. The characteristics of the request (i.e., volume, weight fragility, dimensions,....) as well as its tight delivery due date, say next day. The aim of the study is to produce a reliable and fast optimisation tool which effectively explores the opportunities for order request consolidation which may include at most one transhipment point if necessary. This will reduce operating cost and by product reduce CO2 emission by utilising less vehicles on the roads.

We first formulate this decision problem using two mathematical approaches, namely, a standard Integer 0-1 Linear Programming (ILP) and a set partitioning-based (SPB). For the SPB, all configurations including singleton, pairs and triplets are first defined with their respective cost and saving recorded. To tighten the formulation, valid inequalities are also developed and their effect analysed. This problem is then solved by adapting two known metaheuristics, namely, a variable neighbourhood search (VNS) and a large neighbourhood search (LNS). For the VNS, appropriate neighbourhood structures and local searches are developed and for the LNS, novel removal and insertion operators are examined. To provide the strengths of the two heuristic approaches, we also investigate the effect of their respective hybridisation. Computational experiments using instances varying in size from 50 to 200 shipments with an increment of 50 are carried out and the results are analysed.

VLC-Indoor positioning Layout design, similarities to packing problems

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Abstract

This presentation aims to introduce the layout design problem of an indoor positioning system using Visual Light Communication (VLC) technologies [1]. These technologies allow the transmission of information through a beam of light, which can be used in artificially lighted areas as a positioning system. For this, the element to be tracked must have a Tag that identifies it. This system has shown its potential in location systems where GPS (Global Positioning System) technology is not enough, as in the case of Copper Mines in Chile [2]. Given the success in those cases, where the area to be mapped by the lights was "linear" (i.e. tunnels), it is sought to extend it to 2D areas. Where it is sought to cover an area with the lights, in such a way that the error tolerance in terms of location is respected [3]. Although it is a new problem in technological and decision terms, this problem has many similarities with the *"packing"* family problems. This presentation will discuss those similarities and differences (or new features) concerning *"packing"* problems, and present some interesting results.

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Memetic Algorithm with β Hill-Climbing Algorithm for Protein structure prediction problem

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Abstract

Proteins are the elements that are present in all biological functions of any organism. They are responsible for most of the biological processes involved in our life. The biological function of a protein is defined by its particular three-dimensional structure, known as the native structure. Determining the native structure of a protein is therefore essential for understanding its biological roles. In addition, it can help solve several diseases resulting from protein misfolding, including Alzheimer's, Piron and Parkinson's diseases. Protein structure prediction (PSP) is a challenging problem in computational biology, computer science and operations research. The aim of the PSP problem is to predict the three-dimensional structure of proteins using only their amino acid sequence. Due to the complexity of the PSP problem, simplified models such as the hydrophobic-polar (H-P) model have become used for studying the structure of proteins. In this model, the quality of a structure is measured by the number of interactions between the amino acids in that structure. Indeed, to reach the optimal folding state of a protein, the number of contacts between the hydrophobic amino acids must be maximal. The PSP has been formulated as a combinatorial optimization problem based on the H-P model in different lattice types. In this paper, we introduce an efficient memetic algorithm called MA-PSP to solve the PSP optimization problem in the 3D cubic lattice model. The proposed algorithm uses the β Hill-Climbing algorithm to improve the performance of the standard memetic algorithm. The proposed algorithm was tested using a set of benchmark sequences of different sizes and compared with a number of state-of-the-art algorithms. The obtained results showed that the proposed algorithm is not only able to produce high quality solutions but is also more efficient than most of the state-of-the-art algorithms.

Keywords. Minimal Energy Conformation, Bioinformatics, β Hill-Climbing Algorithm, Memetic Algorithm, 3D Cubic Lattice.

Exact Optimization of Districting Plans with p-Center-Based Dispersion Minimization

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(*joint work with* M. Gabriela Sandoval, Juan A. Dıaz)

Abstract

Territory design deals with the discrete assignment of geographical units into territories subject to planning criteria. In this talk, we present an exact solution method based on an integer programming model with the objective of minimizing a p-center dispersion measure. The solution approach is an iterative algorithm that makes use of auxiliary covering-based models that help validate if, for given values of the objective function of the original problem, it is possible to find feasible solutions with at most p territories. This change allows testing various candidate distance values as lower bounds on the optimal solution of the original problem. These lower bounds are iteratively improved through a cut-generation scheme. Empirical tests on instances with up to 300 basic units reveal that the proposed algorithm performs significantly faster than the best-known exact solution method for this problem.

The average size of maximal matchings in graphs

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Abstract

We investigate the ratio $\mathcal{I}(G)$ of the average size of a maximal matching to the size of a maximum matching in a graph G. If many maximal matchings have a size close to $\nu(G)$, this graph invariant has a value close to 1. Conversely, if many maximal matchings have a small size, $\mathcal{I}(G)$ approaches $\frac{1}{2}$.

We propose a general technique to determine the asymptotic behavior of $\mathcal{I}(G)$ for various classes of graphs. To illustrate the use of this technique, we first show how it makes it possible to find known asymptotic values of $\mathcal{I}(G)$ which were typically obtained using generating functions, and we then determine the asymptotic value of $\mathcal{I}(G)$ for other families of graphs, highlighting the spectrum of possible values of this graph invariant between $\frac{1}{2}$ and 1.

Keywords: Maximal matching, average size, graph invariant, asymptotic value.

The Restricted Inverse Optimal Value Problem on Minimum Spanning Tree under Weighted l_∞ Norm

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(*joint work with* Xiuzui Guan, Hui Wang, BinwuZhang, Panos M. Pardalos)

Abstract

In this paper, we consider the restricted inverse optimal value problem on minimum spanning tree under weighted l_∞ norm. In a connected undirected network $G = (V, E, \mathbf{w})$, we are given a spanning tree T^0, a weight vector $\mathbf{w}$, a lower bound vector $\mathbf{l}$, an upper bound vector $\mathbf{u}$, a cost vector $\mathbf{c}$ and a constant K. We aim to obtain a new weight vector $\mathbf{w^*}$ satisfying the lower and upper bounds such that T^0 is a minimum spanning tree under the vector $\mathbf{w^*}$ with weight K. The objective is to minimize the modification cost $\max_{e_i \in E} c_i|w_i^* - w_i|$ under weighted l_∞ norm. We first analyze some properties of feasible and optimal solutions of the problem and develop a strongly polynomial time algorithm with running time $O(m^2 n)$, where $m = |E|, n = |V|$. Then we reduce the time complexity to $O(m^2 \log n)$ by devising a more complex algorithm using a binary search method. Thirdly, we apply the first algorithm to the restricted inverse optimal value problem under unit l_∞ norm, where $c_i = 1$, and obtain an $O(mn)$ time algorithm. Finally, we give some examples to demonstrate the algorithms and present some numerical experiments to show the effectiveness of these algorithms.

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Hybrid genetic algorithm approach for production-inventory routing problem with perishable products

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(*joint work with* Ceyda Oğuz)

Abstract

In this paper, integrated optimization of production, inventory and distribution decisions for perishable products is considered.This production-inventory routing problem (PIRP) includes a single production plant, a set of retailers with a time varying and deterministic demand, a fleet of homogenous capacitated vehicles to make the deliveries, a single and perishable product, a set of quality levels related to shelf life of the product and a finite planning horizon. A mixed integer linear programming (MILP) model is developed to solve this problem, which naturally combines the well-known lot-sizing problem and vehicle routing problem. Given that our PIRP model is not viable to solve instances with more than 10 retailers and 6 periods of time within a reasonable time, a Hybrid Genetic Algorithm (HGA) is developed to get high quality and near-optimal solutions in a reasonable time. The uniqueness of our approach comes with a simple chromosome representation based on the observations made from the optimal solutions focusing on delivery quantities. Then our decoding mechanism outputs a unique and feasible solution for the PIRP by solving a linear programming model for other production-inventory related decisions and then by utilizing a Tabu Search which is proven to be very efficient for VRP. To deal with infeasible solutions, we developed strong repairing mechanisms, which also provide exploration of the infeasible search space and increase the quality of the diversification.

We generated a new instance set for PIRP consisting of 50 benchmark instances with up to 50 retailers and 10 periods based on the data provided in IRP libraries in the literature. Then, we compared our HGA approach with commercial solver results for small instances and then with a variant of the Two-Phase Iterative Heuristic (TIH) that is adopted from the literature for our problem for larger instances. Computational experiments with our benchmark instances have shown that in small instances, our HGA has averaged optimality gap under 0.15% in less than 1 minute whereas TIH performs under 0.16% in terms of the best output within 30 seconds. In the medium instances, HGA surpassed TIH by averaging 7% and 5% relative gaps in terms of the best objective and the average objective with a CPU time in the range of 7-20 minutes and 7-30 minutes, respectively. Large instance results have shown the superiority of the performance of HGA algorithm which gives 13% and 7% relative gaps compared to TIH algorithm in the ranges of 20-40 minutes for HGA and 40-115 minutes of CPU time for TIH.

Norm minimization problems in data science: an integer programming perspective

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Abstract

The talk addresses data-science problems involving the minimization of vector norms which arise in, among others, sparse regression, certain clustering problems involving hyperplanes [1, 2], and linear classification [3, 4].

We focus on the case where these problems are formulated as (mixed integer) nonlinear optimization problems. We illustrate different mathematical-programming ways to handle the vector norms that such formulations contain to (partially) cope with the (nonlinear and, in many cases, nonconvex) way in which they interact with the other variables of the problem.

We illustrate different geometrical reformulations involving polyhedral norms that lead to easier to solve problems with optimal solutions up to within a polynomial approximation factor of the optimal solution value of the original problem (depending on the norm in which it is formulated).

We also show that an epigraph reformulation obtained by intersecting different relaxations of a p-norm constraint that are in principle redundant leads to tighter bounds when adopted within a spatial-branch-and-bound method and, ultimately, to faster computing times.

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An Application of Stochastic Differential Games with Lagrange Multipliers: Bancassurance

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Abstract

We develop an approach for two player constraint zero-sum and nonzerosum stochastic differential games, which are modeled by Markov regime-switching jump-diffusion processes. We provide the relations between a usual stochastic optimal control setting and a Lagrangian method. In this context,we prove corresponding theorems for two different type of constraints, which lead us to find real valued and stochastic Lagrange multipliers, respectively. Then, we illustrate our results for an example of cooperation between a bank and an insurance company, which is a popular, well-known business agreement type, called Bancassurance. By using stochastic maximum principle, we investigated optimal dividend strategy for the company as a best response according to the optimal mean rate of return choice of a bank for its own cash flow and vice versa. We found out a Nash equilibrium for this game and solved the adjoint equations explicitly for each state. It is well known that the timing and the amount of dividend payments are strategic decisions for companies. The announcement of a dividend payment may reduce or increase the stock prices of a company. From the side of the bank, it is clear that creating a cash flow with high returns would be the main goal. Hence, in our formulation, we provide an insight to both of the bank and the insurance company about their best moves in a bancassurance commitment under specified technical conditions.

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Ordinal Optimization Through Multi-objective Reformulation

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Abstract

Combinatorial optimization with ordinal objective functions considers situations where the quality of an element in a solution can not be quantified. For example, it might not be possible to assign a numerical value to an edge of a graph (representing a street segment), while it is possible to rank the edges. There exist already different definitions of optimality for ordinal objective functions in the context of combinatorial optimization (see e.g. [1,2,3]).

In this talk, we investigate three different definitions of ordinal optimality. We show that all three definitions are equivalent under certain conditions, while two of them are equivalent in general. These optimality concepts can be interpreted as vector dominance relations with a specific ordering cone. Based on this observation, we transform the ordinal optimization problem into a standard multi-objective problem with binary costs. By this transformation, all properties of the underlying problem remain unchanged such that we can apply for example Bellman's principle of optimality to the knapsack problem. We extend our results to multiobjective combinatorial optimization problems combining ordinal and real-valued objective functions.

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Routing open shop with preemption allowed

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(*joint work with* Ilya Chernykh)

Abstract

The routing open shop problem [1] combines the classical open shop problem and the metric TSP. Mobile machines move through the transportation network to perform operations on the immovable jobs, located at the nodes. All the machines start from the same node (the depot) and must return back after performing all their operations. The goal is to minimize the completion time of the last machine's activity, whether it is performing an operation or returning to the depot.

We consider routing open shop problem on a tree-like transportation network with the machine- and direction-dependent travel times with preemption partially allowed. The latter means that only subset of jobs can be interrupted as many times as we need, while for others preemption is prohibited. For this problem we describe a new polynomially solvable special case, for which the optimal makespan is guaranteed to coincide with the standard lower bound, generalizing the known results from [2]. We provide a polynomial algorithm for this case which builds an optimal schedule with at most two interruptions.

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List-3-coloring for Star Convex Bipartite Graphs with Particular Lists

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Abstract

Graph coloring is a well-known and well-studied area of graph theory. Graph coloring (or proper coloring) is the assignment of colors to the vertices of a graph such that no two adjacent vertices have the same color. Here we are interested in some generalizations of graph coloring, namely, list coloring. List coloring is a proper coloring in which each vertex v receives a color from its own list of allowed colors.

The decision versions of list coloring is NP-Complete for general graphs. It remains NP-complete even for bipartite graphs.

In this talk, we give structural results on star convex bipartite and comb convex bipartite graphs. We also give polynomial time solution for the several versions of the list 3-coloring problem when it is restricted to these graph classes.

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Non-parametric efficiency in the CRO industry, 2012-2020. A bootstrap two stage exploration

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This paper employs non-parametric DEA to explore the efficiency levels and trends of a set of Contract Research Organizations (CROs), a type of R&D intensive firm operating along a part of the supply chain of pharmaceutical companies.

In the first stage, we define and solve a constrained optimization problem of the form

$$\min \theta$$

$$s.t. \ (\theta x_j, y_j) \in T$$

Where θ is the efficiency score, x_j is a vector of m inputs and y_j is a vector of s outputs for decision-making unit j, and the technology T is defined as

$$T = \left\{(x, y): \sum_{j=1}^{N} x_j \lambda_j \leq x, \sum_{j=1}^{N} y_j \lambda_j \geq y, \sum_{j=1}^{N} \lambda_j = 1\right\}$$

For each firm in the sample we compute a bootstrap estimator of efficiency along the lines of Simar and Wilson (2000, 2007) and a lower and a higher bound estimator of a 95% confidence interval. Moreover,we increase the discriminating power of the scores for the firms in the efficient frontier by computing unbounded superefficiency scores.

In the second stage we construct a panel and estimate an econometric model relating efficiency computed in the first stage per unit and year to other environmental variables potentially correlated with it. The model is of the form:

$$\theta_{it} = x_{it} \, \beta + \epsilon_{it}$$

Where the dependent variable θ_{it} is represented by the efficiency scores obtained in the first stage, x_{it} is a matrix of covariates, β is a vector of coefficients, ϵ_{it} is the error term, i indexes firms and t time. We work with different probabilistic distributions (Truncated, Tobit and Normal) for the Data Generating Process of the error term. To correct for the potential endogeneity of the covariates and test the robustness of the results we also employ a General Methods of Moment estimator.

Basic results suggest that efficiency in the sample is relatively high and has increased over time in the last decade. It is positively associated to a sound human capital and financial management of firms. Efficiency is also contingent on the size of the company, but not on its operation in the stock markets.

References

Decomposition Algorithms for a Parallel Machine Scheduling Problem with Workforce and Precedence Constraints

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(*joint work with* Maxence Delorme, Manuel Iori, Carlo Alberto Magni)

Abstract

In this work, we consider a scheduling problem with parallel machines and human resources. Compatibility constraints and release dates for the jobs must be respected, as well as precedence and contiguity relations between the jobs (see, e.g., [2]). The aim is to minimize the total weighted tardiness. The problem is inspired by a real-world industrial application, and, because of its generality, can be used to model a large variety of further applications. To solve the problem, we implemented a Mixed Integer Linear Program (MILP) and a Constraint Program (CP). We then tested different decomposition algorithms, using both MILPs and CPs in the master and slave problems. A promising solution method is given by a Combinatorial Benders' decomposition (see, e.g., [1]) where we first schedule the jobs and then assign the machines and human resources to the jobs. The efficiency of the methods is proven by computational tests on realistic instances.

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Local search heuristic for the parallel machine scheduling with transport robots

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Abstract

In this study, we consider a new scheduling problem that appeared from optimization of order processing at a warehouse. We know the set of orders (jobs) that have to be processed through this system. Each order consists of a list of types of items and their amounts. Each order can require multiple types of items, and each type of items can be required for multiple orders. All items (raw materials) are in a storage area of the warehouse on pallets. Each pallet contains a lot of items of the same type. Automatic Guided Vehicles (AGVs) can move these items to the picking area and return them back. We have some identical parallel picking machines and some parking slots for pallets. Each machine can use the pallets from all parking slots. The number of AGVs and parking slots is limited. Our goal is to find a schedule for this system with the minimal total length.

We design a mixed-integer nonlinear mathematical model and find a simple way to linearize it by introducing additional variables and constraints. Unfortunately, our preliminary computational experiments have shown that its use is impractical. Gurobi solver can find optimal solutions for small instances only. Thus, we develop three local search heuristics based on ideas of the Tabu Search (TS), Simulated Annealing (SA)[1] and Hybrid TS-SA algorithm. We present feasible solutions as the permutations of the orders and apply a polynomial-time decoding procedure to get feasible schedules for the parallel machines under the AGVs fleet constraint.

Computational experiments for semi-synthetic test instances with up to 345 orders, 30 robots, and 16 parallel machines indicate the high efficiency of the approach.

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Genetically or geometrically? How to optimally superimpose RNA structures

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Abstract

Comparing objects, looking for differences and similarities, and sorting - these problems have bothered men since the very beginning. When comparing, the first natural activity was to place things side by side to see which one is longer, darker, rounder, etc. With time, a man invented tools to measure various features of objects and compare them without alignment. However, not all areas of life and science have developed such measures and tools. For example, in biology and bioinformatics, sequence and structure alignment is still the primary path toward identifying similarities and differences between the molecules. It is computationally intractable and requires individual methods for different macromolecules. Here, we present two algorithms dedicated to RNA 3D structure alignment. The first is a metaheuristic approach based on a genetic algorithm. The second is a novel heuristics using a geometric search method. Both algorithms apply to compute sequence-independent or sequence-dependent superimposition and allow an investigation of the context of structural similarity. Each of them has a different set of advantages. As shown by a comparative analysis performed on a representative collection of RNA tertiary structures, predicted and experimental, both presented methods are superior to other available tools, like RMAlign [1], R3DAlign [2], or SupeRNAlign [3].

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Compiling Decision Diagrams for Optimization using Iterative Cost-To-Go Approximation

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Abstract

A decision diagram (DD) is a layered directed graph that can be used to compactly represent the solution space of combinatorial optimization problems (COPs). Based on this representation, a COP with a maximization (minimization) objective is turned into the problem of finding a longest (shortest) path in a layered acyclic graph which can be solved in linear time in the number of arcs of the DD, that, however, grows exponentially in the size of the COP. The DD representation of a COP typically relies on a Dynamic Programming (DP) formulation. In that case, every DD layer is associated with a decision variable, nodes correspond to states and arcs represent state transitions induced by decisions.

In the context of combinatorial optimization, an important use of DDs is to provide bounds for COPs. One type of a decision diagram that is being used to obtain a lower (upper) bound for a maximization (minimization) problem is called a restricted DD. In a restricted DD, the size (width) of each layer is limited to a given maximum width. If restricted DDs are compiled top-down, the classical approach is to heuristically select the nodes to preserve in each layer and to delete the rest. One reason for the often poor behavior of this approach is that the heuristics only rely on information collected during the top-down process and do not consider the future impact of the selection decisions on the remaining solution space. In this talk, we propose an approach that iteratively applies the top-down approach and makes use of bottom-up information obtained from previous iterations to guide the selection of nodes to keep.

In preliminary computational experiments with single- and multi-dimensional 0-1-Knapsack Problems, we show that for a given maximum width of the DD, this approach yields substantially better bounds than the traditional top-down approach. Since the idea underlying the approach is fairly general, we are confident that it will also be useful for other problems such as maximum independent set or sequencing problems that we will consider next.

A machine learning techniques based Fuzzy Multi-Criteria Decision Support approach for online advertising effectiveness

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Abstract

Today, digital advertising faces some serious challenges. As the advertising landscape expands every day, digital marketers and agencies find it difficult to keep up. If they do not make a plan to overcome these challenges, they will definitely fight an uphill battle in the end, with little progress they want to make. To tackle this concern, a combined approach based on concepts of Fuzzy Multi-Criteria Decision-Making (Fuzzy MCDM) methods and machine learning techniques for optimizing display advertising campaigns problem has been developed. Many criteria are combined, including the following: technical, economic, social. In the first phase, after applying the fuzzy VIKOR method, the proposed approach consists of choosing a fraud problem as a top advertising problem. In the second phase, we solve the fraud detection problem using our earlier UCB-LSTM-GA model. The achieved results indicate that the combination of fuzzy MCDM model and our model UCB-LSTM-GA provide effective linkages between the fraud detection problems and performance of online advertising objectives.. Our approach achieves as high as 97.7 AUC, precision 97.5 and recall 97.5 using real datasets from TalkingData by the popular tools python. The managerial implication of our work is that the advertisers can apply the proposed methodology to efficiently identify fraudulent clicks and impressions to protect customers' interests and reduce fraud losses and regulatory costs.

A Dynamic Local Search algorithm for the Maximum Quasi-clique Problem

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Abstract

Given an undirected graph $G = (V, E)$ with V the set of vertices and E the set of edges, a subset of vertices C is called a clique if every two vertices in C are adjacent. However, the requirement of complete connectivity among all vertices in C is often overly restrictive for many real-world applications. This has led to many notions of clique relaxations including density relaxations, which comprises the notion of a *quasi-clique*. A quasi-clique is a dense subgraph that has k vertices and density γ, $0 < \gamma \leq 1$ [1]. The maximum quasi-clique problem asks for a quasi-clique with the maximum vertex cardinality for a given γ. This problem arises in many applications in real-world domains, including social networks [4], analysis of massive telecommunication data sets [2], gene co-expression networks and protein interaction networks [3]. In this study, we consider the state-of-the-art Dynamic Local Search algorithm for the maximum clique problem [5], adapting it to the maximum quasi-clique by exploring the *quasi-heredity* property of quasi-cliques. Experimental results on DIMACS test instances [6] indicate that the proposed algorithm is effective in matching the best-known values for almost all tested instances. Comparisons with the most recent approaches in the literature show that the proposed algorithm is competitive in terms of solution quality, achieving even better results for some of the tested instances.

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Discrete optimization algorithms for global defensive alliance problem in graphs

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Abstract

In this talk authors want to present some algorithmic results regarding global defensive alliance (GDA) problem in graphs. Let $G = (V, E)$ be a simple graph, and $S \subseteq V$ be a subset of vertices of G. A vertex $v \in V$ is considered *secured* with respect to S if $v \in S$ and $|N[v] \cap S| \geq |N(v) \setminus S|$, i.e. the number of vertices from S in its closed neighborhood is greater or equal to the number of vertices not in S in its neighborhood. Set S is called a *defensive alliance* if and only if every vertex from S is secured with respect to S. If a defensive set in G is also a dominating set of G, then we call it a *global defensive set* of G.

The decision version of the GDA problem is known to be NP-complete, even if we restrict the problem to subcubic graphs. While for some classes of graphs (most notably trees) polynomial time algorithms for the problem were proposed, there is a lack of methods that could solve GDA problem efficiently in general graphs. Moreover, in the literature there are no approximation algorithms for this problem that achieve a constant approximation ratio.

In this talk we present some optimal and heuristic algorithms solving global defensive alliance problem. We formulated GDA as ILP problem and designed, analyzed, implemented and tested some heuristic approaches, e.g., based on Simulated Annealing.

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Novel heuristics for Compiling Approximate Decision Diagrams for Combinatorial Optimization

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Abstract

Given a Dynamic Programming (DP) formulation of a Combinatorial Optimization Problem COP, it is possible to represent its solution space using a Decision Diagram (DD). Specifically, a DD is a layered directed acyclic graph in which nodes correspond to states and arcs to decisions inducing transitions between states. If the decision variables of the problem are binary then the associated decision diagram for the problem will be a binary decision diagram (BDD) and if the decision variables are integer values then the decision diagram will be a multi-valued decision diagram (MDD).

An application of DDs is to obtain bounds for combinatorial optimization problems. For this purpose different types of decision diagrams are being used where the size of them are linear and are called restricted DD and relaxed DD. Suppose the COP is a maximization (minimization) problem, then a restricted DD gives a lower (upper) bound and a relaxed DD gives an upper (lower) bound on the optimal solution of the problem. One advantage of using a relaxed DD is that it provides a discrete relaxation of the problem. In particular, these bounds can be used in a branch and bound algorithm to solve the problem to optimality.

The most popular approach for compiling relaxed and restricted DDs proceeds layer by layer in a top-down fashion, using simple heurisitics for deciding which nodes to merge (in case of relaxed DDs) and to remove (in case of restricted DDs). In this talk, we propose a more complex heuristic relying on building approximate equivalence classes. In preliminary experiments, we applied our heuristic on one and multi dimensional Knapsack problems. Our computational results show that for the majority of the instances, the bounds obtained by our heuristics is better than the bounds obtained by restricted and relaxed decision diagrams compiled using the traditional heuristics.

Random projections of Quadratically Constrained Programs

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(*joint work with* Leo Liberti and Pierre-Louis Poirion)

Abstract

Random projections are random matrices with approximate congruence guarantees on finite point sets. We apply them to the data of Quadratically Constrained Programs (QCP) and show approximate feasibility and optimality guarantees from new and previous theoretical results. We then apply our findings to the Distance Geometry Problem (DGP), which consists in solving the quadratic equation system

$$\forall \{i,j\} \in E \quad \|x_i - x_j\|_2^2 = d_{ij}^2 \wedge x \in \mathbb{R}^{n \times K},$$

where K is a given integer, and $G = (V, E, d)$ is a simple edge-weighted graph. The DGP is a good way to model certain inverse problems where, given a set of distances, one wants to retrieve the corresponding positions, and is used, among other applications, in the determination of protein structure from distance data from nuclear magnetic resonance experiments.

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Risk-Averse Antibiotics Time Machine Problem

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Abstract

Antibiotic resistance is the phenomenon of a bacterium developing ability to not being affected by a certain type of drug. This ability is gained by mutations after repeated drug applications. After some mutations, the treatment plans may become inefficient due to mutated genotype of the bacterium. Given a set of drugs and a treatment length, the antibiotics time machine problem aims to find the optimal treatment plan of the drugs that maximizes the expected probability of reversing the possible mutations. This problem can be naturally posed as a combinatorial optimization problem with a nonlinear objective function, which can be reformulated as a stochastic mixed-integer linear program (MILP) based on [2].

The risk-neural approach of maximizing the expected probability of reversing the possible mutations might yield poor worst-case performance, and, due to the nature of the antibiotics time machine problem, such an approach may not be preferrable. Therefore, we develop a risk-averse stochastic MILP formulation with scenarios for the antibiotics time machine problem that aims to maximize the performance of a certain percentage of the worst realizations. Due to the large number of scenarios needed to appropriately model the underlying uncertainty, we adopt a scenario decomposition approach [1] and improve its performance by exploiting the special structure of the problem. We carry out extensive computational experiments with real data to highlight the efficacy of our approach and present the trade-off between risk-averse and risk-neutral solutions.

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A branch-and-cut algorithm for the dial-a-ride problem with ride and waiting time minimization and time windows

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Abstract

In recent years, several ridesharing providers launched in large cities. In contrast to the standard dial-a-ride problem, these providers focus on the general public. As they are amongst others in competition with taxis and private cars, it is important for them to ensure short travel times for the customers. In this talk, we consider the resulting dial-a-ride problem with ride and waiting time minimization, which minimizes the relative detours of all customers in relation to the earliest point in time the customer can be picked up. Furthermore, we assume time windows for every customer request. We present a branch-and-cut algorithm with several techniques to improve the search. Moreover, we analyse our techniques in a computational study.

Convex Optimization Over the Efficient Set of Multiobjective Integer Linear Fractional Programs

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(*joint work with* Mustapha Moulaï)

Abstract

The optimization of a nonlinear or linear function on the efficient set is an interesting area of multi-objective programming. This approach allows to avoid enumerating all efficient solutions by evaluating and distinguishing them from each other using a function that summarizes the preferences of the decision makers, called the preference function. In this paper, we present an exact method for optimizing a convex preference function over the efficient set of multiobjective integer fractional programs. We have conducted an experimental study to test the proposed method with different preference functions. The obtained results are encouraging.

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On the Complexity of Flow Shop Scheduling with Job-Dependent Storage Requirements

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Abstract

We consider buffer-constrained flow shop problems that arise when scheduling the loading of media objects from online databases for an automatically assembled multimedia presentation [2]. The media objects are presented sequentially without a predefined order in a given presentation. Each object has a download time and a playback time. The presentation of an object cannot be started earlier than it will finish downloading. It is required to determine the sequence of loading and presentation of objects to minimize the completion time of the entire presentation. This technique has significant value in digital library/museum applications. In this application, the amount of buffer by a job is job-dependent and linearly proportional to its download time. Without loss of generality, we assume that the loading time of an object is equal to its file size. We also suppose that the presentation process is non-resumable, i.e., it cannot be interrupted and resumed later. We consider two different models for loading the objects to the buffer: resumable and non-resumable.

Note that if the buffer size is large enough, for example, it may contain all jobs, then the problem is equivalent to the two-machine flow shop problem without buffer, and it can be solved in $O(n \log n)$ time by Johnson's algorithm. In [1], the question of how the buffer size affects the computational complexity of the problem with non-resumable loading was studied. The authors obtained the lower bound on the buffer size at which the problem remains polynomial solvable.

In this paper we establish the exact borderline between the NP-hard and polynomial-time solvable instances of the both variants of the problem with respect to the ratio between the buffer size and the maximum operation length.

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Accelerating the bi-objective knapsack problem on a CPU-GPU system

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Abstract

The technical difficulty to solve exactly the multiobjective knapsack problem (MOKP) for large instances and/or the problems with more than two objectives imposes the use of parallel high performance computing (HPC) architectures. Parallelism is an approach to accelerate the resolution of multiple objective optimization problems. The appearance of new architectures such as multicore CPUs and GPUs seems particularly interesting in order to reduce resolution times in an economical way. In this conference, we propose a new parallel implementation of biobjective knapsack problem (BOKP) for execution on the graphics-processing unit (GPU) using NIVIDIA CUDA to improve efficiency, achieving high quality results in reasonable execution time. The obtained results show clearly a significant advantage of parallel method compared with sequential solving.

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Hybrid Variable Neighborhood Search for Automated Warehouse Scheduling

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(*joint work with* Yury Kochetov, Daniil Tolstykh, Tong Xialiang, Liu Jiawen)

Abstract

We study a new scheduling problem which arise in real-life applications, such as managing complicated warehouses, storage areas, e-commerce malls. Inspired by the automated warehouse of a huge electronic manufacturer, we consider a new picking and packing process on several production lines equipped with parallel machines and intermediate buffer[1,2]. The picking process is serviced by a limited fleet of transportation robots. Each robot delivers products from the storage to picking stations and back. Moreover, special constraints arise from the availability of parking slots and the duration of the customers' order handling. For this new makespan minimization problem, we design a hybrid Variable Neighborhood Search(VNS)[3] and Tabu Search(TS) framework. The search for a solution is conducted over a space of order permutations. Original randomized decoding procedure is constructed to evaluate the quality of solutions. Infeasible solutions can arise during the search process, thus we design a special mechanism to return into the feasible domain. We have conducted computational experiments on a set of instances based on real data, provided by the Huawei company with up to 1000 orders, 4 production lines, and 50 robots which corresponds to a typical one-day production plan. The proposed approach provides solutions with average relative error less than 2% from the lower bound.

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Time-critical testing and search problems

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(*joint work with* Ben Hermans, Roel Leus, Salim Rostami)

Abstract

In this talk, we introduce a problem in which the state of a system needs to be determined through costly tests of its components by a limited number of testing units and before a given deadline. We also consider a closely related search problem in which there are multiple searchers who want to find a target before a given deadline. These natural generalizations of the classical sequential testing problem [1] and search problem [2] are applicable in a wide range of time-critical operations such as machine maintenance, diagnosing a patient, and new product development. Our results include: The proof that both problems are NP-hard, a pseudo-polynomial dynamic program for the special case of two time slots, a partial-order-based as well as an assignment-based mixed integer program for the general case, an experimental comparison between the two formulations on the testing and the search variant, a pairwise-interchange-based local search procedure capable of efficiently finding near-optimal solutions.

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Container Ship Traffic Model for Optimization Studies

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(*joint work with* Jakub Wawrzyniak, Éric Sanlaville)

Abstract

In this presentation we consider a container ship traffic model for port simulation studies. Such a model is essential for terminal design analyses, testing performance of optimization algorithms. Studies of this type require accurate information about the ship stream to construct test scenarios and benchmark instances. A statistical model of ship traffic is developed on the basis of container ship arrivals of eight world ports. The model provides three parameters of the arriving ships: ship size, arrival time and service time. The stream of ships is divided into classes according to vessel sizes. For each class service time distributions and mixes of return time distributions are provided. A model of aperiodic arrivals is also proposed. The obtained results are used to compare port specific features. The details of the constructed ship traffic model are collected in [1].

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Hybrid metaheuristics for the latency location routing problem

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(*joint work with* Carlos Rey, Paolo Toth, Daniele Vigo)

Abstract

This talk presents three hybrid metaheuristics to solve the Latency Location Routing Problem (LLRP). The LLRP combines two NP-hard problems: the Cumulative Capacitated Vehicle Routing Problem (CCVRP) and the Facility Location Problem (FLP). The LLRP considers a homogeneous fleet of N_v capacitated vehicles, N_d uncapacitated depots from which at most N_f must be opened, and N_c customers with a non-negative demand. The LLRP asks for determining the location of the depots and the routes of the vehicles with the aim of minimizing the total latency of the system, which corresponds to the sum of the arrival times at the customers. The LLRP was introduced recently in [1], where the authors proposed a MILP formulation, and two metaheuristic algorithms: a memetic algorithm and a recursive granular algorithm. More recently, the authors in [2] proposed new formulations and exact algorithms for solving small and medium size instances, and a GRASP-based iterated local search algorithm.

In this talk we propose metaheuristic algorithms which combine simulated annealing with variable neighborhood search (VNS) or variable neighborhood descent (VND) procedures to solve the problem. The simulated annealing process is used as a diversification strategy, and the VNS/VND procedures are applied as an intensification stage. Extensive computational experiments on 76 LLRP benchmark instances were performed. The results show that the proposed algorithms are competitive with the state of the art algorithms both in terms of computing time and solution quality. The hybrid algorithms are able to find or improve the best known solution for the majority of the instances in the benchmark dataset and to find several proved-optimal solutions.

Keywords: cumulative routing, LLRP, location routing, simulated annealing, VNS

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Beyond the Symmetries of the Base Graphs of a Canonical Double Cover

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(*joint work with* Luke Collins)

Abstract

The factorization of a bipartite connected graph under direct product may not be unique but has a unique bipartite factor. The canonical double cover (CDC) of a base graph G is its direct product $G \times K_2$ with the complete 2–vertex graph K_2. Thus if a graph is a CDC, then its bipartite factor under direct product is necessarily K_2. Non–isomorphic graphs with the same CDC have the same degree sequence and the same number of walks of arbitrary length from corresponding vertices. We define a walk–colouring of the vertices of a graph, which assigns the same colour to vertices having the same number of walks of any specific length starting from them. We also consider the inverse problem of determining the base graphs that produce isomorphic CDCs, equivalent to a 2–1 projection mapping of the vertices of a CDC onto the vertices of a base graph. This mapping projects a minimal path in the CDC to a minimal path in base graph. The CDC may have unexpected automorphisms which cannot be lifted from automorphisms of the base graph leading to non-isomorphic graphs having the same CDC. We show that the graphs with isomorphic CDCs are related by Ryser–switching of disjoint edges with the same end-vertex colouring.

Keywords: canonical double covering, Ryser switch, walk colouring.

Acknowledgements: Thanks go to W. Imrich, R. Hammack and T. Pisanski for e–mail communications on the topic.

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Scheduling, Vehicle Routing and Convex Zones Partitioning Problem

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Abstract

The following problem is considered. There is a set of tasks to be processed in defined time windows and placed at several locations (sites). The set of sites should be partitioned into convex zones. For each zone (subset of sites) the specialist to process the tasks on the sites should be defined. Each specialist starts his work shift in his office and can execute the sequence of tasks moving from one site to another. To solve the problem one need to:

- split sites into convex zones;
- assign specialists to zones;
- define specialist's route for each work shift.

We consists bi-criteria objective function: maximization the number of processed tasks and minimization the penalty function based on total routes length and lateness of task processing is considered.

We propose the well-scalable algorithm of generation the set of feasible routes for each specialist's work shift and then solve MILP model to choose the paths in the optimal way. We also present a local search procedure to improve obtained solution. The most interesting scientific contribution is a MILP model which take into account convexity of subset of sites. Numerical experiments based on industrial large-scaled cases showed the efficiency of the proposed approach.

Acknowledgements: The research was done in the Laboratory of Mathematical Modeling, Moscow Research Center, Huawei Russian Research Institute in collaboration with Algorithm & Technology Development Department of Huawei, Shenzhen. Research was sponsored by Huawei's Global Technical Services.

Efficient Project Scheduling with Autonomous Learning

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(*joint work with* Thomas W. M. Vossen, University of Colorado Boulder, USA)

Abstract

Project scheduling models and methods are important building blocks of effective project management. In this work, we study a class of novel project scheduling problems that incorporate autonomous learning. We consider the case that certain jobs can be completed in a reduced amount of time, if scheduled after jobs that lead to acquiring relevant experience. We outline its practical usefulness, discuss problem structure and complexity, and devise efficient algorithms to solve these combinatorial problems.

It is well known that the classical project scheduling problem can be solved efficiently using a topological sorting based scheduling method. However, the new job precedence relation that may lead to learning, is represented by a complicating acyclic learning precedence network. It is not clear how to extend the known approach for project scheduling to the learning case. To better understand the new problem, we first introduce optimization techniques using organic learning. Here, learning opportunities are gradually added in a post-optimization fashion. It turns out that these additive algorithms do not guarantee optimal schedules. Finally, we show that through a more flexible iterative strategy that allows for both additive and subtractive learning integration, we obtain convergence and polynomial complexity.

In a computational study, we demonstrate the potential scheduling benefits that can be obtained when integrating learning compared to classical project scheduling. We also report the effectiveness of organic learning based methods. Furthermore, we provide results from a previous work [1] on model behavior under resource constraints using various constraint programming formulations.

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Best possible algorithms for online scheduling on identical batch machines with periodic pulse interruptions

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(*joint work with* Jun-Qiang Wang, Zhixin Liu, Jun Xu)

Abstract

We consider an online scheduling problem on identical batch machines to minimize the makespan with periodic pulse interruptions. Periodic pulse interruptions are machine unavailable intervals with negligible length, and divide the scheduling horizon into available intervals. Jobs are released online over time and processed simultaneously as batches with the same processing time on batch machines. Every batch needs to be entirely processed in an available interval without any preemption. We show the lower bounds of competitive ratios, and propose the corresponding best possible online algorithms that achieve the lower bounds.

Genomic Matching Optimization Problem

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Abstract

A genome sequence is a list of nucleotides (A, C, T and G) that describes all pieces of information about the construction of an individual. The genomic sequence within the specie is nearly identical between individuals (e.g. for humans, they are 99% alike). Nowadays, it is not yet technologically possible to accurately extract the whole genome sequence of an individual. There are technologies like Illumina to provide many short subsequences of the genome sequence. Those short sequences, called reads, are later assembled into the genome sequence. Illumina typically provides reads of lengths up to 150 nucleotides with an accuracy of 99.9% (on average, a single nucleotide from a thousand is incorrectly presented).

During our research, we wanted to align multiple datasets of short reads. We decided to prepare an optimization problem, which is very important from a bioinformatics point of view. We are assembling the genomes using our software ALGA or GRASShopPER. We prepared a problem definition and some tests and proposed it on the Optil.io platform. The main goal of this platform is to publish and solve optimization problems. We want to compare our solutions with algorithms proposed by other scientists. The task is to decide which pair of reads (one from the first dataset, the other from the second) originates from the same region in the genome sequence. Two subsequences originate from the same region if their position is very close from the perspective of the original genomic sequence.

We want to discuss the difficulties during the preparation of such a contest. Preparation of test cases and scoring method were difficulties to overcome.

We will discuss the intermediate results as of the day of the conference. The problem will be open for submissions also after the conference.

Efficient data reduction rules for the cluster editing problem

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Abstract

In the cluster editing problem, one has to transform a given undirected simple graph into a disjoint union of clusters using fewest edge modifications. The problem is known to be NP-complete and it is therefore unlikely to find an efficient algorithm solving the problem for general graphs. When dealing with such optimization problems, it is common to apply preprocessing techniques to reduce the graph size before running time-consuming algorithms solving the instance. We present several data reduction rules for the cluster editing problem. These rules include a few parameter-independent kernelization rules based on critical cliques and edge-cuts, modifications of some observations successfully used in solving miscellaneous graph problems, as well as several new data reduction procedures. We focus on a computationally efficient realization of presented rules that enables us to run the algorithms on very large graphs. We also show how some of the rules can be adapted to quickly and accurately identify sets of nodes that very often belong to the same cluster in some good solution.

Models for a complex job-shop scheduling problem with additional resources

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(*joint work with* Gaia Nicosia)

Abstract

The addressed problem concerns the organization of the production in a pharmaceutical company that provides a service of particle reduction of active ingredients. The company receives orders for certain types of drug mixtures and has to schedule the production with the main objective of meeting the delivery due dates. The problem is modeled as a complex job-shop scheduling with additional resources and constraints, many of which needed to meet quality requirements (e.g. contamination avoidance). In the literature, some real-life job-shop scheduling problems with additional resources have already been considered (see e.g. [1,3]).

In the addressed problem, each job consists of an ordered sequence of tasks to be executed. Each task has to be assisted by a given number of human operators and must be performed by a specific machine type which, in turn, has to be temporarily placed in a *clean room*. In addition to the standard constraints of a job-shop scheduling problem (precedence, capacity, no-preemption, blocking), some further features have to be considered, such as: the number of human operators is limited, each clean room can host only certain types of machines, some tasks cannot be executed during the night shifts, no-wait constraints apply to some pairs of consecutive operations. The objective function is the minimization of total weighted earliness and tardiness. To solve the problem a mixed integer linear programming and an innovative generalization of the disjunctive graph [2] able to model all the constraints are presented.

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The Nucleolus of the Network Connectivity Game

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We investigate the cost allocation strategy associated with the problem of providing service/communication between all pairs of network nodes. There is a cost associated with each link and the communication between any pair of nodes can be delivered via paths connecting those nodes. The example of a cost efficient solution which could provide service for all node pairs is a (non-rooted) minimum cost spanning tree. The cost of such a solution should be distributed among users who might have conflicting interests. The cost allocation problem is formulated as a cooperative game, to be referred to as a Network Connectivity (NC) game. The objective is to develop a stable and efficient cost allocation scheme. We construct an efficient cost allocation algorithm which finds the nucleolus of the NC game.

On the Quintuple Roman domination in graphs

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(*joint work with* Pilar Álvarez-Ruiz, J. Carlos Valenzuela-Tripodoro)

Abstract

In 2004, Cockaine et al.[4] introduced the concept of Roman domination in graphs. This concept was initially inspired in the papers by ReVelle and Rosing[5] and Stewart[6] related to a defensive strategy of the Roman Empire. This strategy was decreed by the Emperor Constatine I the Great and it is based in the fact that any undefended place of the Empire must have *a stronger* neighbour which is able to defend it without leaving itself undefended. An undefended place is a city so that no legions are established on it, whereas a strong place is a city in which two legions are deployed. This situation may be modeled by a labeling of the vertices of a finite simple graph with labels $\{0, 1, 2\}$, satisfying the condition that any 0-vertex must be adjacent to, at least, a 2-vertex. Roman domination in graphs is a variant of the classic Roman domination parameter that has been extensively studied in the last years. There are hundreds of paper shedding some light on the Roman domination problem and on its many variations. Clearly, the main aim is to obtain such a labeling of the vertices of the graphs with *minimum cost*, that is to say, having minimum weight (sum of all vertex labels).

Formally, a function $f : V(G) \to \{0, 1, 2\}$ is a *Roman dominating function* (RDF) in the graph $G = (V, E)$ if $f(u) = 0$ implies that $f(v) = 2$ for, at least, a vertex v which is adjacent to u. The weight of a RDF is the positive integer $w(f) = f(V)) \sum_{v\in V}^{f(v)}$. The *Roman domination number*, $\gamma(G)$, is the minimum weight among all the Roman dominating functions. Obviously, the set of vertices with a positive label under a RDF f is a dominating set in the graph, and hence $\gamma(G) \leq \gamma_R(G)$.

Beeler et al.[3] (2016), Álvarez et al.[1] (2021), Amjadi et al.[2] (2021) introduced several variations of the Roman domination problem in graphs. In these variations, stronger defensive strategies are considered by means of defending a city with more than one legion.

In this work, we start the study of a generalization of RDF in which we consider that any undefended place should be defended of a sudden attack by, at least, k legions. These legions can be deployed in the city or in any of its neighbours. We focus our attention in the $k = 5$ case, in which we use the set of labels $\{0, 1, \ldots, 6\}$ to guarantee that $f(AN[v]) \geq |AN(v)| + 5$ for any vertex v such that $f(v) < 5$, where $AN(v)$ represents the set of *active neighbours (i.e. with a positive label)* of vertex v.

Global defensive secure structures

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(*joint work with* Kacper Wereszko)

Abstract

Let $S \subset V(G)$ for a given simple non-empty graph G. We define for any non-empty subset X of S the predicate $SEC_{G,S}(X) = true$ iff $|N_G[X] \cap S| \geq |N_G[X] \setminus S|$. Let $\mathcal{H}$ be a non-empty family of graphs such that for each vertex $v \in V(G)$ there is a subgraph H of G containing v and isomorphic to a member of $\mathcal{H}$. We introduce the concept of $\mathcal{H}$-alliance extending the concept of global defensive secure structures. By an $\mathcal{H}$-alliance in a graph G we mean a set $S \subset V(G)$ such that (1) each vertex $v \in S$ belongs to a subgraph H of G that is isomorphic to a member of $\mathcal{H}$, and (2) for each $H \subset G[S]$ isomorphic to a member of $\mathcal{H}$, $SEC_{G,S}(V(H)) = true$. If S is also a dominating set of G, we call it a global $\mathcal{H}$-alliance of G.

If $\mathcal{H} = \{K_1\}$, then such an $\mathcal{H}$-alliance we call a *defensive alliance* (GA) [1] or a *vertex alliance*. If $\mathcal{H} = \{K_2\}$, then such an $\mathcal{H}$-alliance we call an *edge alliance* [2]. In the case of $\mathcal{H}$ is a class of all complete graphs (i.e., $K_1, K_2, \ldots$), then an $\mathcal{H}$-alliance we call a *complete alliance* [3]. If $\mathcal{H} = \{K_1, \ldots, K_k\}$, then an $\mathcal{H}$-alliance we call *k-complete alliance*.

In this talk we present general properties of global defensive secure structures (i.e., $\mathcal{H}$-alliances), algorithms for $\mathcal{H}$-alliance problems (exact and approximation ones), and we provide new $\mathcal{NP}$-complete results for global defensive secure structures for bounded degree graphs. We formulate also $\mathcal{H}$-alliance problem in some special cases as ILP problem and study a few algorithmic approaches.

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An approach for the Online 3D Bin Packing Problem

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1 Introduction

The high volume of purchases through e-commerce platforms have increased the use of new technologies and decision support systems in packing procedures. First, robotic arms used to perform the packing operation have gained interest because of the speed in building the packing pattern. Second, Machine Learning approaches, in conjunction with Operational Research approaches, seek the development of decision-support systems that can deal with the uncertainty in an online environment. This paper tackles the Online 3D Bin Packing Problem (3D-OBPP). In this problem, the items (boxes) are delivered to the packing procedure without knowing the complete sequence information. When each box is revelated, the system must decide how to pack the box into a single open cargo space; and is not allow reorganize the items already packed. The objective is to minimize the total bin required. We propose a maximal-space deep reinforcement learning-based approach that uses several heuristics (corners-first, stacking-first, and best-fit) to build the packing pattern and prepare the system for the following possible items. Our approach is validated using a set of instances based on an actual online operation that uses a robotic arm, and their optimal solution is known. The operation considered in this article also has a distribution band and a machine vision system. The results can show the strengths of our methodology and the impact of using the distribution band in the online packing operation, and how accurate the vision system needs to be. The allowed orientations will be considered for future work.

Demand Forecasting Methods: A Case Study in the Italian Processed Meat Industry

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(*joint work with* Giulia Caselli, Manuel Iori, Marco Lippi)

Abstract

Demand forecasting is acquiring more and more importance in the fast-changing business world, where market instability and economic shocks such as Covid-19 pandemic require firms to be both efficient and flexible. This work is based on a research project aiming at the development of a demand forecasting model for a company that operates in the Italian processed meat segment. The purpose is to obtain a forecast as accurate as possible and then use it at a later stage to carry out an optimal production scheduling (see, e.g., [1], [2]). Especially in the food sector, a proper integration of forecast and production management is essential, because the perishable nature of the items does not allow for over production. In this work, we compared different Machine Learning forecasting algorithms, including Linear Regressor, Random Forest Regressor, Support Vector Regressor and Multilayer Perceptron Regressor. We compared these methods with the ones used in the literature to define a baseline, like random walk and seasonal mean. Extensive computational tests on a two-year real-world data series prove the effectiveness of the algorithms, especially the Support Vector Regressor, in providing an accurate forecast. The resulting model is now used by the company on a daily basis.

Acknowledgements: We thank Inalca S.p.A. for financial support.

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Image data downlink scheduling problem for multi-satellite with characteristic of two-stage cutting stock

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(*joint work with* Zhongbao Zhou)

Abstract

The asynchronous development between data acquisition ability and image data playback capability of high-resolution Earth Observation Satellites (EOSs) results in that the image data formed by one-time observation cannot be completely played back in one transmit chance between the satellite and the ground station (named a data transmission window, DTW). It needs to segment the image data, and then playback in several DTWs. Image data segmentation enriches the extension of the satellite image data downlink scheduling problem, which is an NP-hard combinatorial optimization problem. In this paper, we first analyze the characteristics of this novel problem in deep. Fully using the classic cutting stock problem for reference and considering the timeliness of image data, we then format the problem in mathematical. Two kinds of local search mechanism is finally designed to solve it. The experimental results show that the reasonable image data segmentation scheme not only effectively improves the comprehensive income of image data playback, but also improves the utilization rate of ground station.

Keywords: Image data, Image data segmentation, downlink scheduling, cutting stock, local search

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