CONFERENCES PROGRAM

the 9th International Workshop on Hybrid Metaheuristics
and
the 5th International Workshop on Model-Based Metaheuristics:
Matheuristics 2014

June 11-13, 2014 in Hamburg, Germany

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http://iwi.econ.uni-hamburg.de/mh14/index.html
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Iterative Probabilistic Tree Search for the Minimum Common String Partition Problem
GeNePi: a Multi-Objective Machine Reassignment Algorithm for Data Centres

SESSION TITLE: PERFORMANCE MEASURES AND ALGORITHM COMPARISON

Online Performance Measures for Metaheuristic Optimization
Algorithm comparisons by automatically configurable metaheuristic frameworks: a case study using flow-shop scheduling problems

SESSION TITLE: MATHEURISTICS: LEARNING AND BEYOND

A hybrid Reactive GRASP with Reinforcement Learning
Automatic Configuration: Towards a New Methodology for Generating Hybrid Algorithms
Scientific Program

Tuesday, June 10, 2014

6:00 pm  Informal Get Together; Location: Roxie, Rentzelstraße 6, 20146 Hamburg (Please find directions on the following pages!)

Wednesday, June 11, 2014

9:00 am  Registration, Coffee break

10:00 am  Workshop / Conference Opening

10:30 am - 12:00 am  SESSION TITLE: PROBLEM DECOMPOSITION AND PARTITIONING

Victor Pillac, Pascal Van Hentenryck and Caroline Even:
A Path-generation Matheuristic for Large Scale Evacuation Planning

 Günther Raidl, Thomas Baumhauer and Bin Hu:
Speeding up Logic-Based Benders’ Decomposition by a Metaheuristic for a Bi-Level Capacitated Vehicle Routing Problem

Abdelkader Ouali, Samir Loudni, Lakhdar Loukil, Patrice Boizumault and Yahia Lebbah:
Cooperative Parallel Decomposition Guided VNS for solving Weighted CSP

12:00 am - 1:30 pm  Lunch

1:30 pm - 3:00 pm  SESSION TITLE: HYBRIDS WITH MATHEMATICAL PROGRAMMING STRATEGIES

Dhananjay Thiruvady, Gaurav Singh and Andreas Ernst:
Hybrids of Integer Programming and ACO for Resource Constrained Job Scheduling

Samuel Souza Brito, Haroldo Gambini Santos and Bruno Henrique Miranda Santos:
A Local Search Approach for Binary Programming: Feasibility Search

Simona Mancini:
A Large Neighborhood Search Based Matheuristic for a Rich VRP
### Thursday, June 12, 2014

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|               | **Lucas Assunção, Thiago F. Noronha, Andréa Cynthia Santos and Rafael Andrade:** A Linear Programming Based Heuristic for Robust
Optimization Problems: A Case Study on Solving the Restricted Robust Shortest Path Problem

Coffee break

3:30 pm - 5:30 pm  
**SESSION TITLE: MATHEURISTICS: METHODS AND APPLICATIONS**

*Silja Meyer-Nieberg:*  
Exploring Particle Assisted Evolution Strategies

*Andreas Ernst, Tim Moore, Bowie Owens and Gaurav Singh:*  
A Cross-Entropy Progressive Hedging Matheuristic for Optimising a RAPS System with Storage

*Túlio Toffolo, Haroldo Gambini Santos, Marco Antonio Carvalho, Janniele Soares, Tony Wauters and Greet Vanden Berghe:*  
An Integer Programming Approach to a Generalized Project Scheduling Problem

*Jörn Schönberger:*  
Integrating Linear Programming and Metaheuristic Search for Combined Network Flow and Routing Problems via a Distance Matrix Update Scheme

7:00 pm – 11:00 pm  
**Conference Dinner on board of the MS Concordia,**  
**Starting point: Landungsbrücken, Anleger Überseebrücke / Brandenburger Hafen** (Please find directions on the following pages!)
09:00 am - 10:30 am

**SESSION TITLE: METAHEURISTIC HYBRIDS**

**Jordi Arjona and Antonio Fernandez Anta:**
JAM: A Tabu-based Two-Stage Simulated Annealing Algorithm for the Multidimensional Arrangement Problem

**Christian Blum, José Antonio Lozano and Pedro Pinacho Davidson:**
Iterative Probabilistic Tree Search for the Minimum Common String Partition Problem

**Takfarinas Saber, Anthony Ventresque, Xavier Gandibleux and Liam Murphy:**
GeNePi: A Multi-Objective Machine Reassignment Algorithm for Data Centres

Coffee break

11:00 am - 12:00 am

**SESSION TITLE: PERFORMANCE MEASURES AND ALGORITHM COMPARISON**

**Kay Hamacher:**
Online Performance Measures for Metaheuristic Optimization

**Franco Mascia, Manuel López-Ibáñez, Jérémie Dubois-Lacoste, Marie-Eléonore Marmion and Thomas Stützle:**
Algorithm Comparisons by Automatically Configurable Metaheuristic Frameworks: A Case Study Using Flow-shop Scheduling Problems

12:00 am - 1:00 pm

**SESSION TITLE: MATHEURISTICS: LEARNING AND BEYOND**

**Ismael Izídio De Almeida, Carlos Heitor Pereira Liberalino and Francisco Chagas Lima Junior:**
A Hybrid Reactive GRASP with Reinforcement Learning

**Thomas Stuetzle, Leonardo Bezerra, Jérémie Dubois-Lacoste, Manuel López-Ibáñez, Franco Mascia and Leslie Pérez Caceres:**
Automatic Configuration: Towards a New Methodology for Generating Hybrid Algorithms

1:00 pm - 2:00 pm

Lunch
2:00 pm - 3:00 pm  SESSION TITLE: MEET THE EDITORS

3:00 pm  Farewell / Good Bye
How to get there

Map to the Conference Premises (Esplanade 36, 20345 Hamburg):

The easiest way to get to the conference premises is via the pedestrian bridge from the back exit of train station Hamburg Dammtor (approx. 5-10 min. walking distance) or via bus from the bus station in front of Dammtor train station, at Theodor-Heuss-Platz (line 4 or line 5, direction “ZOB Hauptbahnhof”, 1 stop). Due to a construction site the bus station is right across the street from Esplanade 36 (side entrance of building “Hamburger Spielbank”).
Map for the informal Get Together on Tuesday, 6:00 pm:

Rentzelstraße 6 (from Dammtor station bus lines 4 and 5, direction: Wildacker/Nedderfeld/Langenfelder Damm, 2 stops). Due to a construction site the bus station “Grindelhof” is unavailable. Please exit at station “Universität/Staatsbibliothek” and walk to Rentzelstraße 6.
Maps to the Conference Dinner on Thursday, 7:00 pm

On board of the MS Concordia, Starting point: Landungsbrücken, Anleger Überseebrücke / Brandenburger Hafen. For further information concerning traveling modes, please visit: www.hvv.de
Map from underground station „Landungsbrücken“ to the ship:

The MS Concordia will be situated about here.
Pyomo and PySP to Support Matheuristics for Deterministic and Stochastic Programs
Speaker: David L. Woodruff, UC Davis, USA

Thursday, June 12, 2014, 09:00 am - 10:00 am

Pyomo is a modeling language that supports a full range of linear and non-linear modeling constructs in a Python environment so scripting is natural and powerful. An extension for stochastic programming called PySP provides automated formation of deterministic equivalents and also provides an extensible implementation of progressive hedging. In this tutorial we will very briefly introduce Pyomo and PySP as well and then indicate how researchers can interface their own solvers. This is particularly valuable when it is possible to provide a representation of the problem suitable for calls to solvers such as CPLEX, Gurobi or IPopt as well as calls to a (meta-)heuristic solver.
A Path-generation Matheuristic for Large Scale Evacuation Planning

Authors: Victor Pillac, Pascal Van Hentenryck and Caroline Even, NICTA and Monash University, Australia

Abstract:
In this study we present a general matheuristic that decomposes the problem being solved in a master and sub-problem. In contrast with the column generation technique, the proposed approach does not rely on the explicit pricing of new columns but instead exploits features of the incumbent solution to generate one or more columns in the master problem. We apply this approach to large scale evacuation planning, leading to the first scalable algorithm that complies with emergency services practice.

Speeding up Logic-Based Benders’ Decomposition by a Metaheuristic for a Bi-Level Capacitated Vehicle Routing Problem

Authors: Günther Raidl, Thomas Baumhauer and Bin Hu, Vienna University of Technology, Austria

Abstract:
Benders’ Decomposition (BD) is a prominent technique for tackling large mixed integer programming problems having a certain structure by iteratively solving a series of smaller master and sub-problem instances. We apply a generalization of this technique called Logic-Based BD, which does not restrict the sub-problems to have continuous variables only, to a bi-level vehicle routing problem originating in the timely distribution of printed newspapers to subscribers. When solving all master and sub-problem instances exactly by CPLEX, it turns out that the scalability of the approach is quite limited. The situation can be dramatically improved when using a meaningful metaheuristic – in our case a variable neighborhood search – for approximately solving either only the sub-problems or both, the master as well as the sub-problem instances. More generally, it is shown that Logic-Based BD can be a highly promising framework also for hybrid metaheuristics.
Cooperative Parallel Decomposition Guided VNS for solving Weighted CSP

Authors: Abdelkader Ouali, Yahia Lebbah and Lakhdar Loukil, Laboratoire LITIO, Université d’Oran, Algeria; Samir Loudni and Patrice Boizumault, GREYC, CNRS, Université de Caen Basse-Normandie, France

Abstract:

Tree decomposition introduced by Robertson and Seymour aims to decompose a problem into clusters constituting an acyclic graph. Recently, Fontaine et al. [8] introduced DGVNS (Decomposition Guided VNS) that uses the graph of clusters provided by a tree decomposition to manage the exploration of large neighborhoods. However, for large scale problems, the performance of DGVNS may decrease significantly due to the large number of clusters to be considered sequentially. To overcome this shortcoming we propose CPDGVNS (Cooperative Parallel DGVNS) in which the clusters are explored in parallel through an asynchronous master/slave architecture. Experiments performed on real life instances show the appropriateness and the efficiency of our approach.
Hybrids of Integer Programming and ACO for Resource Constrained Job Scheduling

Authors: Dhananjay Thiruvady, Gaurav Singh and Andreas Ernst, CSIRO, Australia

Abstract:

A recent line of research considers hybrids of Lagrangian relaxation and Ant Colony Optimization (ACO). Studies have shown that for hard constrained optimization problems Lagrangian relaxation can effectively guide ACO to provide good feasible solutions. We consider applying these ideas to create a matheuristic combining ACO with decomposition approaches from mathematical programming for a resource constrained job scheduling problem. We are given a number of jobs which have to be executed on a number of machines satisfying several constraints. These include precedences and release times within machines and the machines are linked via a central resource constraint. By removing the linking constraint, the scheduling problem of each machine can be solved independently as a relatively simple sub-problem. Both Dantzig-Wolfe decomposition with column generation and Lagrangian relaxation are tried to carry out this decomposition. The relaxed solutions can provide useful guidance to determine solutions either via problem specific heuristics and ACO. Empirical results show that the Lagrangian relaxation matheuristic performs well in limited time-frames whereas the column generation based heuristic provides improved lower and upper bounds when run to convergence.

A Local Search Approach for Binary Programming: Feasibility Search

Authors: Samuel Souza Brito, Haroldo Gambini Santos and Bruno Henrique Miranda Santos, Universidade Federal de Ouro Preto – UFOP, Brazil

Abstract:

In this paper we propose a local search approach for NP-hard problems expressed as binary programs. Our search method focuses in the fast production of feasible solutions. The method explicitly considers the structure of the problem as a conflict graph and uses a systematic neighbor generation procedure to jump from one feasible solution to another, using chains of movements. Computational experiments comparing with linear programming and SAT based heuristics of the GNU Linear Programming Kit (GLPK) in MIPLIB 2010 instances showed that our approach is more reliable for the production of feasible solutions in restricted amounts of time.
Authors: Simona Mancini, Politecnico di Torino, Italy

Introduction and Problem Description: Real life freight distribution problems present a high degree of complexity mostly derived by the need to respect a variety of constraints, addressing multi-dimensional vehicle capacity (weight and volume), vehicles characteristics (refrigerated vehicles for perishable food, etc.), route duration/length restriction, time windows, products/products, products/vehicles and/or customers/vehicles compatibility, and often require objective functions more complex than the classical distances minimization, in which different factors must be taken into account. In this paper a new rich Vehicle Routing Problem arising in real life context is introduced and formalized, the Multi Depot Multi Period Vehicle Routing Problem with Heterogeneous Fleet. This research is issued from a transport carrier needing to deal with the weekly planning of delivery operations for a company which disposes from several depots where the good is stored and/or produced, a known fleet of vehicles, located at the depots, and a set of available drivers for which a fixed cost, in addition to a variable cost determined given by the driving time multiplied by a hourly driving cost, must be paid if they are scheduled on the week plan. The planning horizon, as in most real life applications, consists of multiple periods and the period in which each route is performed is a variable of the problem. For each customer is known the set of periods, within the time horizon, in which the delivery may be carried out. Each customer must be served in one of the time slots (typically, but not necessarily, days), in which he is available. Furthermore, other constraints on the periods in which the delivery can be carried out, may be given by the fact that customers need to receive the goods within a given deadline, or the goods must be delivered after a given time slot, because it is not available before. The problem is Multi-Depot, but differently from what happens in classical Multi-Depot vehicle routing problems (MDVRP) in which routes must end at the same depot from which it started, we allow routes ending on a different depot. This version of MDVRP, which did not receive a greatest interest by the academic community, is very common in practical applications. In fact, it could be more convenient to end a route in a different depot with respect to the starting one, avoiding long trip back to the depot. An heterogeneous fleet is considered, composed by vehicles characterized by a different capacity (expressed in terms of loading units), and a cost per Km. Furthermore, each vehicle may have different characteristics (for instance, refrigerated vehicles) which can be required by some customers and must be avoided for other ones cost. The location of each vehicle at the beginning of the time-horizon analyzed is supposed to be known in advance. Not every customer may be served by all the vehicles and from all the depots. These restrictions may be due to specific requirements of the product (for instance, refrigerated vehicles for perishable food, freezer vehicles for ice creams and frozen foods), or to the customer location (for instance, customer located in the city center cannot be served by very large vehicles which are not allowed to enter that zone). Restrictions on the depots from which customers may be served hold when the products requested by the customer are not available at each depot. Restrictions on the maximum route duration coming out from drivers working hours limitations are considered, too. The problem goal is to minimize the total delivery cost.

Methodologies: The Large Neighborhood search heuristic (LNS) belongs to the class of heuristics known as Very Large Scale Neighborhood search (VLSN) algorithms which are
based on the observation that searching a large neighborhood results in finding local optima of high quality, and hence overall a VLSN algorithm may return better solutions. However, searching a large neighborhood is strongly time consuming, hence various filtering techniques are used to limit the search. In VLSN algorithms, the search is typically restricted to a subset of the solutions belonging to the neighborhood which can be searched efficiently. Differently from what happens in other VLSN, in LNS the neighborhood is implicitly defined by the moves used to destroy and repair an incumbent solution. The destroy operators may be defined in different ways. For routing problems, for instance, a destroy operator could consist into breaking k routes letting the others unvaried, or into removing a fixed percentage of the arcs in the current solution. A random (or randomized) component is used to select the arcs to be removed. The repair method rebuilds a feasible solution starting from the partially destroyed one. Generally a greedy construction heuristic is used to rebuild the solution, which is very fast but not always very accurate, since only a sample solution is analyzed in the neighborhood. The innovative aspect of the LNS proposed in this paper concern the possibility of addressing the whole neighborhood in reasonably small computational time. In fact, the large neighborhood search is exploited directly by the model. In this way it is possible to obtain the local minimum with respect to the addressed neighborhood, which makes the intensification phase of the algorithm more powerful and precise. The proposed matheuristic, from now on called MH, works on the customers-to-route assignment variables starting from a feasible initial solution. More precisely at each iteration of the algorithm, p customers are randomly selected; all the others customers are assigned to the same route to which they are assigned in the current solution, while the p selected ones are let free to be assigned to any route. The parameter p can be arbitrarily chosen keeping in mind that small values of p allow a limited perturbation with the risk to remain trapped into local minima, while very big values generate such a large neighborhood search which cannot be easily exhaustively explored in a short computational time. The new obtained solution, which is the local minimum in the neighborhood, is chosen as current solution for the next iteration. The procedure terminates after a maximum number of iterations or a maximum number of iterations without any improvement are reached. This procedure needs an initial feasible solution from which to start, that could be computed in different ways, both with a simple greedy constructive heuristic and with more complex meta-heuristic or directly with the model. In this work an initial solution obtained letting the model run for 10 seconds has been used. The initial solution quality is not a crucial issue, because, due to the strong diversification inserted in the algorithm, the matheuristic is capable to explore regions potentially far, in the solution space, from the starting point and to converge to a very good solution even starting from a poor quality one. This is a strong good point of the method.

Computational results: Computational tests have been carried out on instances with different characteristics. Three different levels of customers-vehicles compatibility and of customer availability have been defined. One instance for each combination of these two parameters has been generated. These levels have been constructed in order to represent realistic cases which may arise in practical applications. In fact, availability and compatibility level may sensibly vary depending on the analyzed context. For instance, in food delivery to the supermarkets, vehicles compatibility is generally low; in fact, frozen or perishable items require specific vehicles, like freezer or refrigerated ones, which generally are a very small subset of the global fleet. Customers’ availability, instead, is very high because supermarkets do not have strict deadlines, and may be served each day of the week. In other contexts, like electronic products home delivery (carried out by amazon or other online shopping website), strictly delivery deadlines are imposed, but vehicles compatibility is around 100%, because products do not have any specific requirement.
The matheuristic provides a remarkable percentage improvement with respect to the model within much quicker computational time. The improvement with respect to the initial solution is above 25% on average, which means that the algorithm is capable to converge to a good solution even starting from a poor one. Improvements are smaller on highly constrained instances, which are the less common in practice. This behavior can be explained by the fact that the model performs better on more constrained problems, and therefore, solutions obtained by the model are already high quality ones. Averaged results on 10 runs are quite similar to best results which is another good point of the algorithm because it shows its robustness with respect to the random component.

Conclusions and Future Perspectives: In this paper a Large Neighborhood Search based matheuristic for a real-life rich VRP has been proposed and computational tests have been carried out on instances with different properties representing realistic distribution contexts. Results coming out from computational tests show the efficacy and the effectiveness of the proposed approach. The most innovative aspect of the proposed approach is the capability of exhaustively exploring a large (or very-large) neighborhood in very small computational time, which make the LNS framework much more effective than a traditional implementation of LNS in which only a subset of the solutions in the considered neighborhood are analyzed. Another good point of this approach is that it is extremely portable, i.e., it can be easily adapted to other vehicle routing problems dealing with assignment variables, such as the 2E-VRP in which customers are assigned to intermediate facilities, or as standard Multi-Depot and Location-Routing problems. Furthermore, this neighborhood search technique may be used in the local search phase in more complex metaheuristics such as Variable Neighborhood Search (VNS), Adaptive Large Neighborhood Search (ALNS) and others.
SESSION TITLE: LARGE NEIGHBORHOOD SEARCH

Session date: Thursday, June 12, 2014, 10:30 am - 12:00 am

*A hybrid metaheuristic to solve the resource allocation problem in bike sharing systems*

Authors: Patrick Vogel, Bruno Albert Neumann Saavedra and Dirk Christian Matfeld, TU Braunschweig, Germany

Abstract:

Bike sharing systems have recently enabled sustainable means of shared mobility through automated rental stations. Spatio-temporal variation of bike rentals, however, leads to imbalances in the distribution of bikes causing full or empty stations. The resource allocation problem tackles imbalances at a tactical planning level by means of bike allocation and relocation. We propose a MIP formulation of an extended dynamic service network design model. The objective is to determine optimal fill levels at stations while minimizing the expected costs of relocation operations. The MIP formulation is hard to solve for big instances due to a large number of binary variables for relocations (stations, times, stations times, periods). Thus, we present a hybrid metaheuristic integrating a large neighborhood search with exact solution methods provided by a solver. The large neighborhood search repetitively limits and controls possible relocation regimes, i.e. a small subset of “free” binary transportation variables. The majority of remaining binary variables are tentatively fixed to zero leading to a fast solvable sub-problem of the resource allocation problem. Therefore, a commercial solver can provide a local optimal value based on the defined neighborhood in a reasonable time. Results obtained indicate that the hybrid metaheuristic outperforms CPLEX for data from Vienna’s bike sharing system “Citybike Wien”.

*A Variable Neighborhood Search using Very Large Neighborhood Structures for the 3-Staged 2-Dimensional Cutting Stock Problem*

Authors: Frederico Dusberger and Günther Raidl, Institute of Computer Graphics and Algorithms, Vienna University of Technology, Austria

Abstract:

In this work we consider the 3-staged, 2-dimensional cutting stock problem, which appears in many real-world applications such as glass and wood cutting and various scheduling tasks. We suggest a variable neighborhood search (VNS) employing "ruin-and-recreate"- based very large neighborhood searches (VLNS). We further present a polynomial-sized integer linear programming model (ILP) for solving the sub-problem of 2-staged 2-dimensional cutting with variable sheet sizes, which is exploited in an additional neighborhood search within the VNS. Both methods yield significantly better results on about half of the benchmark instances from literature than have been published before.
A CP/LNS approach for Multi-day Homecare Scheduling Problems

Authors: Luca Di Gaspero and Tommaso Urli, DIEGM - University of Udine, Italy

Abstract:

Homecare, i.e., supportive care provided at the patients' homes, is established as a prevalent alternative to unnecessary hospitalization or institutional care (e.g., in a rest home or a nursing home). These activities are provided either by healthcare professional or by non-medical caregivers, depending on the patient's needs (e.g., medical care or just instrumental activities of daily living). In this paper, we consider the problem of scheduling Homecare Activities, that is, determining the caregivers' daily tours and the schedules of the homecare service to patients. We present a Constraint Programming (CP) formulation of the problem and we propose a Large Neighborhood Search method built upon the CP formulation.
**A Partition-based Heuristic for the Steiner Tree Problem in Large Graphs**

Authors: Markus Leitner and Ivana Ljubic, University of Vienna, Austria; Martin Luipersbeck and Max Resch, Vienna University of Technology, Austria

Abstract:

This paper deals with a new heuristic for the Steiner tree problem (STP) in graphs, which aims at finding the efficient construction of approximate solutions in very large graphs. The algorithm is based on a partitioning approach in which instances are divided into several subinstances that are small enough to be solved to optimality. A heuristic solution of the complete instance can then be constructed through the combination of the subinstance-solutions. To this end, a new STP-specific partitioning scheme based on the concept of Voronoi diagrams is introduced. This partitioning scheme is then combined with state-of-the-art exact and heuristic methods for the STP. The implemented algorithms are also embedded into a memetic algorithm, which incorporates reduction tests, an algorithm for solution recombination and a variable neighborhood descent that uses best-performing neighborhood structures from the literature. All implemented algorithms are evaluated using previously existing benchmark instances and by using a set of new very large-scale real-world instances. The results show that our approach yields good quality solutions within relatively short time.

**A Matheuristic Algorithm for Prize-collecting Steiner Tree Problem**

Authors: Murodzhon Akhmedov and Roberto Montemanni, Dalle Molle Institute for Artificial Intelligence IDSIA-USI/SUPSI; Italy; Ivo Kwee, Institute of Oncology Research (IOR), Switzerland

Abstract:

The Prize-collecting Steiner Tree Problem (PCSTP) is one of the best studied problems in combinatorial optimization. It has a wide range of applications in the literature, for instance in fiber optics such as gas distribution and district heating. In this study, we focus on its application in functional analysis of genes on bio-genetical graphs. In bio-genetics the possibility of having to interpret huge graphs is highly possible. Since the PCSTP is NP-hard, it is time-consuming to obtain solutions for large instances. Thus, there is a need for efficient and fast heuristic algorithms to discover the hidden knowledge behind the vast biogenetical networks. We propose a matheuristic composed of heuristic clustering algorithms and existing mixed integer linear programming to solve PCSTP. We evaluated the performance of our matheuristic on available real-world benchmark instances from biology and compared it with existing heuristic approaches in the literature. With respect to heuristic results, we obtained solutions with similar or better objective function values. On the other hand the
existing heuristic solved the benchmark instances with smaller running time compared to the proposed matheuristic.

A Linear Programming Based Heuristic for Robust Optimization Problems: A Case Study on Solving the Restricted Robust Shortest Path Problem

Authors: Lucas Assunção and Thiago F. Noronha, Universidade Federal de Minas Gerais, Brazil; Andréa Cynthia Santos, Université de Technologie de Troyes, France; Rafael Andrade, Universidade Federal do Ceará, Brazil

Abstract:

A linear programming based heuristic is proposed in this study, and applied to the Restricted Robust Shortest Path problem (R-RSP). The general scheme can be extended and used to other robust optimization problems. R-RSP is a robust optimization version of the classical restricted shortest path problem, which is an NP-hard problem. The arcs are associated with cost intervals and with a length value. The goal is to find a path connecting an origin to a destination vertex respecting a maximum length constraint and minimizing a robust criterion called restricted robustness cost. To the best of our knowledge, R-RSP has not been studied in the literature and this is the first work to model and to propose procedures for solving the R-RSP. This problem models practical applications such as using electrical vehicles in urban areas, where one looks for a path from an origin to a destination taking into account traffic jams, and satisfying the vehicles autonomy. In addition, an important theoretical result which reduces the search space on many robust optimization problems is generalized to the R-RSP. Computational experiments show the effectiveness of the proposed procedure using the case study of the R-RSP.
SESSION TITLE: MATHEURISTICS: METHODS AND APPLICATIONS
Session date: Thursday, June 12, 2014, 3:30-5:30 pm

Exploring Particle Assisted Evolution Strategies

Author: Silja Meyer-Nieberg, University of the Federal Armed Forces Munich, Germany

Abstract:
Particle swarm optimization (PSO) and evolution strategies (ESs) belong to the class of natural computing approaches. Usually, they are used for continuous optimization. While hybrids between PSO and evolutionary algorithms have been introduced before, a combination between PSO and an ES could not be identified. This paper introduces, discusses, and evaluates a new hybrid metaheuristic, called Particle Assisted Evolution Strategies (PAESs) which combines both concepts.

A Cross-Entropy Progressive Hedging Matheuristic for Optimizing a RAPS System with Storage

Authors: Andreas Ernst, Tim Moore, Bowie Owens and Gaurav Singh, CSIRO Mathematics, Informatics and Statistics, Australia

Abstract:
In many applications the design of a system needs to be optimized but the effectiveness of these choices can only be evaluated by considering the behavior over a long time period or a number of scenarios. Here we consider a particular problem that arises in the design of a control strategy for operating a Remote Area Power Supply (RAPS) system in the presence of storage. The aim is to find a simple strategy that makes efficient use of a diesel generator and storage facility for typical patterns of demand and renewable power generation. We show how this problem can be formulated as a mixed integer programming formulation with a network design structure. We then show how two heuristic algorithms: cross-entropy optimization and progressive hedging can be applied to this problem. We propose a novel way of combining these two methods into a hybrid in a mutually reinforcing way. Finally we show how the combined method can be applied to a general class of mixed integer programming problems that exhibit a particular type of block diagonal structure.

An Integer Programming Approach to a Generalized Project Scheduling Problem

Authors: Túlio Toffolo and Greet Vanden Berghe, KU Leuven, Belgium; Haroldo Gambini Santos, Marco Antonio Carvalho and Janniele Soares, Universidade Federal de Ouro Preto – UFOP, Brazil; Tony Wauters, KaHo Sint Lieven, Belgium
Abstract:

The Project Scheduling Problem consists of scheduling the processing times of jobs (or activities) contained in a project, while respecting precedence constraints between the jobs. This class of problems models many situations of practical interest in engineering and management science in general, and has been addressed by experts of various fields. The subject of this work is the Multi-Mode Resource-Constrained Multi-Project Scheduling Problem, an extension of the PSP that considers multiple projects with resource constraints and multiple possibilities to execute the activities. We produced a hybrid algorithm with several heuristics and Integer Programming (IP) based components: (i) a mode selection IP model; (ii) a project priority estimation heuristic; (iii) an IP constructive algorithm; and (iv) an IP local search algorithm. We present results of computational experiments on different PSP benchmark datasets to demonstrate the efficiency of the proposed approach. These experiments improved best known solutions for several instances of two different problem extensions.

Integrating Linear Programming and Metaheuristic Search for Combined Network Flow and Routing Problems via a Distance Matrix Update Scheme

Author: Jörn Schönberger, University of Bremen, Germany

Abstract:

We investigate a matheuristic approach that contributes to the search for high quality solutions of a vehicle routing problem with customer locations, several warehouses and a vehicle depot. The underlying decision situation can be outlined as follows. A transport service company maintains a fleet of vehicles. Each vehicle has a known maximal payload capacity. In addition, this company maintains a collection of warehouses in which known quantities of a commodity (say: sand, concrete or other bulk materials) are stocked. A customer order determines the quantity of the considered commodity that must be moved by the transport service company to a specified customer location (e.g. a construction site). Considering all specified orders, the available fleet as well as the stocked quantities in the warehouse, the fleet dispatcher aims at minimizing the sum of the route lengths of the vehicles sent out to contribute to the fulfillment of the order portfolio. The outlined decision situation is a generalization of the decision situation known from vehicle routing problems in which a request expresses the need to move a given quantity from a given pickup location to a given delivery location. Also here, customer requests are compiled into routes in order to fulfill customer orders at least costs. However, the major difference compared to the commonly known vehicle routing task is the incomplete request specification by the customer. A customer only specifies the delivery location as well as the quantity to be delivered but the pickup location remains unspecified. Additionally, a customer order quantity sometimes exceeds the maximal vehicle payload. The determination of the pickup location falls into the responsibility of the transport company’s fleet dispatcher who has to decide from which warehouse(s) the customer locations are served. Due to this, the decision task associated with the dispatcher comprises two interdependent decision tasks: First, the determination of the source of supply for each individual customer location and, second, the determination of the vehicle routes. It is allowed and sometimes necessary to split the quantity associated with a customer order into several requests. This links several warehouses with a customer location. We call this combined problem the pickup and delivery problem with split orders (PDPSO) and propose first a mixed-integer linear programming representation. At first glance, it seems to be obvious to adapt routing approaches from the
well-studied vehicle routing problem with split deliveries (VRP SD) to tackle the PDPSO. However, the determination of the split quantities assigned to different requests in the VRP SD is based on the maximal available payload capacity of a vehicle. Such a maximal available payload capacity is of less importance in pickup and delivery problems since en-route deliveries enable a capacity reutilization. Therefore, the primary research task associated with the PDPSO is to find appropriate request quantities that cover the overall order quantity to be delivered to a customer but that also incorporate warehouses that can be reached with least additional travel distances. We propose to determine the quantities to be picked up for a certain customer order at the warehouse(s) by solving a capacity constrained transportation problem using CPLEX (tp-stage). After we have completed the request specification the PDPSO reduces to a pickup and delivery problem which is solved using a metaheuristic based on several neighborhoods (routing-stage). Obviously, the determination of the request quantities in the tp-stage does not consider the need to keep the overall travel distances as low as possible. For this reason, we re-enter the tp-stage and modify the distance matrix of the transportation problem. Assignments of warehouses to customer orders having led to detours will be penalized by increasing the associated entries in the transportation problem’s distance matrix. Furthermore, the selection of assignments of warehouses to customer locations having caused only minor detours is enforced to be preserved in the modified transportation problem’s optimal solution by decreasing the associated values in the distance matrix. Now, the updated transportation problem is solved. The request quantities are updated and the routing-stage is processed followed by an update of the distance matrix of the transportation problem and so on until a termination criterion is fulfilled. We report about initial evaluations of a prototype of the setup matheuristic. The here proposed and prototypically evaluated hybrid heuristic incorporates the determination of an optimal solution of a network flow problem and the approximation of an interwoven routing problem. This matheuristic-concept can be generalized for all (combinatorial) decision problems in which a linear network flow model represents a sub-problem. The communication between the lp solver and the heuristic using the distance matrix modification scheme is a very flexible approach to hybridize a (meta-) heuristic with a mathematical solver.
JAM: A Tabu-based Two-Stage Simulated Annealing Algorithm for the Multidimensional Arrangement Problem

Authors: Jordi Arjona, Universidad Carlos III de Madrid, Spain; Antonio Fernandez Anta, Institute IMDEA Networks, Spain

Abstract:

In this paper we study a version of the Multidimensional Arrangement Problem (MAP) that embeds a graph into a multidimensional array minimizing the aggregated (Manhattan) distance of the embedded edges. This problem includes the minimum Linear Arrangement Problem (minLA) as a special case, among others. We propose JAM, a tabu-based two-stage simulated annealing heuristic for this problem. Our algorithm relies on existing techniques for the minimum linear arrangement (minLA) problem, which are non-trivially adapted to work in multiple dimensions. Due to the scarcity of specific benchmarks for MAP, we have tested the performance of our algorithm with benchmarks for the minLA and Quadratic Assignment Problems (with more than 80 graphs). For each graph in these benchmarks, we provide results for 1, 2 and 3-dimension instances of MAP, enlarging, hence, the benchmarking resources for the research community. The results obtained show the practicality of JAM, often matching the best known result and even improving some of them.

Iterative Probabilistic Tree Search for the Minimum Common String Partition Problem

Authors: Christian Blum, IKERBASQUE and University of the Basque Country (UPV/EHU), Spain; José Antonio Lozano and Pedro Pinacho Davidson, University of the Basque Country (UPV/EHU), Spain

Abstract:

The minimum common string partition problem is an NP-hard combinatorial optimization problem with applications in computational biology. In this work we propose an iterative probabilistic tree search algorithm for tackling this problem. By means of an extensive experimental evaluation we show the superiority of our approach in comparison to a standard greedy algorithm and a metaheuristic based on ant colony optimization from the related literature.
GeNePi: a Multi-Objective Machine Reassignment Algorithm for Data Centres

Authors: Takfarinas Saber, Anthony Ventresque and Liam Murphy, School of Computer Science and Informatics, University College Dublin, Ireland; Xavier Grandibleux, Faculty of Science, University of Nantes, France

Abstract:

Data centers are facilities with a large amount of machines (i.e., servers) and hosted processes (e.g., virtual machines). Managers of data centers (e.g., operators, capital allocators, CRM) constantly try to optimize them, reassigning “better” machines to processes. These managers usually see better/good placements as a combination of distinct objectives, hence why in this paper we define the data center optimization problem as a multi-objective machine reassignment problem. While classical solutions to address this either do not find many solutions (e.g., GRASP), do not cover well the search space (e.g., PLS), or even cannot operate properly (e.g., NSGA-II lacks a good initial population), we propose GeNePi, a novel hybrid algorithm. We show that GeNePi outperforms all the other algorithms in terms of quantity of solutions (nearly 6 times more solutions on average than the second best algorithm) and quality (hypervolume of the pareto frontier is 106% better on average).
Online Performance Measures for Metaheuristic Optimization

Author: Kay Hamacher, TU Darmstadt, Germany

Abstract:

(Global) optimization is one of the fundamental challenges in scientific computing. Frequently, one encounters objective functions or search space topologies that do not fulfill necessary requirements for well understood and efficient procedures like, e.g., linear programming. This methodological gap is filled by metaheuristic optimization approaches. Their search dynamics in high dimensional search spaces and for complex objective functions is not well understood at present. In particular, the choice of parameters driving the procedures is a demanding task. In this contribution we show how insights from time series analysis help to investigate - on a pure empirical basis - metaheuristic schemes. Rather than deriving analytical results on convergence behavior, ex ante, we propose online observation of the search and optimization progress. We apply the proposed method to two different metaheuristics, namely differential evolution and basin hopping.

Algorithm Comparisons by Automatically Configurable Metaheuristic Frameworks: A Case Study Using Flow-shop Scheduling Problems

Authors: Franco Mascia, Manuel Lopez-Ibáñez, Jérémie Dubois-Lacoste and Thomas Stützle, Université Libre de Bruxelles, Belgium; Marie-Éléonore Marmion, LIFL, Université Lille 1, Inria Lille Nord-Europe, France

Abstract:

The benefits of hybrid metaheuristics, in comparison with more classical (non-hybrid) ones are often difficult to quantify, since one has to take into account not only the final results obtained but also the effort spent on finding the best configuration of the hybrid and of the classical metaheuristics. In this paper, we study this trade-off by means of tools for automatic algorithm design, and in particular, we study the difficulty of generating hybrid metaheuristics versus selecting one classical metaheuristic among several. In addition, we tune the parameters of the classical metaheuristics separately and compare the results with the ones obtained when selection and tuning are done at the same time. We carry out experiments on two variants of the permutation flow-shop scheduling problem, that is, minimization of weighted sum of completion times (PFSP-WCT) and minimization of weighted tardiness (PFSP-WT). Our results indicate that the automatic method is always able to match the best classical metaheuristic. Moreover, on the PFSP-WT, hybridization leads to the best results. On the other hand, on the PFSP-WCT, sufficiently tuning the right non-hybrid metaheuristic is as good as the hybrid method.
A Hybrid Reactive GRASP with Reinforcement Learning

Authors: Ismael Izídio De Almeida, Carlos Heitor Pereira Liberalino and Francisco Chagas Lima Junior, University of State of Rio Grande do Norte (UERN), Brazil

Abstract:

Metaheuristics represent an important class of approximative algorithms for solving NP-hard problems. Hybrid metaheuristics have gained large attention in combinatorial optimization research. This paper presents a hybrid version of Reactive GRASP (RG) metaheuristic that incorporates a Reinforcement Learning agent. In the hybrid algorithm proposal, a learner agent, especially the Q-learning algorithm, is used to learn and provide the best parameter to be used in the construction phase of the RG, replacing the probability distribution used in the reactive mechanism. This strategy gives the method an adaptive memory which is updated with the experience gained over the iterations. Hybrid RG-Learning was successfully applied to the p-center location problem. Real instances were used to perform the computational experiments. The results obtained with the hybrid version were compared with those obtained by the traditional RG, showing a better performance in solution quality and in runtime by this new approach.

Automatic Configuration: Towards a New Methodology for Generating Hybrid Algorithms

Authors: Thomas Stuetzle, Leonardo Bezerra, Jérémie Dubois-Lacoste, Manuel López-Ibáñez, Franco Mascia and Leslie Pérez Caceres, IRIDIA, ULB, Belgium

Abstract:

Matheuristics often combine a large number of algorithmic components from different methods, typically taken from heuristic and mathematical programming techniques. Often, this results in algorithms that potentially have a large number of parameters to be set. In recent years, automatic algorithm configuration has not only been shown to be useful for deriving performance-optimizing parameter settings but also a key element towards automatizing the process of designing more powerful algorithmic techniques. In this talk, we will review the main automatic algorithm configuration techniques and their potential. We then illustrate their usage in a number of applications, where they have been shown successfully. These applications reach from generating hybrid local search algorithms to powerful algorithms for multi-objective optimization. We end by highlighting relevant directions for future research.