The 10th International Workshop on

Hybrid Metaheuristics

Plymouth Lecture Theatre

University of Plymouth

June 8-10, 2016

Conference Program

10th International Workshop on Hybrid Metaheuristics

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Welcome to HM 2016

The HM Workshops are intended to be an international forum for researchers in the area of design, analysis, and experimental evaluation of metaheuristics and their integration with techniques typical of other fields. Metaheuristics, such as simulated annealing, evolutionary algorithms, tabu search, ant colony optimization, scatter search and iterated local search, are considered state-of-the-art methods for many problems. In recent years, however, it has become evident that the concentration on a sole metaheuristic is rather restrictive. A skilled combination of concepts from different optimization techniques can provide a more efficient behavior and a higher flexibility when dealing with real-world and large-scale problems. Hybrid Metaheuristics are such techniques for optimization that combine different metaheuristics or integrate AI/OR techniques into metaheuristics.

HM 2016 continues to be the only three-days event entirely dedicated to the integration of metaheuristics and classical techniques typical of other fields, with the primary aim to provide researchers and scholars a wide forum for discussing new ideas and new research directions. In addition to learning more about their own research area, the workshop has served to make researchers aware of how their research might contribute, and become really fruitful also in other research areas.

As always, this edition confirms that hybrid metaheuristics are indeed robust and effective, and that several research areas can be put together. Slowly but surely, this process has been promoting productive dialogue among researchers with different expertise and eroding barriers between research areas.

HM 2016 has received an overall of 43 submissions from different countries, between regular manuscripts and abstracts, with a total of 16 works accepted (15 full papers and 1 extended abstract) on the basis of reviews by the program committee members and evaluations by the program chairs. There will be one additional abstract for oral presentation only. In keeping with the tradition, we had a double-blind peer review process, with 4/5 expert referees per manuscript, so that not only originality and overall quality of the papers could be properly evaluated, but also constructive suggestions for improvement could be provided. In light of this, a special thanks is addressed to each member of the program committee and external reviewers, who devoted their valuable time.

The present selection of manuscripts is of interest for all the researchers working on integrating metaheuristics with other areas for solving both optimization and constraint satisfaction problems. It represents as well a sample of current research demonstrating how metaheuristics can be integrated with integer linear programming and other operational research techniques for tackling difficult and relevant problems.

HM 2016 was held in Plymouth, UK, on June 8-10 2016, and was enriched by the presence of three excellent plenary speakers: Carlos A. Coello Coello, Jin- Kao Hao, and Helena Ramalhinho Lourenço. We would like to express them all our gratitude for having accepted our invitation, and for their participation, which greatly enhanced the quality of the workshop.

Finally, we would like to express our gratitude to everyone that helped us in any way for the success of HM 2016, beginning of course from all authors who have supported the workshop sending their excellent contributions; and all those who have participated to these three days entirely dedicated to Science. A special thanks is also addressed to the publicity chair, Antonio D. Masegosa, for his great job, and his valuable support on the success of HM 2016. Without these components we would not have been able to organize a successful scientific congress.

Plymouth, June 2016

María J. Blesa, Christian Blum, Angelo Cangelosi,
Vincenzo Cutello, Alessandro Di Nuovo,
Mario Pavone, El-Ghazali Talbi

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Programme Overview

Wednesday 8 June		Thursday 9 June		Friday 10 June	
12:00 – 13:40	Registration Desk	10:00 – 11:00	Jin-Kao Hao	9:30 – 11:50	Oral Presentations Session V
13:45 – 14:00	Opening Ceremony	11:00 – 11:20	Coffee Break		
14:00 – 15:00	Carlos A. Coello Coello	11:20 – 13:05	Oral Presentations Session III	11:50 – 12:10	Meet the Editors Closing Remarks
15:00 – 16:10	Oral Presentations Session I	13:05 – 14:30	Lunch		
16:10 – 16:30	Coffee Break	14:30 – 15:30	Helena Ramalhinho Lourenço		
16:30 – 18:50	Oral Presentations Session II	15:30 – 17:50	Oral Presentations Session IV		
		20:00	Social Dinner		

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Plenary Speakers

Wednesday, June 8 ***14:00 – 15:00***

Carlos A. Coello Coello,
CINVESTAV-IPN, Mexico

Evolutionary Multi-Objective Optimization using Hybrid Approaches

The use of evolutionary algorithms for solving multi-objective optimization problems has become increasingly popular, mainly within the last 15 years. From among the several research trends that have originated in recent years, one of the most promising is the use of hybrid approaches that allow to improve the performance of multi-objective evolutionary algorithms (MOEAs). In this talk, some of the most representative research on the use of hybrid approaches in evolutionary multi-objective optimization will be discussed. The topics discussed will include multi-objective memetic algorithms, hybridization of MOEAs with gradient-based methods and with direct search methods, as well as multi-objective hyperheuristics. Some potential paths for future research in this area will also be briefly discussed.

Thursday, June 9 ***10:00 – 11:00***

Jin-Kao Hao
University of Angers, France

Hybrid Methods for some Knapsack Problems: lessons learnt

It is know that complementary solution methods can be advantageously combined to build powerful hybrid methods for hard combinatorial optimization. In this talk, we illustrate our experiences on two hybrid methods applied to several knapsack problems. We first discuss combinations between exact and heuristic methods within the context of multidimensional 0-1 knapsack problem and multiple-choice multidimensional knapsack problem (as well as a satellite photograph scheduling problem). We then show two applications of population based computing combined with local search to solve the quadratic multiple knapsack problem and multi-objective knapsack problem. We finally draw some conclusions based on these experiences.

Helena Ramalhinho Lourenço
Universitat Pompeu Fabra, Spain

From ILS to Hybrid ILS ... and other extensions

Iterated Local Search (ILS) is a conceptually simple and efficient Metaheuristic. The main idea behind ILS is to drive the search not on the full space of all candidate solutions but on the solutions that are returned by some underlying algorithm, typically a local search heuristic. This method has been applied to many different optimization problems with more than 5,000 entries in Google Scholar. In this talk, we will review briefly the ILS method and focus on the extensions of ILS as the hybrid ILS approaches, the different hybridizations implementations and the advantages and disadvantages of these hybridizations. We will also discuss other ILS extensions as the SimILS (Simulation+ILS) to solve Stochastic Combinatorial Optimization Problems, and the MoILS, to solve Multiobjective Combinatorial Optimization Problems. In addition, we will review the most important applications of ILS and extensions in different areas, from Supply Chain Management to Health Care. Finally, future research topics will be presented.

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Programme In Full

Wednesday, June 8

13:45 – 14:00 Open Ceremony by Prof. Vincenzo Cutello and Prof. Angelo Cangelosi

Plenary Speaker – Chair: Mario Pavone

14:00 – 15:00 **Carlos A. Coello Coello**, CINVESTAV-IPN, Mexico
Evolutionary Multi-Objective Optimization using Hybrid Approaches

Oral Presentations Session I – Chair: Angelo Cangelosi

15:00 – 15:35 ***Finding Uniquely Hamiltonian Graphs of Minimum Degree Three with Small Crossing Numbers***
Benedikt Klocker, Herbert Fleischner and Günther R. Raidl
Technische Universität Wien, Austria

15:35 – 16:10 ***Construct, Merge, Solve & Adapt: Application to Unbalanced Minimum Common String Partition***
Christian Blum
IKERBASQUE, University of the Basque Country, Spain

16:10 – 16:30 ***COFFEE BREAK***

Oral Presentations Session II – Chair: Günther R. Raidl

16:30 – 17: 05 ***Variable Neighbourhood Descent with Memory: a Hybrid Metaheuristic for Supermarket Resupply***
Philip Mourdjis[1], Yujie Chen[1], Fiona Polack[1], Peter Cowling[1], Martin Robinson[2]
[1] Department of Computer Science, University of York, United Kingdom
[2] Transfaction Ltd., Cambridge, United Kingdom

17:05 – 17:40 ***Hybridization as Cooperative Parallelism for the Quadratic Assignment Problem***
Danny Munera[1], Daniel Diaz[1], Salvador Abreu[2,1]
[1] University of Paris 1-Sorbonne/CRI, France
[2] Universidade de Évora/LISP, Portugal

17:40 – 18:15 ***Multi-chaotic Approach for Particle Acceleration in PSO***
Michal Pluhacek[1], Roman Senkerik[1], Adam Viktorin[1], Ivan Zelinka[2]
[1] Faculty of Applied Informatics, Tomas Bata University in Zlin, Czech Republic
[2] Faculty of Electrical Engineering & Computer Science, Technical University of Ostrava, Czech Republic

18:15 – 18:50 ***Investigating Edge-Reordering Procedures in a Tabu Search Algorithm for the Capacitated Arc Routing Problem***
Wasin Padungwech, Jonathan Thompson, Rhyd Lewis
School of Mathematics, Cardiff University, Cardiff, UK

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Thursday, June 9

Plenary Speaker – Chair: Mario Pavone

10:00 – 11:00 **Jin-Kao Hao**, University of Angers, France
Hybrid Methods for some Knapsack Problems: lessons learnt

11:00 – 11:20 ***COFFEE BREAK***

Oral Presentations Session III – Chair: Moshe Goldstein

11:20 – 11:55 ***Districting and Routing for Security Control***
Michael Prischink[1,2], Christian Kloimüllner[1], Benjamin Biesinger[1], Günther R. Raidl[1]
[1] Institute of Computer Graphics and Algorithms, Technische Universität Wien, Vienna, Austria
[2] Research Industrial Systems Engineering, Schwechat, Austria

11:55 – 12:30 ***A GRASP/VND Heuristic for a Generalized Ring Star Problem***
Rodrigo Recoba, Franco Robledo, Pablo Romero, Omar Viera
Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay

12:30 – 13:05 ***Neighborhood Composition Strategies in Stochastic Local Search***
Janniele A. S. Araujo[1,2], Haroldo G. Santos[2], Davi D. Baltar[1], Túlio A. M. Toffolo[2,3], Tony Wauters[3]
[1] Computer and Systems Department, Federal University of Ouro Preto, Brazil
[2] Department of Computing, Federal University of Ouro Preto, Brazil
[3] Computer Science Department, CODeS, KU Leuven, Belgium

13:05 – 14:30 ***LUNCH***

Plenary Speaker – Chair: Vincenzo Cutello

14:30 – 15:30 **Helena Ramalhinho Lourenço**, Universitat Pompeu Fabra, Barcelona, Spain
From ILS to Hybrid ILS ... and other extensions

Oral Presentations Session IV – Chair: Salvador Abreau

15:30 – 16:05 ***Hybridization of Chaotic Systems and Success-History Based Adaptive Differential Evolution***
Adam Viktorin, Roman Senkerik, Michal Pluhacek
Faculty of Applied Informatics, Tomas Bata University in Zlin, Czech Republic

16:05 – 16:40 ***DEEPSAM: A Hybrid Evolutionary Algorithm for the Prediction of Biomolecules Structure***
Moshe Goldstein[1,2]
[1] Computer Science Department, Jerusalem College of Technology, Israel
[2] Fritz Haber Research Center for Molecular Dynamics, Institute of Chemistry, Hebrew University of Jerusalem, Israel

16:40 – 17:15 ***A hybrid multi-objective evolutionary approach for Optimal Path Planning of a Hexapod Robot: A preliminary study***

Giuseppe Carbone[1,3], Alessandro Di Nuovo[2,4]
[1] Department of Engineering and Mathematics, Sheffield Hallam University, Sheffield, UK
[2] Department of Computing, Sheffield Hallam University, Sheffield, UK
[3] Department of Civil and Mechanical Engineering, University of Cassino and South Latium, Cassino, Italy
[4] Faculty of Engineering and Architecture, University of Enna "Kore", Enna, Italy

17:15 – 17:50 ***Tabu Search Hybridized with Multiple Neighbourhood Structures for the Frequency Assignment Problem***

Khaled Alrajhi, Jonathan Thompson, Wasin Padungwech
School of Mathematics, Cardiff University, Cardiff, UK

20:00 – 23:00 ***SOCIAL DINNER***

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Friday, June 10

Oral Presentations Session V – Chair: Alessandro Di Nuovo

9:30 – 10:05 ***Robust berth allocation using a hybrid approach combining branch-and-cut and the genetic algorithm***
Ghazwan Alsoufi, Xinan Yang, Abdellah Salhi
Department of Mathematical Sciences, University of Essex, UK

10:05 – 10:40 ***The Capacitated m Two Node Survivable Star Problem. A hybrid metaheuristic approach***
Gabriel Bayá, Antonio Mauttone, Franco Robledo, Pablo Romero
Departamentp de Investigación Operativa, Universidad de la República, Montevideo, Uruguay

10:40 – 11:15 ***Dealing with the strategic level of decisions related to Automated Transit Networks: a hybrid heuristic approach***
Olfa Chebbi[1], Jouhaina Chaouachi[2]
[1] Institut Supérieur de Gestion de Tunis, Université de Tunis, Bardo, Tunisie
[2] Institut des Hautes Etudes Commerciales de Carthage, Université de Carthage, Tunis, Tunisie

11:15 – 11:50 ***The Higher Logic of Metaheuristics***
Michael Heather and Nick Rossiter
United Kingdom

11:50 – 12:10 ***MEET THE EDITORS &***
CONCLUDING REMARKS

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Abstracts

Wednesday, June 8	*Session I*	*15:00 – 16:10*
Session Chair: Angelo Cangelosi		

Finding Uniquely Hamiltonian Graphs of Minimum Degree Three with Small Crossing Numbers

Benedikt Klocker, Herbert Fleischner, and Günther R. Raidl

Institute of Computer Graphics and Algorithms
Technische Universität Wien, Vienna, Austria

In graph theory, a prominent conjecture of Bondy and Jackson states that every uniquely hamiltonian planar graph must have a vertex of degree two. In this work we try to find uniquely hamiltonian graphs with minimum degree three and a small crossing number by minimizing the number of crossings in an embedding and the number of degree-two vertices. We formalize an optimization problem for this purpose and propose a general variable neighborhood search (GVNS) for solving it heuristically. The several different types of used neighborhoods also include an exponentially large neighborhood that is effectively searched by means of branch and bound. To check feasibility of neighbors we need to solve hamiltonian cycle problems, which is done in a delayed manner to minimize the computation effort. We compare three different configurations of the GVNS. Although our implementation could not find a uniquely hamiltonian planar graph with minimum degree three disproving Bondy and Jackson's conjecture, we were able to find uniquely hamiltonian graphs of minimum degree three with crossing number four for all number of vertices from 10 to 100.

Construct, Merge, Solve & Adapt: Application to Unbalanced Minimum Common String Partition

Christian Blum[1,2]

[1] Dept. of Computer Science and Artificial Intelligence,
University of the Basque Country UPV/EHU, San Sebastian, Spain

[2] IKERBASQUE, Basque Foundation for Science, Bilbao, Spain

In this paper we present the application of a recently proposed, general, algorithm for combinatorial optimization to the unbalanced minimum common string partition problem. The algorithm, which is labelled CONSTRUCT, MERGE, SOLVE & ADAPT, works on sub-instances of the tackled problem instances. At each iteration, the incumbent subinstance is modified by adding solution components found in probabilistically constructed solutions to the tackled problem instance. Moreover, the incumbent sub-instance is solved to optimality (if possible) by means of an integer linear programming solver. Finally, seemingly unuseful solution components are removed from the incumbent sub-instance based on an ageing mechanism. The results obtained for the unbalanced minimum common string partition problem indicate that the proposed algorithm outperforms a greedy approach. Moreover, they show that the algorithm is competitive with CPLEX for problem instances of small and medium size, whereas it outperforms CPLEX for larger problem instances.

Variable Neighbourhood Descent with Memory: a Hybrid Metaheuristic for Supermarket Resupply

Philip Mourdjis[1], *Yujie Chen*[1], *Fiona Polack*[1], *Peter Cowling*[1], *Martin Robinson*[2]

[1] Department of Computer Science, University of York, United Kingdom
[2] Transfaction Ltd., Cambridge, United Kingdom

Supermarket supply chains represent an area in which optimisation of vehicle routes and scheduling can lead to huge cost and environmental savings. As just-in-time ordering practices become more common, traditionally fixed resupply routes and schedules are increasingly unable to meet the demands of the supermarkets. Instead, we model this as a dynamic pickup and delivery problem with soft time windows (PDPSTW). We present the variable neighbourhood descent with memory (VNDM) hybrid metaheuristic (HM) and compare its performance against Q-learning (QL), binary exponential back off (BEBO) and {random descent (RD) hyperheuristics on published benchmark} and real-world instances of the PDPSTW. We find that VNDM consistently generates the highest quality solutions, with the fewest routes or shortest distances, amongst the methods tested. It is capable of finding the best known solutions to 55 of 176 published benchmarks as well as producing the best results on our real-world data set, supplied by Transfaction Ltd.

Hybridization as Cooperative Parallelism for the Quadratic Assignment Problem

Danny Munera[1], *Daniel Diaz*[1], *Salvador Abreu*[2,1]

[1] University of Paris 1-Sorbonne/CRI, France
[2] Universidade de Évora/LISP, Portugal

The Quadratic Assignment Problem is at the core of several real-life applications. Finding an optimal assignment is computationally very difficult, for many useful instances. The best results are obtained with hybrid heuristics, which result in complex solvers. We propose an alternate solution where hybridization is obtain by means of parallelism and cooperation between simple single-heuristic solvers. We present experimental evidence that this approach is very efficient and can effectively solve a wide variety of hard problems, often surpassing state-of-the-art systems.

Multi-chaotic Approach for Particle Acceleration in PSO

Michal Pluhacek[1], *Roman Senkerik*[1], *Adam Viktorin*[1], *Ivan Zelinka*[2]

[1] Faculty of Applied Informatics, Tomas Bata University in Zlin, Czech Republic
[2] Faculty of Electrical Engineering & Computer Science, Technical University of Ostrava, Czech Republic

This paper deals with novel approach for hybridization of two scientific techniques: the evolutionary computational techniques and deterministic chaos. The Particle Swarm Optimization algorithm is enhanced with two pseudo-random number generators based on chaotic systems. The chaotic pseudorandom number generators (CPRNGs) are used to guide the particles movement through multiplying the accelerating constants. Different CPRNGs are used simultaneously in order to improve the performance of the algorithm. The IEEE CEC`13 benchmark suite is used to test the performance of the proposed method

Investigating Edge-Reordering Procedures in a Tabu Search Algorithm for the Capacitated Arc Routing Problem

Wasin Padungwech, Jonathan Thompson, Rhyd Lewis

School of Mathematics, Cardiff University, Cardiff, UK

This paper presents two ideas to guide a tabu search algorithm for the Capacitated Arc Routing Problem to a promising region of the solution space. Both ideas involve edge-reordering, although they work in different ways. One of them aims to directly tackle deadheading cycles, and the other tries to reorder edges with the aim of extending a scope of solutions that can be reached from a given solution. Experiments were performed on 134 benchmark instances of various sizes, and the two ideas were shown to have an ability to guide the search to good solutions. Possible issues that may arise when implementing these ideas are also discussed.

Districting and Routing for Security Control

Michael Prischink[1,2], Christian Kloimüllner[1], Benjamin Biesinger[1], Günther R. Raidl[1]

[1] Institute of Computer Graphics and Algorithms, Technische Universität Wien, Vienna, Austria
[2] Research Industrial Systems Engineering, Schwechat, Austria

Regular security controls on a day by day basis are an essential and important mechanism to prevent theft and vandalism in business buildings. Typically, security workers patrol through a set of objects where each object requires a particular number of visits on all or some days within a given planning horizon, and each of these visits has to be performed in a specific time window. An important goal of the security company is to partition all objects into a minimum number of disjoint clusters such that for each cluster and each day of the planning horizon a feasible route for performing all the requested visits exists. Each route is limited by a maximum working time, must satisfy the visits' time window constraints, and any two visits of one object must be separated by a minimum time difference. We call this problem the *Districting and Routing Problem for Security Control*. In our heuristic approach we split the problem into a districting part where objects have to be assigned to districts and a routing part where feasible routes for each combination of district and period have to be found. These parts cannot be solved independently though. We propose an exact mixed integer linear programming model and a *routing construction heuristic* in a greedy like fashion with *variable neighborhood descent* for the routing part as well as a *districting construction heuristic* and an *iterative destroy & recreate* algorithm for the districting part. Computational results show that the exact algorithm is only able to solve small routing instances and the iterative destroy & recreate algorithm is able to reduce the number of districts significantly from the starting solutions.

A GRASP/VND Heuristic for a Generalized Ring Star Problem

Rodrigo Recoba, Franco Robledo, Pablo Romero, Omar Viera

Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay

A generalization of the Ring Star Problem, called Two-Node-connected Star Problem (2NCSP), is here addressed. We are given an undirected graph, pendant-costs and core-costs. The goal is to find the minimum-cost spanning graph, where the core is a two-node-connected component, and the remaining nodes are pendant to this component. First, we show that the 2NCSP belongs to the NP-Hard class. Therefore, a GRASP heuristic is developed, enriched with a Variable Neighborhood Descent (VND). The neighborhood structures include exact integer linear programming models to find best paths as well as a shaking operation in order not to get stuck in a local minima. We contrast our GRASP/VND methodology with prior works from RSP using TSPLIB, in order to highlight the effectiveness of our heuristic. Our solution outperforms several instances considered in a previous reference related to the RSP. A discussion of the results and trends for future work is provided.

Neighborhood Composition Strategies in Stochastic Local Search

Janniele A. S. Araujo[1,2], Haroldo G. Santos[2], Davi D. Baltar[1], Túlio A. M. Toffolo[2,3], Tony Wauters[3]

[1] Computer and Systems Department, Federal University of Ouro Preto, Brazil
[2] Department of Computing, Federal University of Ouro Preto, Brazil
[3] Computer Science Department, CODeS, KU Leuven, Belgium

Methods based on Stochastic Local Search (SLS) have been ranked as the best heuristics available for many hard combinatorial optimization problems. The design of SLS methods which use many neighborhoods poses difficult questions regarding the exploration of these neighborhoods: how much computational effort should be invested in each neighborhood? Should this effort remain fixed during the entire search or should it be dynamically updated as the search progresses? Additionally, is it possible to learn the best configurations during runtime without sacrificing too much the computational efficiency of the search method? In this paper we explore different tuning strategies to configure a state-of-the-art algorithm employing fourteen neighborhoods for the Multi-Mode Resource Constrained Multi-Project Scheduling Problem. An extensive set of computational experiments provide interesting insights for neighborhood selection and improved upper bounds for many hard instances from the literature.

Hybridization of Chaotic Systems and Success-History Based Adaptive Differential Evolution

Adam Viktorin, Roman Senkerik, Michal Pluhacek

Faculty of Applied Informatics, Tomas Bata University in Zlin, Czech Republic

This research paper focuses on hybridization of two soft computing fields – chaos theory and evolutionary algorithms, specifically on the implementation of Chaotic map based Pseudo-Random Number Generator (CPRNG) into the process of parent selection in Success-History Based Adaptive Differential Evolution (SHADE) algorithm. The impact on performance of the algorithm is tested on CEC2015 benchmark set where five different chaotic maps are used for random integer generation. Performance comparison shows that there is a potential in replacing classic Pseudo-Random Number Generators (PRNGs) with chaotic ones. The results provided in this paper show that the choice of CPRNG for given problem is crucial in terms of affecting the performance of the algorithm, therefore the next research step will be focused on the development of the frame-work which will adapt to the solved problem and select the most suitable CPRNG or their combination.

DEEPSAM: A Hybrid Evolutionary Algorithm for the Prediction of Biomolecules Structure

Moshe Goldstein[1,2]

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DEEPSAM (Diffusion Equation Evolutionary Programming Simulated Annealing Method), a hybrid evolutionary algorithm, is presented here. This algorithm has been designed for finding the global minimum, and other low-lying minima, of the potential energy surface (PES) of biological molecules. It hybridizes Evolutionary Programming (EP) with two well-known global optimization methods (the Diffusion Equation Method - DEM, and a kind of Simulated Annealing - SA), and with the L-BFGS quasi-Newton local minimization procedure. This combination has produced a powerful tool (a) for finding a good approximation of the native structure of a protein or peptide, given a Force Field (FF) parameters set and a starting (unfolded) structure, and (b) for finding an ensemble of structures close enough structurally and energetically to the native structure. The results obtained until now show that DEEPSAM is a powerful structure predictor, when a reliable FF parameters set is available. DEEPSAM's implementation is time-efficient, and requires modest computational resources.

A hybrid multi-objective evolutionary approach for Optimal Path Planning of a Hexapod Robot: A preliminary study

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Hexapod robots are six-legged robotic systems, which have been widely investigated in the literature for various applications including exploration, rescue, and surveillance. Designing hexapod robots requires to carefully considering a number of different aspects. One of the aspects that require careful design attention is the planning of leg trajectories. In particular, given the high demand for fast motion and high-energy autonomy it is important to identify proper leg operation paths that can minimize energy consumption while maximizing the velocity of the movements. In this frame, this paper presents a preliminary study on the application of a hybrid multi-objective optimization approach for the computer-aided optimal design of a legged robot. To assess the methodology, a kinematic and dynamic model of a leg of a hexapod robot is proposed as referring to the main design parameters of a leg. Optimal criteria have been identified for minimizing the energy consumption and efficiency as well as maximizing the walking speed and the size of obstacles that a leg can overtake. We evaluate the performance of the hybrid multi-objective evolutionary approach to explore the design space and provide a designer with an optimal setting of the parameters. Our simulations demonstrate the effectiveness of the hybrid approach by obtaining improved Pareto sets of trade-off solutions as compared with a standard evolutionary algorithm. Computational costs show an acceptable increase for an off-line path planner.

Tabu Search Hybridized with Multiple Neighbourhood Structures for the Frequency Assignment Problem

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This study proposes a tabu search hybridized with multiple neighborhood structures to solve a variant of the frequency assignment problem known as the minimum order frequency assignment problem. This problem involves assigning frequencies to a set of requests while minimizing the number of frequencies used. Several novel and existing techniques are used to improve the efficiency of this algorithm. This includes a novel technique that aims to determine a lower bound on the number of frequencies required from each domain for a feasible solution to exist, based on the underlying graph coloring model. These lower bounds ensure that the search focuses on parts of the solution space that are likely to contain feasible solutions. Our tabu search algorithm was tested on real and randomly generated benchmark datasets of the static problem and achieved competitive results.

Friday, June 10 — *Session V* — *9:30 – 11:50*

Session Chair: Alessandro Di Nuovo

Robust Berth Allocation Using a Hybrid Approach Combining Branch-and-Cut and the Genetic Algorithm

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Seaside operations at container ports often suffer from uncertainty due to events such as the variation in arrival and/or processing time of vessels, weather conditions and others. Finding a robust plan which can accommodate this uncertainty is therefore desirable to port operators. This paper suggests ways to generate robust berth allocation plans in container terminals. The problem is first formulated as a mixed-integer programming model whose main objective is to minimize the total tardiness of vessel departure time. It is then solved exactly and approximately. Experimental results show that only small instances of the proposed model can be solved exactly. To handle large instances in reasonable times, the Genetic Algorithm (GA) is used. However, it does not guarantee optimality and often the approximate solutions returned are of low quality. A hybrid meta-heuristic which combines Branch-and-Cut (B&C) as implemented in CPLEX, with the GA as we implement it here, is therefore suggested. This hybrid method retains the accuracy of Branch-and-Cut and the efficiency of GA. Numerical results obtained with the three approaches on a representative set of instances of the problem are reported.

The Capacitated m Two Node Survivable Star Problem. A hybrid metaheuristic approach

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In telecommunications, a traditional method to connect multiterminal systems is to use rings. The goal of the Capacitated m Ring Star Problem (CmRSP) is to connect terminals by m rings which meet at a distinguished node, and possibly by some pendant links, at minimum cost. In this paper, we introduce a relaxation for the CmRSP, called Capacitated m Two-Node Survivable Star Problem (CmTNSSP for short). The CmTNSSP belongs to the NP-Hard class of computational problems. Therefore, we address a GRASP hybrid metaheuristic which alternates local searches that obtain incrementally better solutions, and exact resolution local searches based on Integer Linear Programming models. In consonance with predictions provided by Clyde Monma, the network can be equally robust but cheaper than in the original CmRSP.

Dealing with the Strategic Level of Decisions Related to Automated Transit Networks: a hybrid heuristic approach

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The automated transit networks (ATN) is a new and sophisticated concept which has the possibility to solve problems related to transit in urban areas. In ATN, driverless vehicles run on exclusive guideways in order to provide on-demand transportation service. In this paper, we focus on the strategic level of decision related to ATN. We deal with the problem of determining the best size of fleet of ATN vehicles while satisfying a set of transportation demands. A hybrid heuristic approach is developed while taking into account the objective of finding good quality solutions in a short computational time. Computational results performed in this study demonstrate the efficiency of our approach.

The Higher Logic of Metaheuristics

Michael Heather and Nick Rossiter

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Dynamic and uncertain environments require a higher level of metaheuristics. . Metaheuristics as the methodology of heuristics is itself one level up from heuristics and distinguished from the method of heuristics at the same level as heuristics. The Greek preposition meta itself has some dynamic sense but no sense of level. That has acquired a meaning of an operation at a higher level from its later use for the title to Aristotle's work Metaphysics. Thus metadata is data on data but this may have no dynamic notion as in the example of semantic data tags.

In a strict sense dynamics and uncertainty require a meta-metaheuristics although this assumes that meta is a recursive operation and there is a problem in the recursive use of sets as an abstraction of number which arises essentially from Russell's Paradox. While these can be overcome by assumptions in pure mathematics that is not natural and therefore may not be safe for use in computer science. Thus fuzzy sets have been found a useful method by some to deal with uncertainty in heuristics but difficulties are encountered with logical distribution with fuzzy sets for recursion. For it is well known that a fuzzy set does not have a fuzzy subset. It is necessary therefore to employ a higher level of mathematics with an inherent recursive capability such as category theory to cope with dynamics and uncertainty.

It is well established that category theory shows fuzzy sets to be only a model of the higher three level intuisionistic logic [1]. This three level architecture is the meta-metaheuristics and fuzzy sets are archetypal for any of the set based algorithms to be found in heuristics. It is interesting that many of these algorithms seek to mimic nature and have an inherent three level structure. For example the Bees Algorithms requires three level of agents: the 'employed' bee, the 'scout bee' and the 'on-looker' bee. This natural structure is to be found in the internal logic of the topos in category theory arising from monadic adjointness.

Adjointness in a higher level search space for dynamical and uncertain environments can provide unique solutions but a more complex example is that of parallelism where there are all possible relationships. That requires the top third level with ultimate closure and has no need for recourse to any higher level. Indeed it is the level where it is possible to represent intelligence and consciousness whether natural or artificial.

[1] Barr, M & Wells, C. Category Theory for Computing Science (1999) para 15.6

Notes

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