13th LION
LEARNING & INTELLIGENT OPTIMIZATION CONFERENCE

May 27-31, 2019
Chania, Crete, Greece

Book of Abstracts

SESSION 1

Monday, May 27, 2019, 18:30 – 19:50

1. A Novel Approach for Solving Large-Scale Bike Sharing Station Planning Problems

Christian Kloimüllner and Günther Raidl

In large cities all around the world, individual and motorized traffic is still prevalent. This circumstance compromises the quality of living, and moreover, space inside cities for parking individual vehicles for movement is scarce and is becoming even scarcer. Thus, the need for a greener means of transportation and less individual vehicles inside the cities is demanded and rising. An already accepted and established solution possibility to these problems are public bike sharing systems (PBS). Such systems are often freely available to people for commuting within the city and utilize the available space in the city more efficiently than individual vehicles. When building or extending a PBS, a certain optimization goal is to place stations inside a city or a part of it, such that the number of bike trips per time unit is maximized under certain budget constraints. In this context, it is also important to consider rebalancing and maintenance costs as they introduce substantial supplementary costs in addition to the fixed and variable costs when building or extending a PBS. In contrast to the literature, this work introduces a novel approach which is particularly designed to scale well to large real-world instances. Based on our previous work, we propose a multilevel refinement heuristic operating on hierarchically clustered input data. This way, the problem is coarsened until a manageable input size is reached, a solution is derived, and then step by step extended and refined until a valid solution for the whole original problem instance is obtained. As an enhancement to our previous work, we introduce the following extensions. Instead of considering an arbitrary integral number of slots for stations, we now use sets of predefined station configurations. Moreover, a local search is implemented as refinement step in the multilevel refinement heuristic and we now consider real-world input data for the city of Vienna.

2. A Statistical Test of Heterogeneous Subgraph Densities To Assess Clusterability

Pierre Miasnikof, Liudmila Prokhorenkova, Alexander Y. Shestopaloff and Andrei M. Raigorodskii

Determining if a graph displays a clustered structure, prior to subjecting it to any cluster detection technique, remains an open problem. Attempts to group graph vertices into clusters when a graph does not have a clustered structure is not only a waste of time, but will also lead to misleading conclusions. To address this problem, we introduce a novel statistical test, the δ-test, which is based on comparisons of local and global densities. Our goal is to assess whether a given graph meets the necessary conditions to be meaningfully summarized by clusters of vertices. We

empirically explore our test's behavior under a number of graph structures. We also compare it to other recently published tests. From a theoretical standpoint, our test is more general, versatile and transparent than recently published competing techniques. It is based on the examination of intuitive quantities, applies equally to weighted and unweighted graphs and allows comparisons across graphs. More importantly, it does not rely on any distributional assumptions, other than the universally accepted definition of a clustered graph. Empirically, our test is shown to be more responsive to graph structure.

3. How to use Boltzmann Machines and Neural Networks for Covering Array Generation

Ludwig Kampel, Michael Wagner, Ilias Kotsireas **and** Dimitris E. Simos

In the past, combinatorial structures have been used only to tune parameters of neural networks. In this paper, we employ for the first time, neural networks and Boltzmann machines for the construction of covering arrays (CAs). In past works, Boltzmann machines were successfully used to solve set cover instances. For the construction of CAs, we consider the equivalent set cover instances and use Boltzmann machines to solve these instances. We adapt an existing algorithm for solving general set cover instances, which is based on Boltzmann machines and apply it for CA construction. Furthermore, we consider newly designed versions of this algorithm, where we consider structural changes of the underlying Boltzmann machine, as well as a version with an additional feedback loop, modifying the Boltzmann machine. Last, one variant of this algorithm employs learning techniques based on neural networks to adjust the various connections encountered in the graph representation of the considered set cover instances. Supported by an experimental evaluation our findings can act as a beacon for future applications of neural networks in the field of covering array generation and related discrete structures.

4. A Similarity Hybrid Harmony Search Algorithm for the Capacitated Team Orienteering Problem

Eleftherios Tsakirakis, Magdalene Marinaki, Yannis Marinakis

This paper addresses a new optimization method for a variant of the category of orienteering problems (OP), which is well-known as the capacitated team orienteering problem (CTOP). The main objective of CTOP focuses on the maximization of the total collected profit from a set of candidate nodes or customers by taking into account the limitations of vehicle capacity and time upper boundary of a constructed route. To solve CTOP, we present a new optimization algorithm called the Similarity Hybrid Harmony Search. This methodology includes an innovative "similarity process" technique, which takes advantage the most profitable nodes/customers during the algorithmic procedure aiming to extend the diversification in the solution area. The experimental tests were conducted in the most popular set of instances and the obtained results are compared with most competitive algorithms in the literature.

SESSION 2

Tuesday, May 28, 2019, 10:30 – 12:10

1. Adaptive GVNS heuristics for solving the Pollution Location Inventory Routing Problem

Panagiotis Karakostas, Angelo Sifaleras and Michael Georgiadis

This work proposes Adaptive General Variable Neighborhood Search metaheuristic algorithms for the efficient solution of Pollution Location Inventory Routing Problems (PLIRPs). A comparative computational study, between the proposed methods and their corresponding classic General Variable Neighborhood Search versions, illustrates the effectiveness of the intelligent mechanism used for automating the re-ordering of the local search operators in the improvement step of each optimization method. Results on 20 PLIRP benchmark instances show the efficiency of the proposed metaheuristics.

2. A simple Dual-RAMP for the Capacitated Facility Location Problem

Telmo Matos, Óscar Oliveira and Dorabela Gamboa

Facility Location embodies a class of problems concerned with locating a set of facilities to serve a geographically distributed population of customers at minimum cost. We address the classical Capacitated Facility Location Problem (CFLP) in which the assignment of facilities to customers must ensure sufficient facility capacity and all the customers must be served. This is a well-known NP-hard problem in combinatorial optimization that has been extensively studied in the literature. Due to the difficulty of the problem, significant research efforts have been devoted to developing advanced heuristic methods aimed at finding high-quality solutions in reasonable computational times. We propose a Relaxation Adaptive Memory Programming (RAMP) approach for the CFLP. Our method combines lagrangean subgradient search with tabu search to explore primal-dual relationships as a way to create advanced memory structures that integrate information from both primal and dual solution spaces. The algorithm was tested on the standard ORLIB dataset and on other very large-scale instances for the CFLP. Our approach efficiently found the optimal solution for all ORLIB in-stances and very competitive results for the large-scale ones. Comparisons with current best-performing algorithms for the CFLP show that our RAMP algorithm exhibits excellent results.

3. Landscape-Aware Constraint Handling Applied to Differential Evolution

Katherine Malan

In real-world contexts optimisation problems frequently have constraints. Evolutionary algorithms do not naturally handle constrained spaces, so require

constraint handling techniques to modify the search process. Based on the thesis that different constraint handling approaches are suited to different problem types, this study shows that the features of the problem can provide guidance in choosing appropriate constraint handling techniques for differential evolution. High level algorithm selection rules are derived through data mining based on a training set of problems on which landscape analysis is performed through sampling. On a set of different test problems, these rules are used to switch between constraint handling techniques during differential evolution search using on-line analysis of landscape features. The proposed landscape-aware switching approach is shown to out-perform the constituent constraint handling approaches, illustrating that there is value in monitoring the landscape during search and switching to appropriate techniques depending on the problem characteristics. Results are also provided that show that the approach is fairly insensitive to parameter changes.

4. Learning Probabilistic Constraints for Surgery Scheduling using a Support Vector Machine

Thomas Philip Runarsson

The problem of constructing surgery schedules with limited downstream ward capacity is modeled as a mathematical program with probabilistic constraints. The approach presented is a new approach to the handling of probabilistic constraints via learning. The technique is inspired by models that use slacks in capacity planning. Essentially support vector classification is applied to learn a linear constraint that will replace the probabilistic constraint. The data used to learn this constraint is validated using Monte Carlo simulations and is iteratively discovered during the optimization procedure and then augmented to the training data. The stochastic surgery model presented is inspired by real challenges faced by many hospitals today and tested on real-life hospital data.

5. Adaptive Sequence-based Heuristic for the Three-Dimensional Bin Packing Problem

Oscar Oliveira, Telmo Matos and Dorabela Gamboa

We consider the three-dimensional Bin Packing Problem in which a set of boxes must be packed into the minimum number of identical bins. We present a heuristic that iteratively creates new sequences of boxes that defines the packing order used to generate a new cutting plan. The sequences are generated retaining, adaptively, characteristics of previous sequences for search intensification and diversification. Computational experiments of the effectiveness of this approach are presented and discussed.

SESSION 3

Tuesday, May 28, 2019, 14:00 – 15:40

1. Quadratic Unconstrained Binary Optimization (QUBO) with Extremal Optimization

Stefan Boettcher

We implement a variant of the Extremal Optimization (EO) heuristic, τ-EO, adapted for quadratic unconstrained binary optimization (QUBO) problems. To this end, we transform QUBO from its conventional Boolean presentation into an equivalent spin glass problem with coupled ±1 spin variables exposed to an external field. These fields tend to be rather large compared to the typical coupling, presenting EO with a challenging two-scale problem: How to explore the differences in couplings effectively while sufficiently aligning with the external fields. A dynamic implementation of τ-EO that slowly turns on those fields reproduces the best known results for widely used testbed instances of large sizes. However, these solutions also indicate a fundamental weakness in the design of those testbeds: The optimal state of a large fraction of variables is determined uniquely by trivial properties of the QUBO matrix, such as their row-sums (i.e., the external fields), not by mutual couplings. The effective size of the remaining core of the NP-hard problem is substantially below its nominal size.

2. Stochastic efficiency measures for production units with correlated data

Chiang Kao and Shiang-Tai Liu

While the real world is stochastic in nature, in many cases deterministic data envelopment analysis (DEA) models are used to measure the relative efficiency of a set of production units for simplicity. However, deterministic DEA models are not able to differentiate efficient units. More seriously, the decision maker will be over-confident with the presumably uncertain and probably misleading results. By applying a standard normal transformation, this paper develops a stochastic DEA model which is able to take the correlation between the input/output factors of each production unit to be evaluated into account to obtain the distribution of the stochastic efficiency. The efficiency distribution is more discriminative and informative than the single-valued efficiency, in that the probability that the stochastic efficiency of a unit is greater than that of another unit can be calculated. The case of twenty-five Taiwanese commercial banks discussed in a previous study that assumed the input/output factors to be independent is used to illustrate the characteristics of different models. The data is shown to be correlated, and the results confirm that ignoring the correlations between the input/output factors in measuring efficiency obtains misleading rankings.

3. Optimization of Generalized Halton Sequences by Differential Evolution

Pavel Kromer, Jan Platos and Vaclav Snasel

Many practical applications such as multidimensional integration and quasi-Monte Carlo simulations rely on a uniform sampling of high-dimensional spaces. Halton sequences are d-dimensional quasirandom sequences that fill the d-dimensional hyperspace uniformly and can be generated with low computational costs. Generalized (scrambled) Halton sequences improve the properties of plain Halton sequences in higher dimensions by digit scrambling. Discrete nature-inspired optimization methods have been used to search for scrambling permutations of a d-dimensional generalized Halton sequence that minimized the discrepancy of the generated point sets in the past. In this work, a continuous nature-inspired optimization method, the differential evolution, is used to optimize generalized Halton sequences.

4. A new Mayfly optimization algorithm

Konstantinos Zervoudakis and Stelios Tsafarakis

This paper introduces a new optimization method called the Mayfly Algorithm (MA) to solve optimization problems. The proposed algorithm combines major advantages of both swarm intelligence and evolutionary algorithms and is inspired from the flight behavior of mayflies as well as from their mating process. To evaluate the proposed algorithm, 31 mathematical benchmark functions, including 9 CEC2017 test functions, are employed and the results are compared to those of 6 state-of the art well-known metaheuristic optimization methods. The MA's performance is also assessed using a real-world discrete flow-shop scheduling problem. The comparison results demonstrate the superiority of the proposed method in terms of accuracy, efficiency and convergence speed. The processes of nuptial dance and random flight enhance the balance between algorithm's exploration and exploitation properties and assist its escape from local optima.

5. Multi-Method Optimization in Large-Scale Airport Staff Scheduling

Andreas Klinkert

Staff scheduling and rostering involves a number of hierarchical subproblems including demand modeling, task generation, shift design, days-off scheduling, shift assignment and real-time dispatching. When solving highly constrained large-scale workforce planning problems it is usually not computationally practical to deal simultaneously with all these tasks. Real-world software solutions typically decompose the overall planning task into heuristically designed subproblems which then are tackled by a variety of suitable exact and heuristic methods.

We present results from a major research and business project with Swissport International Ltd., the largest ground handling company worldwide, which provides services for 850 client companies and 265 million passengers a year, with a

workforce of 68'000 personnel at 315 airports. During a long-term strategic cooperation, a high-performance software for automated staff scheduling in airport logistics has been developed, which is able to solve the complex large-scale rostering problems in Swissport's airport operations. The methodology used for solving the associated complex large-scale optimization problems comprises a broad range of optimization techniques including preprocessing, decomposition and relaxation approaches, mixed-integer programming models, and various heuristic procedures.

We start with an introduction to the business environment of the project and show its actual planning context which comprises other software tools and human planning activities related to the workforce scheduling process. We discuss the project requirements and the challenges and goals that shaped the project and the methods used. We provide insight into several aspects of the solution process, including the analysis and preprocessing phase which turned out to be crucial for the entire planning system. The tools developed for this planning phase range from simple but thorough data analysis modules to sophisticated mathematical models for bottleneck analysis, identification of minimal infeasible constraint systems, and rapid presolving techniques. We provide further insight into decomposition strategies, mathematical problem structure, and algorithmic approaches. Finally, we present computational experience with real world instances and discuss operational impacts of the developed planning tool. Bottom line benefits include faster and more robust planning processes, improved roster quality, better fairness, reduced planning capacity requirements, and as a result, substantial financial savings.

SESSION 4

Tuesday, May 28, 2019, 16:10 – 17:30

1. A new hybrid Firefly – Genetic Algorithm for the optimal product line design problem

Konstantinos Zervoudakis and Stelios Tsafarakis

The optimal product line design is one of the most critical decisions for a firm to stay competitive, since it is related to the sustainability and profitability of a company. It is classified as an NP-hard problem since no algorithm can certify in polynomial time that the optimum it identifies is the overall optimum of the problem. The focus of this research is to propose a new hybrid optimization method (FAGA) combining Firefly algorithm (FA) and Genetic algorithm (GA). The proposed hybrid method is applied to the product line design problem and its performance is compared to those of previous approaches, like genetic algorithm (GA) and simulated annealing (SA), by using both actual and artificial consumer-related data preferences for specific products. The comparison results demonstrate that the proposed hybrid method is superior to both genetic algorithm and simulated annealing in terms of accuracy, efficiency and convergence speed.

2. A RAMP algorithm for large-scale Single Source Capacitated Facility Location Problems

Óscar Oliveira, Telmo Matos and Dorabela Gamboa

We present a new algorithm to solve large-scale Single Source Capacitated Facility Location Problem (SSCFLP). This problem considers a set of possible locations for opening facilities and a set of clients to serve. The objective is to minimize the overall cost, determining which facilities to open, ensuring that all clients are served by only one facility, without exceeding their capacities. We propose a Relaxation Adaptive Memory Programming (RAMP) to solve the SSCFLP. This framework efficiently explores the relation between primal and dual sides of the problem. In our approach, the dual problem was obtained with a lagrangean relaxation and solved through subgradient optimization. At each iteration of the subgradient optimization, the dual solution is projected to the primal solution space and subjected to an improvement method. The proposed algorithm obtained high-quality solutions for large-scale instances, proving to be extremely robust achieving very good results in reduced computational time.

3. A Hybrid Immunological Search for the Weighted Feedback Vertex Set Problem

Vincenzo Cutello, Maria Oliva, Mario F. Pavone and Rocco A. Scollo

In this paper we present a hybrid immunological inspired algorithm (Hybrid-IA) for solving the Minimum Weighted Feedback Vertex Set (*M W F V S*) problem. *MWFVS* is one of the most interesting and challenging combinatorial optimization problem, which finds application in many fields and in many real life tasks. The proposed algorithm is inspired by the clonal selection principle, and therefore it takes advantage of the main strength characteristics of the operators of (i) cloning; (ii) hypermutation; and (iii) aging. Along with these operators, the algorithm uses a local search procedure, based on a deterministic approach, whose purpose is to refine the solutions found so far. In order to evaluate the efficiency and robustness of Hybrid-IA several experiments were performed on different instances, and for each instance it was compared to three different algorithms: (1) a memetic algorithm based on a genetic algorithm (*MA*); (2) a tabu search metaheuristic (*XTS*); and (3) an iterative tabu search (*ITS*). The obtained results prove the efficiency and reliability of hybrid-IA on all instances in term of the best solutions found and also similar performances with all compared algorithms, which represent nowadays the state-of-the-art on for *MWFVS* problem.

4. A Hessian Free Neural Networks Training Algorithm with Curvature Scaled Adaptive Momentum

Flora Sakketou and Nicholas Ampazis

In this paper we propose an algorithm for training neural network architectures, called Hessian Free algorithm with Curvature Scaled Adaptive Momentum (HF-CSAM). The algorithm's weight update rule is similar to SGD with momentum but with two main differences arising from the formulation of the training task as a constrained optimization problem: (i) the momentum term is scaled with curvature information (in the form of the Hessian); (ii) the coefficients for the learning rate and the scaled momentum term are adaptively determined. The implementation of the algorithm requires minimal additional computations compared to a classical SGD with momentum iteration since no actual computation of the Hessian is needed, due to the algorithm's requirement for computing only a Hessian-vector product. This product can be computed exactly and very efficiently within any modern computational graph framework such as, for example, Tensorflow. We report experiments with different neural network architectures trained on standard neural network benchmarks which demonstrate the efficiency of the proposed method.

SESSION 5

Wednesday, May 29, 2019, 10:00 – 11:20

1. Model Analysis of Min-Cost Attack-Aware Logical Link Assignment in Software-Defined Networking

A. Rosle, S.C. Tan, S. Ali, C.K. Lee, Z. Yusoff, R. Kapsin

Software-defined network networking (SDN) is a modern architecture that improves network control by making the network itself agile and flexible. Its centralized structure makes it possible for service providers to respond efficiently and quickly to the ever-changing business requirements. However, there are a few limitations of SDN that restricts it from being reliable under certain circumstances such as network failures or attacks. One of it is the link assignment problem, which arises when one or more components of the network fail and unable to maintain connection during transmission. The overall cost of planning and maintaining the network is also a factor that should be taken into consideration when setting up a scalable network. The mathematical model proposed in this article is able to solve the link assignment problem by using cluster backup controllers and logical links to recover from attacks, while minimizing network cost. This paper aims to analyze the link assignment problem in SDN and test the proposed model against three aspects which are the number of attacks on the network, distance between network components and the properties of network. This model is expected to provide an objective cost that represents the overall planning and operating cost of the network in times of failure.

2. On polynomial solvability of one quadratic Euclidean clustering problem on a line

Alexander Kelmanov and Vladimir Khandeev

We consider one problem of partitioning a finite set of points in Euclidean space into clusters so as to minimize the sum over all clusters of the intracluster sums of the squared distances between clusters elements and their centers. The centers of some clusters are given as an input, while the other centers are unknown and defined as centroids (geometrical centers). It is known that the general case of the problem is strongly NP-hard. We show that there exists an exact polynomial algorithm for the one-dimensional case of the problem.

3. Exact Algorithm for One Cardinality-Weighted 2-Partitioning Problem of a Sequence

Alexander Kelmanov, Sergey Khamidullin **and** Anna Panasenko

We consider a problem of 2-partitioning a finite sequence of points in Euclidean space into two clusters of the given sizes with some additional constraints. The solution criterion is the minimum of the sum (over both clusters) of weighted intracluster sums of squared distances between the elements of each cluster and its center. The weights of the intracluster sums are equal to the cardinalities of the desired clusters. The center of one cluster is given as input, while the center of the

other one is unknown and is determined as a geometric center, i.e. as a point of space equal to the mean of the cluster elements. The following constraints hold: the difference between the indices of two subsequent points included in the first cluster is bounded from above and below by given some constants. It is shown that the considered problem is the strongly NP-hard one. An exact algorithm is proposed for the case of integer-valued input of the problem. This algorithm has a pseudopolynomial running time if the space dimension is fixed.

4. Asymptotically Optimal Algorithms for the Prize Collecting Traveling Salesman Problem on Random Inputs

Edward Kh. Gimadi and Oxana Tsidulko

The Prize Collecting Traveling Salesman Problem is a class of generalizations of the classic Traveling Salesman Problem (TSP) where it is not necessary to visit all the vertices. Given the edge costs and a certain profit associated with each vertex, the goal is to find a route which satisfies maximum collected profit and minimum traveling costs constraints. We show polynomial-time approximation algorithms for two variants of the problem and establish conditions under which the presented algorithms are asymptotically optimal on random inputs.

SESSION 6

Thursday, May 30, 2019, 10:30 – 11:50

1. On a cooperative VNS parallelization strategy for the capacitated vehicle routing problem

Panagiotis Kalatzantonakis, Angelo Sifaleras and Nikolaos Samaras

The Capacitated Vehicle Routing Problem (CVRP) is a well-known NP-hard combinatorial optimization problem with numerous real-world applications in logistics. In this work, we conduct an experimental study for the CVRP using well-known benchmark instances and we investigate two parallelization strategies that, coordinate the communication of multiple processors. We experimentally evaluated a non-cooperative and a novel cooperation model, especially in hard instances.

2. Irreducible bin packing: complexity, solvability and application to the routing open shop

Ilya Chernykh and Artem Pyatkin

We introduce the following version of an ``inefficient'' bin packing problem: maximize the number of bins under the restriction that the total content of any two bins is larger than the bin capacity. There is a trivial upper bound on the optimum in terms of the total volume of the items. We refer to the decision version of this problem with the number of bins equal to the trivial upper bound as Irreducible Bin Packing. We prove that this problem is NP-complete in an ordinary sense and derive sufficient condition for its polynomial solvability. The problem has a certain connection to a routing open shop problem being a generalization of the metric TSP and scheduling open shop problem, known to be NP-hard even for two machines on a 2-node network. So-called job aggregation at some node of a transportation network can be seen as an instance of a bin packing problem. We show that for a two-machine case a positive answer to the Irreducible Bin Packing problem question at some node leads to a linear algorithm of constructing an optimal schedule subject to some restrictions on the location of that node

3. An Artificial Bee Colony Algorithm for the Multiobjective Energy Reduction Multi-Depot Vehicle Routing Problem

Emmanouela Rapanaki, Iraklis-Dimitrios Psychas, Magdalene Marinaki and Yannis Marinakis

Artificial Bee Colony algorithm is a very powerful Swarm Intelligence Algorithm that has been applied in a number of different kind of optimization problems since the time that it was published. In recent years there is a growing number of optimization models that trying to reduce the energy consumption in routing problems. In this paper, a new variant of Artificial Bee Colony algorithm, the Parallel Multi-Start Multiobjective Artificial Bee Colony algorithm (PMS-ABC) is proposed for the solution

of a Vehicle Routing Problem variant, the Multiobjective Energy Reduction Multi-Depot Vehicle Routing Problem (MERMDVRP). In the formulation four different scenarios are proposed where the distances between the customers and the depots are either symmetric or asymmetric and the customers have either demand or pickup. The algorithm is compared with three other multiobjective algorithms, the Parallel Multi-Start Non-dominated Sorting Differential Evolution (PMS-NSDE), the Parallel Multi-Start Multiobjective Particle Swarm Optimization (PMS-NPSO) and the Parallel Multi-Start Non-dominated Sorting Genetic Algorithm II (PMS-NSGA II) in a number of benchmark instances.

4. Sonar Inspired Optimization in Energy Problems Related to Load and Emission Dispatch

Alexandros Tzanetos and Georgios Dounias

One of the upcoming categories of Computational Intelligence (CI) is meta-heuristic schemes, which derive their intelligence from strategies that are met in nature, namely Nature Inspired Algorithms. These algorithms are used in various optimization problems because of their ability to cope with multi-objective problems and solve difficult constraint optimization problems. In this work, the performance of Sonar Inspired Optimization (SIO) is tested in a non-smooth, non-convex multi-objective Energy problem, namely the Economic Emissions Load Dispatch (EELD) problem. The algorithm manages to deal with constraints, namely Valve-point Effect and Multi-fuel Operation, and produces only feasible solutions, which satisfy power demand and operating limits of the system examined. Also, with a lot less number of agents manages to be very competitive against other meta-heuristics, such as hybrid schemes and established nature inspired algorithms.

SESSION 7

Thursday, May 30, 2019, 12:30 – 13:50

1. Metaheuristics for Min-Power Bounded-Hops Symmetric Connectivity Problem

Roman Plotnikov **and** Adil Erzin

We consider a Min-Power Bounded-Hops Symmetric Connectivity problem that consists of the construction of communication spanning tree on a given graph, where the total energy consumption spent for the data transmission is minimized and the maximum number of hops between two nodes is bounded by some predefined constant. We focus on the planar Euclidian case of this problem where the nodes are placed at the random uniformly spread points on a square and the power cost necessary for the communication between two network elements is proportional to the squared distance between them. Since this is an NP-hard problem, we propose different heuristics based on the following metaheuristics: genetic local search, variable neighborhood search, and ant colony optimization. We perform a posteriori comparative analysis of the proposed algorithms and present the obtained results in this paper.

2. Optimizing partially defined black-box functions under unknown constraints via Sequential Model Based Optimization: an application to Pump Scheduling Optimization in Water Distribution Networks

Antonio Candelieri, Bruno Galuzzi, Ilaria Giordani, Riccardo Perego and Francesco Archetti

This paper proposes a Sequential Model Based Optimization framework for solving optimization problems characterized by a black-box, multi-extremal, expensive and partially defined objective function, under unknown constraints. This is a typical setting for simulation-optimization problems, where the objective function cannot be computed for some configurations of the decision/control variables due to the violation of some (unknown) constraint. The framework is organized in two consecutive phases, the first uses a Support Vector Machine classifier to approximate the boundary of the unknown feasible region within the search space, the second uses Bayesian Optimization to find a globally optimal (feasible) solution. A relevant difference with traditional Bayesian Optimization is that the optimization process is performed on the estimated feasibility region, only, instead the entire search space. Some results on three 2D test functions and a real case study for the Pump Scheduling Optimization in Water Distribution Networks are reported. The proposed framework proved to be more effective and efficient than Bayesian Optimization approaches using a penalty for function evaluations outside the feasible region.

3. Towards Improving Merging Heuristics for Binary Decision Diagrams

Nikolaus Frohner and Günther Raidl

Over the last years, binary decision diagrams (BDDs) have become a powerful tool in the field of combinatorial optimization. They are directed acyclic multigraphs and represent the solution space of binary optimization problem in a recursive way. During their construction, merging of nodes in this multigraph is applied to keep the size within polynomial bounds resulting in a discrete relaxation of the original problem. The longest path length through this diagram corresponds then to an upper bound of the optimal objective value. The algorithm deciding which nodes to merge is called a merging heuristic. A commonly used heuristic for layer-wise construction is minimum longest path length (minLP) which sorts the nodes in a layer descending by the currently longest path length to them and subsequently merges the worst ranked nodes to reduce the width of a layer. A shortcoming of this approach is that it neglects the (dis-)similarity between states it merges, which we assume to have negative impact on the quality of the finally obtained bound. By means of a simple tie breaking procedure, we show a way to incorporate the similarity of states into minLP using different distance functions to improve dual bounds for the maximum independent set problem (MISP) and the set cover problem (SCP), providing empirical evidence for our assumption. Furthermore, we extend this procedure by applying similarity-based node merging also to nodes with close but not necessarily identical longest path values. This turns out to be beneficial for weighted problems where ties are substantially less likely to occur. We evaluate the method on the weighted MISP and tune parameters that control as to when apply similarity-based node merging.

4. Assessing simulated annealing with variable neighborhoods

Eduardo Lalla-Ruiz, Leonard Heilig, and Stefan Voss

Simulated annealing (SA) is a very well-known metaheuristic commonly used to solve a great variety of NP-hard problems such as the quadratic assignment problem (QAP). As commonly known, the choice and size of neighborhoods can have a considerable impact on the performance of SA. In this work, we investigate and propose a SA variant that considers variable neighborhood structures driven by the state of the search. In the computational experiments, we assess the contribution of this SA variant in comparison with the state-of-the-art SA for the QAP applied to printed circuit boards and show that using variable neighborhoods leads to a better performance.

SESSION 8

Friday, May 31, 2019, 10:30 – 11:50

1. On asymptotically optimal solvability of Euclidean Max m-k-Cycles Cover Problem

Edward Kh. Gimadi and Ivan Rykov

In current paper we consider the NP-hard problem of finding *m* edge-disjoint coverings with *k* cycles of maximum total weight in *d*-dimensional Euclidean space. We construct an algorithm for solving this problem based on asymptotically optimal algorithm for solving Euclidean m salesmen maximization problem, and derive conditions of its asymptotical optimality.

2. A novel solution encoding in the Differential Evolution Algorithm for optimizing Tourist Trip Design Problems

Dimitra Trachanatzi, Manousos Rigakis, Andromachi Taxidou, Magdalene Marinaki, Yannis Marinakis, and Nikolaos Matsatsinis

In this paper, a tourist trip design problem is simulated by the Capacitated Team Orienteering Problem (CTOP). The objective of the CTOP is to form feasible solution, as a set of itineraries, that represent a sequence visit of nodes, that maximize the total prize collected from them. Each itinerary is constrained by the vehicle capacity and the total travelled time. The proposed algorithmic framework, the Distance Related Differential Algorithm (DRDE), is a combination of the widely-known Differential Evolution algorithm (DE) and a novel encoding/ decoding process, namely the *Distance Related* (DR). The process is based on the representation of the solution vector by the Euclidean Distance of the included nodes and offers a data-oriented approach to apply the original DE to a discrete optimization problem, such as the CTOP. The efficiency of the proposed algorithm is demonstrated over computational experiments.

3. Barrier Covering in 2D Using Mobile Sensors with Circular Coverage Areas

Adil Erzin, Natalya Lagutkina and Nika Ioramishvili

In the problems of barrier monitoring using mobile sensors that have circular coverage areas, it is required to move the sensors *to the barrier* (some line) so that each barrier point belongs to the coverage area (disk) of at least one sensor. One of the criteria for the effectiveness of coverage is the minimum of the total length of the paths moved by sensors. If we give up the requirement to move the sensors to the barrier, then the problem (which is NP-hard) will not be easier. But at the same time, the value of the objective function can be reduced. In this article, we first propose a pseudo-polynomial algorithm for solving such a problem, which in the case of equal disks builds the optimal solution in the L_1 metric and a -approximate solution in the Euclidean metric. This algorithm is an effective implementation of the dynamic programming method in which at the stage of preliminary calculations it is

possible to find an analytical form of functions for a finite number of variants of the relative position of the circles and the barrier. The conducted numerical experiment showed that if the requirement to move the sensors to the barrier is skipped, the value of the objective function can decrease several times.

4. Live Soccer Betting Using XGBoost and The Kelly Criterion

Ilkay Boduroglu

Live soccer betting is known to be more challenging for professional wagerers than pregame betting since odds (a.k.a. prices) change very rapidly. We combine a state-of-the-art machine learning tool, XGBoost, with the well-established optimal-bet-size-finder Kelly Criterion to produce optimal bet sizes, given a finite betting portfolio size. We use a limited number of statistics from the first half of the 2018-19 season in the English Premier League. The statistics actually come from variables that are collected in the first half of each of the 190 matches played. The variables that we look into are the number of goals scored as well as the number of successful passes, the number of successful cross balls, and the number of successful corners, all into the penalty area. Our goal is to compute the optimal bet sizes for each available bet regarding a handful of matches just before the second halves of these matches begin (almost concurrently). XGBoost provides us with the probabilities of a home-win, a tie, and an away-win for each match. These probabilities are then entered into a nonlinear optimization model that utilizes the Kelly Criterion to determine the Kelly-optimal bet sizes.

SESSION 9

Friday, May 31, 2019, 14:00 – 15:20

1. Evolving Gaussian Process kernels for translation editing effort estimation

Ibai Roman, Roberto Santana, Alexander Mendiburu and Jose A. Lozano

In many Natural Language Processing problems the combination of machine learning and optimization techniques is essential. One of these problems is estimating the effort required to improve, under direct human supervision, a text that has been translated using a machine translation method. Recent developments in this area have shown that Gaussian Processes can be accurate for post-editing effort prediction. However, the Gaussian Process kernel has to be chosen in advance, and this choice influences the quality of the prediction. In this paper, we propose a Genetic Programming algorithm to evolve kernels for Gaussian Processes. We show that the combination of evolutionary optimization and Gaussian Processes removes the need for a-priori specification of the kernel choice, and achieves predictions that, in many cases, outperform those obtained with fixed kernels.

2. Bayesian Optimization approaches for massively multi-modal problems

Ibai Roman, Alexander Mendiburu, Roberto Santana and Jose A. Lozano

The optimization of massively multi-modal functions is a challenging task, particularly for problems where the search space can lead the optimization process to local optima. While evolutionary algorithms have been extensively investigated for these optimization problems, Bayesian Optimization algorithms have not been explored to the same extent. In this paper, we study the behavior of Bayesian Optimization as part of a hybrid approach for solving several massively multi-modal functions. We use well-known benchmarks and metrics to evaluate how different variants of Bayesian Optimization deal with multi-modality.

3. Predicting the execution time of the interior point method for solving linear programming problems using artificial neural networks

Sophia Voulgaropoulou, Nikolaos Ploskas and Nikolaos Samaras

Deciding upon which algorithm would be the most efficient for a given set of linear programming problems is a significant step in linear programming solvers. CPLEX Optimizer supports primal and dual variants of the simplex algorithm and the interior point method. In this paper, we examine a prediction model using artificial neural networks for the performance of CPLEX's interior point method on a set of benchmark linear programming problems (netlib, kennington, Meszaros, Mittelmann). Our study consists of the measurement of the execution time needed for the solution of 295 linear programming problems. Specific characteristics of the

linear programming problems are examined, such as the number of constraints and variables, the nonzero elements of the constraint matrix and the right-hand side, and the rank of the constraint matrix of the linear programming problems. The purpose of our study is to identify a model, which could be used for prediction of the algorithm's efficiency on linear programming problems of similar structure. This model can be used prior to the execution of the interior point method in order to estimate its execution time. Experimental results show that the model can achieve an accuracy of 72% for the training set.

4. A SAT Approach for Finding Sup-Transition-Minors

Benedikt Klocker, Herbert Fleischner **and** Günther Raidl

The cycle double cover conjecture is a famous longstanding unsolved conjecture in graph theory. It is related and can be reduced to the compatible circuit decomposition problem. Recently Fleischner et al. (2018) provided a sufficient condition for a compatible circuit decomposition, which is called SUD-K5-minor freeness. In a previous work we developed an abstract mathematical model for finding SUD-K5-minors and based on the model a mixed integer linear program (MIP). In this work we propose a respective boolean satisfiability (SAT) model and compare it with the MIP model in computational tests. Non-trivial symmetry breaking constraints are proposed, which improve the solving times of both models considerably. Compared to the MIP model the SAT approach performs significantly better. We use the faster algorithm to further test graphs of graph theoretic interest and were able to get new insights. Among other results we found snarks with 30 and 32 vertices that do not contain a perfect pseudo-matching, that is a spanning subgraph consisting of K2 and K1, 3 components, whose contraction leads to a SUD-K5-minor free graph.