Metaheuristics
Progress in Complex Systems Optimization

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Metaheuristics

Progress in Complex Systems Optimization

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Preface

In the last decades the field of metaheuristics has grown considerably. Seen both from the technical point of view and from the application-oriented side, these optimization tools have established their value in a remarkable story of success. Researchers have demonstrated the ability of these methods to solve hard combinatorial problems of practical sizes within reasonable computational time. In this collection we highlight the recent developments made in the area of Simulated Annealing, Path Relinking, Scatter Search, Tabu Search, Variable Neighbourhood Search, Iterated Local Search, GRASP, Memetic Algorithms, evolutionary-inspired algorithms like Genetic Algorithms, Ant Colony Optimization or Swarm Intelligence, and several other paradigms for a variety of well-known application areas, like location problems, the travelling salesman and vehicle routing problems, timetabling problems and others. A specific part of this volume is also dedicated to papers addressing dynamic and stochastic problems, multi-objective optimization, parallel computation, as well as the discussion of general themes like the exploration of distance metrics for comparing solutions, cooperative learning and the use of statistical methods in metaheuristics' design.

The book is organized as follows. In the first four parts, metaheuristics applications to several combinatorial optimization problems are collected, where each part is dedicated to a particular solution technique. Part V treats problems with dynamic and stochastic characteristics, while Part VI addresses the design and application of distributed and parallel algorithms. The final part, Part VII, collects articles dealing with some ideas on algorithm tuning and design and the presentation of general, reusable software tools.

The first two papers in this volume deal with the application of Scatter Search to the multidemand multidimensional knapsack problem (Hvattum and Løkketangen) and for the fixed-charge multicommodity flow network design problem (Gendreau and Crainic). The main focus of both papers is the adaption of different algorithmic ideas and concepts of Scatter Search in respective application domains and the empirical analysis of these design decisions.

The next two topics cover Tabu Search and its use to solve large scale set covering problems and full truckload routing problems. Reflecting the maturity of Tabu Search, the paper by Caserta intertwines a Tabu Search based primal intensive scheme with a Lagrangian based dual intensive scheme to design a dynamic primal-dual algorithm that progressively reduces the gap between the upper and lower bound, while the paper by Hirsch and Gronalt presents a successful application of Tabu Search which solves a real world pickup and delivery problem of full truckloads in the timber industry.

Part III focuses on some recent bio-inspired methods. The paper of Aras et al. deals with the capacitated multi-facility Weber problem and among three nature-inspired methods developed and implemented for this problem, Simulated Annealing was found to outperform the competing approaches. In the paper of Schirrer et al., the reviewer assignment problem is solved by using a Memetic Algorithm. The algorithm developed is applied to the data gathered from the MIC 2001 and 2003 conferences and then used to solve the reviewer assignment problem for the MIC 2005.

A GRASP application to the TSP (Golbarg et al.) and a randomized iterative improvement algorithm for the university course timetabling problem (Abdullah et al.) are grouped in Part IV. In the former paper GRASP is hybridized with a path-relinking procedure, while the latter one uses a composite neighbourhood structure to further enhance the solution quality of the basic versions of the respective algorithms.

Uncertainty and/or dynamic problem formulations are the joint characteristics of the papers collected in Part V. which highlights the diversity of metaheuristic approaches and application domains.

Dejan Jovanović et al. present a new method for the probabilistic logic satisfiability problem, based on the Variable Neighborhood Search metaheuristic. The next paper by Mauro Birattari et al. introduces ACO/F-Race, an algorithm for tackling general combinatorial optimization problems under uncertainty, and addresses the TSP as an illustration. Abdunnaser Younes et al. present an idea of using diversity to guide evolutionary algorithms and investigate its merit on dynamic combinatorial optimization problems, exemplifying an implementation for the dynamic TSP. Joana Dias et al. develop a Memetic Algorithm for capacitated and uncapacitated dynamic location problems. Alba et al. compare different genetic algorithms applied to the nonstationary knapsack problem and study potentials and difficulties of applying GAs in dynamic contexts. Finally, Bartz-Beielstein and Blum present a Particle Swarm Optimization algorithm for problems in noisy environments. While the first five papers deal with uncertainty or dynamics with respect to some problem data, the last paper addresses the influence of noise in the evaluation of a solution on the convergence properties of a metaheuristic algorithm. It also combines the metaheuristic approach with noise reducing methods from statistics.

The application of metaheuristics to notoriously difficult (NP-hard) optimization problems has become a viable approach with the development of ever increasing computational power. However, as more and richer real world constraints are included into existing models with constantly increasing problem sizes, the inherent complexity asks for even more sophisticated computational methods, including parallel implementations of well-known metaheuristics, as well as the adaption of existing techniques for parallel architectures and the exploitation of parallelism within the algorithms. In this volume, two papers address these issues. Fischer and Merz propose a distributed version of the chained Lin-Kernighan algorithm for the Traveling Salesman Problem and show that – given an equivalent amount of computation time – the distributed version outperforms the original algorithm. Araújo et al. present four slightly differing strategies for the parallelization of an extended GRASP with iterated local search for the mirrored traveling tournament problem, with the objective of harnessing the benefits of grid computing. Computational grids are distributed high latency environments which offer significantly more computing power than traditional clusters. Experiments on such a dedicated cluster illustrate the effectiveness and the scalability of the proposed strategies.

The four papers grouped together in the last part of the book describe new methods with respect to algorithm tuning and design and reusable software tools for designing metaheuristics. First, Paquete et al. describe the usage of experimental design to analyze stochastic local search algorithms for multi-objective problems, particularly exemplified for the biobjective quadratic assignment problem. The goal of the paper is to enhance understanding of the influence of particular algorithm design decisions on the quality of the solutions and the dependance of this influence on problem instance features and characteristics, e.g. correlation between the objectives. Next, Kubiak introduces distance measures and a fitness-distance analysis for the capacitated vehicle routing problem based on a statistical analysis of the fitness landscape of problem instances. Halim and Lau present tuning strategies for tabu search via visual diagnosis, where the user and the computer can collaborate to diagnose the occurrence of negative incidents along the search trajectory on a set of training instances. Finally, Dorne et al. exhibit a software toolkit iOpt which provides reusable code to solve combinatorial optimization problems. A solution procedure for the vehicle routing problem is composed by using this toolkit. The authors explain in detail how to make use of the modeling and solving facilities available in iOpt to tackle this problem. At each step of this building process, they discuss the benefits of using iOpt rather than starting building a solution from scratch. The overall conclusion of this work is that the toolkit allows the user to maximize reuse of his code, significantly reduce the development time and focus attention on the design rather than the coding.

Given the range of potential design decisions and applications of metaheuristics, the 20 papers presented here can only scratch the surface of this vast research field. We hope that this post conference volume will encourage further work in the area of metaheuristic search techniques.

Editing the post conference volume for MIC 2005 would not have been possible without the most valuable input of a large number of people. First of all, we wish to thank all the authors for their contributions. Furthermore we greatly appreciate the valuable help from the referees. Last but not least we are grateful to Monika Treipl for designing and implementing the online reviewing system and to Verena Schmid for editing the final version of the book.

Vienna, Montreal, Graz, Zurich

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