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António Gaspar-Cunha · Carlos Henggeler Antunes
Carlos Coello Coello (Eds.)

Evolutionary Multi-Criterion Optimization

8th International Conference, EMO 2015
Guimarães, Portugal, March 29 – April 1, 2015
Proceedings, Part I

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Editors
António Gaspar-Cunha
Institute for Polymers and Composites/I3N
University of Minho
Guimarães
Portugal

Carlos Coello Coello
CINVESTAV-IPN
Depto. de Computacíon
Col. San Pedro Zacatenco
Mexico

Carlos Henggeler Antunes
Dept. of Electrical and Computer Engg.
University of Coimbra
Coimbra
Portugal

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Preface

EMO is a biennial international conference series devoted to the theory and practice of evolutionary multi-criterion optimization.

The first EMO took place in 2001 in Zürich (Switzerland), with later conferences taking place in Faro (Portugal) in 2003, Guanajuato (Mexico) in 2005, Matsushima-Sendai (Japan) in 2007, Nantes (France) in 2009, Ouro Preto (Brazil) in 2011, and Sheffield (UK) in 2013. The proceedings of this series of conferences have been published as a volume in Lecture Notes in Computer Science (LNCS), respectively, in volumes 1993, 2632, 3410, 4403, 5467, 6576, and 7811.

The 8th International Conference on Evolutionary Multi-Criterion Optimization (EMO 2015) took place in Guimarães, Portugal, from March 29 to April 1, 2015. The event was organized by the University of Minho. Following the success of the two previous EMO conferences, a special track was offered aiming to foster further cooperation between the EMO and the multiple criteria decision making (MCDM). Also, a special track on real-world applications (RWA) was endorsed.

EMO 2015 received 90 full-length papers, which were submitted to a rigorous single-blind peer-review process, with a minimum of three referees per paper. Following this process, a total of 68 papers were accepted for presentation and publication in this volume, from which 40 were chosen for oral and 24 for poster presentation. The selected papers were distributed through the different tracks as follows: 46 main track, 6 MCDM track, and 16 RWA track.

The conference benefitted from the presentations of plenary speakers on research subjects fundamental to the EMO field: Thomas Stüetzle, from the IRIDIA laboratory of Université libre de Bruxelles (ULB), Belgium; Murat Köksalan, from the Industrial Engineering Department of Middle East Technical University, Ankara, Turkey; Luís Santos, from the University of São Paulo and Embraer, Brazil; Carlos Fonseca, from the University of Coimbra, Portugal.

From the beginning, this conference provided significant advances in relevant subjects of evolutionary multi-criteria optimization. This event aimed to continue these type of developments, being the papers presented focused on: theoretical aspects, algorithms development, many-objectives optimization, robustness and optimization under uncertainty, performance indicators, multiple criteria decision making, and real-world applications.

Finally, we would express our gratitude to the plenary speakers for accepting our invitation, to all the authors who submitted their work, to the members of the International Program Committee for their hard work, to the members of the Organizing Committee, particularly Lino Costa, and to the Track Chairs Kaisa Miettinen, Salvatore Greco, and

Robin Purshouse. We would like to acknowledge the support of the School of Engineering of the University of Minho. We would also like to thank Alfred Hofmann and Anna Kramer at Springer for their support in publishing these proceedings.

March 2015

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Plenary Talks

Interactive Approaches in Multiple Criteria Decision Making and Evolutionary Multi-objective Optimization

Murat Köksalan

Industrial Engineering, Middle East Technical University
06800 Ankara, Turkey
koksalan@metu.edu.tr

Abstract. The developments related to Multiple Criteria Decision Making (MCDM) go back a long time. It has been over 50 years since MCDM became an active research area. There have been major developments during this time both in theory and applications.

Evolutionary Multi-objective Optimization (EMO) is a relatively new field that has enjoyed a fast growth. EMO, although heuristic in nature, can successfully handle many complex problems. EMO has started independently from MCDM and there was very little interaction between the researchers in early developments of EMO. Earlier approaches mostly addressed two objectives and attempted to generate the whole PO set. Preference-based approaches that attempt to converge preferred regions are more recent. Efforts to combine forces from the two areas are also more recent.

Although approaches have been developed to characterize the whole Pareto Optimal (PO) frontier/set in both MCDM and EMO, this task is neither useful nor feasible for many complex practical problems. Many of the PO solutions may be less attractive than many dominated solutions for the decision maker (DM). In complex problems from practice, the available computational budget would be more wisely spent if the search is concentrated in the regions of interest to the DM. Therefore, obtaining preference information from the DM and using the obtained information to converge the preferred solutions is important. Incorporating preference information in the solution process has been well-developed in MCDM and is being addressed in EMO in recent years.

In this talk, I will briefly review the historical developments in MCDM. Then I will concentrate on preference-based approaches in general and interactive approaches in particular. I will cover some interactive approaches developed for different types of MCDM problems. I will also cover some of the interactive approaches developed in the EMO field. Multi-objective combinatorial optimization (MOCO) problems are computationally complex and there is a growing interest in this field. I will briefly cover some preference-based approaches in MOCO and emphasize the potential of EMO to address these problems.

Towards Automatically Configured Multi-objective Optimizers

Thomas Stützle

IRIDIA-CoDE, Université Libre de Bruxelles (ULB), Brussels, Belgium
stuetzle@ulb.ac.be

Abstract. The design of algorithms for computationally hard problems is a time-consuming and difficult task. This is in large part due to the large number of degrees of freedom in defining and selecting algorithm components and settings of numerical parameters but also due to a number of aggravating circumstances such as the NP-hardness of most of the problems to be solved and the difficulty of algorithm analysis due to stochasticity and heuristic biases. Even when tackling specific problems or problem classes by off-the-shelf optimizers such as high performing integer programming solvers, their performance can often be improved substantially by using appropriate settings of the parameters that influence search behavior.

While traditionally algorithm design and the choice of specific parameter settings has usually been done manually, over the recent years various automatic algorithm configuration methods have been developed to effectively search large parameter spaces and to support algorithm designers as well as practitioners. These automatic algorithm configuration methods have shown to be able to identify new algorithm designs and performance improving parameter settings in a number of applications and proved in this way to be instrumental for developing high-performance algorithms.

In this talk, we will first introduce the scope and potential impact automatic algorithm configuration methods have and give an overview of the main existing techniques. We will then illustrate the successful application of automatic algorithm configuration methods by a number of case studies where they have been crucial to obtain improved algorithm designs and reach or surpass state-of-the-art performance. In particular, we show how these methods can be applied to automatically configure algorithms for multi-objective optimization and we demonstrate the performance gains that can be achieved for various types of multi-objective optimizers ranging from the two-phase and Pareto local search framework, over multi-objective ant colony optimization algorithms to multi-objective evolutionary algorithms. Next, we show how the same methodology that appeared to be successful for configuring multi-objective optimizers can be used to improve the anytime behavior of algorithms. Finally, we argue that automatic algorithm configuration will transform the way optimization algorithms are developed in the future and give an outlook on future research challenges.

A Review of Evolutionary Multiobjective Optimization Applications in Aerospace Engineering

Luis Santos

Universidada de São Paulo, São Paulo, Brazil
lccs13@yahoo.com

Abstract. Evolutionary Multiobjective Optimization (EMO) has been applied to several relevant problems in Aerospace Engineering for several years. To estabilish a basis of comparison a 10-year span of publications of the aerospace field is analyzed. This basis of publications is comprised by the publications of the professional societies AIAA, ICAS, SAE and their related journals. From the papers selected several aspects will be compared such as:

- The choice of the evolutionary, or bio-inspired methods, such as genetic algorithms or particle swarm.
- The number of objective functions and their type (continuous or discrete)
- The number of design variables and their type (continuous or discrete)
- The number of constraints, the type of constraints, and how the constraints are implemented.
- Convergence criteria and computational cost
- The use of surrogate methods
- and any other relevant aspects regarding applications.

The analysis of these parameters will provide an idea of current level of use and application of EMO methods in Aerospace, providing the EMO research community with a reference to the current industrial practice in the field. The analysis of the data presented aims to encourage potentially novel applications incorporating the advances of the latest EMO research. That may serve as a guide of cooperation between researchers of both fields.

Performance Evaluation of Multiobjective Optimization Algorithms: Quality Indicators and the Attainment Function

Carlos M. Fonseca

CISUC, Department of Informatics Engineering, University of Coimbra
Pólo II, 3030-290 Coimbra, Portugal
cmfonsec@dei.uc.pt

Abstract. The development of improved optimization algorithms and their adoption by end users are intrinsically dependent on the ability to evaluate how well they perform on the problem classes of interest. In the absence of theoretical guarantees, performance must be evaluated experimentally. Beyond the selection of suitable, representative problem instances, which is a crucial step in the design of such experiments, analysis of the results must take both the experimental conditions and the nature of the data collected into account.

A posteriori approaches to multiobjective optimization typically lead to discrete approximations of the true Pareto-optimal front of the given problem in the form of sets of mutually non-dominated points in objective space. When the algorithm is stochastic, such non-dominated point sets are *random*, and vary according to some probability distribution.

In the literature, two main approaches have been proposed to deal with non-dominated point set distributions: *quality indicators* and the *attainment function*. Quality indicators map non-dominated point sets to real values, and make subsequent data analysis simpler by side-stepping the set nature of the data. In contrast, the attainment-function approach addresses the non-dominated point set distribution directly. Distributional aspects such as location, variability, and dependence, are captured by the moments of the set distribution, which can be estimated from the raw non-dominated point set data.

In this presentation, quality indicators and the attainment function are reviewed as tools for the performance evaluation of stochastic multiobjective optimization algorithms. Complexity issues concerning the computation, visualization, and size of the moment estimates, as the number of objectives, number of runs, and size of the Pareto-front approximations grow are highlighted. Recent results relating the statistical distributions of some unary quality indicators to the attainment function are presented, establishing a link between the two approaches. A discussion of opportunities for further work concludes the presentation.

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