

Carlos Cotta, Marc Sevaux, and Kenneth Sörensen (Eds.)

Adaptive and Multilevel Metaheuristics

Studies in Computational Intelligence, Volume 136

Editor-in-Chief

Prof. Janusz Kacprzyk
Systems Research Institute
Polish Academy of Sciences
ul. Newelska 6
01-447 Warsaw
Poland

E-mail: kacprzyk@ibspan.waw.pl

Further volumes of this series can be found on our homepage:
springer.com

Vol. 117. Da Ruan, Frank Hardeman
and Klaas van der Meer (Eds.)
Intelligent Decision and Policy Making Support Systems, 2008
ISBN 978-3-540-78306-0

Vol. 118. Tsau Young Lin, Ying Xie, Anita Wasilewska
and Churn-Jung Liao (Eds.)
Data Mining: Foundations and Practice, 2008
ISBN 978-3-540-78487-6

Vol. 119. Slawomir Wiak, Andrzej Krawczyk
and Ivo Dolezel (Eds.)
Intelligent Computer Techniques in Applied Electromagnetics,
2008
ISBN 978-3-540-78489-0

Vol. 120. George A. Tsihrintzis and Lakhmi C. Jain (Eds.)
Multimedia Interactive Services in Intelligent Environments,
2008
ISBN 978-3-540-78491-3

Vol. 121. Nadia Nedjah, Leandro dos Santos Coelho
and Luiza de Macedo Mourelle (Eds.)
Quantum Inspired Intelligent Systems, 2008
ISBN 978-3-540-78531-6

Vol. 122. Tomasz G. Smolinski, Mariofanna G. Milanova
and Aboul-Ella Hassanien (Eds.)
Applications of Computational Intelligence in Biology, 2008
ISBN 978-3-540-78533-0

Vol. 123. Shuichi Iwata, Yukio Ohsawa, Shusaku Tsumoto, Ning
Zhong, Yong Shi and Lorenzo Magnani (Eds.)
Communications and Discoveries from Multidisciplinary Data,
2008
ISBN 978-3-540-78732-7

Vol. 124. Ricardo Zavala Yoe
*Modelling and Control of Dynamical Systems: Numerical
Implementation in a Behavioral Framework*, 2008
ISBN 978-3-540-78734-1

Vol. 125. Larry Bull, Bernadó-Mansilla Ester
and John Holmes (Eds.)
Learning Classifier Systems in Data Mining, 2008
ISBN 978-3-540-78978-9

Vol. 126. Oleg Okun and Giorgio Valentini (Eds.)
*Supervised and Unsupervised Ensemble Methods
and their Applications*, 2008
ISBN 978-3-540-78980-2

Vol. 127. Régie Gras, Einoshin Suzuki, Fabrice Guillet
and Filippo Spagnolo (Eds.)
Statistical Implicative Analysis, 2008
ISBN 978-3-540-78982-6

Vol. 128. Fatos Xhafa and Ajith Abraham (Eds.)
*Metaheuristics for Scheduling in Industrial and Manufacturing
Applications*, 2008
ISBN 978-3-540-78984-0

Vol. 129. Natalio Krasnogor, Giuseppe Nicosia, Mario Pavone
and David Pelta (Eds.)
*Nature Inspired Cooperative Strategies for Optimization
(NICSO 2007)*, 2008
ISBN 978-3-540-78986-4

Vol. 130. Richi Nayak, Nikhil Ichalkaranje
and Lakhmi C. Jain (Eds.)
Evolution of the Web in Artificial Intelligence Environments,
2008
ISBN 978-3-540-79139-3

Vol. 131. Roger Lee and Haeng-Kon Kim (Eds.)
Computer and Information Science, 2008
ISBN 978-3-540-79186-7

Vol. 132. Danil Prokhorov (Ed.)
Computational Intelligence in Automotive Applications, 2008
ISBN 978-3-540-79256-7

Vol. 133. Manuel Graña and Richard J. Duro (Eds.)
Computational Intelligence for Remote Sensing, 2008
ISBN 978-3-540-79352-6

Vol. 134. Ngoc Thanh Nguyen and Radoslaw Katarzyniak (Eds.)
New Challenges in Applied Intelligence Technologies, 2008
ISBN 978-3-540-79354-0

Vol. 135. Hsinchun Chen and Christopher C. Yang (Eds.)
Intelligence and Security Informatics, 2008
ISBN 978-3-540-69207-2

Vol. 136. Carlos Cotta, Marc Sevaux
and Kenneth Sörensen (Eds.)
Adaptive and Multilevel Metaheuristics, 2008
ISBN 978-3-540-79437-0

Carlos Cotta
Marc Sevaux
Kenneth Sörensen
(Eds.)

Adaptive and Multilevel Metaheuristics

Carlos Cotta
ETSI Informatica (3.2.49)
Campus de Teatinos
Universidad de Malaga
29071, Malaga
Spain
E-mail: ccottap@lcc.uma.es

Marc Sevaux
University of South-Brittany
CNRS, FRE 2734, LESTER
Centre de Recherche - BP 92116
F-56321 Lorient cedex
France
E-mail: marc.sevaux@univ-ubs.fr

Kenneth Sörensen
Fellow of the Flemish Fund for Scientific Research
Centre for Industrial Management
Katholieke Universiteit Leuven
Celestijnenlaan 300a
3001 Leuven
Belgium
E-mail: kenneth.sorensen@cib.kuleuven.be

ISBN 978-3-540-79437-0

e-ISBN 978-3-540-79438-7

DOI 10.1007/978-3-540-79438-7

Studies in Computational Intelligence

ISSN 1860949X

Library of Congress Control Number: 2008925773

© 2008 Springer-Verlag Berlin Heidelberg

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Typeset & Cover Design: Scientific Publishing Services Pvt. Ltd., Chennai, India.

Printed in acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

Adapt or Perish, now as ever, is nature's inexorable imperative
— H.G. Wells (1866-1946)

Preface

The last decades have witnessed a profound change in search and optimization technologies. In those problem domains where complexity results deemed exact techniques unaffordable, the use of metaheuristics has steadily gained popularity and usage. Nowadays, these techniques exhibit a remarkable success record, and are considered cutting-edge methods for solving hard optimization problems. Thus, whenever new problem domains arise metaheuristics are one of the primary weapons in our solving arsenal.

One of the keystones in practical metaheuristic problem-solving is the fact—repeatedly shown in both theory and practice—that tuning the optimization technique to the problem under consideration is crucial for achieving top performance. This tuning/customization is usually on the hands of the algorithm designer, and despite some methodological attempts, it largely remains an scientific art. Needless to say, there exist a number of very useful guidelines available in the literature for algorithmic parameterization, operator design, etc, but these guidelines are in general heuristic in nature.

A longly pursued goal in the field of metaheuristics has been transferring a part of this customization effort to the algorithm itself, endowing it with smart mechanisms for self-adapting to the problem. These mechanisms can involve different aspects of the algorithm, such as for example, self-adjusting the parameters, self-adapting the functioning of internal components, evolving search strategies, etc. While some theoretical results set out limitations on the general robustness of such mechanisms, their usefulness in specific problem classes has been verified. This volume presents recent advances in the area of self-adaptation in metaheuristic optimization. Most articles in this collection arose from a dedicated workshop held in Málaga, Spain, in November 2006 under the auspices of the European Chapter on Metaheuristics (EU/ME).

The volume is organized in two blocks. The first one comprises two review articles that survey the major aspects in the area of self-adaptive metaheuristics, namely hyperheuristics and self-adaptation in evolutionary heuristics. The first paper is authored by K. Chakhlevitch and P. Cowling, and overviews hyperheuristics, a multi-level metaheuristic approach in which an upper heuristic

layer controls the application of some underlying heuristics depending upon the characteristics of the region of the solution space currently under exploration. Different strategies for designing hyperheuristics are discussed, providing pointers to applications along the way. The second paper is authored by J.E. Smith, and focuses on how self-adaptation mechanisms in evolutionary algorithms may be used to control the parameters defining crossover and mutation, as well as the very definition of local search operators used within hybrid evolutionary algorithms.

The second block contains novel techniques involving self-adaptation, or novel applications of these. Araya, Neveu and Riff consider hyperheuristics for strip packing problems. Their hyperheuristic performs hill-climbing on a sequence of greedy low-level heuristics for the mentioned problem, obtaining results that often outperform other heuristics for the strip packing problem. Boutillon, Roland and Sevaux consider a simulated annealing approach to a hardware problem (the optimization of a finite impulse response filter). They focus on the acceptance schedule of the algorithm, and propose a probability-driven schedule that is shown to be competitive with temperature-driven strategies. Brunato and Battiti present an adaptive random search scheme termed reactive affine shaker that adapts the search region via affine transformations. The modifications are done on the basis of information gathered from trial points, and as shown by the experimental results they result in a promising approach for continuous optimization.

Geiger and Wenger consider an adaptive multi-objective vehicle routing problem in which different interacting vehicle agent place bids for orders that are offered in a marketplace. A decider agent communicates with a human user to build a preference model of her preferences. Landa-Silva and Le also consider a multi-objective problem, in this case in the area of nurse scheduling. Their approach uses a decoder mechanisms that incorporates a self-mutation mutation operator for repairing hard-constraint violations. Olague, Dunn and Lutton consider a problem in the area of computer vision, and approach it with an adaptive strategy based on the evolution of interacting co-adapted subcomponents for the problem at hand. They consider issues such as the computation and re-distribution of fitness values, the preservation of diversity, and the aggregation of individuals to form composite solutions.

Santana, Larrañaga and Lozano study the issue of adaptation within the framework of estimation of distribution algorithms (EDAs). They consider a framework in which the underlying probabilistic model can change during evolution, and show how such a dynamic EDA can outperform a static EDA on the satisfiability problem. Sierra Urrechu and Santibáñez Koref also consider an EDA approach, applied in this case to search directions within the search space rather than to solutions as usual. This approach can effectively self-adapt the trajectory of a local-searcher on continuous optimization problems. Cooren, Clerk and Siarry propose a parameter-free particle swarm algorithm that adapts its parameters according to information collected during the optimization process.

It is shown that this approach is competitive with respect to other swarm-based and evolution-based methods.

Sörensen, Sevaux and Schittekat contribute a position paper in which they examine commercial vehicle routing packages and identify multiple-neighborhood search as the key feature for adaptation. They present the thesis that this convergent feature is essential to the flexibility and adaptability of these approaches to different problems, and outline the need for adaptive hyperheuristics to supplement –and eventually, substitute– the role of the human user as designer. Finally, Souffriau, Vansteenwegen, Vanden Berghe and Van Oudheusden consider a hyperheuristic approach based on ant-colony optimization (ACO) with application to a routing problem. A genetic algorithm tunes the parameters of the ACO algorithm on a training set of problems, and the so-adapted algorithm is then tested on a different set of problems providing results very close to optimality.

Overall, this volume is intended both as a reference work for novel researchers in the area of self-adaptation in metaheuristics, and as an inspiring collection of state-of-the-art articles for researchers actively working in the field. We would like to thank all the people who made this volume possible, starting by the authors who contributed the technical content of the book. We also thank Dr. Antonio J. Fernández and Dr. José E. Gallardo from the University of Málaga for their invaluable participation in the organization of the seminal workshop held on this topic in Málaga on 2006. The financial help of the University of Málaga and the European Chapter on Metaheuristics is acknowledged too. Last but not least, thanks are due to Prof. Janusz Kacprzyk for his support to the development of this project, and to Dr. Thomas Ditzinger and the editorial staff of Springer for their kind attention and help.

Málaga (Spain), Lorient (France), Leuven (Belgium)
February 2008

Carlos Cotta
Marc Sevaux
Kenneth Sörensen

Contents

Part I: Reviews of the Field

Hyperheuristics: Recent Developments

Konstantin Chakhlevitch, Peter Cowling 3

Self-Adaptation in Evolutionary Algorithms for Combinatorial Optimisation

James E. Smith 31

Part II: New Techniques and Applications

An Efficient Hyperheuristic for Strip-Packing Problems

Ignacio Araya, Bertrand Neveu, María-Cristina Riff 61

Probability-Driven Simulated Annealing for Optimizing Digital FIR Filters

Emmanuel Boutillon, Christian Roland, Marc Sevaux 77

RASH: A Self-adaptive Random Search Method

Mauro Brunato, Roberto Battiti 95

Market Based Allocation of Transportation Orders to Vehicles in Adaptive Multi-objective Vehicle Routing

Martin Josef Geiger, Wolf Wenger 119

A Simple Evolutionary Algorithm with Self-adaptation for Multi-objective Nurse Scheduling

Dario Landa-silva, Khoi N. Le 133

Individual Evolution as an Adaptive Strategy for Photogrammetric Network Design

Gustavo Olague, Enrique Dunn, Evelyne Lutton 157

Adaptive Estimation of Distribution Algorithms <i>Roberto Santana, Pedro Larrañaga, José A. Lozano</i>	177
Initialization and Displacement of the Particles in TRIBES, a Parameter-Free Particle Swarm Optimization Algorithm <i>Yann Cooren, Maurice Clerc, Patrick Siarry</i>	199
Evolution of Descent Directions <i>Alejandro Sierra Urrecho, Iván Santibáñez Koref</i>	221
“Multiple Neighbourhood” Search in Commercial VRP Packages: Evolving Towards Self-Adaptive Methods <i>Kenneth Sörensen, Marc Sevaux, Patrick Schittekat</i>	239
Automated Parameterisation of a Metaheuristic for the Orienteering Problem <i>Wouter Souffriau, Pieter Vansteenwegen, Greet Vanden Berghe, Dirk Van Oudheusden</i>	255
Index	271
Author Index	275

List of Contributors

Ignacio Araya

Project COPRIN, INRIA, Sophia-Antipolis, France
ignacio.araya@sophia.inria.fr

Roberto Battiti

Dipartimento di Ingegneria e Scienza dell'Informazione, Università di Trento, via Sommarive 14, I-38100 Trento, Italy
battiti@dit.unitn.it

Emmanuel Boutillon

Université Européenne de Bretagne, UBS - Lab-STICC - Centre de Recherche, F-56321 Lorient France
emmanuel.boutillon@univ-ubs.fr

Mauro Brunato

Dipartimento di Ingegneria e Scienza dell'Informazione, Università di Trento, via Sommarive 14, I-38100 Trento, Italy
brunato@dit.unitn.it

Konstantin Chakhlevitch

CASS Business School, City University, London EC1Y 8TZ, UK
konstantin.chakhlevitch.1@city.ac.uk

Maurice Clerc

LiSSi, E.A. 3956 Université de Paris XII, 61 avenue du Général de Gaulle, 94010 Créteil, France
maurice.clerc@writeme.com

Yann Cooren

LiSSi, E.A. 3956 Université de Paris XII, 61 avenue du Général de Gaulle, 94010 Créteil, France
cooren@univ-paris12.fr

Peter Cowling

Department of Computing, University of Bradford, Bradford BD7 1DP, UK
P.I.Cowling@Bradford.ac

Enrique Dunn

CICESE, Km. 107 carretera Tijuana-Eda, 22860 Ensenada, México
edunn@cicese.mx

Martin Josef Geiger

Lehrstuhl für Industriebetriebslehre, Universität Hohenheim, 70593 Stuttgart, Germany
mjgeiger@uni-hohenheim.de

Dario Landa-silva

School of Computer Science, The University of Nottingham, UK
jds@cs.nott.ac.uk

Pedro Larrañaga

Intelligent Systems Group, Department of Computer Science and Artificial Intelligence, University of the Basque Country, Paseo Manuel de Lardizabal 1, 20080 Donostia - San Sebastian, Spain
pedro.larranaga@ehu.es

Khoi N. Le

School of Computer Science, The University of Nottingham, UK
kxl@cs.nott.ac.uk

Jose A. Lozano

Intelligent Systems Group, Department of Computer Science and Artificial Intelligence, University of the Basque Country, Paseo Manuel de Lardizabal 1, 20080 Donostia - San Sebastian, Spain
ja.lozano@ehu.es

Evelyne Lutton

INRIA Rocquencourt, Le Chesnay Cedex, France
evelyne.lutton@inria.fr

Bertrand Neveu

Project COPRIN, INRIA, Sophia-Antipolis, France
bertrand.neveu@sophia.inria.fr

Gustavo Olague

CICESE, Km. 107 carretera Tij-Eda, 22860 Ensenada, México
olague@cicese.mx

María-Cristina Riff

Department of Computer Science, Universidad Técnica Federico Santa María, Valparaíso, Chile
maria-cristina.riff@inf.utfsm.cl

Christian Roland

Université Européenne de Bretagne, UBS - Lab-STICC - Centre de Recherche, F-56321 Lorient, France
christian.roland@univ-ubs.fr

Roberto Santana

Intelligent Systems Group, Department of Computer Science and Artificial Intelligence, University of the Basque Country, Paseo Manuel de Lardizabal 1, 20080 Donostia - San Sebastian, Spain
rsantana@si.ehu.es

Iván Santibáñez Koref

Bionics and Evolutionary Techniques Dept., Technische Universität Berlin, D-13355 Berlin, Germany
isk@bionik.tu-berlin.de

Patrick Schittekat

University of Antwerp, Faculty of Applied Economics, Prinsstraat 13, 2000 Antwerp, Belgium
patrick.schittekat@ua.ac.be

Marc Sevaux

Université Européenne de Bretagne, UBS - Lab-STICC - Centre de Recherche, F-56321 Lorient, France
marc.sevaux@univ-ubs.fr

Patrick Siarry

Laboratoire Images, Signaux et Systèmes Intelligents, LiSSi, E.A. 3956 Université de Paris XII, 61 avenue du Général de Gaulle, 94010 Créteil, France
siarry@univ-paris12.fr

James E. Smith

School of Computer Science, University of the West of England at Bristol, UK
james.smith@uwe.ac.uk

Kenneth Sörensen

Katholieke Universiteit Leuven, Centre for Industrial Management, Celestijnenlaan 300A, 3001 Leuven (Heverlee), Belgium
kenneth.sorensen@cib.kuleuven.be

Wouter Souffriau

KaHo Sint-Lieven,
Information Technology,
Gebroeders Desmetstraat 1, 9000
Gent, Belgium
wouter.souffriau@kahosl.be

Alejandro Sierra Urrecho

Department of Computer Engineering,
Universidad Autónoma de Madrid,
28049 Madrid, Spain
alejandro.sierra@uam.es

Greet Vanden Berghe

KaHo Sint-Lieven, Information
Technology, Gebroeders
Desmetstraat
1, 9000 Gent, Belgium
greet.vandenberghel@kahosl.be

Pieter Vansteenwegen

Katholieke Universiteit Leuven,
Centre for Industrial Management,
Celestijnenlaan 300A,
3001 Leuven (Heverlee), Belgium
pieter.vansteenwegen@cib.
kuleuven.be

Dirk Van Oudheusden

Katholieke Universiteit Leuven,
Centre for Industrial Management,
Celestijnenlaan 300A,
3001 Leuven (Heverlee), Belgium
dirk.vanoudheusden@cib.
kuleuven.be

Wolf Wenger

Lehrstuhl für Industriebetriebslehre,
Universität Hohenheim,
70593 Stuttgart, Germany
w-wenger@uni-hohenheim.de