COMBINATORIAL AND GLOBAL OPTIMIZATION

SERIES ON APPLIED MATHEMATICS

Editor-in-Chief: Frank Hwang

Associate Editors-in-Chief: Zhong-ci Shi and U Rothblum

- Vol. 1** International Conference on Scientific Computation
eds. T. Chan and Z.-C. Shi
- Vol. 2** Network Optimization Problems — Algorithms, Applications and Complexity
eds. D.-Z. Du and P. M. Pardalos
- Vol. 3** Combinatorial Group Testing and Its Applications
by D.-Z. Du and F. K. Hwang
- Vol. 4** Computation of Differential Equations and Dynamical Systems
eds. K. Feng and Z.-C. Shi
- Vol. 5** Numerical Mathematics
eds. Z.-C. Shi and T. Ushijima
- Vol. 6** Machine Proofs in Geometry
by S.-C. Chou, X.-S. Gao and J.-Z. Zhang
- Vol. 7** The Splitting Extrapolation Method
by C. B. Liem, T. Lü and T. M. Shih
- Vol. 8** Quaternary Codes
by Z.-X. Wan
- Vol. 9** Finite Element Methods for Integrodifferential Equations
by C. M. Chen and T. M. Shih
- Vol. 10** Statistical Quality Control — A Loss Minimization Approach
by D. Trietsch
- Vol. 11** The Mathematical Theory of Nonblocking Switching Networks
by F. K. Hwang
- Vol. 12** Combinatorial Group Testing and Its Applications (2nd Edition)
by D.-Z. Du and F. K. Hwang
- Vol. 13** Inverse Problems for Electrical Networks
by E. B. Curtis and J. A. Morrow
- Vol. 14** Combinatorial and Global Optimization
eds. P. M. Pardalos, A. Migdalas and R. E. Burkard

Series on
Applied Mathematics
Volume 14

COMBINATORIAL AND GLOBAL OPTIMIZATION

Editors

Panos M. Pardalos

*Department of Industrial Systems Engineering
University of Florida, USA*

Athanasios Migdalas

*Department of Production Engineering and Management
Technical University of Crete, Greece*

Rainer E. Burkard

*Institute of Mathematics
Technical University of Graz, Austria*

World Scientific

New Jersey • London • Singapore • Hong Kong

Published by

World Scientific Publishing Co. Pte. Ltd.

P O Box 128, Farrer Road, Singapore 912805

USA office: Suite 1B, 1060 Main Street, River Edge, NJ 07661

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

Library of Congress Cataloging-in-Publication Data

Combinatorial and global optimization / editors Panos M. Pardalos, Athanasios Migdalas, Rainer E. Burkard.

p. cm. -- (Series on applied mathematics ; v. 14)

Includes bibliographical references.

ISBN 9810248024 (alk. paper)

1. Combinatorial optimization -- Congresses. 2. Mathematical optimization--Congresses. 3. Nonlinear programming--Congresses. I. Pardalos, P. M. (Panos M.), 1954-- II. Migdalas, Athanasios. III. Burkard, Rainer E. IV. Series.

QA402.5 .C5435 2001

511'.6--dc21

2001046899

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

Copyright © 2002 by World Scientific Publishing Co. Pte. Ltd.

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

Printed in Singapore by Mainland Press

Τή γλῶσσα μοῦ δῶσαν ἑλληνική
το σπίτι φτωχικό στίς ἀμμουδιές τοῦ Ὅμηρου.
Μοναχὴ ἔγνοια ἡ γλῶσσα μου στίς ἀμμουδιές τοῦ Ὅμηρου.
Ἐκεῖ σπάροι καὶ πέρκες
ἀνεμόδαρτα ρήματα
ρεύματα πράσινα μέσ τὰ γαλάζια
ὅσα εἶδα στά σπλάχνα μου ν' ἀνάβουνε
σφουγγάρια, μέδουσες
μέ τὰ πρῶτα λόγια τῶν Σειρήνων
ὄστρακα ρόδινα μέ τὰ πρῶτα μαῦρα ρίγη

I was given the Hellenic tongue
my house a humble one on the sandy shores of Homer.
My only care my tongue on the sandy shores of Homer.
The sea-bream and perch
windbeaten verbs
green currents with the cerulean
all that I saw blazing in my entrails
sponges, medusae
with the first words of the Sirens
pink shells with their first dark tremors

(from Axion Esti, 1959) – Odysseas Elytis

Preface

Combinatorial and global optimization problems appear in a wide range of applications in operations research, engineering, biological sciences and computer science. In combinatorial optimization and graph theory many approaches have been developed that link the discrete universe to the continuous universe through geometric, analytic, and algebraic techniques. Such techniques include global optimization formulations, semidefinite programming, and spectral theory. Major recent successes based on these approaches include interior point algorithms for linear and discrete problems, the celebrated Goemans-Williamson Relaxation of the maximum cut problem, and the Du-Hwang solution of the Gilbert-Pollak's Conjecture. Since integer constraints are equivalent to nonconvex constraints, the fundamental difference between classes of optimization problems is not between discrete and continuous problems but between convex and nonconvex optimization problems.

A conference on *Combinatorial and Global Optimization* was held at Chania, Crete, Greece. The conference was sponsored by the Center of Applied Optimization of the University of Florida, USA, and the Center for Information Technology Transfer (CENIIT) of Linköping Institute of Technology in Sweden. The conference provided a forum for researchers working on different aspects of combinatorial and global optimization to present their recent discoveries, and to interact with people working on complementary aspects of mathematical programming. This volume contains a selective collection of refereed papers based on talks presented at the conference.

We would like to take the opportunity to thank the sponsors, the program committee members, the authors of the papers, the anonymous referees, and World Scientific for making the conference successful and the publication of this interesting book possible.

P. M. Pardalos, A. Migdalas, and R. E. Burkard
Chania, Crete
May 2001

This page is intentionally left blank

Contents

Preface	vii
A Forest Exterior Point Algorithm for Assignment Problems	1
H. Achatz, K. Paparrizos, N. Samaras, and K. Tsipidis	
1 Introduction	2
2 Preliminaries	2
3 Description of the algorithm	3
4 Correctness and complexity of the algorithm	5
5 Concluding remarks	9
References	9
A Hybrid Scatter Genetic Tabu Approach for Continuous Global Optimization	11
I. M. Al-Harkan and T. B. Trafalis	
1 Introduction	12
2 Genetic, scatter search and tabu serach approach	13
3 HSGT algorithm description	16
4 Weight computations	18
5 Computational results	20
6 Conclusions and recommendations	21
Appendix A: Test functions	22
References	29

Exact Rates of Prokhorov Convergence under Three Moment Conditions	33
G. A. Anastassiou and T. Rychlik	
1 Main result	34
2 Outline of proof	38
References	42
Location/Allocation of Queuing Facilities in Continuous Space using Minsum and Minimax Criteria	43
J. Brimberg, R. F. Love and A. Mehrez	
1 Introduction	44
2 The model	45
3 A solution method	48
4 Computational results	50
5 Conclusions	52
References	52
Algorithms for the Consistency Analysis in Scenario Projects	55
R. Feldmann, N. Sensen, B. Monien, and O. Schlake	
1 Introduction	56
2 Definitions	58
3 Complexity	59
4 Algorithms	63
5 Conclusions	72
References	72
Assignment of Reusable and Non-Reusable Frequencies	75
D. A. Fotakis and P. G. Spirakis	
1 Introduction	76

2	Definitions and techniques	77
3	The complexity of radio coloring and radio labelling	81
4	An exact algorithm for constant number of colors	84
5	Algorithms for on-line radio labelling	90
6	Open problems	93
	References	94

Image Space Analysis for Vector Optimization and Variational Inequalities. Scalarization **97**

F. Giannessi and L. Pellegrini

1	Introduction	98
2	A separation scheme	99
3	On the scalarization of vector optimization	101
4	Vector variational inequalities	105
	References	108

Solving Quadratic Knapsack Problems by Reformulation and Tabu Search. Single Constraint Case **111**

F. Glover, G. Kochenberger, B. Alidaee and M. Amini

1	Introduction	112
2	Reformulation	113
3	Computational experiments	115
4	Summary and conclusions	119
	Appendix: Overview of our tabu search algorithm	120
	References	120

Global Optimization using Dynamic Search Trajectories **123**

A. A. Groenwold and J. A. Snyman

1	Introduction	124
---	------------------------	-----

2	The Snyman-Fatti trajectory method	125
3	The modified bouncing ball trajectory method	127
4	Global stopping criterion	128
5	Numerical results	129
6	Conclusions	131
	References	131

On Pareto Efficiency. A General Constructive Existence Principle 133

G. Isac

1	Introduction	133
2	Preliminaries	135
3	The main result	136
4	Realizations of Theorem 1	137
	References	142

Piecewise Linear Network Flow Problems 145

D. Kim and P. M. Pardalos

1	Introduction	146
2	Applications	156
3	Concluding remarks	157
	References	158

Semidefinite Programming Approaches for MAX-2-SAT and MAX-3-SAT: computational perspectives 161

E. de Klerk and J. P. Warners

1	Introduction	162
2	The SDP relaxation of MAX-2-SAT	162
3	Additional valid inequalities	165

4	Solving the SDP relaxation of MAX-2-SAT	166
5	A branch and cut framework	168
6	Numerical experiments	171
7	Future work	172
	References	175

On a Data Structure in a Global Description of Sequences 177

V. Korotkich

1	Introduction	177
2	Structural numbers and their geometric interpretation	179
3	Structural numbers as coordinates of a space and a system of linear equations	181
4	Integer patterns: Means for the visualization of the system	185
5	What picture appears when the system is visualized: An illustrative example	186
6	Definition of the structure and its isomorphic representations: Web of relations	191
7	On descriptive potentialities of the structure: Simple examples of global optimization problems	195
	References	203

Heuristic Solutions of Vehicle Routing Problems in Supply Chain Management 205

Y. Marinakis and A. Migdalas

1	Introduction	206
2	Supply chain management	206
3	The vehicle routing problem	207
4	Classic heuristics for the traveling salesman and the vehicle routing problems	210

5	Metaheuristics for the traveling salesman and the vehicle routing problems	219
6	Computational results	228
	References	231
A New Finite Cone Covering Algorithm for Concave Minimization		237
C. Meyer and B. Jaumard		
1	Introduction	238
2	Basic operations	239
3	Algorithm	246
4	Conclusions	247
	References	247
A Diagonal Global Optimization Method		251
A. Molinaro, C. Pizzuti and Y. D. Sergeyev		
1	Introduction	252
2	Diagonal information global optimization algorithm and its new convergence conditions	253
3	A new diagonal information algorithm	256
4	Numerical results	258
5	Conclusions	260
	References	262
Frequency Assignment for Very Large, Sparse Networks		265
R. Murphey		
1	Introduction	266
2	Minimum order and minimum span assignments	267
3	Alternate graph approach	272
4	Local search	275

5	Experimental results	276
6	Conclusions	280
	References	280
A Derivative Free Minimization Method for Noisy Functions		283
V. P. Plagianakos and M. N. Vrahatis		
1	Introduction	283
2	Optimization of noisy functions	284
3	A derivative-free minimization method for imprecise problems and its convergence	286
4	Numerical applications	289
5	Concluding remarks	293
	References	294
Tight QAP Bounds via Linear Programming		297
K. G. Ramakrishnan, M. G. C. Resende, B. Ramachandran and J. F. Pekny		
1	LP-based lower bounds for the QAP	298
2	Experimental results	299
3	Concluding remarks	301
	References	302
GPS Network Design: An Application of the Simulated Annealing Heuristic Technique		305
H. A. Saleh and P. J. Dare		
1	Introduction	306
2	Simulated annealing technique	307
3	Formulation of the GPS surveying problem	307
4	The GPS-simulated annealing algorithm	309
5	Computational results	309

6 Further work and conclusion 310

References 311

Global Optimization for Crack Identification:Impact-Echo Experiments317

G. E. Stavroulakis

1 Introduction 317

2 Global optimization for inverse problems 319

3 Mechanical modelling 320

4 Inverse problem 326

5 Conclusion 328

References 329

Normal Branch and Bound Algorithms for General Nonconvex Quadratic Programming 333

H. Tuy

1 Introduction 333

2 A generic BB algorithm 335

3 Examples 338

4 Quadratic system equivalent to a linear system 340

5 General decoupling scheme 344

6 Linear relaxations 345

7 Semidefinite relaxation 349

References 353