Ajith Abraham, Aboul-Ella Hassanien,
Patrick Siarry, and Andries Engelbrecht (Eds.)

Foundations of Computational Intelligence Volume 3

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Foundations of Computational Intelligence Volume 3

Global Optimization

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Preface

Foundations of Computational Intelligence

Volume 3: Global Optimization: Theoretical Foundations and Applications

Global optimization is a branch of applied mathematics and numerical analysis that deals with the task of finding the absolutely best set of admissible conditions to satisfy certain criteria / objective function(s), formulated in mathematical terms. Global optimization includes nonlinear, stochastic and combinatorial programming, multiobjective programming, control, games, geometry, approximation, algorithms for parallel architectures and so on. Due to its wide usage and applications, it has gained the attention of researchers and practitioners from a plethora of scientific domains. Typical practical examples of global optimization applications include: Traveling salesman problem and electrical circuit design (minimize the path length); safety engineering (building and mechanical structures); mathematical problems (Kepler conjecture); Protein structure prediction (minimize the energy function) etc.

Global Optimization algorithms may be categorized into several types: Deterministic (example: branch and bound methods), Stochastic optimization (example: simulated annealing). Heuristics and meta-heuristics (example: evolutionary algorithms) etc. Recently there has been a growing interest in combining global and local search strategies to solve more complicated optimization problems.

This edited volume comprises 17 chapters, including several overview Chapters, which provides an up-to-date and state-of-the art research covering the theory and algorithms of global optimization. Besides research articles and expository papers on theory and algorithms of global optimization, papers on numerical experiments and on real world applications were also encouraged. The book is divided into 2 main parts.

Part-I: Global Optimization Algorithms: Theoretical Foundations and Perspectives

In Chapter 1, Snasel et al. [1] introduce the fundamentals of genetic algorithm and illustrate a Higher Level Chromosome Genetic Algorithm (HLCGA) for solving combinatorial optimization problems. The developed HLCGA is applied for Turbo code interleaver optimization process aiming to leverage the efficiency of turbo code based digital communications.

Bacterial foraging optimization algorithm (BFOA) has been widely accepted as a global optimization algorithm for distributed optimization and control. Das et al. [2] in Chapter 2 provide all the related work on BFOA, which ranges from the foundational aspects, mathematical model, hybridization and adaptation to novel applications.

In the Third Chapter, Geem [3] presents the theoretical foundations of the Harmony Search (HS) algorithm, which mimics music improvisation where musicians try to find better harmonies based on randomness or their experiences, which can be expressed as a novel stochastic derivative rather than a calculus-based gradient derivative. The chapter also presents three applications that demonstrate the global optimization feature of the HS algorithm.

Festa and Resende [4] in the Fourth Chapter give an excellent overview of different ways to hybridize Greedy Randomized Adaptive Search Procedures (GRASP) to create new and more effective metaheuristics. Several types of hybridizations are considered, involving different constructive procedures, enhanced local search algorithms, and memory structures.

In the Fifth Chapter, Pant et al. [5] present the foundations of Particle Swarm Optimization (PSO) and some of the recent modified variants. The main focus is on the design and implementation of the modified PSO based on diversity, mutation, crossover and efficient initialization using different distributions and Low-discrepancy sequences.

Habet [6] in the Sixth Chapter presents a nice overview of Tabu Search (TS) metaheuristic algorithm to solve various combinatorial optimization problems. The TS algorithm is illustrated to solve a real-life optimization problem under constraints.

In the Seventh Chapter, Liberti et al. [7] introduce Mathematical Programming (MP) for describing optimization problems. MP is based on parameters, decision variables and objective function(s) subject to various types of constraints. A reformulation of a mathematical program P is a mathematical program Q obtained from P via symbolic transformations applied to the sets of variables, objectives and constraints. This chapter presents a survey of existing reformulations interpreted along these lines with some example applications.

Shcherbina [8] in the Eighth chapter provides a review of structural decomposition methods in discrete optimization and gives a unified framework in the form of Local Elimination Algorithms (LEA). Different local elimination schemes and related notions are considered. The connection of LEA schemes and a way of transforming the directed acyclic graph of computational LEA procedure to the tree decomposition are also presented.

In the Ninth Chapter, Avdagic et al. [9] present the general problem of decision making in unknown, complex or changing environment by an extension of static multiobjective optimization problem. Implementation of multiobjective genetic algorithm is used for solving such problems and the population of potential solutions to the problem for different test cases, such as homogeneous, – non-homogeneous, and the problem with changing number of objectives and decision making is also illustrated.

Abraham and Liu [10] in the Tenth Chapter illustrate the problem of premature convergence for the conventional PSO algorithm for multi-modal problems involving high dimensions. Analysis of the behavior of the PSO algorithm reveals that such premature convergence is mainly due to the decrease of velocity of particles in the search space that leads to a total implosion and ultimately fitness stagnation of the swarm. This paper introduces Turbulence in the Particle Swarm Optimization (TPSO) algorithm to overcome the problem of stagnation. The parameters of the TPSO are adapted by a fuzzy logic controller.

Part-II: Global Optimization Algorithms: Applications

In the Eleventh Chapter, Stoean et al. [11] propose an evolutionary algorithm approach for solving the central optimization problem of determining the equation of the hyper plane deriving from support vector learning. This approach helps to open the 'black-box' of support vector training and breaks the limits of the canonical solving component.

In the Twelfth Chapter, Baragona and Battaglia [12] Illustrate how evolutionary computation techniques have influenced the statistical theory and practice concerned with multivariate data analysis, time series model building and optimization. Chapter deals with variable selection in linear regression models, non linear regression, time series model identification and estimation, detection of outlying observations in time series with respect to location and type identification, cluster analysis and grouping problems, including clusters of directional data and clusters of time series.

Baron et al. [13] in the Thirteenth Chapter introduce a heuristic based on ant colony optimization and evolutionary algorithm and further hybridized with a Tabu search and a greedy algorithm to accelerate the convergence and to reduce the cost engendered by the evaluation process. Experimental results reveal that it is possible to offer the decision maker a reduced number of more accurate solutions in order to choose one according to technical, economic and financial criteria.

Elizabeth and Goldbarg [14] in the Fourteenth Chapter present the outlines for the development of Transgenetic Algorithms and reported the mplementation of these algorithms to a single and to a bi-objective combinatorial problem. The mono objective problem is the uncapacitated version of Traveling Purchaser Problem, where the proposed algorithm managed to find nine new best solutions for benchmark instances. The proposed approach is described and a didactic example with the well-known Traveling Salesman Problem illustrates its basic components. Applications of the proposed technique are reported for two NP-hard combinatorial problems: the Traveling Purchaser Problem and the Bi-objective Minimum Spanning Tree Problem.

Abdelsalam [15] in the Fifteenth Chapter presents a model that aims to support the optimal formulation and assignment of multi-functional teams in integrated product development (IPD) organizations - or any project-based organization. The model accounts for limited availability of personnel, required skills, team homogeneity, and, further, maximizes organization's payoff by formulating and

assigning teams to projects with higher expected payoffs. A Pareto multi-objective particle swarm optimization approach was used to solve the model. The model was applied a hypothetical example that demonstrates the efficiency of the proposed solution algorithm and it allows personnel to work in several concurrent projects and considers both person-job and person-team fit.

In the Sixteenth Chapter, Omara and Arafa [16] illustrate two variants of genetic algorithms with some heuristic principles for task scheduling in distributed systems. In the first variant, two fitness functions have been applied one after another. The first fitness function is concerned with minimizing the total execution time (schedule length) and the second one is concerned with the load balance satisfaction. The second variant of genetic algorithm is based on task duplication technique.

Estimation of distribution algorithms (EDAs), are evolutionary algorithms that try to estimate the probability distribution of the good individuals in the population. Mohammed and Kamel [17] in the last Chapter present a new PSO algorithm that borrows ideas from EDAs. This algorithm is implemented and compared to previous PSO and EDAs hybridization approaches using a suite of well-known benchmark optimization functions.

We are very much grateful to the authors of this volume and to the reviewers for their great effort by reviewing and providing useful feedback to the authors. The editors would like to express thanks to Dr. Thomas Ditzinger (Springer Engineering Inhouse Editor, Studies in Computational Intelligence Series), Professor Janusz Kacprzyk (Editor-in-Chief, Springer Studies in Computational Intelligence Series) and Ms. Heather King (Editorial Assistant, Springer Verlag, Heidelberg) for the editorial assistance and excellent collaboration to produce this important scientific work. We hope that the reader will share our joy and will find the volume useful

December 2008

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