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Advanced Metaheuristic Algorithms and Their Applications in Structural Optimization

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Preface

The main purpose of the present book is to develop a general framework for population-based metaheuristic algorithms based on some basic concepts of set theory. The basic idea of the framework is to divide the population of individuals into a number of subpopulations of identical sizes. Then, in each iteration of the search process, different subpopulations independently explore the search space and do not communicate with each other. The division process is carried out in such a way that the diversity in each subpopulation is maintained automatically. Furthermore, subpopulations are close to each other in terms of their average fitness values. The reason for this is that individuals are fairly distributed among the subpopulations. Once an iteration is completed, subpopulations are merged to constitute the population of the next generation. However, before the next iteration starts, the population is redivided into subpopulations, and then the search process continues. In this way, a high diversity is maintained in the subpopulations throughout the search process. The main aim of the framework is to maintain an appropriate balance between global exploration and local exploitation abilities during the search process. It has been recognized for many years that a successful metaheuristic algorithm should be able to perform a wide exploration in the early stages and a deep exploitation during the final stages of the search process. The proposed framework makes it possible that different subpopulations independently explore the search space at the same time. As a result, in the early stages of the search process, the candidate solutions are scattered all over the search space instead of focusing on a small region. This guarantees that different regions of the search space are evenly explored and that the search is not limited to a small region, which significantly reduces the possibility of getting trapped in local optima and premature convergence. Therefore, exploration is favored in the early stages of the search process. In addition, because of the presence of different subpopulations, as the search process continues, the search is guided towards different promising regions of the search space rather than concentrating on the most promising region obtained so far. Therefore, exploitation is promoted during the final stages of the search process. The number of subpopulations can change with the number of iterations.

Chapter 1 explains the purpose of the book and provides an overview of the remaining chapters. In Chap. 2, the set-theoretical shuffled shepherd optimization algorithm is introduced and applied to the optimal design of reinforced concrete cantilever retaining walls. Chapter 3 introduces the set-theoretical variants of the teaching-learning-based optimization algorithm for structural optimization with frequency constraints. In Chap. 4, enhanced versions of the shuffled shepherd optimization algorithm are developed for structural optimization. In Chap 5, a number of set-theoretical metaheuristic algorithms are applied to reliability-based design optimization of truss structures. In Chap. 6, optimal analysis is used in the service of frequency-constrained optimization of cyclic symmetric structures with set-theoretical Jaya algorithm. Discrete structural optimization with set-theoretical Jaya algorithm is discussed in Chap. 7. In Chap. 8, enhanced forensic-based investigation algorithm is introduced and its application to structural optimization with frequency constraints is examined. In Chap. 9, improved slime mould algorithm is developed for structural optimization with frequency constraints. Finally, in Chap. 10, improved arithmetic optimization algorithm is proposed for discrete structural optimization.

We would like to take this opportunity to acknowledge a deep sense of gratitude to a number of colleagues and friends who have helped us in different ways in the process of writing this book. Our special thanks are due to Dr. Thomas Ditzinger, the Editorial Director of Interdisciplinary and Applied Sciences and Engineering from Springer, for his constructive comments and suggestions during the preparation of this book. Our sincere appreciation is extended to our Springer colleagues who prepared the layout design of this book. We would also like to thank our colleagues, Dr. Mohammad Kamalinejad, Mr. Ataollah Zaerreza, and Mr. Ali Joudaki, for their contribution to our shared knowledge. Finally, we especially appreciate the support and patience of our wives, Mrs. L. Kaveh and Mrs. M. Bakhshian, during the preparation of this book.

We would like to thank the publishers who permitted some of our papers to be utilized in the preparation of this book, consisting of Springer, Elsevier, and Budapest University of Technology and Economics.

Every effort has been made to render this book error-free. However, the authors would appreciate any remaining errors being brought to his attention through their email addresses: alikaveh@iust.ac.ir (Ali Kaveh) and kiarashbiabani@yahoo.com (Kiarash Biabani Hamedani).

Tehran, Iran
June 2022

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