Adaptation, Learning, and Optimization

Volume 20

Series editors

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About this Series

The role of adaptation, learning and optimization are becoming increasingly essential and intertwined. The capability of a system to adapt either through modification of its physiological structure or via some revalidation process of internal mechanisms that directly dictate the response or behavior is crucial in many real world applications. Optimization lies at the heart of most machine learning approaches while learning and optimization are two primary means to effect adaptation in various forms. They usually involve computational processes incorporated within the system that trigger parametric updating and knowledge or model enhancement, giving rise to progressive improvement. This book series serves as a channel to consolidate work related to topics linked to adaptation, learning and optimization in systems and structures. Topics covered under this series include:

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- machine learning, data mining & mathematical programming
- hybridization of techniques that span across artificial intelligence and computational intelligence for synergistic alliance of strategies for problem-solving.
- aspects of adaptation in robotics
- agent-based computing
- autonomic/pervasive computing
- dynamic optimization/learning in noisy and uncertain environment
- systemic alliance of stochastic and conventional search techniques
- all aspects of adaptations in man-machine systems.

This book series bridges the dichotomy of modern and conventional mathematical and heuristic/meta-heuristics approaches to bring about effective adaptation, learning and optimization. It propels the maxim that the old and the new can come together and be combined synergistically to scale new heights in problem-solving. To reach such a level, numerous research issues will emerge and researchers will find the book series a convenient medium to track the progresses made.

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Recent Advances in Evolutionary Multi-objective Optimization

Springer

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To my family

—Slim Bechikh

To my spouse Anima

—Rituparna Datta

To my parents

—Abhishek Gupta

Preface

This book surveys the recent advances in the field of evolutionary multi-objective optimization. In fact, most real problems are multi-objective in nature, i.e. they involve multiple conflicting objectives to be minimized or maximized simultaneously in limited resources. The resolution of such type of problems gives rise to a set of non-dominated solutions forming the Pareto front. Evolutionary algorithms have been recognized to be well-suited to solve multi-objective problems, thanks to their ability in providing the decision-maker with a set of trade-off solutions in a single run in addition to their insensitivity to the geometrical features of the objective space. However, real-world applications usually have one or several aspects that need further efforts to be tackled. In this book, we survey recent achievements in handling five aspects. The first aspect is dynamicity where the objective functions and/or the constraints may change over time. In this case, the optimization algorithm should track the Pareto front after the occurrence of any change. The second aspect is the presence of hierarchy between the objectives. This kind of problems is called bi-level where an upper level problem has a lower level one in its constraints. The main difficulty in bi-level programming is that the evaluation of an upper level solution requires finding the optimal lower level one, which is computationally expensive. The third aspect is the objective space high dimensionality. This aspect means solving many-objective problems involving more than three objectives. The main difficulty in dealing with such type of problems is that most solutions become equivalent to each others; therefore making the algorithm behaving like random search. The fourth aspect is the emerging notion of evolutionary multitasking which is inspired by the cognitive ability to multitask. Shown to be a natural extension of population-based search algorithms, multitasking encourages multiple heterogeneous search spaces belonging to distinct tasks to be unified and searched concurrently. The resultant knowledge exchange provides the scope for improved convergence characteristics across multiple tasks at once, thereby facilitating enhanced productivity in decision-making processes. The fifth aspect is the presence of constraints where the evolutionary algorithm

should search for solutions in the decision space while respecting a set of predefined constraints so that it outputs a set of feasible non-dominated solutions.

This book provides both methodological treatments and real-world insights gained by experience, all contributed by specialized researchers. As such, it is a comprehensive reference for researchers, practitioners, and advanced-level students interested in both the theory and the practice of using evolutionary algorithms in tackling real-world applications involving multiple objectives. The book provides a comprehensive treatment of the field by offering chapters whose topics are disjoint or having minimal overlaps, each tackling a single multi-objective aspect. Moreover, the last chapter highlights a number of practical applications showing the usability of multi-objective evolutionary algorithms in practice; thereby motivating researchers and engineers to use evolutionary approaches in solving their encountered problems.

Tunis, Tunisia — Slim Bechikh
Daejeon, Republic of Korea — Rituparna Datta
Singapore, Singapore — Abhishek Gupta

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Dr. Slim Bechikh received the B.Sc., the M.Sc., the Ph.D., and the Habilitation degrees in Computer Science with Business from the University of Tunis (ISG), Tunis, Tunisia, in 2006, 2008, 2013, and 2015 respectively. He is Associate Professor with the Computer Science Department of the University of Carthage (FSEG), Nabeul, Tunisia. His main research interests include multi-objective optimization, evolutionary computation, bi-level programming, and their applications. He worked as a researcher for 5 years within the Optimization Strategy and Intelligent Computing lab (SOIE), Tunisia. He is a reviewer for many journals such as IEEE Transactions on Evolutionary Computation, IEEE Transactions on Cybernetics, Soft Computing, etc; and many conferences such as IEEE CEC, ACM GECCO, ACM SAC, etc. More information about his research can be found from his Webpage: https://sites.google.com/site/slimbechikh/. E-mail: slim.bechikh@gmail.com

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