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Multiobjective Evolutionary Algorithms and Applications

With 183 Figures

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Preface

Many real-world design tasks involve optimizing a vector of objective functions on a feasible decision variable space. These objective functions are often noncommensurable and in competition with each other, and cannot be simply aggregated into a scalar function for optimization. This type of problem is known as the multiobjective (MO) optimization problem, for which the solution is a family of points known as a Pareto optimal set, where each objective component of any member in the set can only be improved by degrading at least one of its other objective components.

The multiobjective problems are often difficult to solve without the aid of powerful and efficient optimization algorithms. To obtain a good solution via conventional multiobjective optimization techniques such as the methods of inequalities, goal attainment or weighted sum approach, a continuous cost function and/or a set of precise settings of weights or goals are required, which are usually not well manageable or understood. Moreover, these algorithms usually give only a single solution at the end of each run, instead of finding the entire Pareto optimal set for the multiobjective optimization.

Emulating the Darwinian–Wallace principle of "survival-of-the-fittest" in natural selection and adaptation, evolutionary algorithms evaluate performances of candidate solutions at multiple points simultaneously. Unlike conventional methods that often combine multiple attributes to form a composite scalar objective function, multiobjective evolutionary algorithms (MOEAs) incorporate the concept of Pareto's optimality or modified selection schemes to evolve a family of solutions at multiple points along the tradeoffs simultaneously. They have been found to be very efficient and effective in solving sophisticated multiobjective problems where conventional optimization tools fail to work well.

The purpose of this book is to provide a comprehensive treatment on the design and application of multiobjective evolutionary algorithms. It emphasizes both the theoretical developments and practical implementations of multiobjective evolutionary algorithms without the requirement of profound mathematical knowledge. The text has been written for a wide readership and can be read by engineers, researchers, senior undergraduates and graduate students who are interested in the field of evolutionary algorithms and multiobjective optimization. The assumed background for the book is some basic knowledge of evolutionary computation.

The book is organized into two parts. The first part, consisting of nine chapters, covers the theory and development of multiobjective evolutionary algorithms. The second part contains five chapters and provides a number of practical applications of evolutionary multiobjective optimization.

Chapter 1 gives the definition of multiobjective problem and the background of multiobjective optimization. Chapter 2 presents a survey and highlights the development trends of multiobjective evolutionary algorithms. Chapter 3 provides a conceptual framework for evolutionary multiobjective optimization and studies the effect of various distribution preservation mechanisms. Chapter 4 introduces a goal-sequence domination scheme that allows specifications such as hard/soft priorities and constraints to be incorporated for better decision support in multiobjective optimization. Besides, a few advanced features for multiobjective evolutionary algorithms are also presented in the chapter.

The concept of dynamic population size in multiobjective evolutionary algorithms is discussed in Chapter 5. Chapter 6 presents the idea of cooperative coevolution and distributed computing for multiobjective optimization. A new deductive approach of dynamic search space incorporating inductive learning for evolutionary multiobjective optimization is presented in Chapter 7. The performance comparisons of various multiobjective evolutionary algorithms are given in Chapter 8. Chapter 9 presents a graphical user interface-based multiobjective evolutionary algorithm toolbox for interactive computer-aided multiobjective optimization. A number of case studies including control system designs and vehicle routing problems are presented in Chapters 10 through 14, which illustrate the practical applications of multiobjective evolutionary algorithms.

Finally, we are very grateful to a number of current and former graduate students, especially Y.J. Yang, C.K. Goh, Y.H. Chew, and R. Sathikannan, for their contributions to this book.

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