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Preface

Decision making under a hierarchical structure is commonly found in the real world, yet the optimization of such decisions is typically difficult due to the highly inter-dependent nature among the decisions by the decision-makers at different levels of the hierarchical organization. Problems in such a domain are referred to as multi-level decision making. The basic concept of multi-level decision making is that an upper-level decision-maker sets his or her goal and/or decision and then asks each subordinate level of the organization for their decisions. The decisions of the lower levels are then submitted and modified by the upper level with consideration of the overall benefits of the organization. This mutually interactive process is continued until reaching a solution, which is satisfactory to all the decision-makers. Apparently, the degree of interaction and the degree of satisfaction depend on the management style of the upper level. This decision-making process is extremely useful to the hierarchy decentralized organizations that are pervasive in various industries.

To solve the multi-level decision making, the problems are typically modeled by multi-level programming, which contains a set of nested optimization problems over a single feasible region and the control of the decision variables is partitioned among the levels where one decision variable may impact the objective of several levels. There have been many traditional approaches proposed for solving the multi-level programming problems, such as the decomposition principle, goal programming, multi-objective programming, and game theory. However, almost all of these traditional approaches cannot meet the common features, the interactive nature in particular, of the decision process of a multi-level decentralized organization. By contrast, soft computing approaches use a collection of algorithms to find inexact solutions to computationally difficult tasks for which conventional methods do not yet provide low cost and time-feasible solutions. Approaches in this category such as fuzzy logic can facilitate the implementation of interactive decision making among levels.

The principal constituents of soft computing are fuzzy logic, artificial neural networks, meta-heuristics, etc. In order to increase the computational efficiency of the basic multi-level programming algorithms, fuzzy set theory that suggests a completely different philosophy of exploring the typical fuzziness, vagueness, or the not-well-defined nature of a large decentralized hierarchy organization has been applied to solve the problems. The resulting fuzzy interactive sequential approach appears to be a useful and efficient one. The advantages of the fuzzy approaches are that not only the computational requirements are reduced tremendously, but the representation of the system is also more realistic.

A particular type of artificial neural networks, recurrent neural networks such as Hopfield network, with their dynamic learning capability appears to be a suitable tool to cope with the dynamic nature of multi-level programming problems. Hybrid neural network approaches that combine neural networks with meta-heuristics have also be proposed to solve the bi-level programming problems. Meta-heuristics are a high-level problem-independent algorithmic framework that provides a set of guidelines or strategies to develop heuristic optimization algorithms. Typical meta-heuristics, such as genetic algorithms, simulated annealing, and swarm particle optimization, are widely used to solve discrete or nonlinear optimization problems. Meta-heuristic algorithms do not use gradient information and thus are less likely to be trapped in a local optimum. Their structures also enable the implementation of parallel search of the solution space and thus are able to improve the efficiency of the solution procedure.

This book can be divided approximately into five subjects. The first subject, including Chaps. 1 and 2, summarizes the solution approaches of multi-level programming and introduces the classical approaches for solving the problems. The emphasis is on the numerical solution aspects, and no theoretical treatment is included.

The second subject, which includes Chaps. 3–6, presents knowledge representation and fuzzy decision making. For the frequent use of linguistic expressions in the interactions between the various levels of management in a hierarchy organization, emphasis is placed on linguistic representation by the use of fuzzy concepts. The major content of this part is reproduced from our previous book, entitled *Fuzzy and Multi-level Decision Making: An Interactive Computational Approach*, published by Springer.

The third subject (Chap. 7) presents the use of auction mechanism in solving the bi-level programming problems, where the managers make resources allocation decisions in a heterogeneous and distributed fashion. The fourth subject (Chap. 8) summarizes the three popular meta-heuristics, genetic algorithm, particle swarm optimization, and tabu search, and their applications to solving the multi-level programming problems. The final subject (Chap. 9) introduces the use of Hopfield networks in solving optimization problems and their application to bi-level programming problems.

Several examples and algorithms are adopted from the original publications as acknowledged in the text. In particular, we are grateful for the following permissions from the copyright owners: Elsevier, Fig. 6.1, Figs. 7.1–7.4, Tables 7.1–7.5,

Example 7.1, Figs. 9.1–9.5, Table 9.1, Examples 9.1 and 9.2; and Inderscience, Sect. 8.2.

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