Preface

Optimization and optimal control are very powerful tools in engineering and applied mathematics. Problems in the fields are derived from real-world applications in finance, economics, telecommunications, and many other fields. There have been major algorithmic and theoretical developments in the fields of optimization and optimal control during the last decade. Lately simulation-based optimization methods are becoming a very popular approach for solving optimization problems due to developments of computer hardware. This book brings together recent developments in these areas as well as recent applications of these results to real-world problems. This book is aimed at both practitioners and academics and assumes that the reader has appropriate background in the above fields. The book consists of 21 chapters contributed by experts around the world who work with optimization, control, simulation, and numerical analysis.

The first eight chapters of the book are concerned with optimization theory and algorithms.

The spatial branch-and-bound algorithm for solving mixed-integer nonlinear programming problems uses convex relaxations for multilinear terms by applying associativity. The chapter by Belotti et al. gives two different convex relaxations using associativity in different ways and proves that having fewer groupings of longer terms yields tighter convex relaxations. Numerical examples show the efficiency of the algorithm.

The gap functions are generally used to investigate variational inequality problems through optimization problems. The chapter by Altangerel and Wanka investigates properties of gap functions for vector variational inequalities using the oriented distance functions. Enkhbat and Barsbold study the problem of finding two largest inscribed balls in a polyhedron so that sum of their radiuses is maximized. The problem is formulated as a bilevel programming problem and a gradient-based method is proposed to solve the program. The chapter by Tseveendorj gives a short survey on the theoretical and algorithmic results for mathematical programs with equilibrium constraints which have many applications in telecommunication and transportation networks, economical modeling, and computational mechanics.

Many real-world optimization design problems contain uncertainties which are characterized as parameters. The chapter by Kao and Liu studies linear programming problems with interval-valued parameters. For linear programs, the objective value is also interval-valued. They formulate two bilevel programs to calculate the lower and upper bounds of the objective values of the interval linear programs. These bilevel programs are then reduced to a single-level nonlinear program which can be tackled by standard nonlinear algorithms.

In order to solve optimization or control problems, existing simulation model or tools can be used. However, the transition is not simple. Here simulation means solving a system of state equations by a fixed-point iteration. The chapter by Griewank et al. quantifies and estimates the complexity of an optimization run compared to that of a single simulation, measured in terms of contraction rates. The chapter by Majig et al. considers the generalized Nash equilibrium problem. The problem can be formulated as a quasi-variational inequality problem. Using this reformulation, they propose a method for finding multiple, hopefully all, solutions to the generalized Nash equilibrium problem. Numerical experiments are provided to show the efficiency of the proposed approach. The chapter by Lorenz and Wanka studies scalar and vector optimization problems with objective functions, which consist of a convex function and a linear mapping and cone and geometric constraints. They formulate dual problems and establish weak, strong, and converse duality results between the dual and original programs.

Network optimization is one of the main fields of optimization and has many real-world applications. The next two chapters are concerned with network optimization problems and their applications in telecommunication. The minimum connected dominating set problem has a wide range of applications in wireless sensor networks and it gives an efficient virtual backbone for routing protocols. However, in some real-world problems, routing paths between pairs of vertices might be greater than the shortest path between them. In that case, minimum routing cost connected dominating set (MOC-CDS) is applied. The chapter by Liu et al. considers a variation of the MOC-CDS in the graph so-called g-MOC-CDS. They also propose a polynomial-time approximation scheme for the problem. The chapter by Charalambous studies some distributed power control algorithms for wireless ad hoc networks and discusses their convergence under uncertainties. The chapter also suggests directions for future research in the field.

The next four chapters are concerned with direct and indirect applications of optimization.

Nowadays, urban planning has been very critical for the development of many world cities. In their chapter, Keirstead and Shah model urban planning using optimization framework. The chapter by Enkhbat and Bayanjargal studies an extension of the classical Solow growth theory where the production function is an arbitrary continuous differentiable function and the saving and depreciation rates depend on time. The per capita consumption problem is reduced to a parametric maximization problem and a finite method for the problem is proposed. The chapter by Asada studies the existence of cyclical fluctuations in continuous time dynamic optimization models with two state variables. The results are applied to a continuous time dynamic optimization economic model. The chapter by Lippe focuses on modeling and optimizing fuzzy-rule-based expert systems. It gives an overview of existing methods that combine fuzzy-rule-based systems with neural networks and presents a new tool for modeling an existing fuzzy-rule-based system using an artificial neural network.

The next four chapters are concerned with optimal control and its applications. The chapter by Gao and Baoyin introduces a smoothing technique for solving bang-bang optimal control problems. In order to speed up the convergence of this algorithm, an integration switching method based on a termed homotopy method is applied. They also provide some numerical examples illustrating the effectiveness of their method.

There are many methods for solving optimization and optimal control problems. However, it is hard to select the best approach for specific problems. The paper by Gornov et al. discusses and provides a set of optimal control problems that can be used to test the efficiency of different algorithms.

Lately parallel computing has been widely used to tackle real-world large-sized problems. The paper by Tyatushkin gives an algorithm for solving optimal control problems in the form of parallel computing. The algorithm uses a sequence of different methods in order to obtain fast convergence to an optimal solution. The chapter by Gornov and Zarodnyuk proposes an algorithm for finding global extremum of nonlinear and nonconvex optimal control problems. The method uses a curvilinear search technique to implement the tunneling phase of the algorithm. Numerical examples are presented to describe the efficiency of the proposed approach.

It is important to note that many optimization and optimal control algorithms require using methods in numerical analysis. The remaining three chapters are concerned with methods for solving system of linear equations, nonlinear equations, and differential equations. The chapter by Garloff et al. gives a survey on methods for finding the enclosure of the solution set of a system of linear equations, where the coefficients of the matrix and the right-hand side depend on parameters. Based on the methods, the chapter presents a hybrid method for the problem when the dependency is polynomial. The chapter by Bouhamidi and Jbilou proposes a new method for solving stiff ordinary differential equations using block Krylov iterative method. Some numerical examples are given to illustrate the efficiency of the proposed method. The chapter by Tugal and Dashdondog considers modifications of the Chebyshev method for solving nonlinear equations that are free from second derivative and prove semilocal convergence theorems for the methods.

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