OPTIMIZATION AND OPTIMAL CONTROL

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Aims and Scope
Optimization has been expanding in all directions at an astonishing rate during the last few decades. New algorithmic and theoretical techniques have been developed, the diffusion into other disciplines has proceeded at a rapid pace, and our knowledge of all aspects of the field has grown even more profound. At the same time, one of the most striking trends in optimization is the constantly increasing emphasis on the interdisciplinary nature of the field. Optimization has been a basic tool in all areas of applied mathematics, engineering, medicine, economics and other sciences.

The series *Springer Optimization and Its Applications* publishes undergraduate and graduate textbooks, monographs and state-of-the-art expository works that focus on algorithms for solving optimization problems and also study applications involving such problems. Some of the topics covered include nonlinear optimization (convex and nonconvex), network flow problems, stochastic optimization, optimal control, discrete optimization, multiobjective programming, description of software packages, approximation techniques and heuristic approaches.

OPTIMIZATION AND OPTIMAL CONTROL

Theory and Applications

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Conquering the world on horseback is easy; it is dismounting and governing that is hard.
– Chinggis Khan

Translation adapted from *The Gigantic Book of Horse Wisdom* (2007) by Thomas Meagher and Buck Brannaman.

Preface

Optimization and optimal control are the main tools in decision making. In optimization we often deal with problems in finite-dimensional spaces. On the other hand, in optimal control we solve problems in infinite-dimensional spaces. Many problems in engineering, physics, economics and other fields can be formulated as optimization and optimal control problems.

This book brings together recent developments in optimization and optimal control as well as recent applications of these results to a wide range of real-world problems. The book consists of 24 chapters contributed by experts around the world who work with optimization and optimal control either at a theoretical level or at the level of using these tools in practice. Each chapter is not only of expository but also of scholarly nature.

The first 12 chapters focus on optimization theory and equilibrium problems. The chapter by A. Antipin studies optimization problems generated by sensitivity functions for convex programming problems. Methods for these problems are proposed and properties of the sensitivity functions are analyzed. The chapter by M.A. Goberna gives an overview of the state of the art in sensitivity and satiability analysis in linear semi-infinite programming. In the chapter by G. Kassay, scalar equilibrium problems are considered. Applications of these problems in nonlinear analysis are discussed and some new results concerning the existence of exact and approximate solutions are presented. The chapter by G. Isac presents the concept of scalarly compactness in nonlinear analysis. Applications of the concept to the study of variational inequalities and complementarities problems are discussed. The chapter by N.X. Tan and L.J. Lin formulates Blum–Oettli type quasi-equilibrium problems and establishes sufficient conditions for the existence of their solutions. The chapter by R. Enkhbat and Ya. Bazarsad formulated the response surface problems as quadratic programming problems. Solution approaches for these quadratic programming problems based on global optimality conditions are proposed. The chapter by D.Y. Gao et al. proposes a canonical dual approach for solving a fixed cost mixed-integer quadratic programming problem. It is shown that, using so-called canonical duality theory, the problem can be

reduced to canonical convex dual problem with zero gap which can be tackled by many efficient local search methods. The chapter by B. Luderer and B. Wagner considers the problem of finding the intersection of the convex hulls of two sets containing finitely many points each. An algorithm for the problem is proposed based on the equivalent quasi-differentiable optimization problem. The chapter by M.-A. Majig et al. proposes an evolutionary search algorithm for solving the global optimization problem with box constraint. The algorithm finds as many solutions of the problem as possible or all solutions in some cases. The evolutionary search also employs a local search procedure. The chapter by L. Altangerel and G. Wanka deals with the perturbation approach in the conjugate duality for vector optimization on the basis of weak ordering. New gap functions for vector optimization are proposed and their properties are studied. The chapter by D. Li et al. gives an overview of six polynomially solvable classes of binary quadratic programming problems and provides examples and geometric illustrations to give intuitive insights of the problems. The chapter by B. Jadamba et al. deals with an ill-posed multi-valued quasi-variational inequality problem. A parameter identification problem that gives a stable approximation procedure for the ill-posed problem is formulated and generalizations of this approach to other problems are discussed.

The next five chapters are concerned with optimal control theory and algorithms. The chapter by Z.G. Feng and K.L. Teo considers a class of optimal feedback control problems where its dynamical system is described by stochastic linear systems subject to Poisson processes and with state jumps. They show that the problem is equivalent to a deterministic impulsive optimal parameter selection problem with fixed jump times and provide an efficient computational method for the later problem. In the chapter by V. Maksimov, controlled differential inclusions involving subdifferentials of convex functions are considered. In particular, the three problems, the problem of prescribed motion realization, the problem of robust control, and the problem of input dynamical reconstruction, are suited. Stable feedback control-based algorithms for solving the problems are presented. The chapter by B.D.O. Anderson et al. proposes a new algorithm for solving Riccati equations and certain Hamilton-Jacobi-Bellman-Isaacs equations arising in H_∞ control. In the chapter by D. Vrabie and F. Lewis, a new online direct adaptive scheme is constructed in order to find an approximate solution to the state feedback, infinite-horizon, optimal control problem. In the chapter by A.S. Buldaev, iterative perturbation methods for nonlinear optimal control problems which are polynomial with respect to the state are proposed.

The remaining seven chapters are largely devoted to applications of optimization and optimal control. The chapter by H.P. Geering et al. explains how stochastic optimal control theory can be applied to optimal asset allocation problems under consideration of risk aversion. Two types of problems are studied and corresponding solution techniques are presented. The chapter by F.D. Fagundez et al. considers scheduling problems in the process industry.

A nonlinear dynamic programming model for the process scheduling is proposed and the results are compared with those of different mixed integer nonlinear programming models. The chapter by D. Fortin is concerned with quantum computing and Grothendieck's constant. A non-cooperative quantum game is presented and it is also shown that for many instances of rank-deficient correlation matrices Grothendieck's constants go beyond $\sqrt{2}$ for sufficiently large size. The chapter by H. Damba et al. considers a problem of identifying a pasture region where the grass mass in the region is maximized. The chapter by W.-J. Hwang et al. considers the rate control problem in wired-cum-wireless networks. It is shown that there is a unique solution for end-to-end session rates and infinitely many corresponding optimal values for wireless link transmission rates of the optimization problems, where the optimization variables are both end-to-end session rates and wireless link transmission rates. The chapter by N. Fan et al. explores the relationship between biclustering and graph partitioning. Several integer programming formulations for the different cuts including ratio cut and normalized cut are presented. In the chapter by M. Tamaki and Q. Wang, a best choice problem in queue theory is considered. The problem is to find a procedure to select the best applicant by selecting or rejecting the applicants. They give the explicit rule for the best choice problem where the number of applicants is uniformly distributed.

We would like to take this opportunity to thank the authors of the chapters, the anonymous referees, and Springer for making the publication of this book possible.

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