

SECOND-ORDER VARIATIONAL ANALYSIS IN CONIC PROGRAMMING WITH APPLICATIONS TO OPTIMALITY AND STABILITY*

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Abstract. This paper is devoted to the study of a broad class of problems in conic programming modeled via parameter-dependent generalized equations. In this framework we develop a second-order generalized differential approach of variational analysis to calculate appropriate derivatives and coderivatives of the corresponding solution maps. These developments allow us to resolve some important issues related to conic programming. They include verifiable conditions for isolated calmness of the considered solution maps, sharp necessary optimality conditions for a class of mathematical programs with equilibrium constraints, and characterizations of tilt-stable local minimizers for cone-constrained problems. The main results obtained in the general conic programming setting are specified for and illustrated by the second-order cone programming.

Key words. variational analysis, second-order theory, conic programming, generalized differentiation, optimality conditions, isolated calmness, tilt stability

AMS subject classifications. 49J52, 90C30, 90C31

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1. Introduction. The major motivation for this paper comes from considering the following parametric problem of *conic programming* in finite-dimensional spaces:

$$(1.1) \quad \begin{array}{ll} \text{minimize} & \varphi(q, y) - \langle p, y \rangle \\ \text{subject to} & g(y) \in \Theta, \end{array}$$

where $y \in \mathbb{R}^m$ is the *decision variable*, $x = (q, p) \in \mathbb{R}^s \times \mathbb{R}^m$ is the two-component *perturbation parameter* (with q signifying the *basic* perturbations and p the *full* ones), $\Theta \subset \mathbb{R}^l$ is a *closed convex cone*, and $\varphi: \mathbb{R}^s \times \mathbb{R}^m \rightarrow \mathbb{R}$ and $g: \mathbb{R}^m \rightarrow \mathbb{R}^l$ are *factor continuously differentiable*, i.e., of class C^2 . These are our *standing assumptions* in this paper unless otherwise stated.

The characteristic feature of the optimization problem (1.1) is the *cone constraint* given by $g(y) \in \Theta$, which unifies remarkable subclasses of conic programs when the cone Θ is given in a particular form. Among subclasses in conic programming well-recognized theoretically and most important for applications, we mention problems of

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Approximation, Optimization and Mathematical Economics Marc Lassonde, 2012-12-06 The articles in this proceedings volume reflect the current trends in the theory of approximation optimization and mathematical economics and include numerous applications The book will be of interest to researchers and graduate students involved in functional analysis approximation theory mathematical programming and optimization game theory mathematical finance and economics

Modern Nonconvex Nondifferentiable Optimization Ying Cui, Jong-Shi Pang, 2021-12-02 Starting with the fundamentals of classical smooth optimization and building on established convex programming techniques this research monograph presents a foundation and methodology for modern nonconvex nondifferentiable optimization It provides readers with theory methods and applications of nonconvex and nondifferentiable optimization in statistical estimation operations research machine learning and decision making A comprehensive and rigorous treatment of this emergent mathematical topic is urgently needed in today's complex world of big data and machine learning This book takes a thorough approach to the subject and includes examples and exercises to enrich the main themes making it suitable for classroom instruction Modern Nonconvex Nondifferentiable Optimization is intended for applied and computational mathematicians optimizers operations researchers statisticians computer scientists engineers economists and machine learners It could be used in advanced courses on optimization operations research and nonconvex and nonsmooth optimization **Multiobjective**

Problems of Mathematical Programming Andrzej Lewandowski, 1991 This book presents recent developments in methodology theory software and implementation of Decision Support Systems It deals with the theory and algorithms for multiple criteria optimization and discusses topics like multiple criteria optimization in hierarchical systems relations between simulation and gaming for conflict resolution and sensitivity and trade off analysis in multiobjective programming In addition it treats applications and computer implementations of Decision Support Systems This includes experience in applying Decision Support Systems for industry management bank management and water system management

Perturbation Analysis of Optimization Problems J. Frederic Bonnans, Alexander Shapiro, 2013-11-22 The main subject of this book is perturbation analysis of continuous optimization problems In the last two decades considerable progress has been made in that area and it seems that it is time now to present a synthetic view of many important results that apply to various classes of problems The model problem that is considered throughout the book is of the form $P \min x \text{ subject to } G x \in E$ $K \times x \in X$ Here X and Y are Banach spaces K is a closed convex subset of Y and $X \in \mathbb{R}$ and $G: X \rightarrow Y$ are called the objective function and the constraint mapping respectively We also consider a parameterized version P_u of the above problem where the objective function $x \mapsto u$ and the constraint mapping $G: x \mapsto u$ are parameterized by a vector u varying in a Banach space U Our aim is to study continuity and differentiability properties of the optimal value $v(u)$ and the set $S(u)$ of optimal solutions of P_u viewed as functions of the parameter vector u Topological Aspects of Nonsmooth Optimization Vladimir Shikhman, 2011-11-18

This book deals with nonsmooth structures arising within the optimization setting. It considers four optimization problems namely mathematical programs with complementarity constraints, general semi infinite programming problems, mathematical programs with vanishing constraints and bilevel optimization. The author uses the topological approach and topological invariants of corresponding feasible sets are investigated. Moreover, the critical point theory in the sense of Morse is presented and parametric and stability issues are considered. The material progresses systematically and establishes a comprehensive theory for a rather broad class of optimization problems tailored to their particular type of nonsmoothness. Topological Aspects of Nonsmooth Optimization will benefit researchers and graduate students in applied mathematics especially those working in optimization theory, nonsmooth analysis, algebraic topology and singularity theory. *Subject Guide to Books in Print*, 1993 *Books in Print Supplement*, 1984 **Parametric Optimization and Related Topics**, 1989 Parametric Optimization and Related Topics II Jürgen Guddat, 1991 Advances in Distributed and Parallel Processing: Applications in optimization, fluid dynamics, and VLSI Harry W. Tyrer, 1994 Mathematics of Operations Research, 1988. Articles of mathematical interest as well as operations research and management science. *Subject Catalog*, 1982. Library of Congress, 1982 *Lecture Notes in Pure and Applied Mathematics*, 1983 *Subject Catalog* Library of Congress, **SIAM Journal on Control and Optimization** Society for Industrial and Applied Mathematics, 2000 **Perturbations, Approximations and Sensitivity Analysis of Optimal Control Systems** A. L. Dontchev, 1983 **Mathematical Reviews**, 2000 **Optimality and Stability in Mathematical Programming** M. Guignard, Mathematical Programming Society, 1982 **Optimization and Nonlinear Analysis** Simeon Reich, 1992-07-13. Comprises the proceedings of the workshop on Optimization and Nonlinear Analysis held at the Technion in March 1990 organized by the Binational US Israel Scientific Research Fund and the Institute for Advanced Studies in Mathematics at the Technion Dynamics of Continuous, Discrete and Impulsive Systems, 2000

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