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

BORIS S. MORDUKHOVICH†, JIŘÍ V. OUTRATA‡, AND HÉCTOR RAMÍREZ C.§

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:

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

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 *tilt* ones), $\Theta\subset\mathbb{R}^l$ is a *closed convex cone*, and $\varphi\colon\mathbb{R}^s\times\mathbb{R}^m\to\mathbb{R}$ and $g\colon\mathbb{R}^m\to\mathbb{R}^l$ are *twice continuously differentiable*, i.e., of class $\mathcal{C}^2$. 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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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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