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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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web joan miró i ferrà mɪ'roʊ mi roh 1 us also miː'roʊ mee roh 2 3 catalan ʒu'am mi'ɾoj fə'ra 20 april 1893 25 december 1983 was a spanish painter sculptor and ceramicist born in barcelona professionally he was simply known as joan miró