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A polynomial approximation-based approach for chance-constrained optimization

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We proposed a polynomial approximation-based approach to solve a specific type of chance-constrained optimization problem that can be equivalently transformed into a convex programme. This type of chance-constrained optimization is in great needs of many applications and most solution techniques are problem-specific. Our key contribution is to provide an all-purpose solution approach through Monte Carlo and establish the linkage between our obtained optimal solution with the true optimal solution. Our approach performs well because: First, our method controls approximation errors for both the function value and its gradient (or subgradient) at the same time. This is the primary advantage of our method in comparison to the commonly used finite difference method. Second, the approximation error is well bounded in our method and, with a properly chosen algorithm, the total computational complexity will be polynomial. We also address issues associated with Monte Carlo, such as discontinuity and nondifferentiability of the function. Thanks to fast-advancing computer hardware, our method would be increasingly appealing to businesses, including small businesses. We present the numerical results to show that our method with Monte Carlo will yield high-quality, timely, and stable solutions.

Keywords: chance-constrained optimization; simulation; convex optimization

AMS Subject Classification: 90C15; 90C25

1. Introduction

The chance constraint will greatly complicate the optimization problem, and its motivation is clear and realistic. Consider a linear programming

$$\begin{aligned} \min \quad & c'x \\ \text{subject to:} \quad & Tx \geq \xi \\ & Ax \leq b \\ & x \geq 0, \end{aligned}$$

where $x \in \mathbb{R}^n$, $c \in \mathbb{R}^n$, and ξ is a random vector. We need the constraints, $Tx \geq \xi$ to hold for a prescribed probability $\alpha \in (0, 1)$ rather than *always* being true for all realizations of ξ. Thus,

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