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Robustness analysis in Multi-Objective Mathematical Programming using Monte Carlo simulation

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Abstract: In most multi-objective optimization problems we aim at selecting the most preferred among the generated Pareto optimal solutions (a subjective selection among objectively determined solutions). In this paper we consider the robustness of the selected Pareto optimal solution in relation to perturbations within weights of the objective functions. For this task we design an integrated approach that can be used in multi-objective discrete and continuous problems using a combination of Monte Carlo simulation and optimization. In the proposed method we introduce measures of robustness for Pareto optimal solutions. In this way we can compare them according to their robustness, introducing one more characteristic for the Pareto optimal solution quality. In addition, especially in multi-objective discrete problems, we can detect the most robust Pareto optimal solution among neighboring ones. A computational experiment is designed in order to illustrate the method and its advantages. It is noteworthy that the Augmented Weighted Tchebycheff proved to be much more reliable than the conventional Weighted Sum method in discrete problems, due to the existence of unsupported Pareto optimal solutions.

Keywords: multi-objective programming, robustness analysis, Monte Carlo simulation

1. Introduction

Optimization affected by parameter imprecision has been a focus of the mathematical programming community during the last twenty years. Solutions to optimization problems can exhibit remarkable sensitivity to perturbations in parameters of the problem, thus often rendering a computed solution infeasible, or significantly suboptimal, or both. (Bertsimas, 2011) Therefore the concept of robustness in mathematical programming has drawn attention of the scientific community in this field and it is usually under the umbrella of "robust optimization". By using the term "robustness" we actually mean that there is some kind of uncertainty (or imprecision) in the model and we want to be "at the safe side". Uncertainty can be present in various forms (uncertain data linked with future outcomes, imprecise model parameters etc).

Robustness can be defined as a degree to which a solution is insensitive to underlying assumptions within a model. Key elements of robust optimization are volatility and flexibility. The former asks for a solution that is relatively stable to data variations and hedges against bad outcomes while the latter is concerned with keeping options open in a sequential decision process having recourses for the effects of earlier decisions (Greenberg and Morisson, 2008).