Dealing with uncertainty in constrained optimisation using decision theory

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I. Introduction

Uncertainty is unavoidable, especially in the behaviour of complex engineered systems. The increase in the computational resources for simulation has created an increasing demand for the analysis of uncertainty and for the use of its results in support to decision making.

Uncertainty can be considered to be essentially of two different types: randomness due to inherent variability in the system behaviour and imprecision due to a lack of knowledge about the system. The former type of uncertainty is often referred to as objective, aleatory, stochastic whereas the latter is often referred to as subjective or epistemic, and this type we mostly model using imprecise probabilities.

II. Problem

We consider constrained optimisation problems [1] with a real-valued, bounded objective function on an arbitrary space. The constraints are expressed as a relation between the optimisation variable and the problem parameters. There is uncertainty about these problem parameters, which turns the optimisation problem into an ill-specified problem.

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III. Completed work

We have solved this conundrum by reformulating such constrained optimisation problems under uncertainty to decision problems under uncertainty, where the uncertainty has been removed from the constraints. For this decision-theoretic reformulation, we investigate two different optimality criteria, which have been proposed in the literature on imprecise probabilities [2]: maximinity and maximality. We investigate what results can be obtained for different types of parameter uncertainty models: linear expectations, vacuous expectations and possibility distributions, and combinations of these. We have also applied this method in different application contexts, for different types of optimisation problems; the shortest path problem with uncertainty, fuzzy linear programming, constrained optimisation in fuzzy finite element problems (loaded beam), bridge collision problem [3].

IV. Future work

We are still working on fuzzy linear programming problems, to find more efficient solution methods and algorithms.

References

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