Interval analysis using Multilevel Quasi-Monte Carlo,

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Abstract

Interval analysis has proven to provide robust bounds on the performance of structures when there is only limited data available on the uncertainty. Calculating the interval bounds on the output side of a computational model typically involves a global optimisation algorithm or vertex analysis for monotonic models, where numerous model evaluations are required. The computational cost, measured as computation time and number of deterministic model evaluations corresponding to this optimisation, increases with the number of interval dimensions and even further for highly detailed models. Recent developments have shown very promising results in the context of reducing the computational cost for probabilistic fields. Multilevel techniques as Multilevel Monte Carlo and Multilevel Quasi-Monte Carlo have been shown to reduce the computational cost significantly for numerical models.

This paper presents Interval Multilevel Quasi-Monte Carlo to decrease the computational cost of interval analysis for linear models. In this approach, intervals are represented as Cauchy random variables, which enables the use of probabilistic sampling techniques for interval analysis. A computationally efficient technique for intervals analysis and linear models is then achieved by using the Multilevel Quasi-Monte Carlo framework. The efficiency of this Interval Multilevel Quasi-Monte Carlo technique is illustrated with an academic case study on a linear finite element model to compare the developed technique with a vertex analysis in terms of accuracy and computational cost.