Imprecise Subset Simulation for Reliability Analysis

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Abstract

The objective of this work is to quantify the uncertainty in structural reliability that results from lack of available data, necessary to precisely identify probability distributions for the model input parameters. To this end, we propose a computationally efficient framework that incorporates multimodel Bayesian/information theoretic method for probabilistic inference (Zhang and Shields (2018)) in the context of the popular Subset simulation (SuS) (Au and Beck (2001)), in order to estimate the uncertainty in the probability of failure estimates for a given structure. Our motivation stems from the fact that subset simulation is very efficient and precise when the probability model on the parameter space (and hence the conditional levels) is uniquely prescribed. However, when the probability model is uncertain and represented by multiple models the location of each conditional level is uncertain which induces uncertainty in the probability of failure estimate. The proposed method consists of two steps: First, a multi-model Bayesian/information theoretic framework is utilized in order to assess the model-form and parametric uncertainty of the input random variables. Subsequently, imprecise SuS is conducted for the identified family of distributions. It is shown that this uncertainty may be large in relation to the probability of failure estimate itself, especially when data sets are small. The outcome of the proposed method is imprecise probabilities of given response quantities in the form of probabilities of probabilities that allows us to bound response quantities of interest in a probabilistic manner and therefore assess confidence in our probabilistic estimates.

References

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