Sensitivity Measures for Minimizing Model Uncertainty in Probabilistic Analysis

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Abstract

The central theme in this paper is practical use of numerical simulation models. One example is finite element models; another is simulation of demand on transportation networks. Both are addressed in this paper in the context of two specific contributions.

The first contribution in this paper is to place the simulation models within a framework of probabilistic models. "Upstream" models simulate natural hazards and long-term deterioration, while "downstream" models estimate impacts such as damage and cost of under-performance. Reliability analyses are carried out to produce cost exceedance probabilities and other measures of risk. These analyses involve numerous models and random variables. A general-purpose, multi-model reliability freeware called Rt is applied and extended in this study to carry out these analyses. A particular novelty in this work is the circumvention of conditional probability models in favor of simulation-type probabilistic models, as described in this paper.

The second contribution is a detailed methodology for tackling model uncertainties. This is a particular pressing issue in the adoption of simulation models in practice. A significant extension of the research direction described by Haukaas and Gardoni (2011) is presented here. This contribution has important philosophical and practical implications. From a philosophical viewpoint it is suggested that the epistemic (reducible) uncertainty in the simulation models can be addressed by the same probabilistic means as the aleatory (irreducible) uncertainty, i.e., by random variables. This view, which implies that discretization errors are addressed by probabilistic means if they are unknown, is compared with approaches that tackle epistemic uncertainties by other means; see, e.g., Oberkampf and Roy (2010). The practical implication of the proposed methodology is that model uncertainty functions are integrated into the simulation code. For example, in the finite element code, model uncertainty functions trigger increase in the model uncertainty under conditions of significant element distortion, high degree of nonlinearity, etc.

References

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