Reliability-based Design under Integrated Input Variable and Metamodel Uncertainty based on Bayesian Approach

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Abstract

Reliability analysis is of great importance in the advanced product design, which is to evaluate reliability due to the associated uncertainties. Until recently, conventional reliability analyses dealt mostly with the aleatory uncertainty, which is irreducible and related with inherent physical randomness that is completely described by a suitable probability model; see Haldar and Mahadevan (2000). In reality, however, epistemic uncertainties are prevalent, which results from the lack of knowledge due to the insufficient data, and can be reduced by collecting more information; see Gelman et al. (2003). These two uncertainties are encountered in the input variables such as dimensional tolerances, material properties and loading conditions, and can be addressed by using a Bayesian approach; see Gunawan and Papalambros (2006). For realization of the Reliability Based Design Optimization (RBDO), use of metamodel that approximates the original response by a finite number of analyses, is necessary, which is often required in the case of costly computation such as finite element model. In this case, consideration of uncertainty due to this is also needed; see O'Hagan (2006). In this study, an integrated method addressing the input variables and metamodel uncertainty in the RBDO is proposed in a single Bayesian framework. Mathematical examples are used to demonstrate the proposed method and an engineering design problem is also addressed, which is to find an optimum design of a coil spring in a vehicle suspension.

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