Bayesian Updating with Structural Reliability Methods

Abstract:
Bayesian updating is a powerful method to learn and calibrate models with data and observations. Because of the difficulties involved in computing the high-dimensional integrals necessary for Bayesian updating, Markov chain Monte Carlo (MCMC) sampling methods have been developed and successfully applied for this task. The disadvantage of MCMC methods is the difficulty of ensuring the stationarity of the Markov chain. We present an alternative to MCMC that is particularly effective for updating mechanical and other computational models, termed Bayesian updating with structural reliability methods (BUS). With BUS, structural reliability methods are applied to compute the posterior distribution of uncertain model parameters and model outputs in general. An algorithm for the implementation of BUS is proposed, which can be interpreted as an enhancement of the classic rejection sampling algorithm for Bayesian updating. This algorithm is based on the subset simulation, and its efficiency is not dependent on the number of random variables in the model. The method is demonstrated by application to parameter identification in a dynamic system, Bayesian updating of the material parameters of a structural system, and Bayesian updating of a random field–based finite-element model of a geotechnical site.

Stichworte:
Bayesian updating, Structural reliability, Sampling, Measurements, Monitoring, FEM