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Summary: Bayesian updating provides a sound mathematical framework for probabilistic calibration as new information emerges. Bayesian Updating with Structural reliability methods (BUS) reformulates the acceptance domain in rejection sampling as a failure domain in reliability analysis, offering considerable potential for higher efficiency and accuracy. Kriging-based Monte Carlo Simulation has been studied to facilitate the application of BUS for problems with expensive-to-evaluate likelihood functions. Nevertheless, as the implementation of BUS often involves a rare event, the number of required Monte Carlo samples can become unaffordable. This gap is addressed here through Bayesian Updating with Active learning Kriging-based Adaptive Importance Sampling (BUAK-AIS). An importance sampling density based on Gaussian mixture distribution is introduced, and the discrepancy between the adopted and theoretically best sampling densities is measured through the Kullback-Leibler cross entropy. The proposed method includes an active learning framework that adaptively extends the training set and optimizes the parameters of the Gaussian mixture distribution based on the cross entropy and the current Kriging model. As BUS uses accepted samples to estimate the posterior distribution, the present work discusses the estimate for the first moment of the posterior distribution, and proposes a criterion to check the sufficiency of the number of accepted samples to guarantee robust estimations. A new stopping criterion is also developed by quantifying the error introduced by Kriging. Three numerical examples and an engineering application concerning model updating of cable-stayed bridges in the construction process are investigated, demonstrating the efficiency and accuracy of the proposed method.

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References:


