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Bayesian Calibration for the Quantification of Conditional Uncertainty of Input Parameters in Chained Numerical Models

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Numerical models have become essential tools to study complex physical systems. The accuracy and robustness of their predictions is generally affected by different sources of uncertainty (numerical, epistemic). In this work, we deal with parameter uncertainty of multiphysics simulation consisting of several numerical models from different physics which are coupled with one another. Our motivating application comes from the nuclear field where we have a fission gas behavior model of the fuel inside a reactor core depending on a thermal model. As each of the two models has its own uncertain parameters, our objective is to estimate the possible dependence between the uncertainty of input parameters $\theta \in \mathbb{R}^p$ $(p \geq 1)$ of the gas model conditionally on the uncertainty of the fuel conductivity $\lambda \in \mathbb{R}$ of the thermal model. To do so, we set out a nonparametric Bayesian method, based on several assumptions that are consistent with both the physical and numerical models. First, the functional dependence $\theta(\lambda)$, is assumed to be a realization of Gaussian process prior whose hyperparameters are estimated on a set of experimental data of the gas model. Then, assuming that the gas model is a linear function of $\theta(\lambda)$, the Bayesian machinery allows us to compute analytically the posterior predictive distribution of $\theta(\lambda)$ for any set of realizations of the conductivity λ. The shape of $\theta(\lambda)$ obtained shows the necessity of such a conditional parameter calibration approach in multiphysics simulation.

Keywords

Conditional Bayesian calibration, Gaussian process, emprical Bayes, cut-off models.

Classification

Both methodology and application

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