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Probabilistic uncertainty analysis: parallel computing aspect

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Abstract

In the numerical solution of dynamical system governed by partial differential equation (PDE), high-resolution finite element models are widely utilized to reduce the discretization error. Such an approach fails to enhance confidence in simulation-based predictions when the underlying PDE exhibit significant variability in their data and model, leading to two types of uncertainty, namely the data and modeling uncertainty. When substantial statistical information is available, uncertainty in data can be adequately represented by stochastic processes. This approach is known as so-called parametric method. However, with the growing complexities of the uncertainty involved in parametric modeling or presence of substantial model uncertainty, a matrix variate distribution approach based on maximum-entropy theory may be used to reflect uncertainty of the discrete systems. Typically this is referred to as nonparametric method. Finite element methods (FEM) coupled with simple Monte Carlo simulation are frequently adopted in numerical solution of stochastic PDEs. Although versatile in application, this method is usually computationally expensive. Such approach therefore may become infeasible for large-scale system in practical applications. To circumvent or at least alleviate some of the limitations, the efforts are directed towards improving computational efficiency both in probabilistic and geometric aspects. This presentation reports an integrated approach which couples high performance computing techniques with stochastic reductions and efficient statistical sampling scheme.