REDUCED-ORDER MODELING OF STOCHASTIC TRANSPORT PROCESSES

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A new methodology for reduced-order solution of stochastic partial differential equations is presented. This involves a concurrent model reduction approach on spatial and random domains.

A Proper Orthogonal Decomposition (POD) approach coupled with the method of snapshots is used to reduce the dimensionality of the finite element space on the spatial domain. POD methods have been extremely popular in fluid mechanics applications and have recently been extended to other interesting areas. They have been shown to be capable of representing complicated phenomena with a handful of degrees of freedom.

On the random dimension, a Generalized Polynomial Chaos Expansion (GPCE) is used to generate the reduced subspace. GPCE involves expansion of the random variable as a linear combination of basis functions defined using orthogonal polynomials from the Askey series.

This concurrent model reduction is applied to stochastic natural convection and heat transfer problems involving random material properties and boundary conditions. Comparisons with full-order model solutions based on a FEM model coupled with Monte-Carlo sampling will be discussed along with other potential applications. It is observed that owing to the multiplicative nature of the concurrent model reduction, extremely large computational gains are realized without significant loss of accuracy.