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An adaptive polynomial chaos expansion for accelerating the solution of Spectral Stochastic FEM problems

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Over the last two decades, the majority of stochastic FEM research work has focused on developing various methodologies for the numerical solution of the stochastic partial differential equations involved in structural mechanics problems. Among these, the most commonly used are intrusive Galerkin-based methods and non-intrusive Monte Carlo methods with non-intrusive solvers. The stochastic PDEs are sampled at a set of points in the random space leading to a corresponding set of independent deterministic problems and Galerkin-based methods spanning system response to a set of polynomials of the basic random variables, namely the polynomial chaos expansion. The polynomial chaos coefficients are consequently calculated from the solution of a system of linear equations representing the set of coupled deterministic PDEs defined in the tensor product space which is defined on the Cartesian product of the physical and random domain.

In this work, a methodology is proposed to construct an adaptive sparse polynomial chaos expansion of the response of stochastic systems whose input parameters are modeled with random fields. In this context, the concept of variability response function is utilized in order to compute an a priori low cost estimate of the spatial distribution of the second-order error of the response, leading to an increase of sparsity of the coecient matrix of the corresponding linear system of equations. Large-scale numerical examples are provided, showcasing the efficiency of the above mentioned methodology.

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