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Assessing the numerical efficiency of Monte Carlo and Spectral Stochastic FEM in structural problems

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In this work, a computational performance assessment is attempted between non-intrusive Monte Carlo and intrusive SSFEM methods for large-scale stochastic systems in the framework of high performance computing environments. Specifically, an assessment of the range of the relative superiority of these approaches with regard to a variety of stochastic parameters is performed. In both approaches, the solution of the resulting algebraic equations is performed with a combination of primal and dual domain decomposition methods implementing custom-tailored preconditioners. The solution of repeated simulations of the Monte Carlo method is accelerated with an A-orthogonalization procedure which enhances the convergence properties of subsequent simulations, while the solution of the augmented equations of the SSFEM method is enhanced with preconditioners which combine the block diagonal features of the resulting matrices as well as the sparsity pattern of the off block-diagonal terms.

Numerical results are presented demonstrating the efficiency of the proposed implementations on a parametric study of a large-scale 3D problem with various stochastic characteristics and useful conclusions are derived regarding the ranges of stochastic parameters in which non-intrusive solvers have a superior performance compared to intrusive ones and vice versa.

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