A MULTISCALE METHOD WITH PATCHES FOR THE PROPAGATION OF LOCALIZED UNCERTAINTIES IN STRUCTURAL DYNAMICS

Florent Pled, Mathilde Chevreuil, Anthony Nouy

Uncertainty quantification in structural computation has gained an ever increasing interest in the scientific community during the last decades. The propagation of localized uncertainties through stochastic computational models is critical for the design and analysis of mechanical structures and components. The input uncertainties in the computational model may stem from intrinsic variabilities in the material properties or epistemic variabilities resulting from partial or limited information about the geometry, the boundary or initial conditions. Classical monoscale approaches require either local refinement or enrichment techniques to cope with the high complexity of multiscale stochastic problems. On the contrary, multiscale coupling approaches based on substructuring, domain decomposition or multigrid methods have been designed to solve such intractable high-dimensional problems. A multiscale method based on patches has been recently proposed in [1] for the solution of linear stochastic multiscale models (with localized uncertainties) and extended to a broader class of non-linear stochastic multiscale models (with localized uncertainties and non-linearities) in [2]. It relies on a partition of the domain into several subdomains of interest (called patches) containing the different sources of uncertainties and possible non-linearities, and a complementary subdomain. The multiscale solution is then computed using a global-local iterative algorithm that involves the solution of a sequence of linear global problems (with possibly deterministic operators and uncertain right-hand sides) over a deterministic domain and (non-)linear local problems (with uncertain operators and right-hand sides) over patches.

In the present work, the method is extended to linear structural dynamics problems featuring localized uncertainties. The convergence of the iterative algorithm is analyzed. The proposed multiscale approach offers the possibility to use different global and local computational models with suitable discretizations as well as stand-alone global and local solvers. At the local level, the stochastic problems are solved using sampling-based approaches combined with adaptive sparse approximation methods [3] in order to efficiently derive sparse representations of high-dimensional stochastic local solutions with controlled accuracy. The performances of the multiscale domain decomposition method are illustrated through numerical experiments carried out on a linear vibration stochastic problem with localized random material heterogeneities.

References

[1] Mathilde Chevreuil, Anthony Nouy, and Elias Safatly. A multiscale method with patch for the solution of stochastic partial differential equations with localized uncertainties. *Computer Methods in Applied Mechanics and Engineering*, 255(0):255–274, 2013.

[2] Anthony Nouy and Florent Pled. A multiscale method for semi-linear elliptic equations with localized uncertainties and non-linearities. *ESAIM: M2AN (submitted)*, February 2017. 37 pages.

[3] Abdellah Chkifa, Albert Cohen, and Christoph Schwab. Breaking the curse of dimensionality in sparse polynomial approximation of parametric PDEs. *Journal de Mathématiques Pures et Appliquées*, 103(2):400–428, 2015.