Localization of multiscale problems with random defects

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Abstract: With respect to the application of composite materials with random defects, we consider elliptic multiscale problems with perturbed diffusion coefficients based on a certain reference configuration. We propose a method that is deduced from the Petrov Galerkin version of the Localized orthogonal decomposition (LOD) method. It has originally been proposed in [2] and decomposes the solution space in a fine and a coarse scale part. In the standard version, localized fine scale basis correctors with respect to a fine mesh are computed and subsequently incorporated to a coarse Galerkin method.

Considering perturbations of a reference coefficient, our novel method takes advantage of the reference problem as it uses a certain percentage of the correctors for the coarse basis functions. In order to value the effect of the perturbation on each corrector, the derivation of an a priori error bound is required. It contains an a priori computable error indicator that is localized for each element. Setting a tolerance for recomputing results in a mixed LOD space that is assorted with a particular amount of reference and perturbed corrector functions. For perturbations that arise from a smooth variable transformation, we derive another benefit as we are able to transform defects in position to a (less expensive) defect in value. With respect to Monte Carlo simulations in the context of random defects caused by machine failures, our method reduces computational effort significantly.

References

[1] Fredrik Hellman and Axel Målqvist. *Numerical homogenization of time-dependent diffusion.* In: arXiv preprint arXiv:1703.08857 (2017).

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