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ON ADAPTIVE CONTROL OF FINE-SCALE ERRORS IN TWO-SCALE FINITE ELEMENT ANALYSIS

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We consider engineering problems of mechanics involving two length scales; typically the (structural) macroscale and the (material) microscale. We shall present a strategy for two-scale finite element analysis of such structures with the pertinent error control in chosen quantities of interest at the material length scale.

When analyzing a structure as discussed above, two principally different strategies may be envisioned: The straightforward approach is to resolve the material length scale inside the entire structure, which will carry an extremely high computational cost in the case that the separation of scales is vast. An alternative approach is to first solve an approximate (homogenized) problem on the macroscale after which the local quantities are evaluated from the solution to a subdomain problem. The boundary conditions on the local subdomain are typically obtained from the solution of the macroscale problem. Both the properties of the homogenized macroscale problem and the connection between the macroscale solution and the resolved subdomain of interest may be derived from the assumed existence of a Representative Volume Element (RVE). This notion presumes scale separation in the sense that the subscale solutions interact only via their homogenized results on the macroscale.

In this presentation, we adopt a novel Finite Element (FE) algorithm for bridging the length scales, cf. [1], where subscale modeling is introduced to resolve the features of the solution not captured by the macroscale FE-mesh. Most importantly, the approach to the subscale modeling, e.g. homogenization, can be chosen adaptively based on the relation of the macro-scale mesh diameter to the typical length scale of the material substructure. In order to benefit from the possibilities of the method, we construct an adaptive scheme based on the pertinent a posteriori error estimator. In particular, we discuss how to accurately compute local quantities of interest on the material length scales while accounting for error from homogenization as well as FE-discretization.

Simple examples for 2D deterministic structures will be presented, illustrating the behavior of the proposed numerical framework. The strategy will be discussed for different ratios of the structural-to-material length scales.

REFERENCES

[1] F. Larsson and K. Runesson. On two-scale adaptive FE analysis of micro- heterogeneous media with seamless scale-bridging. *Computer Methods in Applied Mechanics and Engineering*, Vol. **200**,2662–2674, 2011.