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ON GOAL-ORIENTED ERROR ESTIMATION FOR MODEL ORDER REDUCTION IN COMPUTATIONAL HOMOGENIZATION OF HYPERELASTIC MICROSTRUCTURES

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We consider computational homogenization of hyperelastic microstructures. By solving a boundary value problem on a Representative Volume Element (RVE), the effective response is obtained in terms of the homogenized (macroscale) stress–strain relation. This can either be used to fit an empirical model on the macroscale in the sense of virtual material testing, or it can be linked to a macroscale boundary value problem in a nested fashion. Seeking finite element approximations for both the maco- and microscales, the latter approach is often referred to as FE^2, and involves the solution of an RVE-problem in each macroscale quadrature point. FE^2 analyses clearly become extremely expensive for finer meshes on either scale. Therefore, it becomes natural to consider model order reduction techniques for reducing the cost of the RVE-problems, see e.g. [1]. However, in order to have a reliable approximation, it is crucial to quantify the introduced errors.

In this contribution, we consider goal-oriented error control for applying reduced order modeling to the RVE-problem. In that, we consider the error measured in the relevant outputs (so-called quantities of interest). First, we introduce a hierarchical estimator that in a low-cost fashion predicts the error in macroscopic stress by incorporating an hierarchically enriched basis to the problem. Secondly, we generalize the approach presented in [2] to give approximate bounds when disregarding linearization errors. We investigate the behavior of the proposed error estimators in a few numerical examples for hyperelastic microstructures. In particular, we compare the different estimators (and further simplifications thereof) with respect to accuracy, robustness and computational cost.

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