Reduced Finite Element square techniques (RFE\textsuperscript{2}): towards industrial multiscale FE software

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ABSTRACT

The FE\textsuperscript{2} method has gained a considerable interest within the simulation science community because of its generality and potential. Indeed, multiscale problems with complex micro-structures and constitutive behaviors can be tackled whereas classical homogenization techniques fail at predicting overall material properties. However, the multiplicative cost of different scale discretizations has significantly restricted their common use and distribution among industrial FE codes.

The reduced order modeling techniques proposed in [1] and [2] are assessed for an industrial case study of a 3D reinforced composite laminate. Essentially, the main dominant strain micro-structural modes are obtained through standard reduced order modeling techniques applied over snapshots of a representative training strain space. Additionally, a reduced number of integration points is obtained by exactly integrating the main energy modes resulting from the training energy snapshots. The outcome consists of a number of dominant strain modes integrated over a remarkably reduced number of integration points which provide the support to evaluate the constitutive behavior of the micro-structural phases.

Different performance ratios between the full (high fidelity) and reduced simulations are obtained for a given user prescribed error. In fact, the ratio between the number of sampling points, i.e. integration points, of a standard FE\textsuperscript{2} and the reduced sampling points provided by the RFE\textsuperscript{2} technique scales with the complexity of the analyzed microscopic cells and, for relative errors below 1\%, this ratio can easily reach three or four orders of magnitude when the amount of micro-structural sampling points is up to 10\textsuperscript{6}.

Consequently, this technology results in feasible and affordable FE\textsuperscript{2} simulations suitable for industrial purposes.

REFERENCES
