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THE GENERALIZED FINITE ELEMENT METHOD AS A FRAMEWORK FOR MULTISCALE STRUCTURAL ANALYSIS

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ABSTRACT

This presentation reports on recent advances of the Generalized Finite Element Method (GFEM) for problems with strong interactions between two or more scales. This method is based on the solution of interdependent global (structural) and local scale problems. The local problems focus on the resolution of fine scale features of the solution in the vicinity of, e.g., three-dimensional propagating cracks while the global problem addresses the macro scale structural behavior. The local solutions are embedded into the global solution space using the partition of unity method. The local problems are accurately solved using the *hp*-GFEM and thus the proposed method does not rely on analytical solutions. Fine scale computations can be performed at patches associated with nodes of coarse scale finite element meshes. These computations do not involve exchange of data among patches and are thus naturally parallelizable. Numerical examples demonstrating this are presented.

An a-priori error estimate for the proposed enrichment functions is presented along with numerical verification. The convergence analysis shows that the method can deliver the same accuracy as direct numerical simulations (DNS) while using meshes with elements that are orders of magnitude larger than in the DNS case. Furthermore, the method is fully compatible with the standard FEM and thus can be integrated with existing analysis software. We show an example of a non-intrusive implementation in Abaqus.

In this presentation we also report on extensions of the method to three-dimensional problems exhibiting localized nonlinear behavior. Our nonlinear model problem focuses on structures with plastic deformations at regions that are orders of magnitude smaller than the dimensions of the structural component. We show that the proposed GFEM can produce accurate nonlinear solutions at a reduced computational cost compared with available FEMs.