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io-port 06002792

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An unfitted hp-adaptive finite element method based on hierarchical B-splines for interface problems of complex geometry.

Comput. Methods Appl. Mech. Eng. 200, No. 47-48, 3358-3380 (2011).

Summary: Generating finite element discretizations with direct interface parameterizations constitutes a considerable computational expense in case of complex interface geometries. The paper at hand introduces a B-spline finite element method, which circumvents parameterization of interfaces and offers fast and easy meshing irrespective of the geometric complexity involved. Its core idea is the adaptive approximation of discontinuities by hierarchical grid refinement, which adds several levels of local basis functions in the close vicinity of interfaces, but unfitted to their exact location, so that a simple regular grid of knot span elements can be maintained. Numerical experiments show that an hp-refinement strategy, which simultaneously increases the polynomial degree of the B-spline basis and the levels of refinement around interfaces, achieves exponential rates of convergence despite the presence of discontinuities. It is also demonstrated that the hierarchical B-spline FEM can be used to transfer the recently introduced Finite Cell concept to geometrically nonlinear problems. Its computational performance, imposition of unfitted boundary conditions and fast hierarchical grid generation are illustrated for a set of benchmark problems in one, two and three dimensions, and the advantages of the regular grid approach for complex geometries are demonstrated by the geometrically nonlinear simulation of a voxel based foam composite.

Keywords: high-order B-spline finite elements; regular grid; hierarchical refinement; interface problems; complex geometries; finite cell method
doi:10.1016/j.cma.2011.08.002