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High order eXtended Finite Element Method and Level Sets: Uncoupling geometry and approximation

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ABSTRACT

Recently, the use of high order approximation has been promoted in the X-FEM context [1, 2, 3]. These contributions were dedicated to the construction of strategies that allow to recover optimal convergence rates for moderately high order approximations (linear, quadratic and cubic). The main issue comes from the necessity of controlling geometrical approximations accuracy to maintain the optimal convergence of the approach. The objective of the present contribution is to study the application of the X-FEM to the context of p finite elements where p reach high values (typically $p = 10$). Thanks to this approach, complex geometries can be treated by means of a high order approximation defined on a coarse mesh. A strategy is proposed for uncoupling the geometrical description of the domain of interest and the approximation. This strategy, which is derived from [2, 4] is based on an uniform coarse mesh that defines the high order approximation of the mechanical fields and an adapted one that defines the geometrical features by means of level-sets. The geometric and the approximation meshes are connected through a shared quadtree/octree structure. Numerical examples involving level-set based parts, convergence studies, mechanical computations and numerical homogenization show good promise for this approach in both 2D and 3D.

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