An Error-estimate-free Mesh Refinement and Coarsening Method for the Phase Field Approach to Fracture

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ABSTRACT

The phase field model shows great advantage in the numerical simulation of fracture, since the crack is a natural outcome of numerical computation and there is no need to track the discontinuities in the displacement field, which avoids the complexity of crack topologies. However, an extremely fine mesh is required to ensure the accuracy and convergence of the method; as a result, adaptive mesh refinement becomes a viable choice to reduce the computational cost.

In this work, we first examine three *a posteriori* mesh refinement methods, namely a recovery-based one, a residual-based one, and an energy-based one proposed by Mosler and Ortiz [1, 2], for a one-dimensional phase field problem. We then select the last one for developing an h-adaption method for the phase field, in which the criterion of mesh refinement and coarsening is directly driven by the same minimum potential energy principle characterizing the underlying physical problem; thus, no error estimates are required during the adaption process. We first use the criterion to find the edges which, if bisected, lead to a certain decrease in the total potential energy, and then bisect these edges with an algorithm named longest-edge-propagation path (LEPP[3]). Next, when the crack length is increased, the mesh around the initial crack tip should be coarsened while new refined elements are required to establish around the new crack front. It should be emphasized that the coarsening process is also built on the total potential energy criterion. We illustrate the performance of the proposed methods by means of several representative numerical examples.

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