A-FEM That Is 100+ Time Faster Than X-FEM in Simulating Arbitrary Cracking Problems in Solids

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Abstract

This poster presents the formulation and implementation of a new augmented finite element method (A-FEM) that can account for multiple, arbitrary intra-element discontinuities with a demonstrated improvement in numerical efficiency by two orders of magnitude, as compared to the extended finite element method (X-FEM). It will be shown that the new formulation enables the crack displacements to become natural outcomes of the elemental equilibrium consideration, which makes it possible to derive explicit, fully condensed elemental equilibrium equations in a mathematically rigorous way. The straightforward derivation process also allows for repeated elemental augmentation to include multiple interactive cracks within a single element without the need of additional nodes or DoFs, which greatly expedites the handling of multiple cracks merging/bifurcation in complex heterogeneous materials. Furthermore, the new A-FEM enables a unified treatment of both weak and strong discontinuity within a single element. The A-FEM's excellent capability in high-fidelity simulation of interactive cohesive cracks in heterogeneous solids will be demonstrated through ample numerical examples. This method can account for cracking and their interactions in polymers and polymer composites which modeling them was not a simple and error free task.