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Fracture simulation using a nonlocal particle model

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ABSTRACT

Extensive researches have been done to simulate crack initialization, propagation, branching, and coalesce from different engineering disciplines. Various numerical methods have been developed, which can be generally grouped into two categories: the continuum-based methods and the discontinuous approaches. For cracking problems, the classical finite element method (FEM) uses mesh matching and remeshing techniques which is computationally very expensive. The cohesive elements does not require very dense mesh near the crack tip region, but usually requires the crack path as a priori knowledge for the computational efficiency. eXtended FEM (XFEM) treats the discontinuity via level sets method and enrich the crack tip elements with analytical solution for the stress or displacement from linear elastic fracture mechanics. Arbitrary crack branching and coalesce is still challenging in the XFEM framework. The discontinuous approaches, such as lattice spring models and peri-dynamics, can handle fracture problems very efficiently. No additional criteria are needed as the crack growth is a natural outcome of the system evolution. As the elongation of the connecting bonds exceeds the critical value, it breaks and the crack propagates automatically. However, there are some other issues with the discontinuous approaches, such as restriction on effective Poisson's ratio and crack path preference. A Volume-Compensated Particle Method (VCPM) was proposed by Chen et al. to solve these issues within the discontinuous framework. In the VCPM, both pairwise and nonlocal potentials are used to describe interactions among particles. One unique issue in the regular lattice particle method is the directional preference of the crack propagating path due to the regular lattice topology. The objective of this study is to investigate a general formulation using the VCPM concept to eliminate/reduce the crack path preference in the fracture simulation.