Mechanical Engineering Doctoral Defense

A Novel Nonlocal Lattice Particle Framework for Modeling of Solids

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abstract

Fracture phenomena have been extensively studied in the last several decades, and continuum mechanics-based approaches, such as Finite Element Methods (FEM), are widely used for simulation. One well-known issue of this approach is the stress singularity at the crack tip/front. Another known issue of fracture simulation using continuum-based formulation is the requirement of guiding criterion for various cracking behaviors, such as initiation, propagation and branching.

Comparing to the continuum based formulation, the discrete based approaches, such as Lattice Spring Method (LSM), Discrete Element Method (DEM) and Peridynamics, have certain advantages while modeling various fracture problems of solids due to their intrinsic characteristics in modeling discontinuities. A novel, alternative, and systematic framework using a nonlocal lattice particle method is proposed in this study. The uniqueness of the proposed method is the inclusion of both pair-wise local potential and multi-body nonlocal potential in the formulation. First, the basic idea of the proposed framework for 2D isotropic solid is presented. Both mechanical deformation and fracture process are simulated and model verification and validation are performed with existing analytical solutions and experimental observations. Following this, the extension to general 3D isotropic solids using the proposed nonlocal lattice particle method is given. Failure predictions using the 3D simulation are compared with experimental testing results and very good agreement is observed. Next, a lattice rotation scheme is proposed to simulate the anisotropic solids. The consistency and difference compared to the classical material tangent stiffness transformation method are discussed in detail. Finally, some conclusions and discussions based on the current study are drawn at the end.

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