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Generalized derivative operator and its application in fracture mechanics

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Governing equations in classical continuum mechanics utilize derivative operators applied to functions that have spatial derivatives at every point in the domain. Derivative operators, therefore, cannot be directly used in governing equations to model spatial discontinuities such as those found in solid fracture and crack propagation. Non-Ordinary State-Based Peridynamics (NOSB-PD) replaces Partial Derivative Equations (PDE) with their integro-differential counterparts which are suitable for material failure simulation. Nevertheless, NOSB-PD suffers from the presence of spurious oscillations on the boundary of solid as well as in the crack tip. Inadequate approximation of the deformation gradient tensor and internal forces are the main reasons for these fictitious oscillations. Moreover, use of NOSB-PD with non-uniform discretization results in unreliable outcomes. To improve the accuracy of the deformation gradient tensor, the Generalized Derivative Operator (GDO) for any square- integrable L2 function is defined using the Taylor series expansion. The generalized derivative operators are determined using the bi-orthogonal basis corresponding to the monomial basis which is used in the finite truncation of the Taylor series expansion. The classical form of the governing equation in reference configuration is reformulated using the derivative operators (GDO based governing equation). Furthermore, the GDO based governing equation is a good extension to NOSB-PD to non-uniform discretization. Moreover, the proposed method can be applied to a wide range of damage modeling scenarios to capture various aspects of solid fracture. A rectangular block with different boundary conditions is used to show the capabilities of the method by simulating the crack initiation and crack propagation.

Biography

Hooman Zarreh is a Doctoral candidate at the Auckland Bioengineering Institute of The University of Auckland in New Zealand. He is currently working on the fracture mechanics of solids. His research is primarily focused on developing alternative formulations for peridynamics, which is a relatively new approach to simulate spatial discontinuities such as crack propagation and fracture fragmentation. He has investigated how conventional methods such as the finite element method as well as mesh-based particle methods (e.g., the material point method) can be used to simulate large solid deformations, which are frequently encountered prior to fracture.

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