An adaptive higher order phase field formulation for brittle fracture of deforming surfaces

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ABSTRACT

In phase field formulations for fracture modeling the crack is represented by a smooth transition between undamaged and fully broken material. These formulations do not require ad hoc criteria to model crack initiation and evolution which makes them beneficial for the prediction of fracture. The fracture process is described by a Partial Differential Equation (PDE) stemming from the minimization of an energy functional based on Griffith's theory of fracture. A higher order crack density functional including the Laplacian of the phase field variable is employed for the energy functional [1]. The employed shell framework is based on a curvilinear surface description and the shell deformation is specified by the Kirchhoff-Love thin shell equation [2]. Constitutive relations are given in surface energy form and the in-plane response is fully decoupled from the out-of-plane response. Thickness integration is used to split the latter [3]. Both the phase field evolution equation and the thin shell equation include fourth-order derivatives which necessitates an at least C^1-continuous discretization. The Isogeometric Analysis (IGA) framework is used to obtain the higher continuity. The parametric domain is locally refined adaptively based on LR (Locally Refinable) NURBS [4] to allow for a small transition zone. In contrast to LR B-Splines, LR NURBS offer the possibility of exact geometric representations of conic sections. Numerical examples study crack evolution based on stretching and bending contributions.

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