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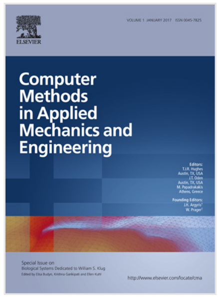

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A framework for polyconvex large strain phase-field methods to fracture

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Abstract

Variationally consistent phase-field methods have been shown to be able to predict complex three-dimensional crack patterns. However, current computational methodologies in the context of large deformations lack the necessary numerical stability to ensure robustness in different loading scenarios. In this work, we present a novel formulation for finite strain polyconvex elasticity by introducing a new anisotropic split based on the principal invariants of the right Cauchy-Green tensor, which always ensures polyconvexity of the resulting strain energy function. The presented phase-field approach is embedded in a sophisticated isogeometrical framework with hierarchical refinement for three-dimensional problems using a fourth order Cahn-Hilliard crack density functional with higher-order convergence rates for fracture problems. Additionally, we introduce for the first time a Hu-Washizu mixed variational formulation in the context of phase-field problems, which permits the novel introduction of a variationally consistent stress-driven split. The new polyconvex phase-field fracture formulation guarantees numerical stability for the full range of deformations and for arbitrary hyperelastic materials.

Keywords: Phase-field, fracture mechanics, polyconvexity, finite deformations, isogeometric analysis.

1. Introduction

The numerical prediction of fracture patterns is one of the most challenging problems in computational solid mechanics. In classical fracture mechanics, Griffith and Irwin [16, 23] formulated the propagation of brittle fracture by assuming that the material fails locally upon the attainment of a specific fracture energy related to a critical energy-release rate. However, due to the complexity of the evolving fracture surfaces in three-dimensional scenarios, the evaluation of appropriate interface conditions is an extremely challenging task in the context of finite element discretisations.

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