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A polytree-based adaptive approach to limit analysis of cracked structures

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Abstract

We in this paper present a novel adaptive finite element scheme for limit analysis of cracked structures. The key idea is to develop a general refinement algorithm based on a so-called polytree mesh structure. The method is well suited for arbitrary polygonal elements and, furthermore, traditional triangular and quadrilateral ones, which are considered as special cases. Also, polytree meshes are conforming and can be regarded as a generalization of quadtree meshes. For the aim of this paper, we restrict our main interest in plane-strain limit analysis to von Mises-type materials, yet its extension to a wide class of other solid mechanics problems and materials is completely possible. To avoid volumetric locking, we propose an approximate velocity field enriched with bubble functions using Wachspress coordinates on a primal-mesh and design carefully strain rates on a dual-mesh level. An adaptive mesh refinement process is guided by an $\mathbb{L}^2$-norm-based indicator of strain rates. Through numerical validations, we show that the present method reaches high accuracy with low computational cost. This allows us to perform large-scale limit analysis problems favorably.

Keywords: Fracture; plasticity; incompressibility; polytree; adaptivity; limit analysis.

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