T-spline-based isogeometric cohesive zone modeling of interface debonding

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Cohesive zone (CZ) models based on non-linear relationships between tractions and opening displacements are widely adopted within finite element frameworks to analyze fracture of materials and interfaces. Herein we focus specifically on debonding at bimaterial interfaces, or more in general on problems where the path of the debonding crack is known *a priori*.

A drawback of CZ models is that, unless a sufficiently fine mesh is provided around the crack front, the computed load-deflection response is non-smooth and may exhibit artificial snap-throughs and snap-backs [1]. This is due to the inability of coarse meshes to capture correctly the strain field in the process zone around the crack front during its propagation.

In contrast to refinement of the entire domain, local refinement of the process zone is a computationally more efficient alternative. To this end, different surface enrichment strategies have been developed in the literature using different types of enrichment functions for CZ interface elements [1,2], as well as for contact elements [3]. These techniques, however, only affect the interacting surfaces and leave the bulk behaviour of the solid unaltered. Moreover, they typically do not increase the degree of continuity of the parameterization at the inter-element boundaries which is also responsible for unphysical stress oscillations at the interface.

The isogeometric analysis framework [4] has already demonstrated to guarantee substantial advantages in the computational treatment of unilateral contact [5]. Differently from non-uniform rational B-splines (NURBS) built on rectangular grids in the parameter space, T-splines allow local refinement due to the introduction of T-junctions and extraordinary points. This approach is particularly suitable for CZ models, due to the high resolution required by these models in the process zone. Furthermore, in the isogeometric setting the discretized crack surfaces feature higher order inter-element continuity with respect to classical finite elements.

In this contribution, debonding problems at known interfaces are treated with CZ modeling within the T-spline-based isogeometric framework. The interface is discretized with zero-thickness contact elements which account for both contact and debonding within a unified framework, using a Gauss-point-to-surface formulation. The continuum is discretized with cubic T-splines, as well as with arbitrary order Lagrange polynomial elements for comparison purposes. Results for mode-I double cantilever beam (DCB) and mode-II end-notched flexure beam (ENF) tests with varying resolutions of the process zone are presented and compared in terms of load-deflection relationship. The ability of T-spline interpolations for fracture modeling is discussed.

References

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