Phase-field simulation of brittle fracture in complex shell structures using LR-NURBS adaptive mesh refinement

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ABSTRACT

The simulation of fracture and crack propagation in structures including thin members as plates and shells is a challenging topic in structural engineering. In the proposed approach, an isogeometric rotation-free formulation for Kirchhoff-Love shells is coupled with a phase-field model for brittle fracture in which the tension-compression decomposition of the strain energy [1] is performed at various points through the thickness, still maintaining a definition of the kinematics and of the phase-field based on midsurface variables [2].
Within the framework of Isogeometric Analysis, the discretization of the geometries is performed employing Locally Refined (LR) NURBS as basis functions [3]. This choice allows for a local refinement of the mesh, that would be impossible using traditional NURBS, in order to correctly resolve the high gradient transition of the phase-field around the cracked area. In the proposed methodology, we employ an adaptive mesh refinement based on the evolution of the phase-field, owing to analyses that are capable to simulate cases in which the crack path is unknown in advance, with reduced computational costs.
In order to simulate complex structures that include multiple surface patches, we adopt a penalty approach for coupling adjacent patches applicable either to smooth or kinked patch interfaces, regardless to their discretization [4]. The method imposes displacements and rotational continuity, while additional considerations are employed in order to guarantee the continuity of the phase-field across the patch interfaces.

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