Adaptive local surface refinement for isogeometric contact, fracture and topology optimization

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Many applications in science and engineering are characterized by localized surface phenomena. These can appear in the geometry, such as surface wrinkles and cracks, in the constitution, such as material interfaces, and in the boundary conditions, such as contact. Further, the localized interfaces induced by these phenomena can move across the domain. Wrinkles and cracks can propagate, material interfaces can evolve, and contacting bodies can peel and slide. In the computational simulation of these examples it is advantageous to use adaptive local surface refinement. Such a refinement approach adapts the numerical discretization in both space and time to where and when it is needed most. In this they have to account for the underlying numerical description of the surface and its phenomena. The nature of many surface phenomena necessitates smooth discretizations such as those provided by isogeometric analysis.

This work presents an adaptive local finite element refinement strategy for surface phenomena based on NURBS discretizations, which provides at least C1-continuity between elements [1]. It uses a local representation of the parameter space based on the Bezier extraction operator [2] and the local refinement approach of [3]. Further, it allows for local coarsening of previously refined regions. The strategy is applied to the simulation of peeling and sliding contact, shell fracture, and surface topology optimization [1, 4]. The latter two cases are based on Kirchhoff-Love thin shell theory and high order phase field methods that both require C1-continuity for their efficient computational description. It is shown that the formulation is able to locally adapt the discretization and thus increase computational efficiency. In the case of contact, the formulation can be extended to 3D through the use of local surface enrichment [5]. It is also demonstrated that the proposed strategy can handle patch interfaces and domain discontinuities such as surface folds.

References

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