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Coupling of an isogeometric surface and bulk finite element discretization for contact problems

Peter Otto[1], Laura De Lorenzis[2] and Jörg F. Unger[1]

[1] Bundesanstalt für Materialforschung und -prüfung (BAM), Unter den Eichen 87, 12205 Berlin, Germany, peter.otto@bam.de and joerg.unger@bam.de
[2] Institut für Angewandte Mechanik, Technische Universität Braunschweig, Pockelsstraße 3, 38106 Braunschweig, Germany, l.delorenzis@tu-braunschweig.de

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The finite element (FE) framework is a standard tool for the simulation of mechanical problems providing advantages like automated meshing algorithms and efficient quadrature rules. However, for contact problems, the FE discretization is - due to the $\mathcal{C}^0$ continuity at element intersections - characterized by a non-smooth normal field.

Conversely, isogeometric discretizations provide a smooth normal field also at inter-element borders and were recently applied to contact mechanical problems using the mortar method [1]. The application of isogeometric analysis for complex volumetric problems has not reached the same level of automation as the FE-framework, i.e. due to the intricate mesh generation.

This work aims at combining the advantages of both discretization procedures by coupling an isogeometric contact surface with a bulk FE-discretization. The isogeometric contact interface is represented by a NURBS surface, which is tied to the FE mesh. For the discretization of the bulk parts, higher order spectral elements [2] are used. The contact problem is discretized with the mortar method and a penalty approach is used to enforce the contact constraints. Two different types of coupling of the NURBS surface and the bulk part are considered: mortar and pointwise mesh tying. The mortar mesh tying approach shows accurate results, whereas the pointwise tying leads to large oscillations in the contact stresses. Element-based quadrature is applied for mortar tying, as well as for mortar contact discretizations. Using an isogeometric layer, the related quadrature error can be efficiently reduced by a higher degree interpolation or increased integration order.

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