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A cut finite-element method for fracture and contact problems in large-deformation solid mechanics

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There is a variety of numerical methods to handle problems with interfaces in solid mechanics. Most methods can be classified into two groups: the diffuse-interface methods and the sharp-interface methods. There is an important class of methods within the latter group – the fictitious domain methods, to which the CutFEM approach belongs. This class of methods allows the interface to cut through the elements and to avoid any kind of mesh generation that conforms to the mesh. This is extremely convenient from the practical point of view when non-stationary interfaces are considered, as the interfaces can move independently of the mesh. Initially, the CutFEM method has been proposed for linear PDEs [1,2]. Recently, a generalisation of the CutFEM method to large deformations and arbitrary constitutive behaviour of materials in solid mechanics has been performed [3].

In this talk, the results of [3] are further generalised to cases when the interface represents a more complex physical behaviour – fracture, i.e. separation of the interface, and contact between the separated surfaces [4]. The starting point is the case of the simple solid-solid phase boundary (e.g. a discontinuity in material behaviour), which is first generalised to fracture (crack opening), then generalised to contact. The contact case is considered separately and provides an additional challenge because the contact points might not coincide in the reference configuration of the material. From the numerical point of view, two goals are addressed here. The first goal is to ensure that any incremental generalisation of the approach contains a prior approach as a particular case, i.e. the phase boundary problem is a particular case of the fracture problem, while the latter can become a particular case of the contact problem under certain specific conditions. The second goal is to ensure that the weak form obtained for the contact problem is symmetric with respect to the choice of the contact surfaces for the integration. The presentation of the method is followed by a number of numerical examples highlighting the applicability of the approach.

References

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