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3D CRACK PROPAGATION WITH THE XFEM AND A HYBRID EXPLICIT-IMPLICIT CRACK DESCRIPTION

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ABSTRACT

Typical simulations of crack propagation can be structured into (at least) two major fields that are treated successively throughout the computation: Field 1 is the approximation of displacements, stresses, and strains in the domain based on a *given* crack. Field 2 is the determination of the crack increment, i.e. crack angle and length at the crack tip (in 2D) or along the crack front (in 3D) and the update of the overall crack geometry. Depending on whether quasi-static or dynamic crack propagation is considered, the simulation is carried out in pseudo-time or physical time, respectively.

The XFEM has proven its potential in addressing field 1 in numerous publications [1]; that is, the XFEM is able to achieve accurate and efficient approximations of displacements, stresses, and strains in cracked domains where discontinuities and singularities appear within elements. No conceptual challenges with respect to XFEM-related issues such as (i) the definition of the enrichment functions, (ii) quadrature, or (iii) the treatment of additional degrees of freedoms are found when going from 2D to 3D crack propagation. This is particularly true, when the level-set method is used for the *implicit* description of the crack geometry which facilitates the treatment of each of the mentioned XFEM-issues.

On the other hand, field 2, i.e. the crack increment and update, is not easily addressed by the level-set method, especially not in 3D crack propagation. It is very cumbersome to formulate (transport) models for the level-set functions that describe the crack geometry such that they consider for a certain crack increment. Therefore, a method is suggested, which also uses an *explicit* crack description by means of polyhedra (e.g., a triangular surface mesh in 3D) [2]. The crack update is then easily considered by adding new elements along the crack front. In order to maintain the advantages of an implicit description in field 1 (i.e., in the XFEM-part), level-set functions are determined in each propagation step based on the explicit description. In this sense, the crack is defined hybridly by an explicit (master) and implicit (slave) description.

Numerical results are presented in the field of bone fracture and hydraulic fracturing and prove the success of the method.

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