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3D-XFEM modeling of composite materials based on octree subdivion

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ABSTRACT

Since its creation in 1999, the eXtended Finite Element Method (XFEM) has been succesfully used in a large number of engineering applications. Based on the approximation space enrichment, this method is able to tackle and resolve, with a great degree of accuracy, problems involving discontinuties and singularites such as crack propagation or materials intefaces for instance.

In this work, we develop an eXtended Finite Element model with the aim of modeling the mechanical behavior of composites consisting in a hosting matrix in which are embedded inclusions of different shapes, orientations and constitutive materials.

The Levelset method is used to represent both the matrix and the holes (or inclusions). The levelsets can come from a discrete function interpolated on a mesh or from image data's.

The proposed XFEM discretization is based on an adaptive octree partition. The underlying mesh is initially set as a cube that encloses the domain of interest. This cube is split recursively with the aim of capturing accurately the geometry of both the matrix and the holes (or inclusions).

From the ”finite element computation” point of view, each eight-node hexahedral element is split into 6 (or more cleverly into 5) tetrahedra. This simpler shape is used in order to allow a simple integration of shape functions and their enrichement. With this assumption, all non-enriched elements share the same stiffness matrix and only a few templates have to be implemented for the elements that are crossed by an interface. The finite element assembly process is greatly accelerated.

It would be interesting to note that we use discontinuous enrichments only because they allow to speed up the assembly process. In the case of composites modeling, Lagrange multipliers are used for imposing Dirichlet boundary conditions and for re-connecting material interfaces.

In the last part of the work, the efficiency of our XFEM model is evaluated through several discriminating tests. Numerical simulations of materials with inclusions and holes in the 3D case are carried out. Our estimates are then compared with Abaqus finite element computations.

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