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Dynamic simulation of crack propagation in 3D by X-FEM method

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ABSTRACT

This paper presents numerical methods developed in the fast explicit dynamic finite element code EUROPLEXUS of CEA Saclay. A new model of crack propagation has been implemented, using XFEM method for the structure coupled with level-sets methods to represent the crack. Crack geometry is described with two level-sets. The most widely used method to compute level-sets propagation consists in solving Hamilton-Jacobi equations, as described by Gravouil[1]. However this method lacks robustness, even used with a regular finite differences mesh, thus it has been chosen to develop a $3D$ geometric method to update both level-sets.

A local criteria in the edge of the crack, used by Haboussa[2] among others, gives characteristic parameters of the linear fracture. Mechanical equivalent quantities (strain, deformation) around the crack front are weighted by a Gaussian function, which gives more importance to Gauss integration points located near the crack tip. The maximum of the equivalent stress tensor near the crack tip $\sigma_{\theta\theta}$ gives the direction of the crack, and the Kaninen[3] equation gives the crack velocity $\dot{a}$.

Besides, because of the discontinuous displacement field, the numerical integration for elements cut by the crack yields performance issues. Increasing the number of quadrature points is cpu time consuming and quite hard to handle if it is chosen to change the number of points only for elements in the vicinity of the crack. Another approach proposed here consists in keeping constant the number and position of quadrature points and modifying their weights in cut elements to obtain an accurate integration of several reference discontinuous fields.

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