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Explicit dynamics for the eXtended Finite Element Method

Thomas Menouillard[1], **Alain Combescure**[2] **and Ted Belytschko**[1]

[1] Northwestern University
2145 Sheridan Road
Evanston IL, 60208, USA
[tedbelytschko, t-menouillard]@northwestern.edu

[2] LaMCoS INSA-Lyon, UMR5259
18-20 rue des Sciences
69621 Villeurbanne, FRANCE
alain.combescure@insa-lyon.fr

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ABSTRACT

The computation of dynamic fracture has been a challenging domain for many years. The goal is to simulate complex dynamic fracture in short computation times with reasonable accuracy. The eXtended Finite Element Method (X-FEM) [1] aims at avoiding the cost of remeshing during crack propagation. This work focuses on the development on efficient time integration procedures and plasticity models in the eXtended Finite Element Method for explicit dynamics for crack propagation, in particular the difficulties associated with obtaining the diagonal mass matrix and accuracy near crack tip (in plasticity). At first we consider the critical time step and the description of correct dynamic behavior near discontinuity for the mass lumping technique. Song et al. [4] presented a graph of critical time step as a function of the position of crack in the X-FEM element. It shows the first difficulty: the critical time step tends to zero when the crack becomes close to a node. Here a method for a diagonalisation that does not adversely effect the time step is described, it is an extension of Menouillard et al. [2], Moës et al. [3] and Remmers et al. [5]. It is compared to the consistent mass in figure 1 which shows the time

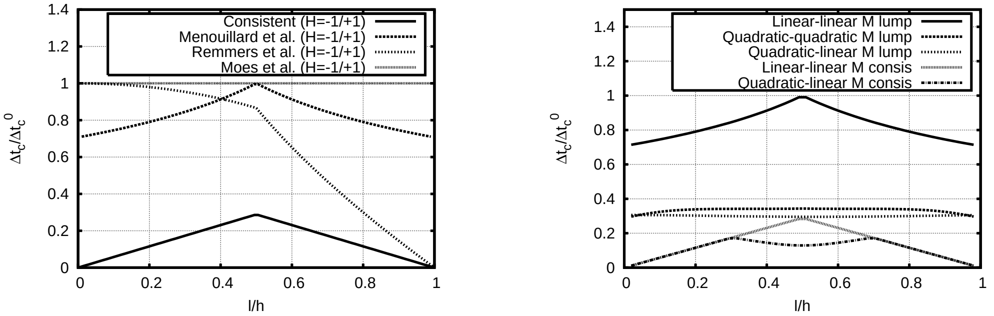

Figure 1: Critical time step as a function of crack position l/h (at left with different lumping techniques, at right with higher order elements).

step for a crack in a one-dimensional element at a distance l from one of the nodes, in terms of l/h, where h is the element size.

Second, quadratic elements are considered. The critical time step for this case is given for different options about the standard and enriched basis. Moreover, not only the critical time step is important, but the kinematic description of the discontinuity must be accurate too. Thus the second difficulty for the lumping technique, consists in describing correctly the vicinity of a crack in a structure when a tensile wave is reaching the crack. Here we consider some higher order descriptions. Note that Menouillard et al. [3] has shown for some lumping techniques, the wave does not propagate through with a discontinuous enrichment function. For example, critical time is given on figure 2 for the enriched function $\psi = r^2$ as a function of crack tip position. Moreover, the use of this additional enrichment should not be too costly. This aims at catching state variables near crack tip (i.e plasticity) more accurately during the dynamic crack propagation. We examine the accuracy of the energy dissipation.

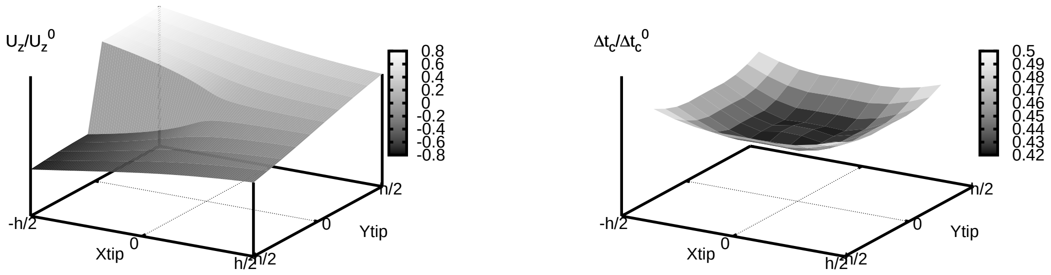

Figure 2: Displacement field (at left) and normalized critical time step (at right), as a function of crack tip position in a linear quadrilateral element containing the crack tip, with the enriched function $\psi = r^2$.

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