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A NUMERICAL APPROACH TO SIMULATE DUCTILE FAILURE WITH MESH ADAPTIVITY WITHIN THE FINITE STRAIN FRAMEWORK

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Predictive numerical simulation of ductile failure is a necessary step in the design of industrial structures for which full-scale experimental approaches are not conceivable (e.g. ductile tearing of an aircraft fuselage). The failure process of ductile materials involves extensive plastic strains together with the nucleation and growth of voids in a localized area whose size is not negligible in comparison with the size of the structure. Physically-based models can be used to describe the failure of the underlying microstructure, which is done in an average sense by means of a damage variable. There are many constitutive models aiming at representing the failure process, but standard local damage models all share the following limitations: (i) solving finite element problems involving material softening leads to mesh dependence; (ii) a continuous description is valid up to the onset of fracture but cannot properly describe the actual surface creation process nor the kinematics associated with crack opening. In this work, a regularized continuous-discontinuous approach is used in order to solve those issues for any type of damage model.

To achieve mesh objectivity, damage evolution is described thanks to continuous non local models [1, 2]. The quality of the finite element results is ensured thanks to an implicit resolution scheme, preferred to an explicit one. During computation, a mesh adaptivity procedure is used to control accuracy and to keep the elements well shaped, which is necessary in the presence of large strains. To minimize error accumulation during transfer, a local remeshing strategy is preferred to a global one. An error indicator is used to determine where mesh refinement is needed and, only in these areas are the fields at the integration points smoothed for transfer. The rest of the mesh is kept unchanged and the fields are thus transferred exactly. To simulate crack initiation and propagation, this mesh adaptivity procedure is combined with a new orientation criterion. This criterion relies on the projected gradient of a smoothed field to determine the orientation of the

next crack increment. The strategy offers the possibility to use any unbounded field which is representative of the material degradation for the determination of the crack orientation (e.g. damage, effective plastic strain,...). This approach allows to simulate crack initiation inside the structure (see Figure 1) which would be impossible with a criterion using an averaged direction toward the most damaged points.

Up to this point, the strategy had only been applied to mode I-II 2D and 3D cases within the small strain framework [3](see Figure 2). This contribution deals with the extension of the methodology to the finite strains framework and the underlying challenges.

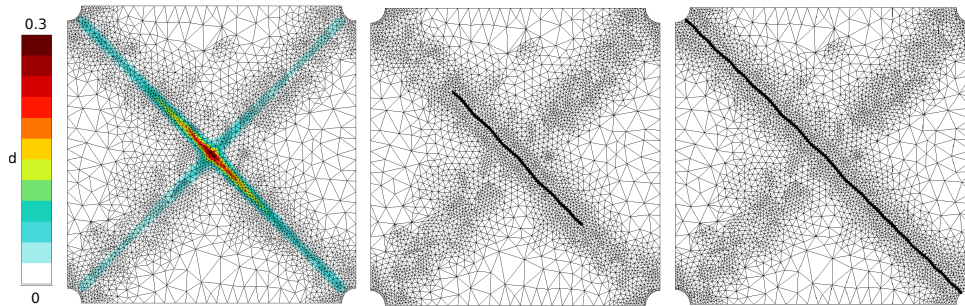


Figure 1: If damage first reaches its maximum value inside the structure (left), a crack initiates inside the specimen and propagates (middle) to finally cut it into two parts (right).

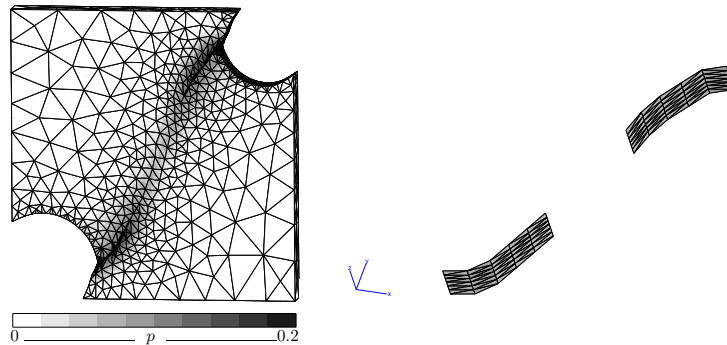


Figure 2: Application to a 3D specimen with mode I-II propagation: the crack surface (right) is consistent with the spatial distribution of effective plastic strain (left)

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