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VECTOR LEVEL SET CONTOURING ALGORITHM AND ASSOCIATED ENRICHMENT FUNCTIONS FOR THE EXTENDED FINITE ELEMENT METHOD

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The Level Set method is now a well established technic to represent embeded closed surface within a mesh not conforming to the surface [1]. It is now comonly used in the context of the eXtended Finite Element Method (XFEM) [2]. Most application of the level set method within the XFEM use a linear per element representation of the signed distance function to compute enrichment function and to cut the elements into integration cells. Thus in the classical Level Set / XFEM Approach, each edge of the mesh can be cut at most once with the surface represented by the Level Set function (single cut). Therefore, the number of cutting patern for simplex elements is quite small and a cutting algorithm is relatively easy to implement. When one want to represent volume with a small thickness embedded in a body, like a small renforced layer, or a thin damaged zone, using linear Level Set, one has to design a mesh that insure that each edge is at most cutted once, meaning that the element size must be small compared to the thickness of the interest zone.

A Vector Level Set Function, is an implicit representation of the surface for which at each node of the discretized volume, a vector is known, pointing to the closest point of the embedded surface as well as an appartenance value that tell if the point is inside or outside of the closed surface. The Vector Level Set Function is therefore a more detailed implicit representation of a closed surface than the classic Level Set. Indeed, it does support edge that are cut twice by the surface of interest. In order to couple this representation of an embedded surface with the XFEM, relevant cutting algorithm have been developped, both for two dimensional and three dimensional mesh. They permit to extract a mesh of the surface which contain only node on the edges of the embedding mesh and build integration cells which are either inside or outside the closed surface. Since each edge can now be cut at most twice, our algorithm is called the double-cut algorihtm. While in two dimensions, the number of cutting patern is easily tractable, in three dimensions we used computational geometry tools in order to pre-build all the different patterns in a

fast access data-base. These off line computation are done once and for all. The "on line" part of the double-cut algorithm, relying on the data base that contains all the topological possibilities, is fast and robust.

The paper detail first the double cut strategy, and discuss some purely geometrical results on the contouring of complex shapes containing thin layers and comparing the results with those obtained using the classical single cut algorithm. In a second part, relevant enrichment strategies, able to represent field discontinuity along the embeded surfaces are presented. Examples of simple mechanicals problem using the double-cut strategy and needing these enrichment are presented. Finally, the Vector Level Set representation, associated to the double cut strategy and the enrichment strategy is used to solve some damage/ fracture transition problem modeled using the Thick Level Set approach (TLS) [3] which was the initial motivation for the presented developments.

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