Some recent advances in remeshing techniques for complex 3D crack growth industrial applications

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Robust and efficient strategies for simulation of cracked structures are of great interest for a wide range of industrial applications.

However, the usual finite element method, which is one of most popular tool for computational mechanics is suffering many limitations that prevent its use to robustly and accurately predict critical damage tolerance analysis of 3D structures.

To tackle those difficulties, the computational mechanics community has developed various methods in order to deliver strategies able to simulate crack growth on complex industrial structures. Thus, alternative techniques, such as meshless methods, boundary element methods, or partition of unity derived methods have been highly investigated.

Concerning the standard finite element approach, recent improvements of meshing and remeshing techniques allow the generation of complex 3D meshes that could be refined in local areas of interest where a crack could propagate. Thus, inserting the discontinuity surface in those refined uncracked meshes became one of the last drawback of those methods. Traditional approaches, usually based on a cracked CSG model, or mesh generation with boolean operations, generally lack of robustness which makes it difficult to deal with complex geometries.

In order to fundamentally push the lines of remeshing based techniques, a new algorithm as been developed. Our approach is mostly based on a fast and efficient crack insertion algorithm. The robustness and quickness of this method is obtained by the way the output cracked mesh is represented (linked to element mesh size near the surface of discontinuity). In fact, each volume element of the input mesh that crosses the crack surface is cut. An important assumption is that the generated surface can be approximate by the polygonal elements built on the input element edges intersection points. Some special treatments are also performed on element faces to carry out the crack front intersection and some topological difficulties that could arise for highly curved cracks. This obtained mesh is finally rebuilt using an adaptive remeshing strategy in order to eliminate bad quality elements and provide a suitable discretization for accurate finite element solution and stress identity factors computation.

This approach has been implemented in the Z-set finite element software co-developed by Onera. This technique has already been successfully applied to some complex 3D cracked structures mesh generation and used to treat very efficiently various 3D crack growth simulations in the context LEFM for industrial structures (with even multiple coalescing cracks), adaptive cohesive zone modeling and damage to fracture transition.