From CAD and digital imaging to fully automatic and adaptive stress analysis

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Abstract

This presentation focuses on the recent development of the scaled boundary finite element method and its application with quadtree/octree mesh generation algorithm to achieve a fully automatic and adaptive procedure for engineering analysis. The process includes the mesh generation from CAD models or digital images, stress analysis of the numerical models, error estimation and adaptive remeshing.

The scaled boundary finite element method was originally developed for elastodynamic analysis of unbounded domains. It was later applied successfully to solve stress singularity problems in fracture mechanics. In these situations, the problem domains are often modelled as one or a few subdomains. Mesh refinement is typically performed by increasing the number of elements at the boundary. Most of the studies were limited to problems of simple geometry.

The scaled boundary finite element procedure has recently been extended to develop polytope (polygon in 2D and polyhedron in 3D) elements. The polytope elements may have arbitrary number of faces/edges as long as the scaling requirement is satisfied. They provide a much higher degree of flexibility in mesh generation than standard finite elements do. The semi-analytical solution of the displacement and stress fields leads to the development of a simple error estimator.

The quadtree/octree algorithm for mesh generation complements ideally the polytope elements based on the scaled boundary finite element technique. The octree algorithm provides an efficient approach for automatic mesh generation of CAD models and images and for adaptive refinement. The existence of finite number of unique octree cells reduces significantly the computational cost on element analysis. The use of polytope elements overcomes the difficulties faced by octree mesh on treating hanging nodes and curved boundaries. Numerical examples will be presented to demonstrate the accuracy, efficiency and robustness of the proposed procedure. Potential applications and extensions will be discussed.

Keywords: Scaled boundary finite element method, Polygon elements, Adaptive analysis, Image-based analysis, Quadtree, Octree.