Stress Analysis of Complex Geometries by Implicit Surfaces and the Scaled Boundary Polyhedral Finite Elements

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Abstract

Most of computer aided engineering analysis methods are based on a descretization process where the engineer with the aid of sophisticated CAE tools, creates the mesh for methods such as finite elements. Using these tools are complex and time consuming. For three dimensional complex geometries where most of difficulties occur, the elements often have to be in the shape of tetrahedral or hexagonal volumes. This is one of the main reasons of hindering the full automation, adaptive methods, moving boundary problems and imposing huge pre-processing costs during an engineering analysis. A great deal of simplicity can be therefore achieved if polyhedral shaped elements can be directly processed.

We present a formulation for an arbitrary shaped polyhedral element that is based on the Scaled Boundary Finite Element Method (SBFEM). Only the surface of the polyhedra should be discretized using ordinary finite element shape functions. Firstly, for pre-processing we use an octree mesh and define our geometry using signed distance functions to the nodes of the otcree cells. Secondly, based on the signed distance functions, we cut the octree cells to form the actual geometry. The cutting process can be an outer surface of the solid, inner surface of an inclusion or a material boundary. Next, we then present a simple method to verify if the resultant polyhedrons of the cutting process fulfil the scaling requirement (the whole boundary is directly visible from the scaing centre) of the SBFEM. Then, through several simple to complex numerical examples, we study the robustness and convergence behaviour of the method. We finally conclude that the presented method can be considered as a fully automated meshing approach meanwhile maintaining its accuracy in comparison to its conventional counterparts such as finite elements.

Keywords: Scaled Boundary Finite Elements, SBFEM, Automated Analysis, Implicit Surfaces