

Finite Element Mesh Generation and its Applications

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ABSTRACT

Over a few decades of research and development, the finite element method (FEM) has well established its place in providing useful numerical solutions to practical engineering problems, ranging from solid mechanics, fluid mechanics, structural mechanics to the more challenging bio-engineering mechanics systems. The rapid increase in computer speed along with a significant price cut in powerful computing machines enable realistic engineering structures to be analyzed by the FEM employing thousands of node points.

As the concept of the FEM is based on the decomposition of a continuum into a finite number of subregions (elements), the pre-requisite for an effective use of the method is an automatic procedure for a sound discretization of the structure into valid elements. After more than three decades of development, the mesh generation algorithms for FEM have now reached a quite mature stage on many fronts, in particular, the problem of mesh generation on 2D planes and over curved surfaces can now be considered as completely resolved. Over the volumes, the discretization of complex solid objects into tetrahedral elements can be achieved almost in an automatic manner even for the most complex industrial and bio-medical systems.

Even though some of the mesh generation techniques are applicable in more than one geometry, the paper basically follows the order of mesh generation on 2D domains, over curved surfaces and within volumes. Within this framework of classification based on geometrical dimensions, the techniques are further divided into the generation of simplex elements (triangles in 2D and tetrahedra in 3D) and non-simplex elements, such as quadrilaterals, hexahedra, etc. The two most popular methods for FEM mesh generation, namely the Delaunay triangulation and the Advancing Front Approach, are described in full details.