SKELETON-BASED COMPUTATIONAL METHOD FOR GENERATION OF 3D FINITE ELEMENT MESH SIZING FUNCTION

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This paper presents a computational method for generating a 3D finite element (FE) mesh sizing function using a discrete medial surface, or skeleton. The desired FE mesh size at a point depends on geometric properties such as the proximity between geometric entities, feature size, and surface curvature. The transition of the element size should be smooth, i.e., the gradients of a sizing function should be continuous. This paper focuses on generating mesh sizing function for geometry-adaptive 3D FE mesh; it does not consider physics-based factors such as boundary layer, cracks, etc.

Unlike previous methods, the proposed method uses medial axis transform (MAT) as it measures the proximity between geometric entities and detects feature size. The MAT is defined as the locus of the center of the maximal sphere as it rolls inside a solid along with the associated radius function. As the generation of continuous MAT is expensive, a discrete medial is used to study the interior complexity, and radius of curvature is used to study the boundary complexity of a solid.

A discrete MAT generation and interpolation of sizing function are the two main steps in the algorithm and are discussed in the following paragraphs. A discrete medial is generated by propagating a wave on a voxel model of an input solid. The wave front propagates from the boundary towards the interior in a layered pattern and meets the opposite front at a medial point. If the maximal ball at a medial point touches adjacent faces of the solid, then that medial point is not considered. This eliminates medial surface patches that touch the edges and vertices; thus, avoiding excessively fine mesh around every edge and vertex. The radius of a medial point is calculated using the Manhattan distance metric. The medial points along with its radius function, become source points for the interpolation of the sizing function.

The sizing function is then interpolated at every grid node of the voxel model using the source points. These source points can be medial-based as discussed above, curvature- based, or user-defined. A source point is defined by its center, size, radius of scope, and local gradient function. The radius of scope of all the source points is calculated using the radius function of MAT, which is a measure of local thickness of the solid. The gradient of the final sizing function is controlled by the local gradient function of the source points and the interpolation scheme used. The sizing function is stored using the grid [2] rather than using a background mesh [1]. Using a voxel grid, size at a point can be calculated quickly. As the voxel-based medial may miss small features, work is under way to develop an octree-based medial to make the algorithm more robust.

References

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