MODIFIED ADVANCING-FRONT METHOD FOR A ROBUST GENERATION OF 3D INITIAL MESHES

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Abstract — **Several methods to generate tetrahedral meshes for the finite element method exist. However, a method with a guarantuee of progress of the iteration is still recommended. The presented algorithm constructs a coarse initial mesh from a given boundary mesh. The algorithm uses a modified advancing-front approach.**

I. INTRODUCTION

For the calculation of electromagnetic fields using the finite element method, an adaptive solution procedure is recommended. Several methods for mesh generation exist ([1],[2],[3]). The problem investigated in this paper is the generation of an initial tetrahedral mesh starting from a given boundary surface triangulation. One well-known approach is the use of an advancing-front scheme. This algorithm does not always yield a valid mesh, unless nodes are inserted inside the volume. The presented algorithm is a modified advancing-front method containing a proof, that per iteration step, at least one valid tetrahedron can be formed.

II. ORIENTATION OF A TRIANGLE

Consider a triangle in space. The three vertices have a local node number: 1, 2 and 3. They determine the orientation of the normal direction to the triangle, i.e. if one considers the edges 12 and 23 and makes the vector-product of these edges, one unique side of the triangle is determined.

III. THE ALGORITHM

One closed volume is considered at a time. Volumes are allowed to be non-convex and multiply-connected. The normals of the front have to be oriented to the inside of the volume. This property has to be maintained when the front is updated.

One iteration step consists of the 4 basic operations:

1. Consider an arbitrary triangle from the front.
2. Construct the line perpendicular to the face and through the centerpoint of the triangle.
3. Find the nearest intersection of that line with any of the triangles in the front, causing the newly formed line segment to start at the inside of the volume. This can be verified using the orientation property of the triangles.
4. A new node is inserted in the middle of this line segment. This node must be inside the volume, otherwise there should have been a closer intersection or the orientation of the triangle was wrong.

After a node has been inserted, all valid tetrahedra are formed. In the worst case (Fig. 1) in which not one single valid tetrahedron could be constructed, the distance between the new node and the considered triangle is halved until at least one valid tetrahedron can be inserted. As the node approaches the triangle, there has to be a situation where the triangle is fully visible and a valid tetrahedron can be formed. Also, when the node had to be moved, all possible valid tetrahedra must be inserted.

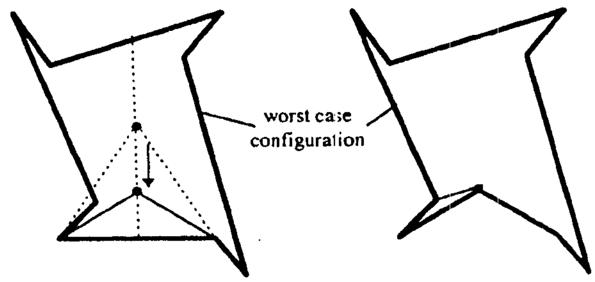

Fig. 1: Repositioning of the inserted node and updating of the front.

It is obvious that with the considered triangle, at least one valid tetrahedron can be formed. This means that the algorithm has a guaranteed progress since the non-discretized volume decreases.

For convex volumes, the algorithm stops after one iteration step. The quality of the inital mesh can be improved by applying a Laplacian smoothing technique, face-edge swapping or by inserting extra nodes.

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