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Quad-dominant mesh improvement using medial axis

Phil Sikorski*[,a] , Tobias Krenz [a]

[a]*Beuth Hochschule für Technik Berlin - University of Applied Sciences, Department II, Luxemburger Str. 10, 13353 Berlin, Germany*

Abstract

Automatic mesh generation is part of many applications and everyday work of an engineer. To optimize the generation and minimize the manual post processing, we use the medial axis to find problematic areas. We then create feature lines for the mesh generation. These feature lines are bound by certain restrictions given by quality criteria.

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Keywords: delimitation of areas; voronoi; medial axis; mesh improvement; quad-dominant meshes

1. Introduction

In this work, we want to improve the automatic mesh generation for two dimensional quad-dominant meshes. To realize our goal, we first have to look at the quality criteria for quad-dominant meshes. We especially choose the criteria catalogue from HyperMesh by Altair Engineering Inc.

2. Quality Criteria

In this part we present a few quality criteria we take in consideration for our feature line creation. It is crucial to create them in a way they would not interfere with a good quality mesh. The main purpose is to help the mesh generation at problematic areas. All of the criteria and how they are calculated is described in the Student Guide from Altair University [1]. All element quality checks are categorized in different acceptance values.

* Corresponding author. *E-mail address:* phil.sikorski@beuth-hochschule.de

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2.1. Aspect Ratio

The aspect ratio is the division of the side with the maximum length and the side with the minimum length.

2.2. Warpage

A quad element will be split into two triangles and then the quad will be split again using the other corners. The maximum angle created from the two triangles is the warpage.

2.3. Skewness

Skew is calculated in different ways for triangle and quad elements. It is the minimum angle between a vector from each vertex to the midpoint of the opposing side and the vector between to midpoints of two adjacent sides for the calculation for a triangle. For quad elements it is just the minimum angle between the two lines of joining the midpoints of opposing sides. The skew is finally calculated 90° minus the angle α.

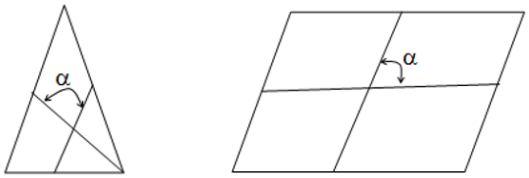

Fig. 1. Angle in triangle (left) and quad (right) element.

2.4. Overview

In this overview you find more quality criteria which will be included in the calculation of the quality index in HyperMesh.

Table 1. Overview of mesh quality criteria in HyperMesh.

Criterion	Ideal Value	Acceptable
Aspect Ratio	1.0	< 1.3
Warpage	0°	< 10°
Skewness	0°	< 45°
Jacobian	1.0	> 0.6
Distortion	1.0	> 0.6
Stretch	1.0	> 0.2

3. Feature Line Construction

The basis is a 2d surface of which we compute the medial axis. All we need are the outer and inner loops of the surface. Then we create the Voronoi diagram described in [4]. This Voronoi diagram is made out of Bisectors which can be divided into three different types, shown in Fig. 2.

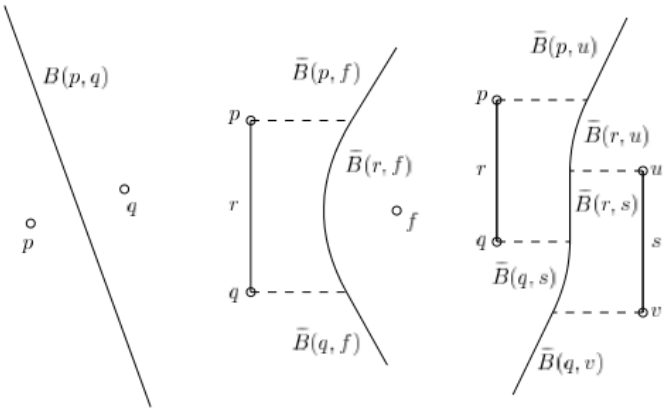

Fig. 2. Three types of Bisectors [4].

The three types are Point-Point-Bisector (left), Point-Line-Bisector(middle) and Line-Line-Bisector (right). The categorization helps to find some important feature lines. We found two separate approaches to get a better mesh.

3.1. Area distinction

We use the Line-Line-Bisector to create rectangular areas. In these areas the mesh generator will create an almost perfect quad mesh. If the origin lines of the Bisector are parallel they are used to find the biggest area surrounded by these lines like shown in Fig. 3.

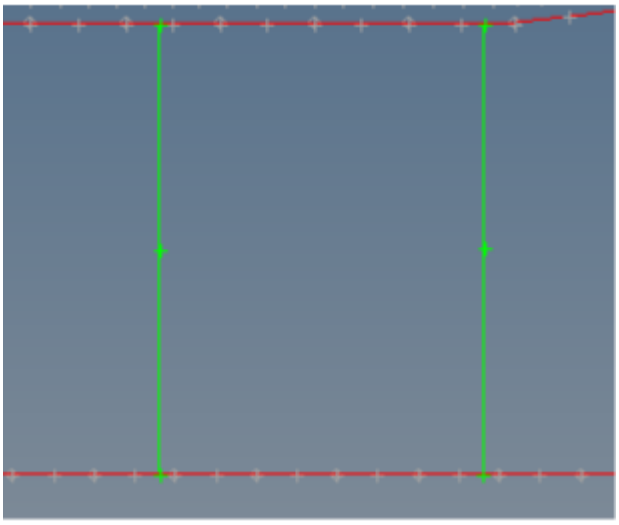

Fig. 3. Rectangular area found with a Line-Line-Bisector

3.2. Bottleneck

To find bottlenecks we utilize the Point-Line-Bisectors. The medial axis is linked directly to the distance from both sides and we can easily find the exact point for the bottleneck. The loops will be approximated with linear parts. Fig. 4 shows that we try to create the feature line in a way it is orthogonal to one of the origin line.

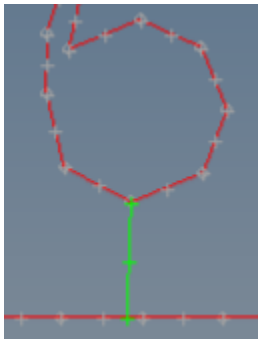

Fig. 4. Feature line for a bottleneck.

4. Conclusion and Future Work

In Fig. 5 you can see a slight improvement in the marked areas. Actually it is a 15 % improvement in quality index for this particular example. There are just 9 failed elements after creating the feature lines. The rectangular areas are pretty good in terms of meshing quality for structural meshes. The feature lines for the bottlenecks help the meshing algorithm to avoid creating triangles.

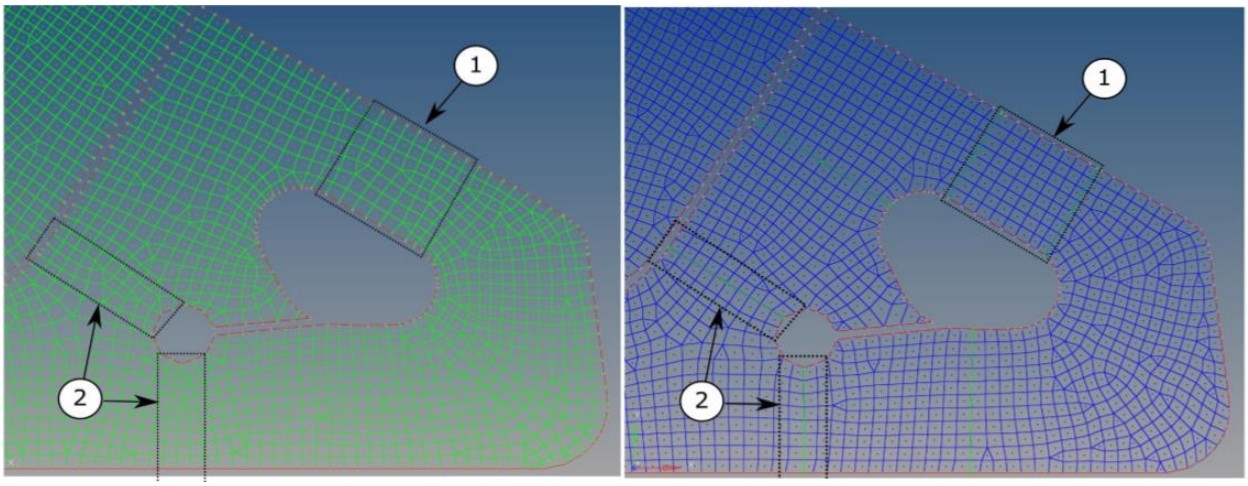

Fig. 5. Standard mesh (left) and optimized mesh (right).

Future tests with more practical example need to be made to confirm a better mesh generation and improve the algorithmic strategies to find feature lines. We also need to test this method with other meshing software.

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