Untangling High-order Curvilinear Triangular Meshes Via an Angular Approach
IX International Conference on Adaptive Modeling and Simulation – ADMOS 2019

Mike Stees† and Suzanne M. Shontz*

† Department of Electrical Engineering and Computer Science
Information and Telecommunication Technology Center
University of Kansas
Lawrence, KS 66045 United States
email: mstees@ku.edu, web page: https://www.linkedin.com/in/mikestees

* Department of Electrical Engineering and Computer Science
Bioengineering Program
Information and Telecommunication Technology Center
University of Kansas
Lawrence, KS 66045 United States
email: shontz@ku.edu, web page: http://people.eecs.ku.edu/~shontz

ABSTRACT

High-order finite element methods have increased in popularity due to the additional accuracy which is obtained by increasing the polynomial degree of the basis function associated with each mesh element. This requires a corresponding elevation of the polynomial degree of linear meshes. High-order meshes can then be used to represent a curved geometry with many fewer elements and hence when coupled with high-order finite element methods results in a computational savings.

In order to generate high-order meshes, the linear mesh elements are elevated to the specified polynomial degree. This requires the addition of nodes on the element edges and interiors. The newly added boundary nodes are then projected onto the exact boundary of the curved geometry. Finally, the interior nodes are moved to their final positions using a deformation technique. This procedure often results in a mesh with invalid elements near the boundary and/or elements that are of low quality. Hence the mesh curving procedure typically requires the use of a mesh untangling and/or mesh smoothing method as the final step.

In this talk, we will present our method for untangling high-order curvilinear triangular meshes [1]. Our approach is a local edge-based optimization method for untangling high-order curvilinear meshes based on the unsigned angles of curvilinear triangles. For each interior mesh edge, two triangles which share the edge are identified, and their distortion is then computed. For each pair of triangles with a negative minimum distortion measure, an unconstrained optimization problem is then solved with the goal of minimizing the sum of the unsigned angles adjacent to the mesh edge.

Our optimization-based method for untangling high-order curvilinear triangular meshes is a heuristic which has been used successfully to untangle second- and third order meshes with invalid elements. Several numerical examples in two dimensions will be presented which demonstrate the capabilities of our method. Future work will include exploring the use of signed angles and extending our method to untangle curvilinear high-order tetrahedral meshes.

REFERENCES

[1] M. Stees and S.M. Shontz (2018), An angular approach to untangling high-order curvilinear triangular meshes, Proc. of the 27th International Meshing Roundtable.