BOUNDARY GENERATION METHODS FOR OPTIMAL 2D DELAUNAY TRIANGULATION

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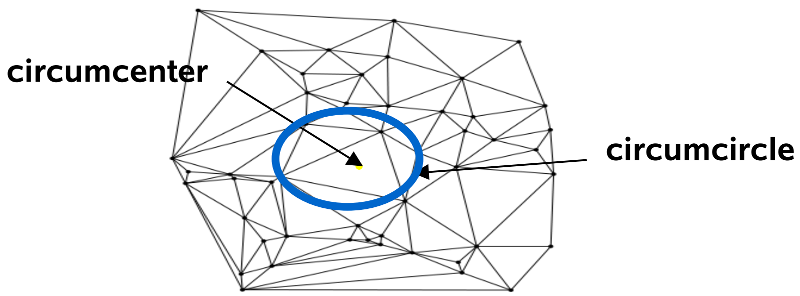
ABSTRACT. We examine current methods for choosing the boundary of an image in order to allow for an optimal Delaunay triangulation, as well as present pseudocode of new potential methods for boundary generation. One method, the Offset Boundary method, generates a smoothed boundary while adhering to the fidelity requirement; once the boundary is generated an optimal triangulation can then be created using traditional Delauany methods.

INTRODUCTION

Mesh generation is a crucial building block in the finite element studies involved in aircraft design and evaluation. These studies assist in evaluation of the properties of models and the materials under various pressure, temperature, and deformation conditions. One of the most popular methods for triangular mesh generation is the Delaunay mesh generation algorithm, which generates triangulations in which no point lies inside the circumcircle of any triangle.



MOTIVATION

Our research can be related to the use of x-ray systems to inspect aircraft for cracks and other deformations. According to Ryan Ghem of Aerospace Engineering magazine*, NASA is using new technology created by Digitome, enabling them to look through shuttle wings and jet-engine turbine blades to see defects that would be invisible to the current imaging systems. Digitome has developed a method of inspection using nondestructive penetrating radiation, typically x-rays, that produces raster images, which are a major input for the Delaunay mesh generation algorithm. The development of image to mesh conversion tools for these and similar inputs is the focus of our research.

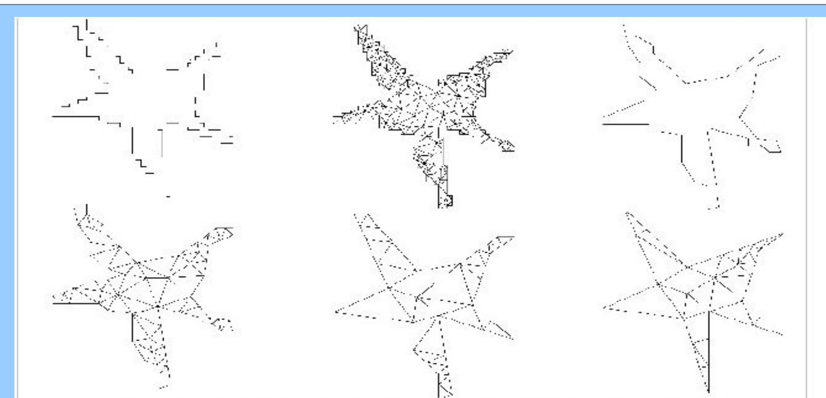
*Ryan Gehm. Digitome 'Sees' Defects for NASA. Aerospace Engineering: Tech Focus, p. 23. April 2005

CURRENT METHODS

The Trivial method distinguishes the boundary of a pixelized image from the exterior and creates a triangulation that adheres to this boundary. The triangulation output of this method is comprised of too many triangles.

The Line-Simplification method begins with the pixelized image boundary of the Trivial method and applies the Douglas-Peucker algorithm, which smoothes the pixelized lines to a user-specified tolerance level. This method results in poor quality elements in the triangulation output.

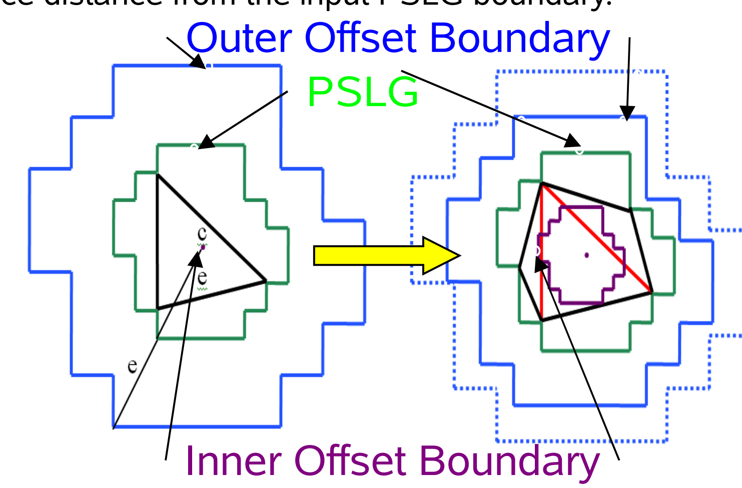
TESTING. In order to test these methods, we implemented Triangle, the quality mesh generator created by Jonathan Shewchuck.



(Top Left) Original image. (Top Middle) Triangulation of original image. (Top Right) Image after line-simplification with tolerance 1.0 (Bottom Left) Triangulation. (Bottom Middle) Triangulation of image with tolerance level of 2.0. (Bottom Right) Triangulation of image, tolerance of 3.0.

NEW METHODS

The **Bounding Box method** begins with a PSLG bounded in a box containing many poor quality triangles. If a PSLG point lies within the selection disk of a chosen triangle, the point is inserted. The bounding box is then refined. This algorithm terminates when no poor quality triangles remain. **The Offset Boundary method** begins with the creation of an outer offset boundary and inner offset boundary. An initial mesh is created, which consists of one triangle. Each loop of the algorithm shifts the offset boundaries towards the input PSLG. If a mesh edge intersects the new offset boundary range, a new point is inserted. The algorithm terminates once the inner and outer boundaries are a certain tolerance distance from the input PSLG boundary.



CONCLUSIONS

The current methods do not produce boundaries which provide for optimal triangulations. Hybrid methods are more promising; we have developed algorithms for two hybrid methods. One in specific, The Offset Boundary method, guarantees that the fidelity requirement will be met. **Future work** in this area includes implementation of the Offset Boundary method and supplementing the Bounding Box method with an algorithm that creates additional poor quality triangles during the refinement process.