Genetic Algorithms, Another Tool for Quad Mesh Optimization?

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Abstract

The purpose of this paper is to investigate the use of a genetic algorithm (GA) to perform the finite element analysis mesh smoothing process. It is the goal of this paper to take a simple quadrilateral mesh and smooth it using a GA into a useful model that will provide a correct solution. The GA smoothing technique is demonstrated on two simple quadrilateral mesh examples. Only one node is moved at a time in the examples.

A distortion metric is used to quantify the "goodness" of a quadrilateral element and serves as the fitness function for the GA. Other implementation details such as convergence criteria, population size, cross-over probability and mutation rate are discussed in the paper. Early results from the two simple check problems are presented. Finally, planned future work is outlined and possible GA smoothing applications are discussed.

Keywords: Genetic Algorithm, Artificial Intelligence, FEA Mesh Smoothing, Mesh Optimization

1. Introduction

The goal of most finite element analyses (FEA) is to verify the suitability of an engineering design. The challenge is to build a sufficiently accurate model in the available time. One of the most time-consuming tasks in building a finite element model is generating and optimizing the finite element mesh.

Many algorithms have been developed to create the elements of the model, a process called meshing, but the meshes are often constructed of poorly shaped and thus error prone elements. Smoothing, a technique of correcting the poorly shaped elements, is an emerging science with several useful methods available. No one smoothing technique works all of the time.

It is the purpose of this paper to explore the use of a simple genetic algorithm (GA), an artificial intelligence (AI) method, to control the execution of the smoothing process. GAs will take longer to run than most conventional methods such as Laplacian smoothing but may prove useful for smoothing difficult meshes (non-convex meshes for example). This paper describes application of a GA to smooth a poorly formed simple convex quadrilateral mesh. Future work includes application of a GA to solve a non-convex mesh and other more complex meshes. The final goal of this project is to apply GAs to smooth non-convex 3D surfaces. It is hoped that GA smoothing may ultimately be able to smooth hexahedral meshes.

Quadrilateral Elements Quadrilateral elements are more accurate, in general, than triangular elements for 2D stress analysis. For the same reasons, hexahedral elements are more accurate than tetrahedral elements for 3D stress analysis, especially when working with materials with a high Poisson's ratio such as rubber (Key, 1997). Quad and hex meshes are harder to generate than comparable triangle and tet meshes.