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11/23/13
MATH 198
Proposal

Topology Optimization

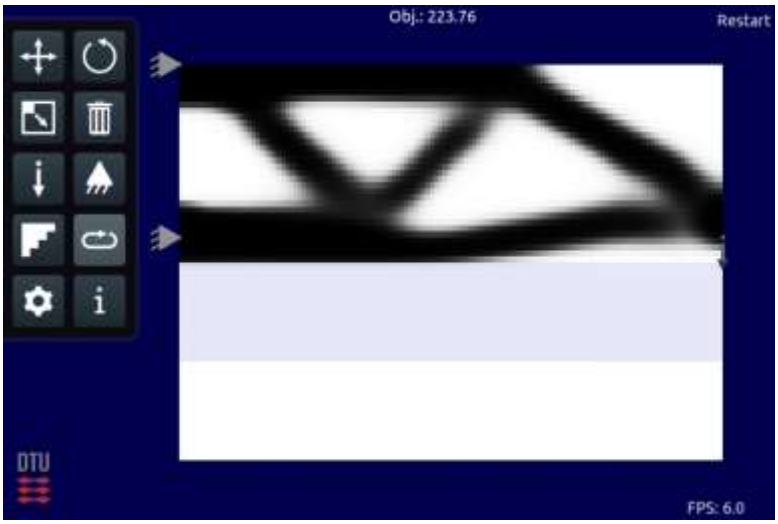
Abstract

Current methods of Topology Optimization use series of differential equations to model stress and strain on millions of infinitesimal elements of a single solid. This process is repeated hundreds of times, following one of many optimization algorithms. Large clusters of computers working in parallel take hours to optimize a small part.

The goal of this project is to create a simplified version of the Topology Optimization process. A Java RTICA will be created which uses only basic concepts of physics and mechanics. The RTICA's "toy physics" will approximate the results of programs that utilize more sophisticated models of physics. The program will consist of three main elements, to be explained below.

Graphical User Interface

The GUI of this project will be constructed from Java, using *Zen Graphics* (Angrave, 2010). The display and control will be designed to imitate *TopOpt*, an iPhone application (Aage *et al, 2013,* figure 1). The most basic controls of this program will allow a user to move the forces used in the analysis. An expanded version of the program would feature similar customization for supports, material controls, and options for specifying optimization parameters. This GUI will be created only after other elements of the program are completed.



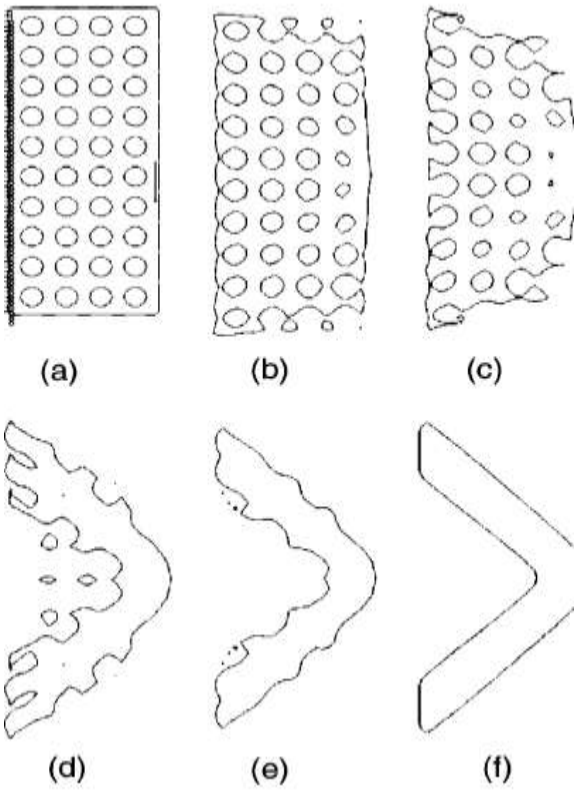
***TopOpt* iPhone Screenshot**
(Figure 1)

Finite Element Analysis

The finite element analysis used in this project will be created using a simulated GUI testbed. The creation of the F.E.A. will be one of the more challenging aspects of this project, and thus time constraints require that it be designed before the GUI is completed. The F.E.A. will be designed entirely using simple physics concepts.

Optimization Process

The material will be optimized using a Level Set Algorithm (Bendsoe & Sigmund, 2003, Figure 2). This method will operate by altering material along the boundary of material. Boundary material under low stress will be removed, and boundary material under high stress will be reinforced with additional material.



Topology Optimization by Level Set Algorithm
(Figure 2)

In terms of programming, while the vast majority of the code will be original, ideas could potentially be from published Matlab code (Sigmund, 2001). Sigmund's 99 line program is effective, but due to its compact nature difficult to read.

Timeline

While exact dates are difficult to predict, the order of this project is mandated by the interconnectedness of its three parts, and will be as follows:

1. Simulator GUI created
2. F.E.A. created and tested
3. Optimization algorithm created and tested
4. GUI fully designed

Results

This project will be publicized through four primary means. First, a twenty minute demonstration of the program will be prepared. A webpage will be created for viewing of the main aspects of the project. The annotated code and application will be placed into the MATH 198 repository for distribution. Finally, a LaTeX PDF will be prepared describing the results of this project.

References:

Aage, Niels, Morten, N. J., Casper, A. S. & Signmund, O. (2013) *Interactive Topology Optimization on Hand-held Devices.* Structural and Multidisciplinary Optimization, 47, 1-6. http://dx.doi.org/10.1007/s00158-012-0827-z

Angrave, L. (2010). *Zen Graphics* [Java Class]. Publisher: Author.

Bendsoe, M. P., & Sigmund, O. (2003) *Topology Optimization: Theory, Methods, and Applications.* New York: Springer Publishing.

Signmund, O. (2001). *A 99 line topology optimization code written in Matlab*. Structural and Multidisciplinary Optimization, 21, 120-127. http://link.springer.com/article/10.1007/s001580050176#page-1