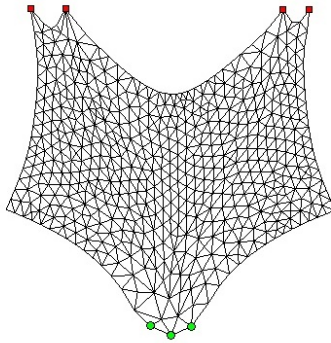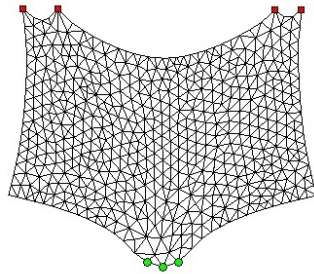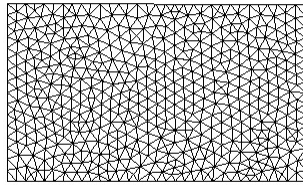# Triangulation Program

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1 Introduction

1.1 What Does This Thing Do?

The main purpose of this program is to create and manipulate two dimensional triangle meshes. Through this program you will first be able to design any closed polygon shape by clicking out its vertices in a clockwise or counter clockwise fashion. After creating your shape, you can divide it into your chosen number of triangles. Finally, the program gives you the tools to fix boundary points and apply a force to this mesh. You can choose the intensity of this force and the number of times you'd like to apply it in increments. This creates either a single image or multiple images which you can save as a JPEG or GIF respectively.

1.2 Installing and Running

After downloading and unzipping the file, add it to your MATLAB working directory. To run the program make sure you are in the meshMaker folder so that you see meshMaker.m and the three folders described below. Now enter "meshMaker" into the MATLAB command line and the GUI will open.

2 Program Portions

2.1 meshMaker.m

This is the script which calls the main function of the program. As stated above, to run the entire program simply type "meshMaker" into the MATLAB command line and press enter.

2.2 customFunctions Folder

When applying a force to your mesh you can select one of my nine premade functions or enter the name of a custom function that you have made. If you have gone with the latter, then you will have to put your function in this folder. For more details on how to format this function see **Choosing a Function**.

2.3 saveFiles Folder

All of the saves that you make while using the program will automatically be saved in this folder. If it is just an image, the file will be saved as a JPEG with the name that you specified. However if you save a video, a folder will be made with your chosen name. Inside the folder will be both the GIF of the full animation and each image as a JPEG. Each will have the same name that you specified and the image names will be indexed in their numerical order.

2.4 supportFiles Folder

This folder contains all the files that are responsible for running the program. These files are separated into three sections: plotting, triangulation, and finElements. To view or make changes to any aspect of the program simply choose the folder that corresponds with your area of interest. For more information on the purpose of each file simply type "help filename" in the MATLAB command line to learn more.

3   Mesh Creation

3.1   Starting a New Plot

After opening the GUI you will be presented with a blank graph and a grid of buttons. To begin creating your shape, first decide if you'd like to draw it out in a clockwise or counter clockwise fashion. Keep in mind that in order to make a closed polygon you cannot cross over any lines. The program will keep you from doing so automatically but it helps when drawing your shape to remember this.

To begin drawing, click either of the **Start Plot** buttons. After doing so, crosshairs will appear over your cursor and you can begin clicking the graph to place the vertices of your shape. The edges between each of your clicks will automatically be drawn as solid lines, and a dotted line will indicate what the final edge (that which bridges the gap between your first and last vertex) will look like. When you are satisfied with your shape, including the dotted line, just hit enter and it will be finalized. If at any point you are unsatisfied with your polygon, simply hit enter to finalize your plot and click **Start Plot** to begin again.

3.2   Adding Triangles

Now that you have a closed polygon, you can parse it into the number of triangles that you want. Change the number of triangles from 0 to a number you wish and hit **Triangulate (Auto Shift)**. After it is done loading, you will have a mesh of your desired density or close to that which you requested.

The reason it could not have exactly the number of triangles you asked for has to do with the triangle addition algorithm that was used. To explain it briefly, when attempting to add one additional triangle to the mesh, the program will find the triangle with the worst quality and bisect it, thus creating one extra triangle. However we are already at the worst triangle, so to save time if it has a neighboring triangle on its longest side we will extend the bisection to cut the neighboring triangle as well. This massively increases the speed and efficiency of the program but just eliminates the ability to hit exactly the number of triangles desired every time.

3.3   Vertex Shifting

Vertex shifting is the process of repositioning a vertex shared by many triangles such that it increases the quality of all the triangles attached to it. By using the **Triangulate (Auto Shift)** button, the program will do this for you. However if you would like to control the shifts yourself, just add triangles with the **Triangulate** button and then use the **Vertex Shift** button afterwards.

You can even choose which vertices you would like to target by changing the value which determines the number of triangles a vertex has to be a part of in order for it to be eligible for a vertex shift. The default value for this will be three as this will make all vertices able to shift (any interior vertex of a shape with at least three sides must have at least three line segments attached to it). Feel free to use this button multiple times, even after triangulating with auto shift, and watch the quality of the mesh increase.

3.4   Window Properties

To better see your ideal mesh, I added the ability to change the viewing window. You can choose exactly what you would like the **xMin**, **xMax**, **yMin**, and **yMax** to be and then make these changes by hitting **Set Axis Manually**. To shift the window with the mouse, use **Click New Origin** and utilize the crosshairs to indicate where you would like the new center of the graph to be. Finally you can use **Zoom In** and **Zoom Out** to better see your mesh and **Axis On/Off** to toggle the blue axis in the background.

3.5 Saving Your Mesh

Now that your mesh is finished edit the **Name** field and click **Save Image**. Your mesh will be saved as a JPEG with your chosen name in the saveFiles folder. If you use the same name of a file already in the folder it will overwrite it.

3.6 Apply Forces!

With your custom mesh you can now manipulate it by clicking **Apply Forces Using Finite Elements**. This will close your mesh creation window and open a new one with more buttons and options detailed below.

4 Applying Forces

4.1 Setting Boundary and Force Points

Before you apply a force to your mesh you have to choose which vertices will be fixed in place and which will receive the force. You must choose at least two boundary (fixed) points and one force point. To begin selecting the boundary click **Select Boundary**. Crosshairs will appear which will help you click all the points in the mesh that you would like to fix, these will turn red. If you make any mistakes just reclick the point and it will be removed from the boundary. When you are satisfied with your selection hit enter. To instead make all available points part of the boundary use the **Toggle all Boundary** button. Click this again to remove all the points from the boundary. Similarly, for the force points the buttons **Select Force Points** and **Toggle all Force** work exactly the same, coloring vertices chosen green instead of red.

4.2 Choosing a Function

Use the drop down menu to pick from nine premade functions or a tenth custom function option. Below is a short description of each of these forces.

Name	Purpose
fUp	**Will apply a force upwards** .
fDown	**Will apply a force downwards**
fLeft	**Will apply a force to the left**
fRight	**Will apply a force to the right**
fHorzPinch	**Will apply a force to the right if a point is to the left of the origin, and a force to the left if a point is to the right**
fVertPinch	**Will apply a force downwards if a point is above the origin, and a force upwards if a point is below**
fOut	**Will apply a force away from the origin**
fIn	**Will apply a force towards the origin**
fSpin	**Will simulate a clockwise spin by applying different forces to each quadrant**
fCustom	**Will apply your custom function**

4.3 Go!

Now it's finally time to see the result of the force. Start with **Single Step Force** to test your current **Constant** value. Hit **Go!** and watch the mesh become altered by the force function you chose. If the results are not as desired, hit **Reset**, adjust the **Constant**, and try again. Once you have found a constant that works for your specific mesh and force function, you are ready to move onto a **Multi Step Force**.

This allows you to apply the force as many times as you want in increments of the **Constant** you found above. For example if you did a **Single Step Force** with a **Constant** of 10.0 and you wanted to see that force applied in more detail, you would set **Constant** to 1.0 and **Num Steps** to 10. In this way you would see the ten steps that make up the overall animation you witnessed before.

4.4 Window Properties

As with the mesh creation program, I again added the ability to change the viewing window. You can choose exactly what you would like the **xMin**, **xMax**, **yMin**, and **yMax** to be and then make these changes by hitting **Set Axis Manually**. To shift the window with the mouse, use **Click New Origin** and utilize the crosshairs to indicate where you would like the new center of the graph to be. Finally, you can use **Zoom In** and **Zoom Out** to better see your mesh and the **Show/Hide** toggles for **Axis**, **Boundary**, and **Force Points** to turn these visual elements on or off.

4.5 Saving Images and Videos

Save Current Image will work just as before in the mesh creation portion of the program. Just edit the **Name** field before you save and your mesh will be saved as a JPEG with your chosen name in the saveFiles folder. Again, if you use the same name of a file already in the folder it will overwrite it.

Save Current Video works slightly differently. By clicking this button, the program will use the current values of **Constant** and **Num Steps** and save that animation. It is therefore recomended before you click **Save Current Video** to use the **Go!** button to know exactly what video you will be saving. While saving, the GUI will update you on its progress and afterwards you will have a folder in saveFiles with the name you chose. Inside this folder will not only be a GIF of the force being applied to the mesh, but all the images that make up this GIF file saved in numerical order.