Image-to-Mesh Conversion Tool (I2MTool) for Image-Driven Simulations

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Introduction

The goal of this research project is to improve upon the current Image-to-Mesh Conversion tool (I2MTool) [1], created by the Center for Real-time Computing (CRTC) [2], for medical imaging computing. The I2MTool will contain features not seen in any current medical imaging tool. Many visualization tools do not contain full functionality to display both mesh tessellations and images. 3D Slicer [3] is a software for image analysis, but the tool does not display tessellations. In Figures 1-3, a CBC3D extension was added to 3D Slicer, however the tool still lacks the full functionality to display tessellations and images. Paraview [4] is a data analysis and visualization tool that displays tessellations, but does not display images. Figure 4 shows an output mesh created from the Image-to-Mesh Conversion Tool. There is no tool that combines the functionality to display tessellations and images, so the I2MTool will be enhanced to incorporate these visualization features.

Approach

1) Implement CBC3D extension into 3D Slicer
   - **a. CBC3D [5] is one of CRTC's 3D image-driven grid generation software used in Medical Image Computing applications.**
   - **b. Body Centric Cubic (BCC) [6]: generates mesh from an input labeled image.**
   - **c. Mesh Compression (MC) [7]: deforms the input tetrahedral mesh towards the boundaries of the input labeled image.**
2) Implement several visualization techniques on the I2Mtool, more specifically:
   - **a. a loading bar to increase the tool's user-friendliness**
   - **b. a feature to display a multi-material (or tissue) labeled mesh**
   - **c. a feature that will allow the user to cut a cross-section of a mesh to view its interior**

Future Work

The current version of the I2MTool can only display a mesh with one solid color for the entire mesh for the CBC3D module. However, the module is able to generate multi-tissue meshes, which can be viewed in multiple colors in other tools such as Paraview. The functionality to display a multi-material (or tissue) labeled mesh will be added to the I2MTool soon. A feature to cut a cross-section of a mesh to view its interior using the CBC3D module will also be implemented soon. The effects of Machine Learning and experiments on how Machine Learning frameworks can be used to enhance the CBC3D module will be researched in the future. A portable version of the Image-to-Mesh Conversion tool will be implemented in the future.

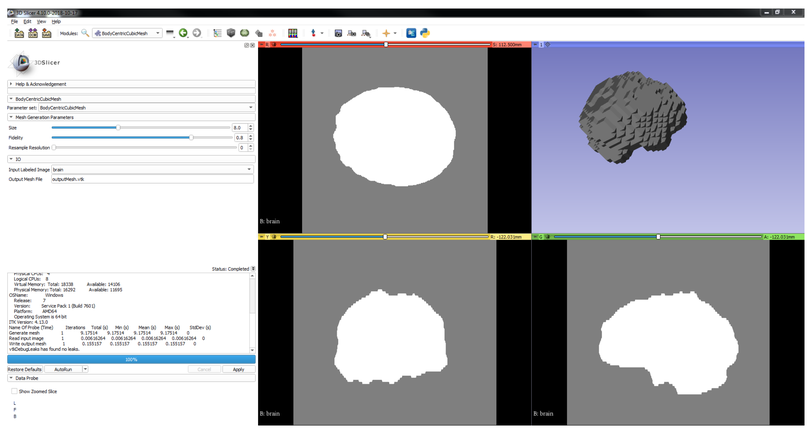

Figure 1: Body Centric Cubic Mesh Module from the CBC3D 3D Slicer extension, the GUI for this particular module can be seen on the left with the top right panel showing BCC tetrahedral mesh that this module generates

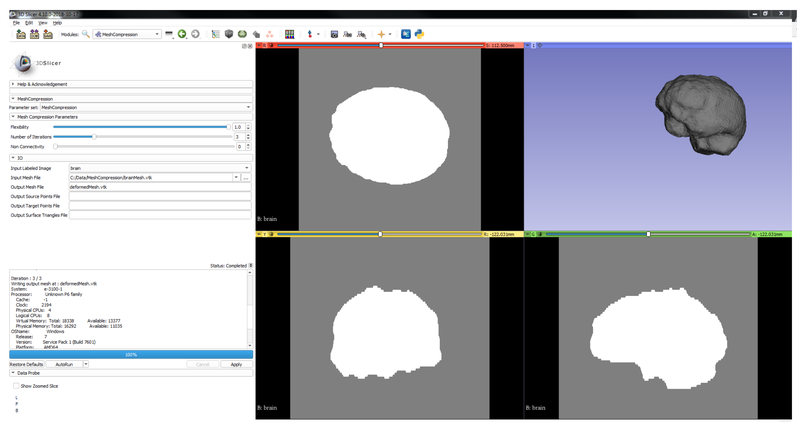

Figure 2: Mesh Compression Module from the CBC3D 3D Slicer extension, the GUI for this particular module can be seen on the left with the top right panel showing the deformed mesh that this module generates

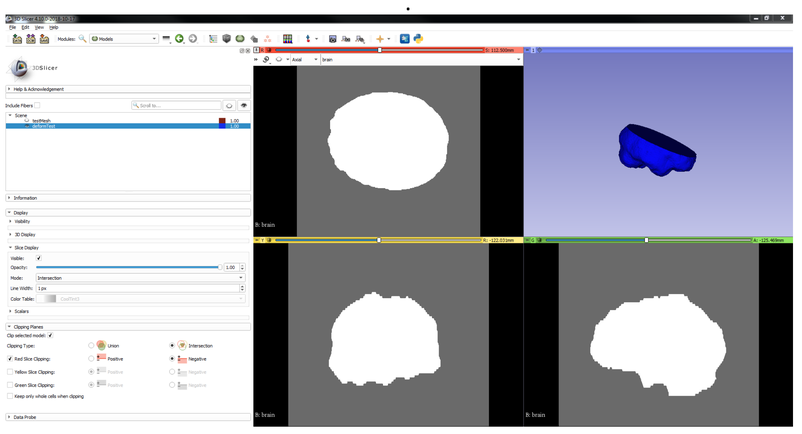

Figure 3: Mesh Compression method within 3D Slicer, the GUI for this particular module can be seen on the left, and the top right panel shows the newly registered image after being sliced through the X axis

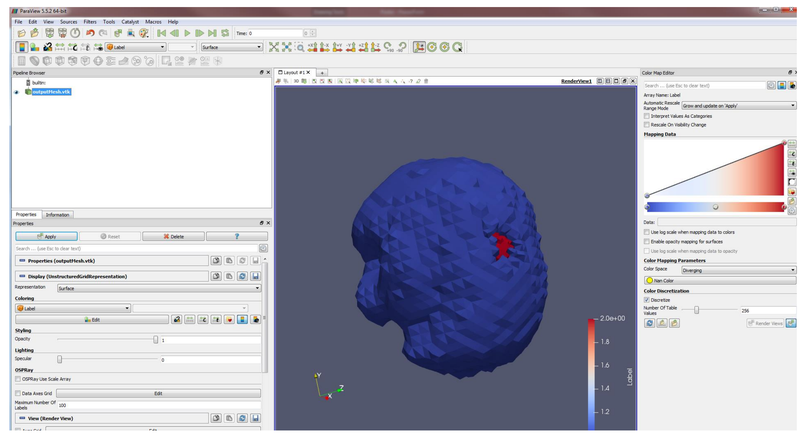

Figure 4: Output mesh created by the I2Mtool displayed in Paraview. The brain tumor is red and the brain is blue. Future work will be done to allow CBC3D to automatically display multiple colors.

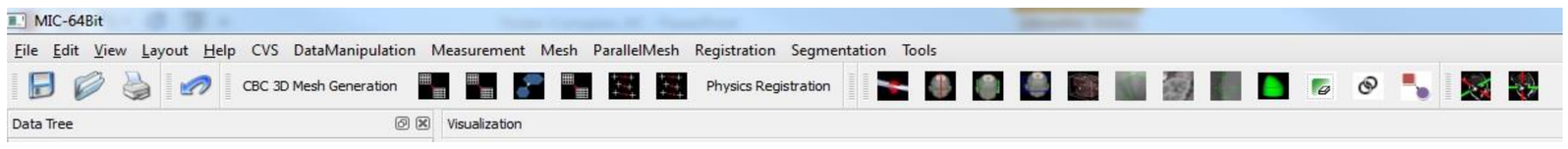

Figure 5: The GUI of the I2MTool allows for using several mesh generation/refinement methods, visualization tools, saving, loading, and printing images/meshes.

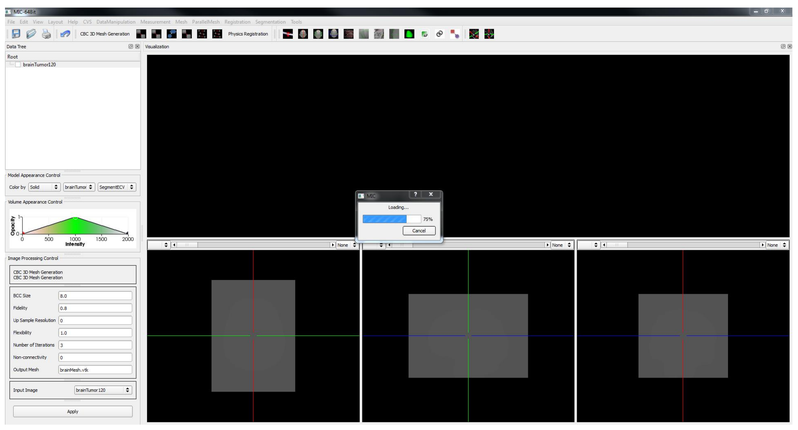

Figure 6: CBC3D method within the I2MTool, the GUI for this module can be seen on the left with the top panel showing the deformed mesh that this module generates

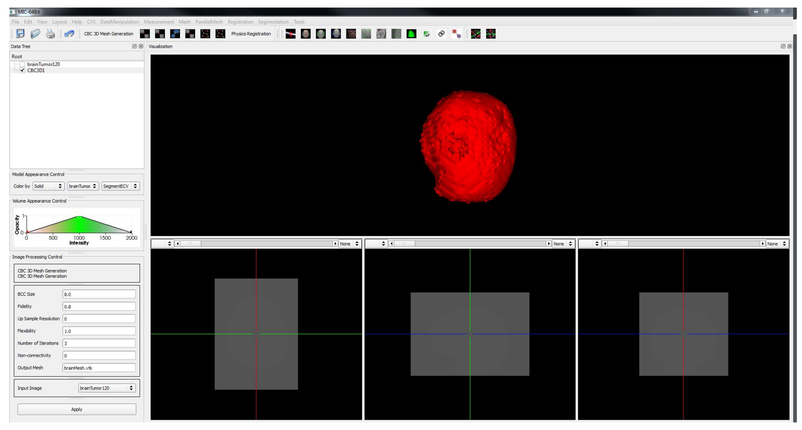

Figure 7: CBC3D method within the I2MTool, the GUI for this module can be seen on the left with the top panel showing the deformed mesh that this module generates

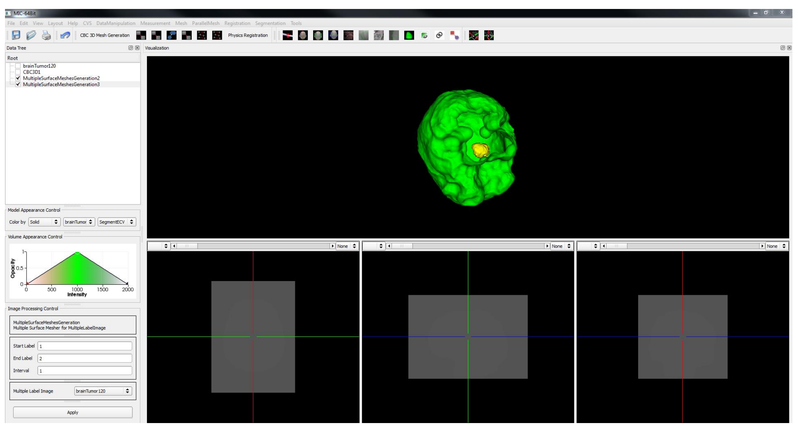

Figure 8: Multiple Surface Mesh Generation method within the I2MTool, the GUI for this module can be seen on the left with the top panel showing the meshes that this module generates. The brain tumor is yellow and the brain is green.

References

[1] Garner, K., Feng, D., Drakopoulos, F., Liu, Y., & Chrisochoides, N. Image-to-Mesh Conversion Tool. Retrieved January 23, 2019.
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