CSCI2240 Advanced Graphics Capstone - Patrick Ortiz

Title: Reimplementing Optimizing Object Decomposition to Reduce Visual Artifacts in 3D Printing

Abstract:

Following the steps outlined in the paper, Optimizing Object Decomposition to Reduce Visual Artifacts in 3D Printing, I and a group completed a pipeline that takes a triangle mesh of an object, then determines the optimal way to break down the model into individual components with designated orientations such that they can be 3D printed with few or no supports incident to the outside of the model. The optimization is written in C++ and takes an obj file as input and outputs several obj files with each of the generated components with their ideal printing directions.

The optimization involves four distinct phases. First, the model is oversegmented, meaning we designate many more segments or pieces than we intend to output. These are chosen by randomly sampling 1 of 512 printing directions in the unit sphere, then placing "seeds" throughout the mesh from which we build patches of triangles that make up the mesh.

The next step is called "initial segmentation" where we take the segments, then merge them into optimal patches using an ILP solver for the optimization that takes into account the amount of supports incident to a patch and its printing direction. The second to last step is "refined segmentation" where the segments are further made into clean cuts by reducing the noise and artifacts between patches.

The final step is the fabrication step which ended up being implemented by me from scratch. The segments, being of triangle meshes, do not have volume and thus need to be tetrahedralized. The paper gave few details on how to do this, so we tetrahedralized the entire mesh, then sent a ray from each tetrahedron to the surface, and assigned the tetrahedron the label of the surface's triangle that it hit. From there, we then had to find a way to perform Laplacian smoothing on only the interface vertices between two patches. Finally, we convert the completed segments back into surface meshes and subtract them by an inset of the original mesh to obtain the final components.

This project incorporated my knowledge of 3D printing and basic manufacturing from when I had been planning to be in Engineering, so using my prior coursework and skills in service of my current passion made for a great experience.