Approximate Convex Decomposition for 3D Triangle Meshes

Will Chen

william_b_chen@brown.edu

Within geometry processing, convex decomposition splits a potentially concave (curves "inward") 3D triangle mesh that into multiple components that are convex (curves"outward"). Convex decompositions have many applications. Fast and precise collision detection algorithms, which are utilized in physics simulations, virtual reality, game engines, and animations, have been specially designed for convex shapes. More applications of convex decomposition include acceleration of point location algorithms (checking if a point is within an object), which can be accelerated for convex objects. Because exact convex decomposition is proven to be an NP-Hard problem, so many state-of-the-art methods seek to approximate the exact convex decomposition while maintaining the original shape as much as possible.

Our project aims to combine aspects of two different methods from two papers: *Approximate Convex Decomposition and Transfer for Animated Meshes, Thul et. al. 2018* and *Approximate Convex Decomposition for 3D Meshes with Collision-Aware Concavity and Tree Search, Wei, Liu et al.* and implement a software framework to decompose a .obj file representing a triangle mesh to multiple .obj files representing each of the original mesh's convex components.

The first method we implement is a greedy search through the mesh that finds hyperplanes to cut the mesh at the most locally concave edges (*Thul et. al. 2018*). This process is repeated until the decomposed components are of a satisfactory convexity. We utilized a concavity metric from *Liu et al.* that measured the similarity between a decomposed component and its convex hull. The second method is from *Liu et al.* that utilizes a Monte Carlo tree search to find the most optimal axis-aligned cutting planes to split the mesh into its components. Finally, we demonstrate applications of our decomposed convex components by simulating rigid body physics such as collision and gravity in Blender.

From our project, we seek to better understand state-of-the-art graphics research and implement them ourselves. We also hope that our combination of different methods produces a novel approach to convex decomposition.