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6.S079 Final Project

Problem and motivation

We wish to simulate the behavior of deformable objects. Specifically, we will handle elastic and plastic materials. We will work with both dynamics and statics, but mostly focus on statics.

This work is very applicable to fabrication. We will simulate the behavior of various objects before we 3D print them. 3D printing an object takes a very long time and the material can often be expensive. Thus, simulating the behavior of the object before we print is extremely useful. We do not want to realize after printing that the object doesn't behave correctly.

Background

A great deal of work has been done on simulating deformable objects. Perhaps the simplest approach is to model the object with a mass-spring system. This can be used to simulate objects such as cloth and hair. My partner and I have already implemented a real-time cloth simulation.

However, the discrete mass-spring approach is limited and most current simulations use the finite element method. This approach divides up an object into a number of small, continuous elements.

Previous work in computer graphics has mostly used tetrahedral elements. For example, in 2012 SIGGRAPH conducted the course “FEM Simulation of 3D Deformable Solids.” This course entirely focused on tetrahedral elements. As another example, NVIDIA researcher Matthias Müller-Fischer has used tetrahedra to simulate the fracturing of cinderblock and clay.

Proposed Technical Method

We will also use the finite element method. However, we will use hexahedral elements (cubes) instead of tetrahedral elements. The main reason for this is that it is easier to construct meshes using cubes than using tetrahedra.

Our implementation will be in 3D and will be written in C++. One of the group members, Arjun, is currently doing a UROP on simulating the static behavior of a hexahedral mesh (the UROP is with PhD student Desai Chen). We believe this experience will be helpful for our project.

After writing the code for the simulation, we will apply our work to fabrication. We will first measure the properties of the MakerBot plastic in the lab. We will use these properties to build a material model that we can put into our code. Finally, we will simulate the behavior of objects before we 3D print them and check our results.

Expected Results

We hope to accurately simulate the behavior of deformable objects before we print them. We will start with simple objects and work our way up to more complex ones.

The hardest part will be to accurately measure the material properties of the MakerBot plastic and construct a valid material model.