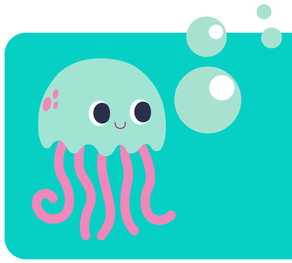

Jelly Physics

Creating Soft-Body Dynamics in a Virtual Environment

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CSE 493V
VR Systems

Problem

Based on its properties and material, an object will react differently when manipulated. If the object is a rigid body, like a metal ball, it will not deform when we touch it. If the object is a soft body, like Jello, it will react to forces and deform but retain its shape to some degree. We aim to create a VR experience that allows the user to interact with floating virtual soft-body objects using head tracking through the headset and hand movement/interaction through the use of hand controllers.

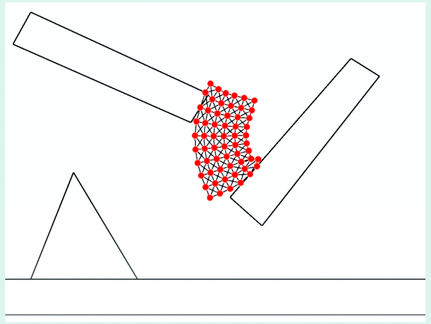

Figure 1: A soft-body mesh deforming because of outside forces (from Youtube Video R.3 in References)

Related Work/Motivation

This project is a study in programming the physics of soft-body objects and allowing the user to interact with virtual objects in various ways. We consulted a few articles and papers to familiarize ourselves with the concept of soft-body dynamics and possible applications of soft-body objects, including the physics behind soft-body objects and examples of applications of soft-body rendering. (R.1, R.2 in References)

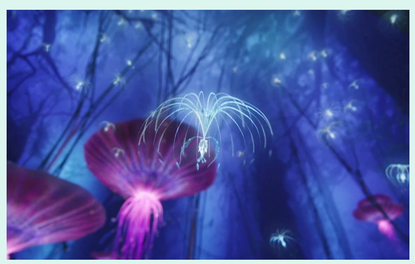

Figure 2: A jellyfish-like woodsprite from Avatar

This project was initially inspired by the Pandora scene in Avatar, with jellyfish-like woodsprites floating in the bio-luminescent forest. We wanted to design an atmospheric, relaxing interactive VR experience. The challenge is in getting convincing soft-body physics, with realistic deformation from hand movement, and simulating the movement of the objects based on human interaction.

Approach/Solution

We had to address a few technical challenges including realistically simulating soft-body physics and the interactions between the objects and the user. Through our research, we found that simulating a fluid environment was computationally intense, and this would be compounded by the limited resources of standalone VR headsets. Additionally, while the process of creating and rendering soft-body objects is well-documented, it is more difficult to find information on building a fluid environment. We decided to imitate these fluid interactions for the soft-body objects in a zero-gravity environment, where these objects would float around the user and be interactive, in order to save computational power and achieve the desired effect.

Method

We decided to break the project into a series of steps, with each step increasing in complexity, starting with rigid-body objects and escalating to soft-body collisions.

1. Started by experimenting with rigid bodies and rigid body collisions since rigid-body objects have very simplistic collisions.
2. Replaced the single rigid-body object with a soft-body object, working to make sure mesh deformation behaved as expected
3. Populated the scene and added hand-controller interactions so the user could interact with the soft-body objects.

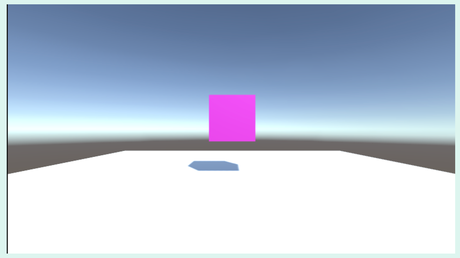

Figure 3: A frame from our initial version with a rigid cube in a no-gravity environment

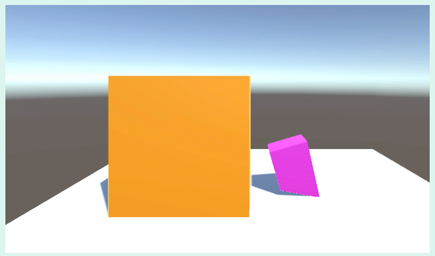

Figure 4: A frame from our second version with a soft-body cube with jelly-like deforming

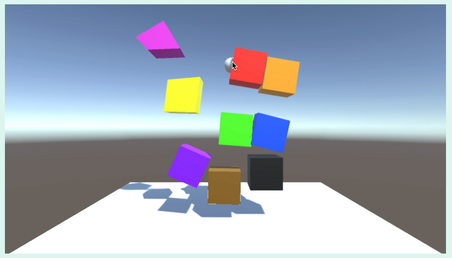

Figure 5: Multiple soft-body cubes colliding and squishing in a no-gravity environment

Results

Final Project:
A virtual environment filled with floating objects with jelly-like behavior that users could interact with to move around.

Limitations:

- Populating a scene with many such "Jelly" Objects will be computation-heavy, especially when the objects have more complex meshes with more vertices
- Usage of simple physics equations to calculate mesh deformation may not work for more complex meshes where vertices can collide

Figure 6: A frame from our final version with multiple soft-body objects colliding in the user's field of view, available for interaction

Future Work:

- The current behavior of the "Jelly" Objects is similar to that of Jello. In the future, we would want to adapt this program to render object collisions and squishing that is more graceful and gradual, like the desired movement of the jellyfish-like woodsprites from Avatar.
- Our main goal with this virtual experience was to create an interactive environment that would engage and calm users. While we have a good grasp on the soft-body physics required for the calm floating "Jelly" objects, decorating the rest of the environment and adding calming audio elements would help fulfill our initial goal.

References

R1. "Physically Based Deformable Models in Computer Graphics", Andrew Nealen, Matthias Müller, et.al, 2005.
R2. "Modeling And Simulation Of Soft Bodies", Jaruwan Mesit, 2010.
R3. "But How DO Soft Body Simulations Work?" (Youtube Video), Gonkee, 2021.
R4. "Discontinuous Fluids", Jeong-Mo Hong, Chang-Hun Kim, 2005.