Fluid Simulation Interaction with 3D Mesh Objects

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In this paper we aim to discover how fluid water interacts with different real-world objects through graphical simulation. Our project involves designing a fluid simulator to model the fall of water and raindrops. It also involves loading in a mesh into the scene and having it interact with the fluid simulation. In our research, we aim to ensure that the fluid interacts with the mesh in a realistic way. This idea is interesting as it allows for an efficient method to see the interaction between simulation and real-world objects. Specifically, we can see the effects of large amounts of water on various objects which have real-world significance, such as local government officials testing and simulating city infrastructure in handling water during heavy rain seasons. Other interesting use cases might include seeing how water gathers to improve flood handling methods with water flow in streets, dams, etc. We will implement the fluid simulation based off of the "Position Based Fluids" paper published by Macklin and Muller and associated with NVIDIA. Previous research in this area focuses on fluid simulation in a bounded box and the interaction of the fluid with the walls of the container. The "Position Based Fluids" paper also talks about similar research. Our project aims to expand on this concept and make it more novel by exploring particle simulation in an unconstrained environment. We are working with independent particles randomly spread across the entire scene. Furthermore, the particles we create will interact with custom objects of different shapes rather than wall planes. This concept will also add to the novelty of our project.

CCS Concepts: • **Fluid Simulation**; • **Graphical Mesh Representation**;

Additional Key Words and Phrases: fluid simulation, mesh representation, computer graphics, physics simulation

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1 WHAT HAS BEEN ACCOMPLISHED SO FAR

Our goal for this milestone was twofold - to simulate a preliminary version of rain particles falling in a scene, and generating basic custom meshes and importing them into our renderer. As a starting point, we used Project 4, Clothsim, to render and define the particles. We then did extensive research and read the Position Based Fluids paper. The paper itself is different from our research since we are trying to simulate random rain particles instead of fluid in a container. Our initial goal was to implement the entirety of the Position Based Fluids paper and only use project 4 to render it. However, we realized that the point mass system in ClothSim was quite sophisticated and worked well with the renderer. Moreover, pointmasses without springs could be seen as independent rain particles. As a result, we pivoted our approach and decided to take features of incompressibility and other dynamics from the paper, and apply it to custom made point masses inspired by Project 4. This will make our implementation more efficient as we would not be storing unnecessary complex data and our render time would be optimised. Additionally, it would give us a chance to explore the combination of different techniques and find more optimal ways to solve our problem, rather than using an existing approach. Lastly, since we are not using the same water cube structure mentioned in the paper, this combined approach will give us more flexibility to modify our basic structure of our rain mesh. So far, we were able to implement the paper from ground up, set up the positions, velocities and collision detection for neighboring particles. Independent of this, we were also able to render individual rain particles in our clothsim simulator. Our next goal is to be able to combine the two. For the second task, we were planning to import an existing mesh into our renderer and test the water particles on that. However, this was more challenging than we expected. The current ClothSim renderer only supported a single plane or spherical object at a time when reading from the JSON. To load a custom mesh into clothsim, we need to be able to render multiple planes in clothsim. We fixed this issue by changing the way the JSON is parsed in the main.loadObjectsFromFile() function. We still need to convert the .dae file into a json containing all the triangles comprising the mesh and change the collision code so that it works with triangles instead of infinitely wide planes. Being able to render multiple objects in ClothSim was a good first step to achieve our goal of rendering any mesh of our choosing. Alternatively, we could model our mesh as a cloud of point masses held together by spring constraints and interpolated to form a mesh (similar to the code in Cloth.buildClothMesh()). This will be similar to the cloth mesh. However, we need our mesh to be more rigid so we will modify the spring constraints accordingly. The first step will be to generate a pointcloud based on a .dae file which will act as the mesh of point masses.

2 PRELIMINARY RESULTS

Our results have been quite promising so far. We were able to generate complex meshes made up of primitive shapes such planes and spheres.

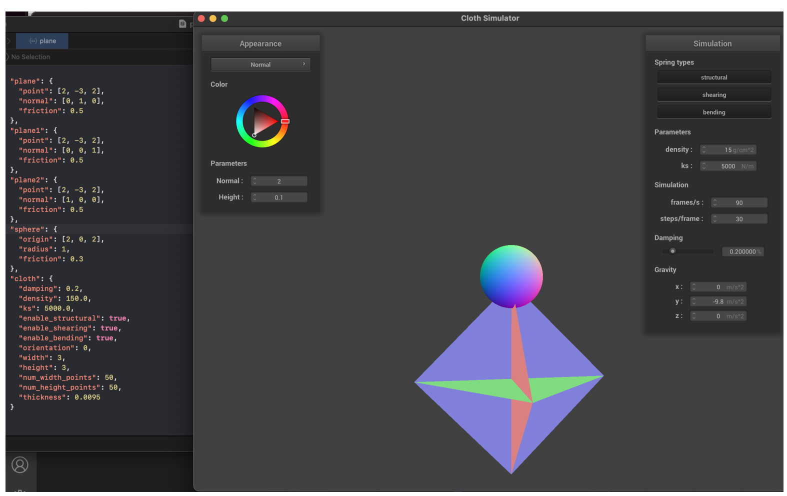

Fig. 1. Custom Scene Loaded into ClothSim

Figure 1 displays a water tight complex mesh made up of multiple planes and spheres. We will modify these meshes to display buildings and houses in a city. Designing our own meshes allows us to make custom shapes and test the reliability of our simulation on different geometries.

We were also able to generate raindrops at arbitrary positions that are capable of falling downwards and interacting with the mesh.

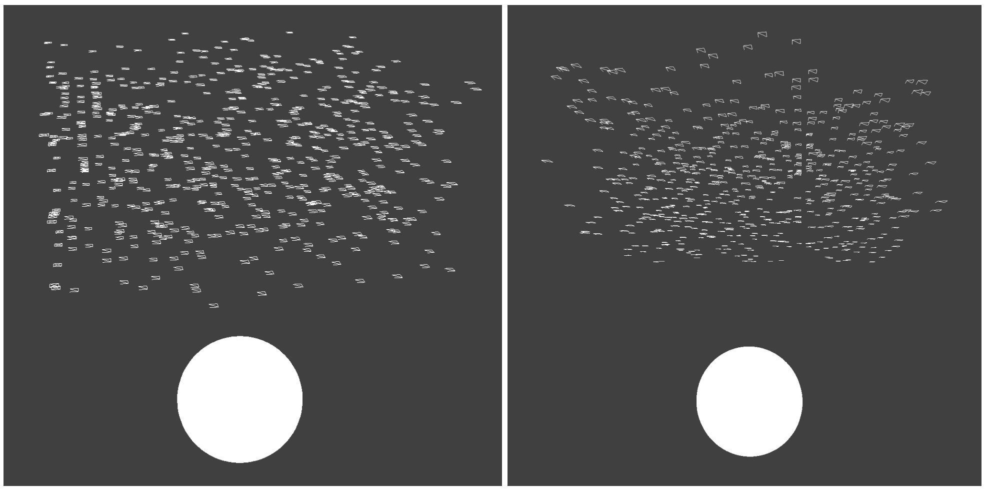

Fig. 2. Rain particles distributed randomly above a sphere mesh

Figure 2 shows a set of rain particles defined as point masses. When the simulation is run, these particles fall downwards and interact with the sphere. The particles, as shown in the video, slide off of the sphere.

Lastly, we simulated the physics of rain into the point masses. We were able to incorporate physical specifications for each particle such as the density, mass, pressure and viscosity of fluid. Adding custom specifications will allow us to experiment with different types of fluids in the future.

We were able to change the the way the JSON is parsed in the main.loadObjectsFromFile() function in ClothSim so that it can handle rendering multiple different objects. Below is a scene of 3 planes and a sphere being rendered.

2.1 Progress Relative to Plan

According to our initial plan, we planned to divide the task amongst the team members and focus on the fluid simulation. We wanted to use the Position Based Fluids paper to simulate independent rain water particles instead of simulating a cohesive fluid and build upon project 4, Clothsim, with these calculations. We have made good progress on it so far. We were able to initialise particles of rain and have it fall on the sphere from project 4. So far, we are maintaining the rigid structure of the water. However, in the next iteration, before the final submission, we will replace the cube structure randomly positioned, freely falling particles. The second aspect of the project was to create a custom mesh on which the rain particles would fall. For this milestone, our goal was to use an already existing mesh and load it into the Project 4 renderer as a test mesh. However, we faced a lot of challenges on this front, because we werent able to render custom objects. Because of this we were not able to successfully complete it by this milestone deadline. However, we have a clear idea about how to approach this task and will pivot towards the new solution for the final deliverable.

2.2 New Work Plan

We will aim to finish the Fluid Simulation by April 28th so that we have one fully functioning aspect of our original project goal finished. We will also have another person help out with the mesh generation aspect of the project since the mesh creation was much harder than anticipated, as explained in the previous section. We will aim to have the mesh generation completed by May 1st, so that we have 3 days for integrating the two parts together before the final project deadline.

REFERENCES

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