\_\_Slide 1

My name is Simon Walker and I did my project on Gravitational N-body simulations.

I chose this topic thanks to my involvement in my astronomy class where we were discussing how we can predict the positions of celestial objects as well as what future systems might look like.

\_\_\_Slide 2

My original interest is that I loved the black hole scene from Interstellar.

The mathematics and accuracy behind the way they rendered and animated that visual shot was amazing and that has honestly inspired me to do what I do today.

In my astronomy class, we watched a simulation on youtube of two merging supermassive blackholes which I found to be incredibly interesting but way out of my league.

So instead I decided to do my project on gravitational N-body simulations.

As I did my research, I discovered that this has been done plenty of times, so I was lucky to have a bunch of resources at my disposal.

\_\_\_ Slide 3

I came into many problems while working on this project.

I originally wanted to recreate the solar system and have a spaceship fly through it, being under the effects of the planets and the star.

So far, I have only been able to simulate particles under the effects of each other.

Where their gravity is pulling and pushing them away causing some problems when some are flung off into the void.

[Show Video Clip 1]

\_\_ Slide 4

I also found it difficult to implement an Octree into the code that I had already written.

An Octree is a tree data structure where each internal node has exactly eight children.

This would have helped me by splitting up my universe into separate sections where I would only consider the particles in each of those sections.

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I am currently still working on trying to implement this data structure so that my maximum number of particles, (that I can run on my system), can be more than 500.

I did, however, try to fake it by running the simulation over a set number of particles.

For example, when I tested this out of 1000 particles, I ran it from 0-100, 101-200 etc etc.

This did give me a system that ran, but it still struggled with any more particles than that.

I also tried to create a star planet system, but I have so far been unable to create this with the current state of my code.

[Show video of carious simulation parameters]

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I have realized that this is because I am using a brute force method, where I go through every particle in the system and calculate the force that is being exerted upon it.

It is tedious and runs in Big O n^2 time which is not efficient at all.

I did research more into the Octree data structure where I read about a different method called Barnes-Hut.

This implementation is an approximation algorithm used when you are dealing with n-body simulations.

This one has a runtime of Big O n log n which is already better than what I have done so far.

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This algorithm divides the n bodies into groups and store them into an Octree where each node is a representation of a region in this three-dimensional space.

The topmost node in this tree represents the entire space, so when we need to calculate the net force that is acting on all the bodies we start there until all the nodes have been traversed.

What makes this special, is that if a group, for instance A, of particles are a certain distance away from the center mass of another group, B, then group A is treated as being one particle that effects group B.

We calculate an average force of the particles in group A that will end up affecting group B then update its position based off of that force.

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After more testing, I realized that I need to add limits to these partciles.

Last night I realized that a lot of my particles had a huge increase to their velocity due to my own math error.

So I will try to fix that before I attempt to do more particles

<https://en.wikipedia.org/wiki/Octree>

<https://www.youtube.com/watch?v=DoLe1c-eokI>

<http://www-inf.telecom-sudparis.eu/COURS/CSC5001/new_site/Supports/Projet/NBody/sujet.php>

<https://en.wikipedia.org/wiki/N-body_simulation>

<https://en.wikipedia.org/wiki/Barnes%E2%80%93Hut_simulation>