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Capstone Proposal

# Project Goal

I have selected Fluid Simulation and Rendering as the subject of my capstone. I have divided the topic into three demos to be completed in sequence, but plan to spend the vast majority of my time on the final two demos. The demos cover both the most widespread (relevant) method of fluid simulation as well as new, but niche methods. The purpose of this project is to gain experience implementing fluid effects, to have demos of the fluid effects to share with fellow academics as a learning tool, and to have portfolio pieces that will interest future employers.

# Target Users

The targets of these demos are academics (fellow simulators, artists, and physicists) and potential employers. I wish to contribute the source code to academics so that it may be used by others as a learning tool and launching point for other projects. I wish to use the demos themselves as portfolio pieces to show potential employers something visually impressive to get myself into an interview.

# Technical Complexity

I have separated this section per demo due to the nature of this project.

### Demo One

The first demo is the most widely seen method of simulating fluids in the industry: make a surface plane and move its vertices. My primary technical difficulty will come from changing the positions of the vertices of the plane in real-time.

##### Requirements

* Implementation of waves and simulation of dropped objects on a simple plane
* Basic key input

### Demo Two

The second demo is a significantly more complex simulation of fluids that involves creating multitudes of particles that each represent small volumes of the fluid, then simulating and rendering the scene dynamically from those particles. My technical difficulties here will include using a new rendering technique to show particles as a single object, learning and applying the physics equations, managing a very large number of particles, and applying constraints to the particles without affecting the formulas.

##### Requirements

* Particles flow in an appropriately fluid-like manner (physics)
* Particles are rendered to the screen in a way that makes them look like fluid (rendering / shading)
* Particles interact with some sort of barrier, such as an invisible wall (physics)
* Scene renders at more than 60 fps (algorithms)
  + If the demo can only run at 60fps then the system is not optimized enough to run in a game, but 60 fps is an acceptable benchmark to reach before continuing to the third demo.

### Demo Three

The third demo is an extension of the scene from demo two with modified calculations and support for a physical obstruction in the fluid. This demo will serve as the primary portfolio piece and most important technical resource for academia.

##### Requirements

* Everything from demo two
* Particles interact with a physical barrier (a 3D model, perhaps) in a realistic manner

This <http://www.youtube.com/watch?v=6WZZARzpckw> is a video of the formulas I will be using for this demo in action.

# Project Backlog

1. As a student I want the first demo to develop a general understanding of the staple fluid simulation technique used in video games.
2. As a student I want the second demo to develop understanding of particle-based fluid simulation, rendering, and usage.
3. As a student I want the third demo to develop understanding of position-based particle fluid simulation, how it is rendered, and how it is used.
4. As a future job-searcher I want the three demos to be demos to all be portfolio pieces, be it as a program or as a video of the demo.
5. As an academic I want the source of all three demos in order to use them as learning materials.

# 2-Week Plan

After the first demo, the workflow of this project will rely heavily on the results of spiking implementations of the second two demos. I will most likely spend one to two weeks testing the components of the second demo before beginning. If these spikes prove that the second and/or third demos are not feasible then I will resort to the fallbacks outlined in the Appendix section.

### Week 1

Complete the first demo

### Week 2

* Spike the key sections of the second demo
  + Rendering particles that have no geometry
  + Applying physics equations to the particles
  + Applying constraints to the particles

# Appendix

Due to the riskiness of this project I have outlined potential “backup” work below.

## Fallback Potential of the First Demo

##### If the final project is scrapped:

* Interactive demo with a GUI
* Floating objects
* Water-like rendering

##### If both other projects are scrapped:

* Interactive demo with a thoughtfully created GUI (more work than a bunch of haphazard buttons)
* Wakes and ripples for floating objects
* More of a scene than just a box of fluid
  + Something along the lines of a beach, brook, etc.
* Shading algorithms for:
  + Looking into fluid (camera above, object below)
  + Looking out from fluid (camera below, object above)
  + Looking within fluid (both camera and object below)
  + Waterfall

Take note that as the later programs are scrapped the technical difficulty and focus for the project as a whole shifts from simulating fluid to creating a video game implementation more typical of the industry.

## Fallback User Stories

As a student, if the third demo is not feasible, then I want the first demo to develop significant understanding of the staple fluid simulation technique, its implementation in a video game, and how to display it attractively.

As a student, if the second and third demos are not feasible, then I want the first demo to show mastery of the staple fluid simulation technique and camera-based shading of the scene.