Exploring Fluid Simulation

Project Proposal

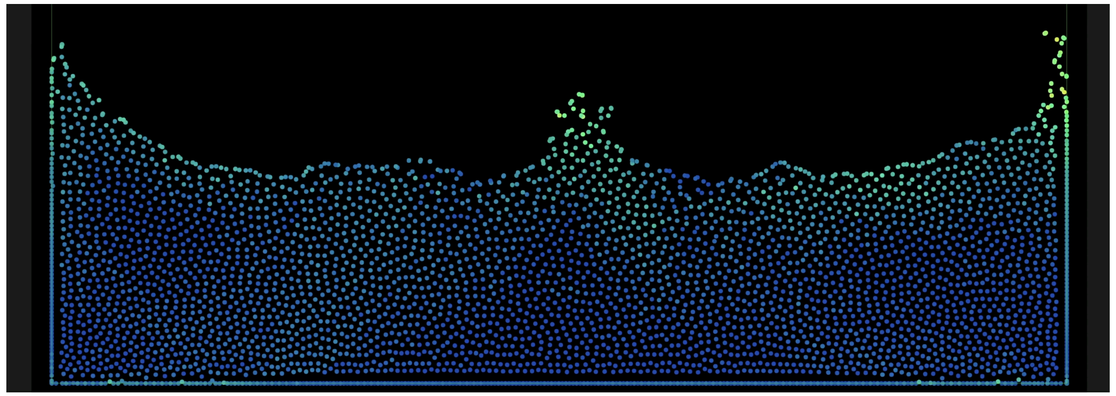
Christopher Lee

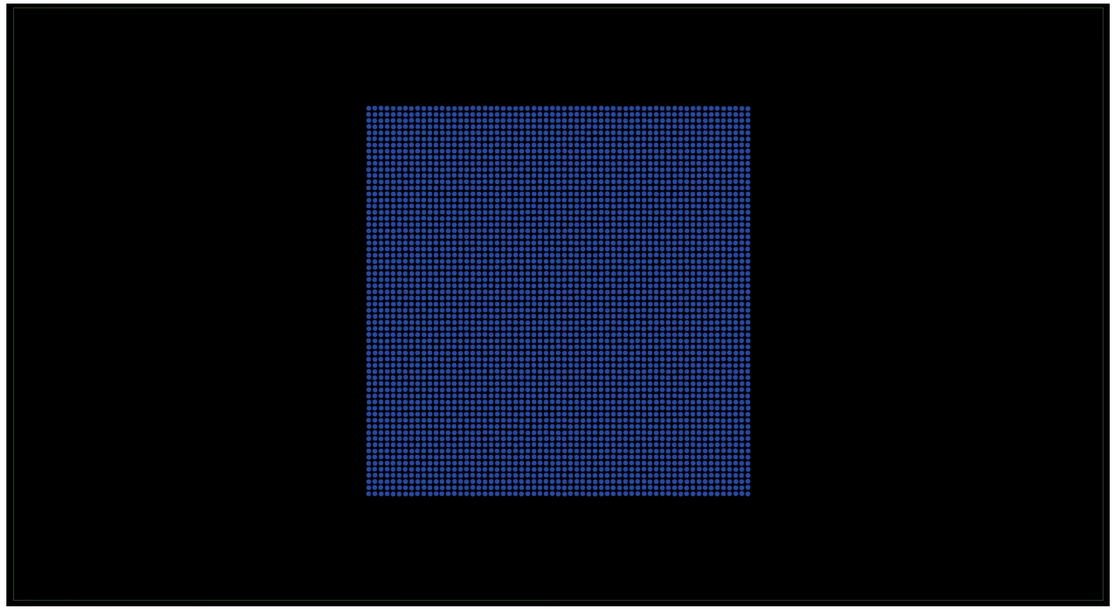
Agenda

1. Background
2. Success Criteria
3. Requirements
4. Timeline
5. Risks and New Skills
6. Equity Statement
7. Summary

What is Fluid Simulation?

- Computational techniques to simulate a fluid (liquid or gas)
- 2D or 3D environment
- Collection of particles
- Wide range of applications
  - Aerospace
  - Animation
  - Environment

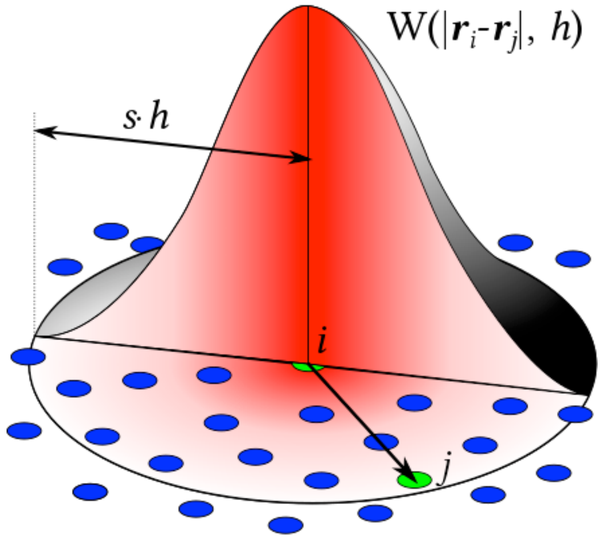




Footage from Sebastian Lague — Coding Adventure: Simulating Fluids

Smoothed-Particle Hydrodynamics

- Computational technique to simulate behavior of fluids
- Collection of particles resembles a fluid
- Smoothing radius and function
- Weight / influence
- Pressure force



JIcercos, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

Success Criteria

Baseline:

- 2D environment
- Accounts for physical properties (density and pressure)
- Visually accurate and appealing
- Well-documented code base
- Understandable

Exceptional:

- 3D environment
- Accounts for viscosity
- Physically accurate
- UI components to customize initial parameters
- Optimize with compute shader (GPU)

Requirements

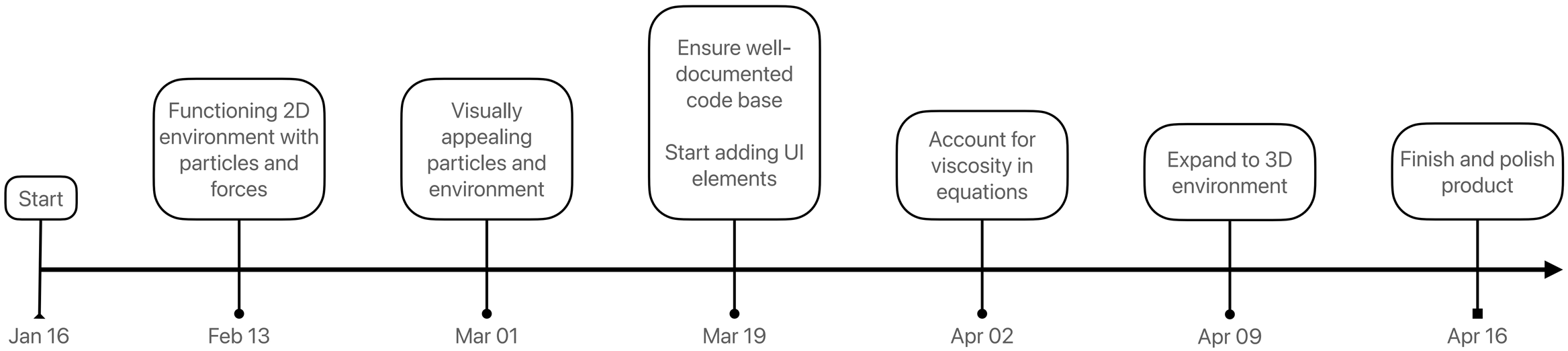
Software:

- Highly performant programming language
- Capable and fast game engine
- Modern text editor or IDE

Hardware:

- Modern computer with decent computing power

Timeline


Start
Functioning 2D environment with particles and forces
Visually appealing particles and environment
Ensure well-documented code base
Start adding UI elements
Account for viscosity in equations
Expand to 3D environment
Finish and polish product
Jan 16
Feb 13
Mar 01
Mar 19
Apr 02
Apr 09
Apr 16

Timeline

Priority Objectives

Functioning 2D environment with particles and forces

Visually appealing particles and environment

Ensure well-documented code base

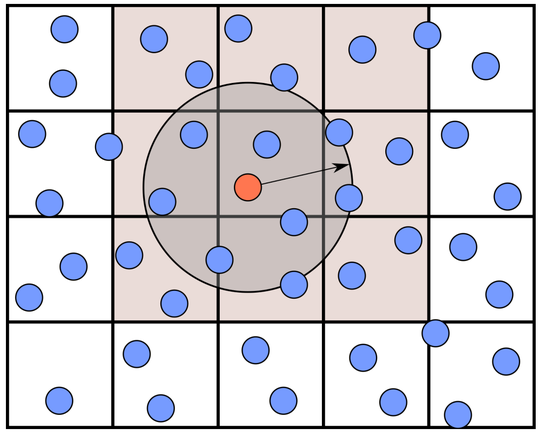
Start adding UI elements

Risks

- Unable to understand and apply physics
  → fail to achieve physically-accurate simulation
- Fail to optimize for large number of particles
- Unable to move from 2D to 3D environment
- Rust (language) and Bevy (game engine) are not the best tools

New Skills

- Expanding understanding of physics
- Learning Rust and Bevy
- Entity Component System (ECS)



$$\nabla A_i \approx \rho_i \left(\frac{A_i}{\rho_i^2} \langle \nabla \rho \rangle + \langle \nabla \left(\frac{A_i}{\rho_i} \right) \rangle \right)$$
$$= \rho_i \sum_j m_j \left(\frac{A_i}{\rho_i^2} + \frac{A_j}{\rho_j^2} \right) \nabla_i W_{ij} \, .$$

Equity Statement

- Make fluid simulation accessible to everyone
  - Well-documented code
  - Easy-to-understand for non-physics people

- Teach a basic understanding of how fluids move
  - Outline key equations and implementation in code

Summary

- 2D / 3D fluid simulation
- Smoothed-Particle Hydrodynamics (SPH)
- Employ modern and fast software (Rust and Bevy)
- Well-documented codebase
- Accessible for everyone

Thank You!