Exploring Fluid Simulation

Results

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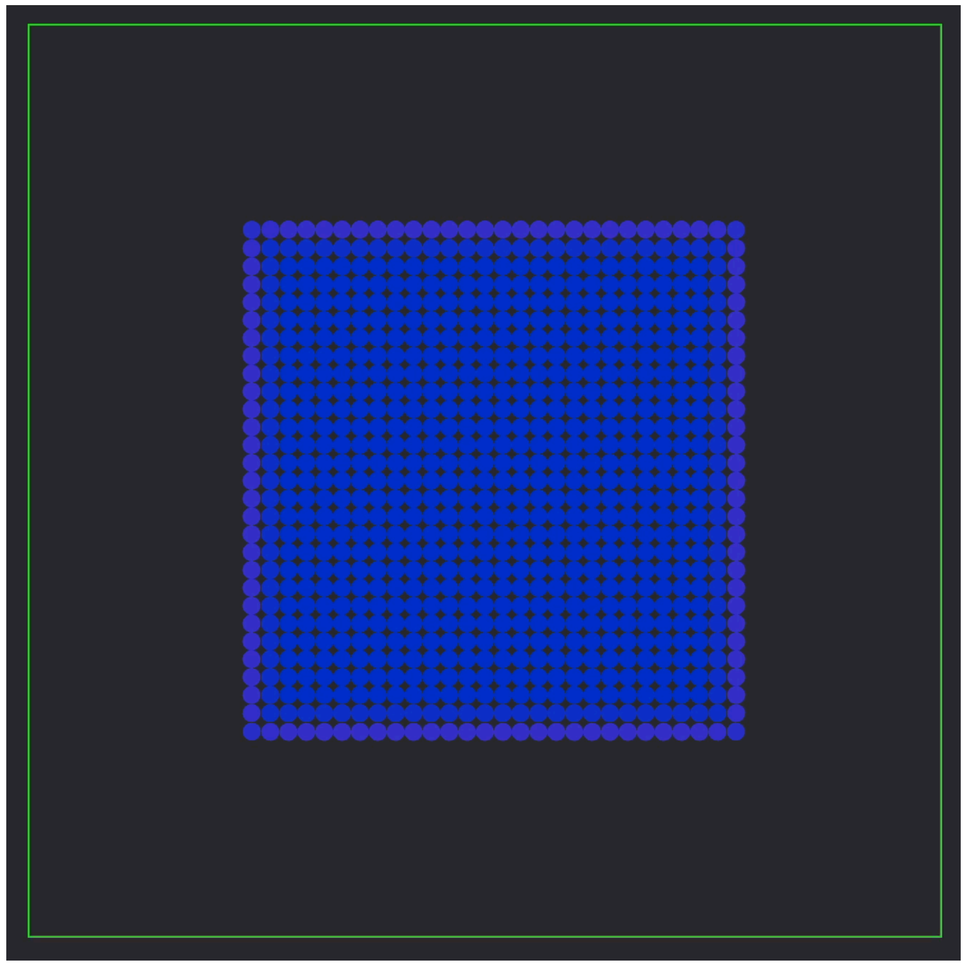
Introduction

- Objective: develop a basic, **accessible**, 2D fluid simulation
- Smoothed-particle hydrodynamics
  - Collection of particles resembles a fluid
  - Pre-defined smoothing function determines pressure force applied on each particle



Requirements

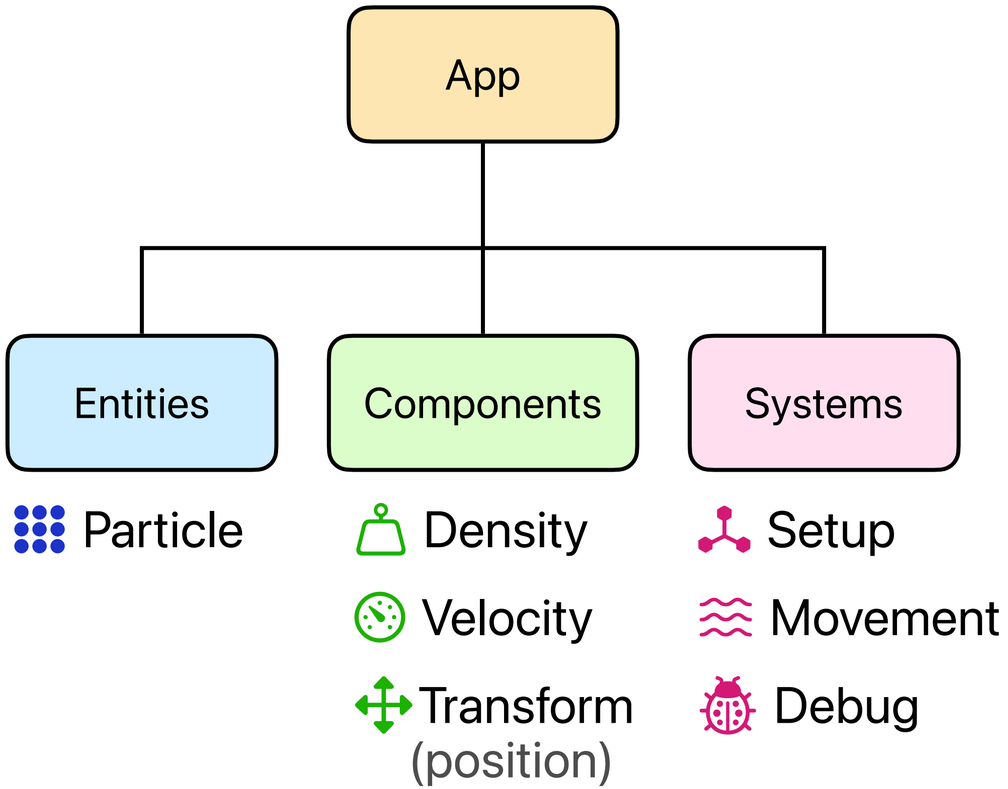
Software:

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

Hardware:

- Modern computer with decent computing power

System Architecture



Game loop

for all **particles**:
  density = result of smoothing function

↓

for all **particles**:
  velocity += acceleration due to **external forces**

↓

for all **particles**:
  velocity += acceleration due to **pressure forces**

↓

for all **particles**:
  transform += **velocity**

Initial Success Criteria

Baseline:

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

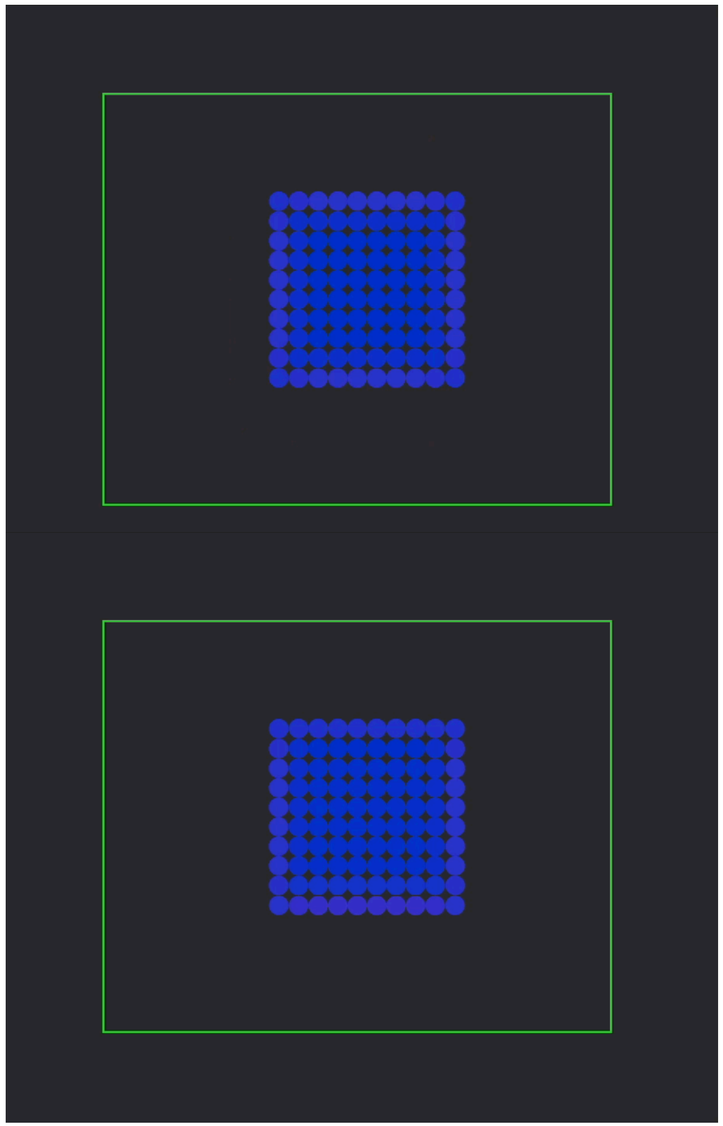
Exceptional:

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

Results

- Achieved most baseline objectives
- Boundary issues, as expected by previous papers
- Performant without neighborhood search optimizations
- Used the smoothing function:

$$f(d,r) = \frac{15}{\pi d^6} \begin{cases} (r-d)^3 & \text{if } 0 \leq d \leq r \\ 0 & \text{otherwise} \end{cases}$$



Demo

What I Learned

Rust	→	write **fast**, memory-safe applications	!
Bevy	→	use a **performant** game engine	!!
ECS	→	understand basics of entity component systems	!
Git	→	**effectively**-manage a codebase	✓
Physics	→	smoothed-particle hydrodynamics	!!!

Future Work and Improvements

- Add interactivity to simulation — left click to repel, right click to attract particles
  - Add / remove objects (squares, triangles, etc.)
- Implement UI to customize initial parameters, once a polished UI-framework for Bevy is stable
- Properly integrate solution to account for boundary situations
- Add README documentation and installation instructions

Equity Statement

Given the history of a male-dominated engineering industry in both the workforce and educational settings...

- Make fluid simulation **accessible** to **everyone**
- Spark interest in physics and computational simulation
- Well-documented code
- Easy-to-understand and follow software architecture
- Outline the basic procedure on how to create a virtual simulation
- Publish code on public Github repository

Thank You