# Position Based Fluids

CIS 565 Final Project

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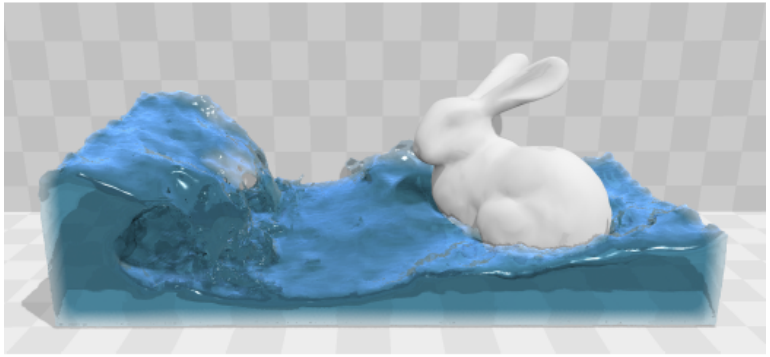
# Introduction

- SPH exists
  - Costly computation
  - Hard to run in real-time
- Position Based Dynamics
- Gauss-Seidel v. Jacobi Iteration Solver

# Plan

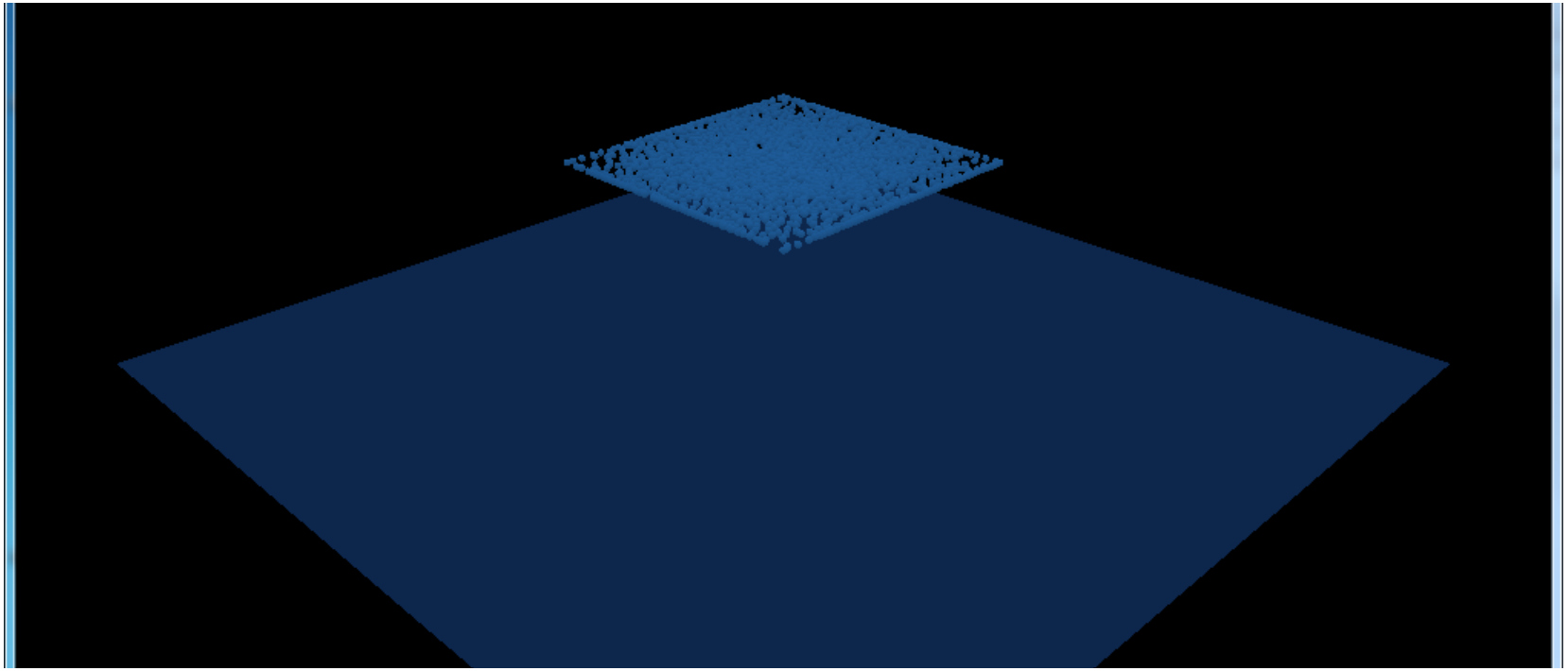
- “Position Based Fluids”
  - M. Macklin, M. Müller
- “Screen Space Fluid Rendering with Curvature Flow”
  - W. van der Laan, et al.



# Progress

- Framework
  - Point-based particle representation
  - Rendering simple spheres for visualization
- Math
  - Density Constraint
  - Tensile Instability
  - Vorticity Confinement

# Progress



Screen shot of fluid simulator running

# Density Constraint

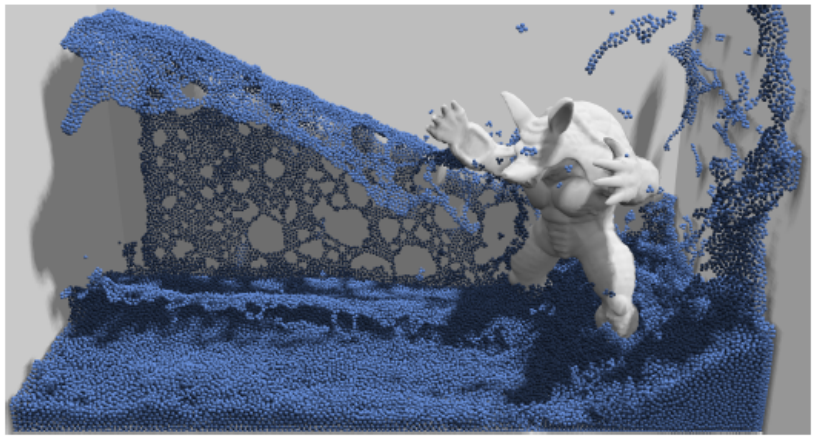
$$\lambda_i = -\frac{C_i(\mathbf{p}_1, \ldots, \mathbf{p}_n)}{\sum_k \left|\nabla_{\mathbf{p}_k} C_i\right|^2 + \varepsilon}, \qquad \Delta \mathbf{p}_i = \frac{1}{\rho_0} \sum_j (\lambda_i + \lambda_j) \nabla W(\mathbf{p}_i - \mathbf{p}_j, h).$$

- Utilizing SPH Pressure
- Helps keep # required neighboring particles low

# Tensile Instability

$$s_{corr} = -k\left(\frac{W(\mathbf{p}_i - \mathbf{p}_j, h)}{W(\Delta\mathbf{q}, h)}\right)^n \qquad \Delta\mathbf{p}_i = \frac{1}{\rho_0}\sum_j (\lambda_i + \lambda_j + s_{corr})\nabla W(\mathbf{p}_i - \mathbf{p}_j, h)$$

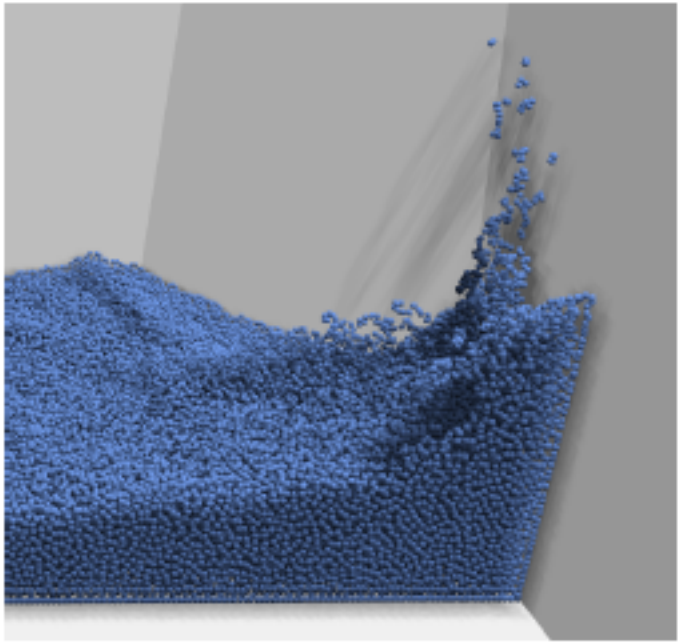
- Artificial pressure term
- Simulates surface tension



# Vorticity Confinement

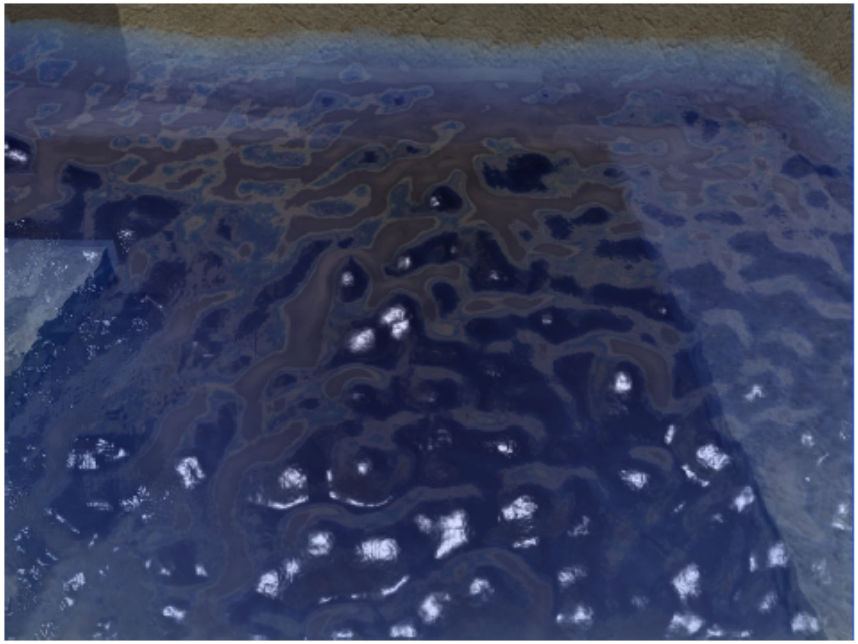
$$\omega_i = \nabla \times \mathbf{v} = \sum_j \mathbf{v}_{ij} \times \nabla_{\mathbf{p}_j} W(\mathbf{p}_i - \mathbf{p}_j, h) \qquad \mathbf{f}_i^{vorticity} = \varepsilon (\mathbf{N} \times \omega_i)$$

- Add back energy into system
- Approximate gradient of magnitude of curl



# Future

- Parameter Tuning
- GPU Hash Grid
- Rendering



# References


- Images/equations from:
  - [1] M. Macklin and M. Muller. Position based Fluids. ACM Trans. Graph., 32(4):104:1-104:12, July 2013.
  - [2] W. J. van der Laan, S. Green, and M. Sainz. Screen space fluid rendering with curvature flow. In Proceedings of the 2009 Symposium on Interactive 3D Graphics and Games, I3D '09, pages 91-98, New York, NY, USA, 2009. ACM.