

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.



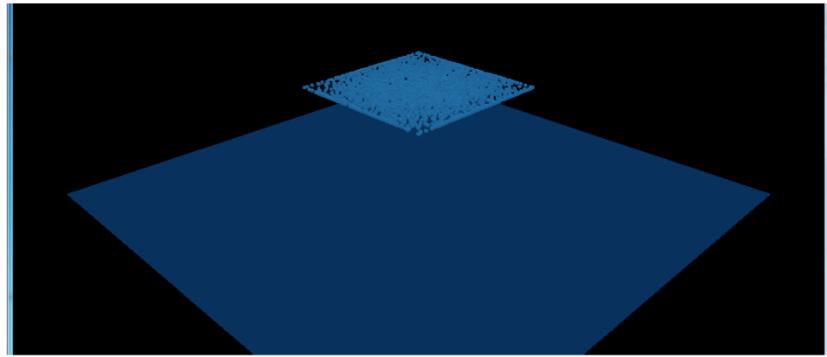
Image Reference: Bunny in water bath [1]

Progress

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

Joseph

Progress



Screen shot of fluid simulator running

Image : screen shot of fluid simulator in process

Density Constraint

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

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

Equations from [1]

Tensile Instability

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

- ◆ Artificial pressure term
- ◆ Simulates surface tension

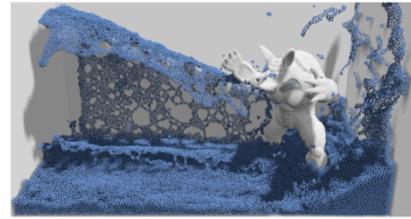


Image: Surface tension simulated with artificial pressure term [1]

Vorticity Confinement

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

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

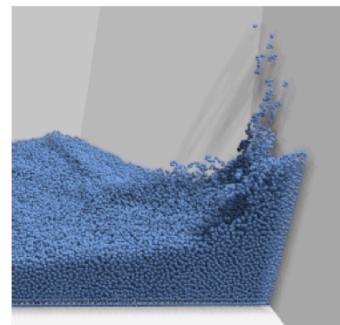


Image Reference : Voriticity Confinement – energy added in dam breaking case [1]

Future

- ◆ Parameter Tuning
- ◆ GPU Hash Grid
- ◆ Rendering

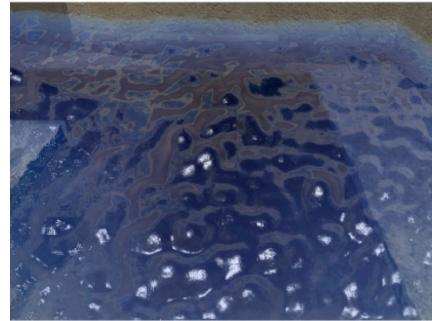


Image Reference : Bilateral Gaussian smoothing in screen space rendering [2]

References

- ◆ Images/equations from:
 - ◆ [1] M. Macklin and M. Müller. 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.