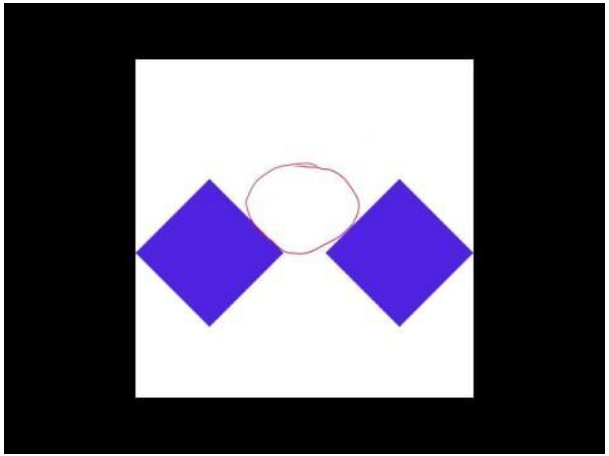
Physically-Based Simulation Final: Goo(f)-Balls

Virginia Ramp, Nikola Dodik, Felice Serena

Scenario: Slime-like blob

- Squeezable and squishable
- Returns to rest-shape
- Splitting under high forces
- Real time
- Steerable



Milestones: Minimal Target

Milestone 1: 2D World, Collision handling

- 2D rigid body framework: DONE
- Rendering: DONE

Milestone 2: SPH implemented: SSPH DONE, PCISPH/IISPH NOT NEEDED

Milestone 3: Additional velocity correction for viscoelasticity: DONE

Milestone 4: One-way interaction with world: DONE

Milestone 5: Get all the different constants (viscosity, density, etc.) right DONE

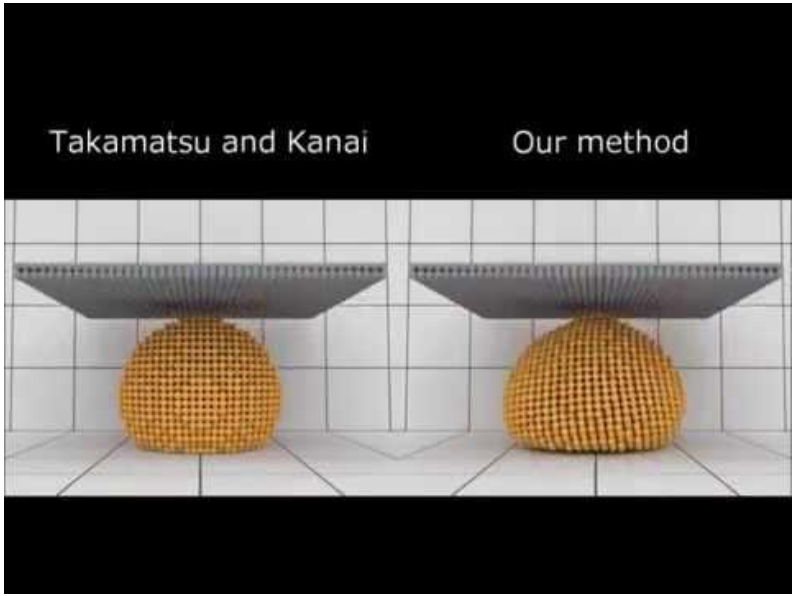
Milestones: Desired Target

Milestone 1: Steerable movement DONE

Milestone 2: Two-way interactions DONE

Milestone 3: Implement rest shape DONE

Milestone 4: Create demos DONE



Milestones: Bonus Target

Milestone 1: Improve 2D version DONE

Milestone 2: Stick to walls DONE

Milestone 3: Splitting, Merging DONE

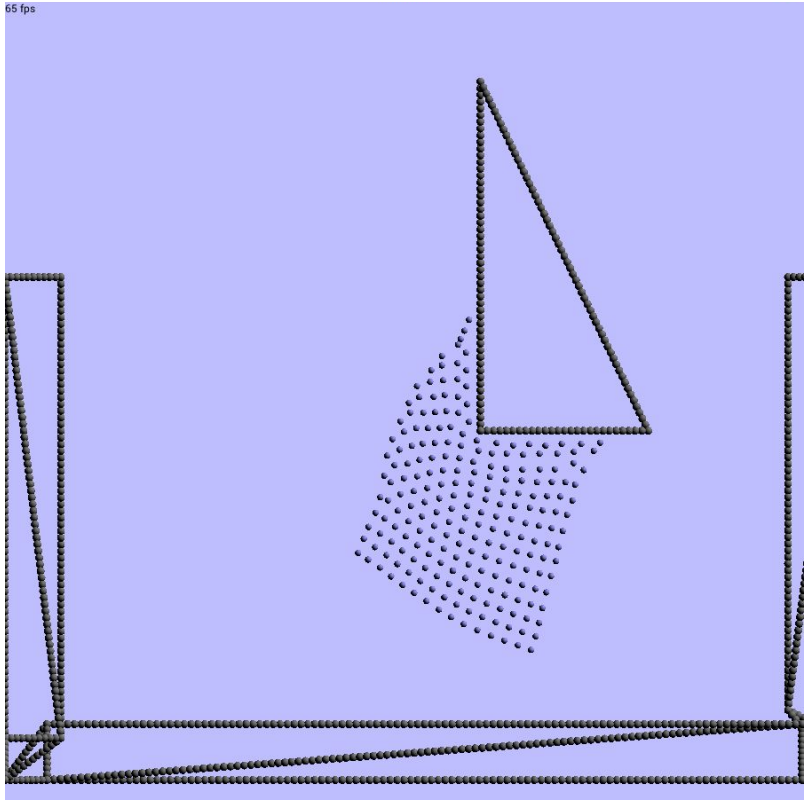
Core Concepts

- Forward Euler integration
- Momentum preserving pressure force
- SSPH viscosity force
- Boundary particles: adjusted velocity correction coefficients for boundaries
- Position based velocity correction
- Spatial Hashing for particle neighborhood

Demos

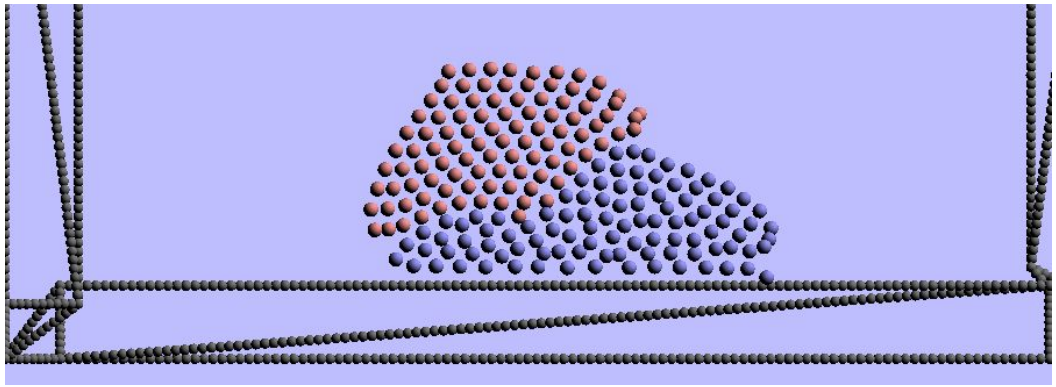
Benchmarks

- Highly scene dependent performance
- min FPS: 11 (1000 particles)
- max FPS: 50 (100 particles)
- Spatial Hashing takes ½ of time
- Single threaded performance



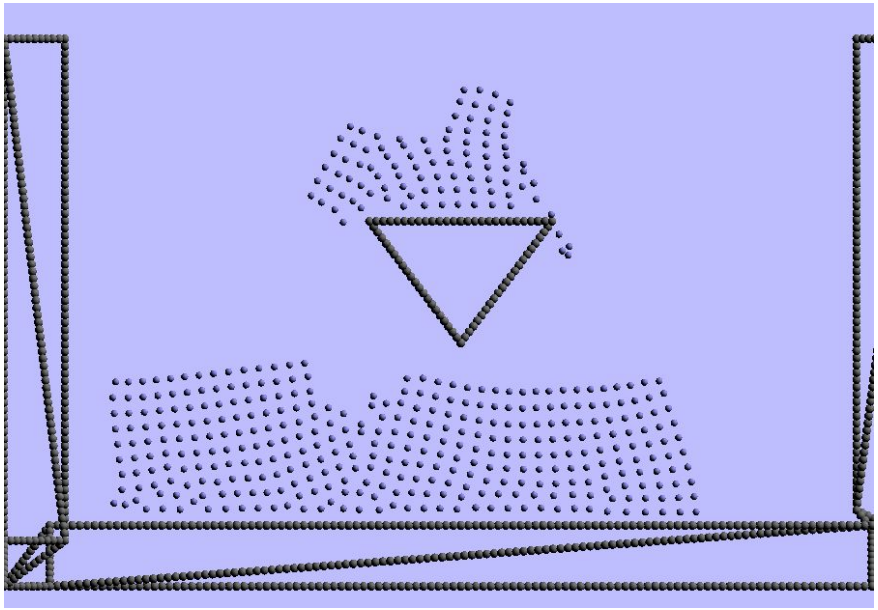
Lessons Learned

- Make sure, your math’s right
- Test your unit tests
- Choosing SPH parameters can be tricky
- Kernels should be used as template arguments, not by inheritance



Contribution

- Demonstrated real time feasibility of CPU implementation
- Robust enough for interactive use
- Desired features possible
- SSPH sufficient for general use
- Flexible and extensible framework



Open issues for Game-Implementation

- CPU parallelization, GPU
- Particle vs. Fluid values to save memory
- Scaling to large worlds
- Visco-elasticity implicitly depends on time step
- Lot of fine tuning of values

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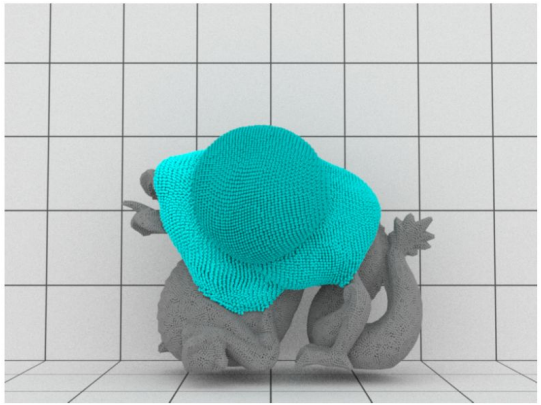
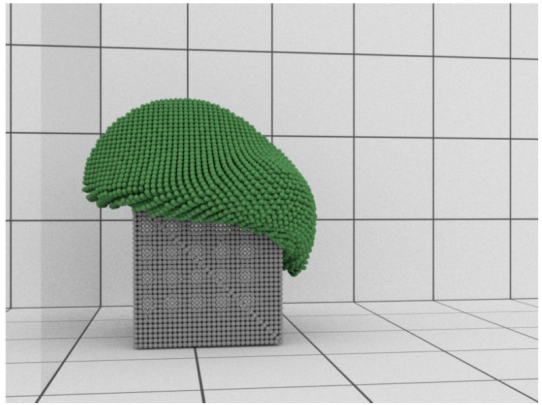
Main paper

- **Volume preserving viscoelastic fluids with large deformations using position-based velocity corrections**, Takahashi, Tetsuya & Dobashi, Yoshinori & Fujishiro, Issei & Nishita, Tomoyuki. (2014)

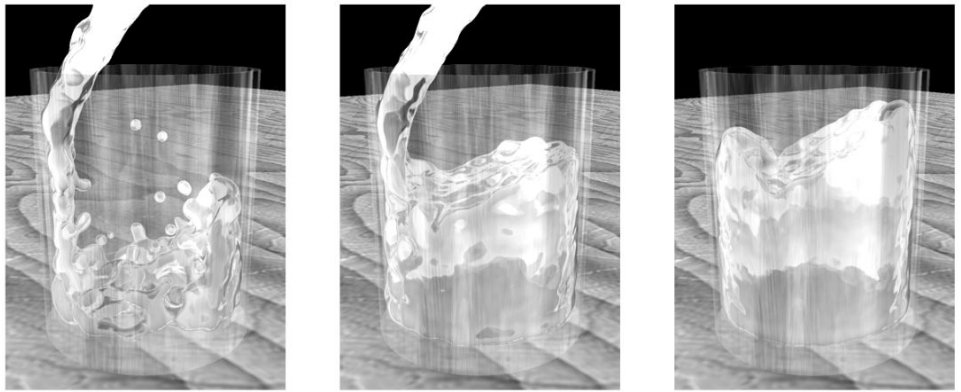




Studied work: SSPH

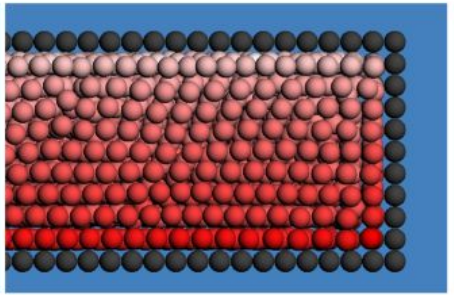
- **Particle-Based Fluid Simulation for Interactive Applications [Müller et al., 2003]**

- Basic SPH framework
- Kernels

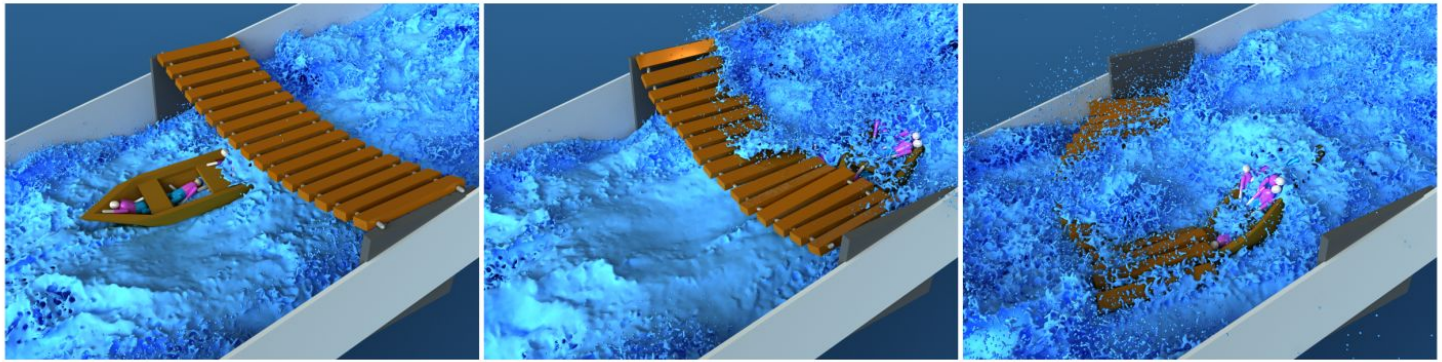


Studied work: Rigid-Fluid coupling

- **Versatile Rigid-Fluid Coupling for Incompressible SPH [Akinci et al., 2012]**



- Boundary particles



Studied work: Incompressible fluid models

- **PCISPH: Predictive-Corrective Incompressible SPH [Solenthaler et al., 2009]**

- **IISPH: Implicit Incompressible SPH [Ihmsen et al., 2014]**