Simulation of Water in a Gravity Field

Philipp Lindenberger, Sebastian Winberg
Physically-Based Simulation 2020
Our Inspirational Picture
Our Project Idea

- Play around with SPH and (gravity) forces
- Initial main goals:
  - SPH solver and improved SPH (PCISPH)
  - Boundary particle handling
  - Possibly rigid-fluid interaction
  - Nice final scene and rendering
What We Talked About Last Time

- 2D and 3D SPH simulation
- Uniform spatial hashing and parallelization
- (Gravity) force fields
- Surface Tension (only fluid-fluid)
- Simple boundary handling
Basic Implementation Details

- More (gravity) force fields supported (continuous/non-continuous)
- Implemented compact hashing with help of [Ihmsen et al. 2010] and SplishSplash
- Some more parallelization (OpenMP, std::for_each)
- Supports loading and exporting particles as .bgeo using Partio library
PCISPH

- Based on [Solenthaler et al. 2009]
- Predictive, corrective pressure update method
- Makes fluid very incompressible
- [Ihmsen et al. 2010] for versatile boundaries and rigid-fluid coupling
  - Adaptive time steps
  - Shock detection
Surface Tension

- Cohesion and surface area minimization
- In zero-g particles move apart quite quickly
- More quickly
- Also implemented adhesion
Boundary Particles

- Used uniform spatial sampler from SplishSplash to get initial boundary particle positions
- Method based on [Akinci et al. 2012]
- Only requires single layer samples
- Allows for complex mesh geometries
- Adhesion now supported!
Rigid-Bodies Coupling

- Expansion of boundary particle framework
- Apply negated fluid boundary forces on rigid-bodies
- Used collision detection from homework 2 for fairly simple rigid-body update step
- Allows for floating cubes (and boats)!
Overview of What We Did

- Simple SPH in 2D and 3D
- Complex gravity force fields
- Uniform spatial and compact hashing
- Code parallelization
- PCISP
- Adaptive time stepping
- Shock detection
- Surface tension (area minimization, cohesion, adhesion)
- Boundary particles (pressure, friction)
- Rigid-Fluid coupling
- Particle import/exporting
- Modeling and simulation of fluid scene
- Rendering
- One more thing...
Rendering

- Set out to create satisfying rendering
- Creating scene in Blender 2.8
- Import and sample meshes for boundary handling
- Exporting of particles in .bgeo with Partio
- Final scene composition and rendering with Houdini
- Final rendering took ~7h
Bonus: Lagrangian Neural Stylization Transfer

- Wanted to play a little more with gravity
- Used open-source code to stylize another, more complex scene
- Fits well with the theme of surrealism
Thanks for your attention!

Philipp Lindenberger
Sebastian Winberg