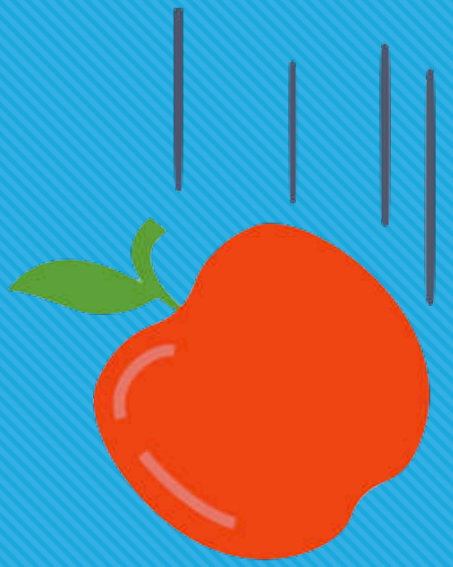
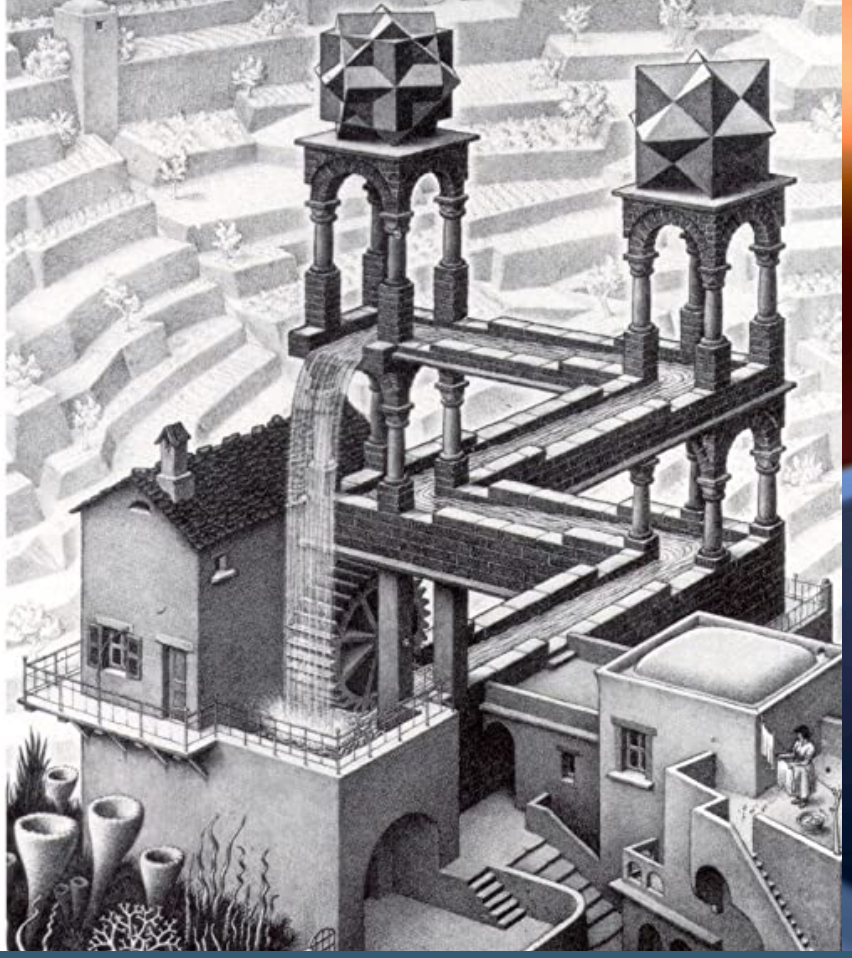
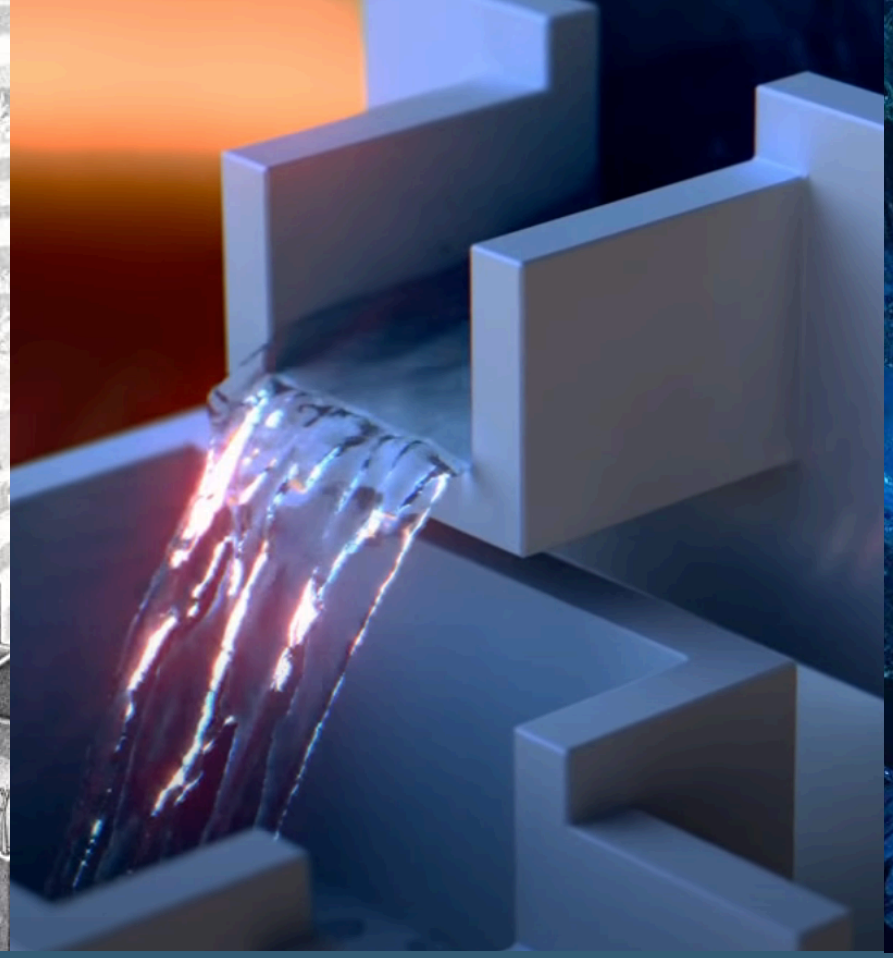
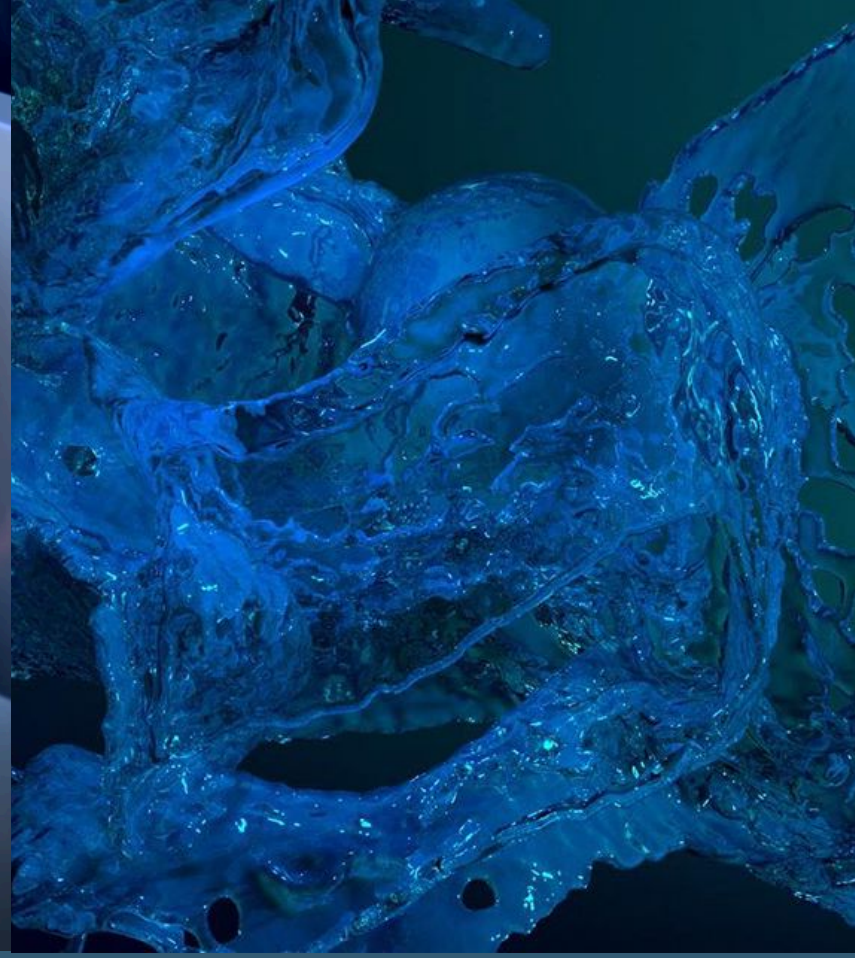
Simulation of Water in a Gravity Field



Philipp Lindenberger, Sebastian Winberg

Physically-Based Simulation 2020

Group 25

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

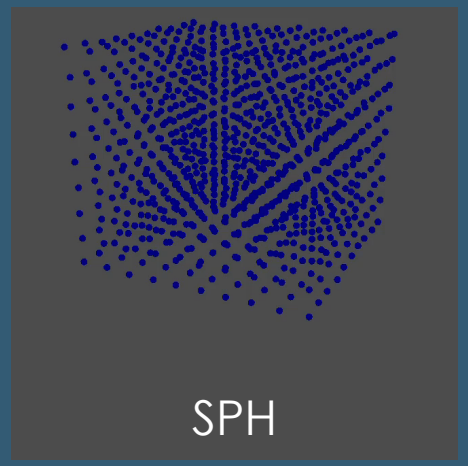
- 2D and 3D SPH simulation
- Uniform spatial hashing and parallelization
- (Gravity) force fields
- Surface Tension (only fluid-fluid)
- Simple boundary handling

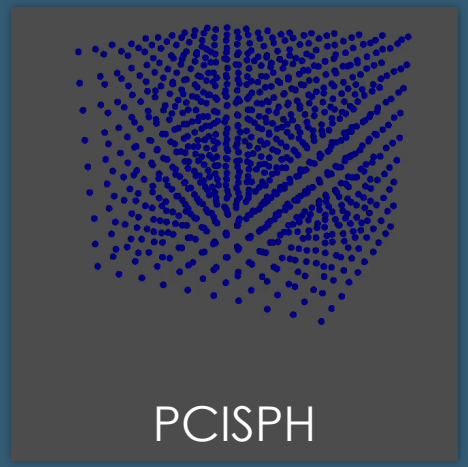
Basic Implementation Details

- 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



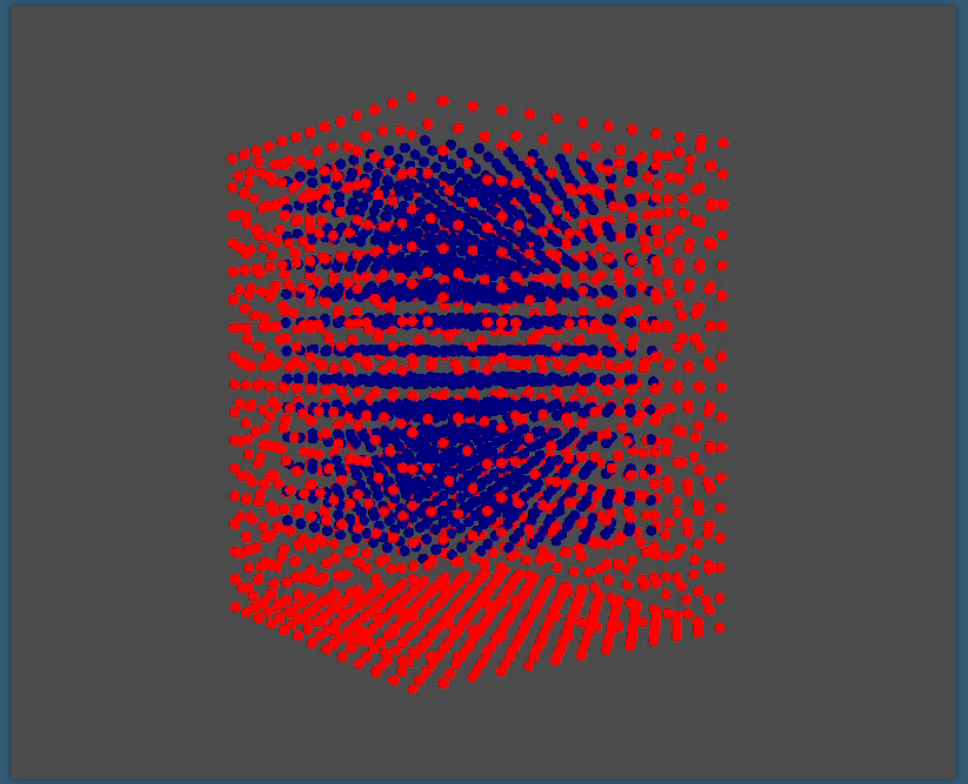


Surface Tension

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

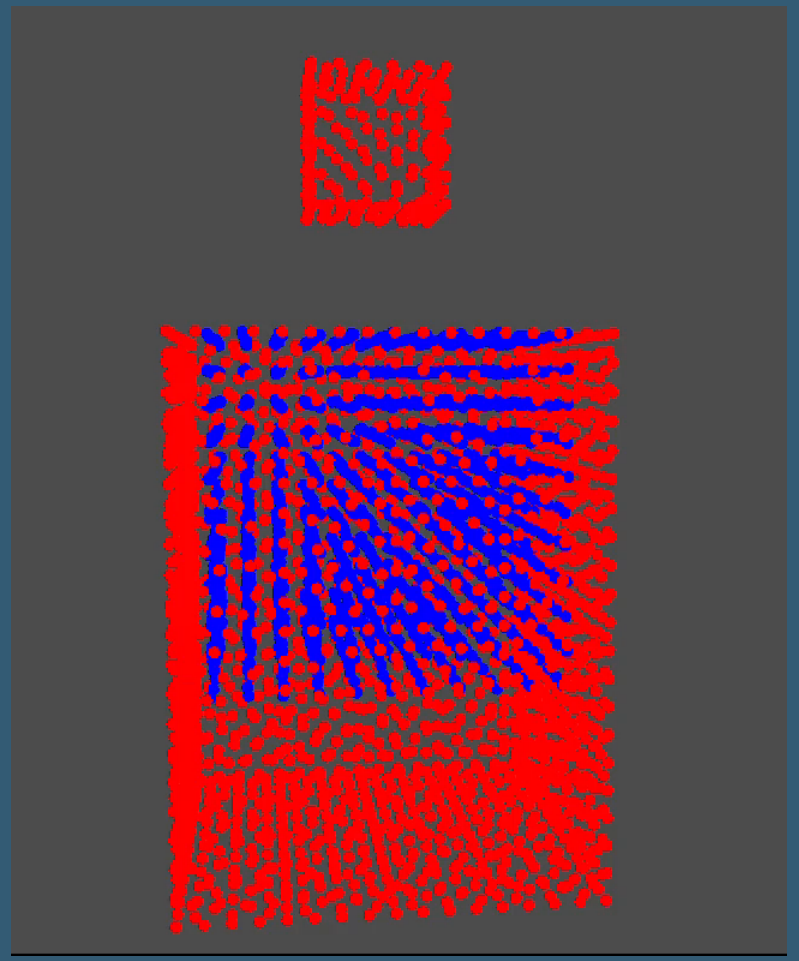
Boundary Particles

- 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)!

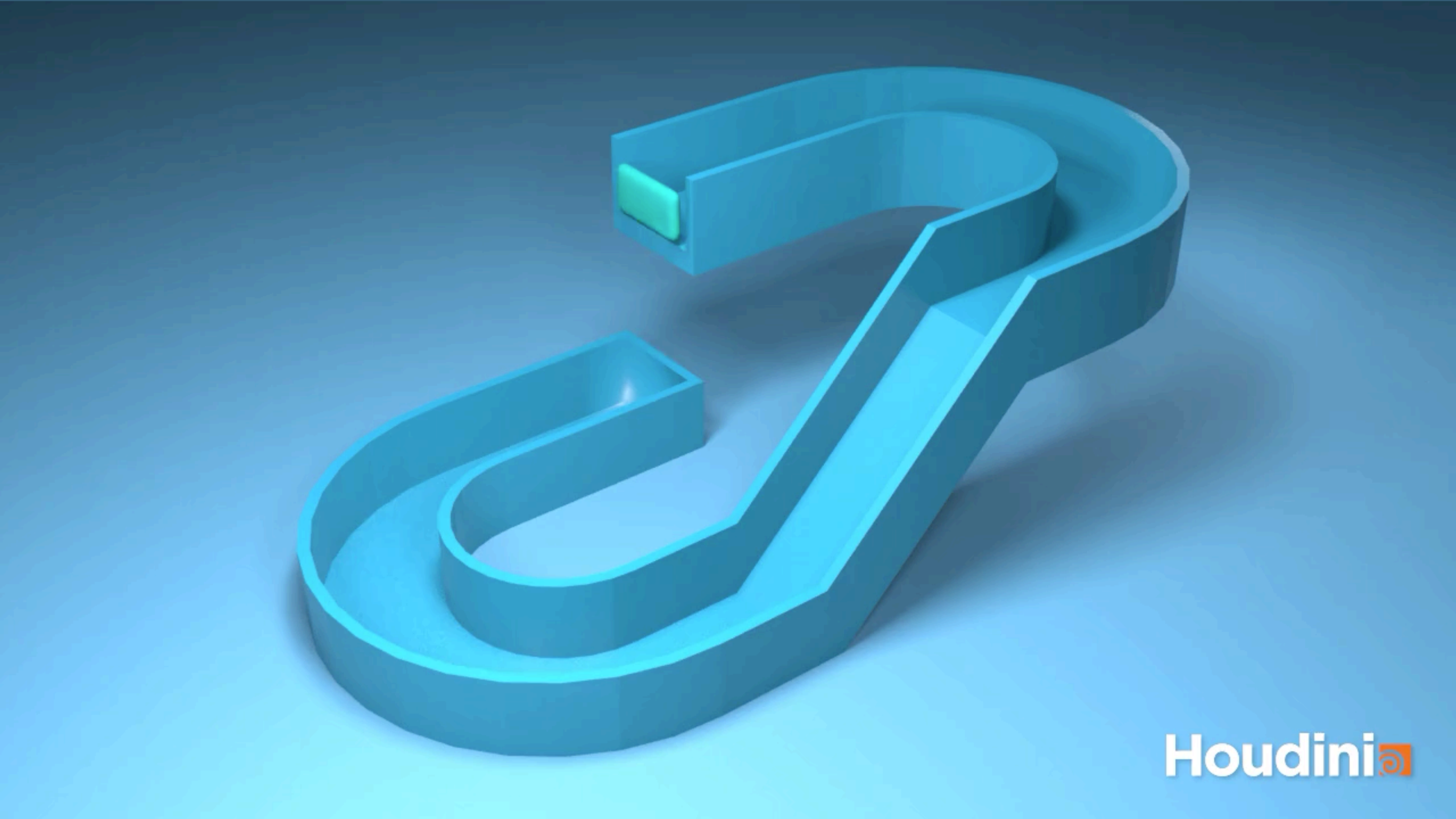


Overview of What We Did

- 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

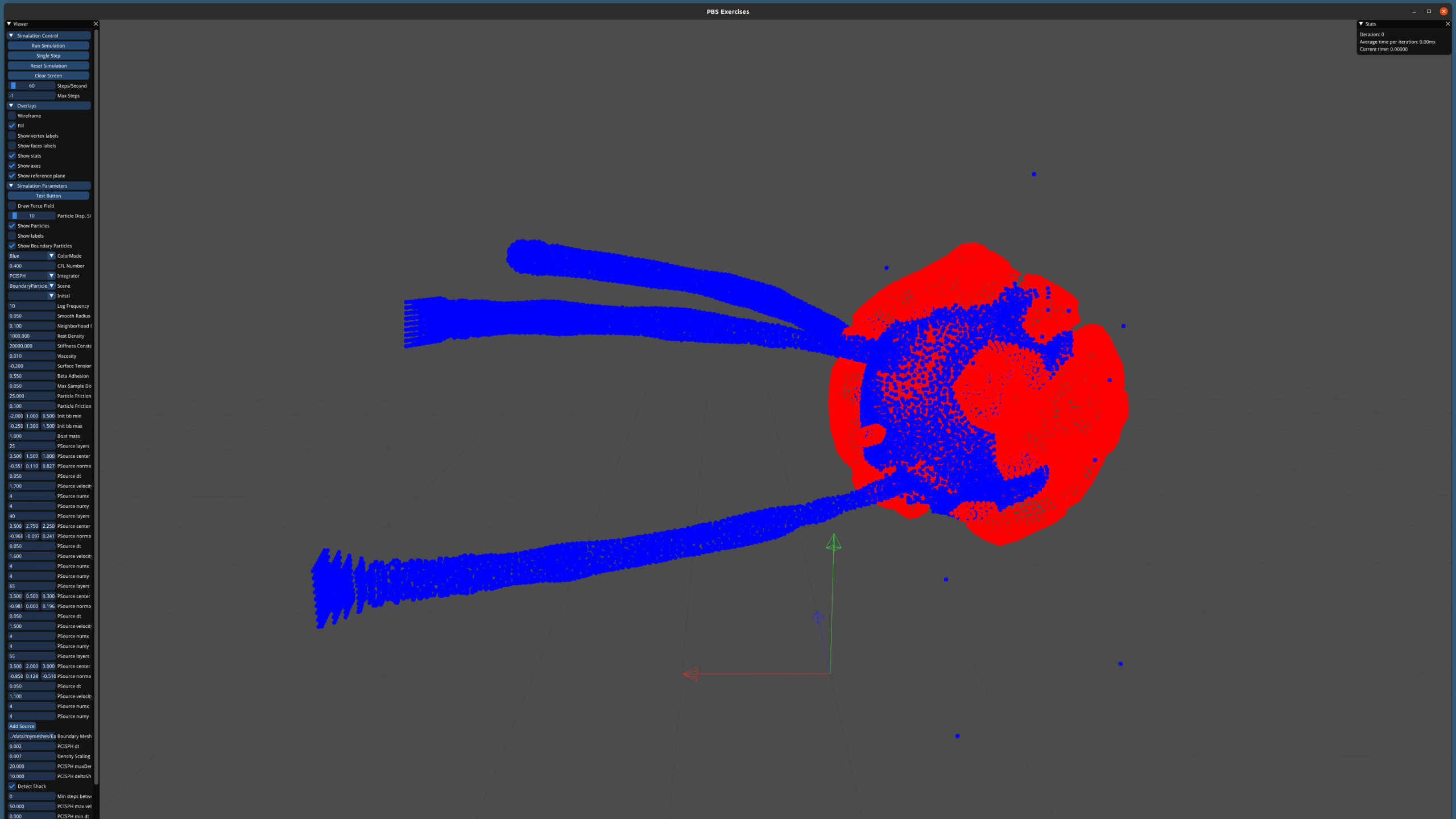
- Set out to create satisfying rendering
- Creating scene in Blender 2.8
- Import and sample meshes for boundary handling
- Exporting of particles in .bgeo with Partio
- Final scene composition and rendering with Houdini
- Final rendering took ~7h

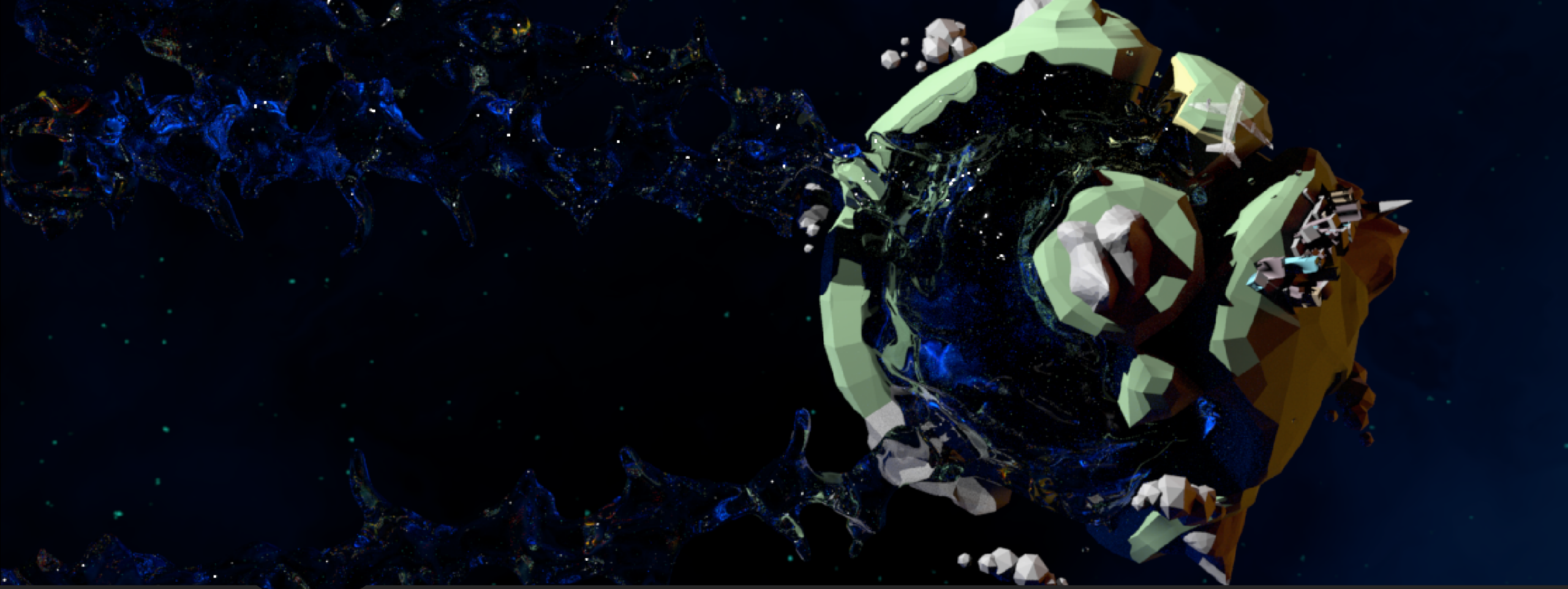

Houdini

Bonus: Lagrangian Neural Stylization Transfer

- Wanted to play a little more with gravity
- Seminar presentation of LNST [Kim et al. 2020] in course "Advanced Topics of Computer Graphics and Vision"
- Used open-source code to stylize another, more complex scene
- Fits well with the theme of surrealism


Houdini


PBS Exercises
Viewer
Simulation Control
Run Simulation
Single Step
Reset Simulation
Clear Screen
60
Steps/Second
-1
Max Steps
Overlays
Wireframe
Fill
Show vertex labels
Show faces labels
Show stats
Show axes
Show reference plane
Simulation Parameters
Test Button
Draw Force Field
10
Particle Disp. Si
Show Particles
Show labels
Show Boundary Particles
Blue
ColorMode
0.400
CFL Number
PCISPH
Integrator
BoundaryParticle
Scene
Initial
10
Log Frequency
0.050
Smooth Radius
0.100
Neighborhood I
1000.000
Rest Density
20000.000
Stiffness Consta
0.010
Viscosity
-0.200
Surface Tensior
0.550
Beta Adhesion
0.050
Max Sample Dis
25.000
Particle Friction
0.100
Particle Friction
-2.000 1.000 0.500
Init bb min
-0.250 1.300 1.500
Init bb max
1.000
Boat mass
25
PSource layers
3.500 1.500 1.000
PSource center
-0.551 0.110 0.827
PSource norma
0.050
PSource dt
1.700
PSource velocity
4
PSource numx
4
PSource numy
40
PSource layers
3.500 2.750 2.250
PSource center
-0.966 -0.097 0.241
PSource norma
0.050
PSource dt
1.600
PSource velocity
4
PSource numx
4
PSource numy
65
PSource layers
3.500 0.500 0.300
PSource center
-0.981 0.000 0.196
PSource norma
0.050
PSource dt
1.500
PSource velocity
4
PSource numx
4
PSource numy
55
PSource layers
3.500 2.000 3.000
PSource center
-0.850 0.128 -0.510
PSource norma
0.050
PSource dt
1.100
PSource velocity
4
PSource numx
4
PSource numy
Add Source
../data/mymeshes/Ea
Boundary Mesh
0.002
PCISPH dt
0.007
Density Scaling
20.000
PCISPH maxDer
10.000
PCISPH deltaSh
Detect Shock
0
Min steps betwe
50.000
PCISPH max vel
0.000
PCISPH min dt
Stats
Iteration: 0
Average time per iteration: 0.00ms
Current time: 0.00000



Thanks for your attention!

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Sebastian Winberg