Physically-Based Simulation
Position Based Fluids

Group 17

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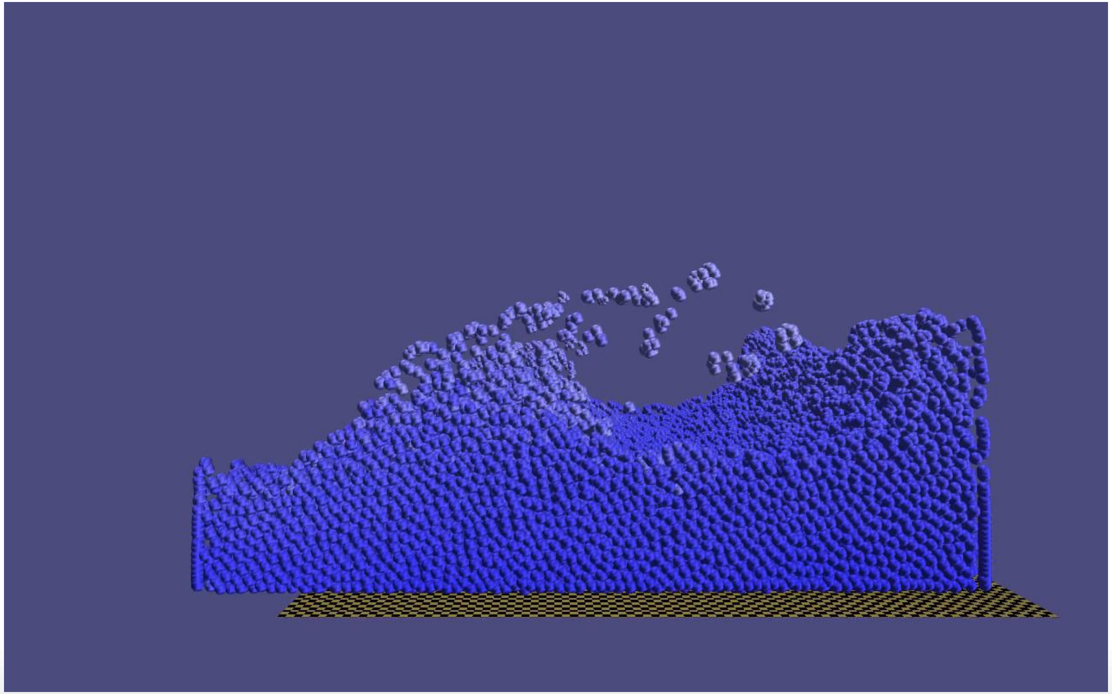
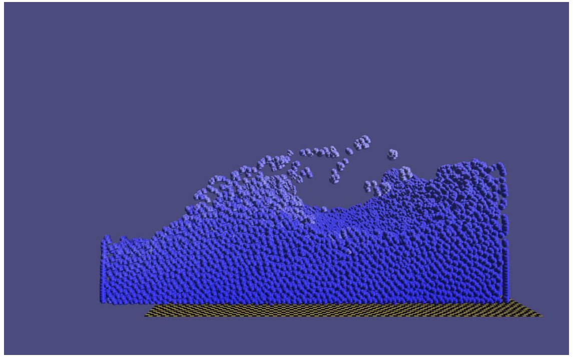
Demo

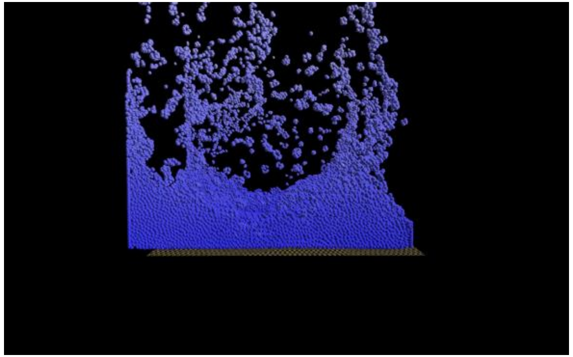


27K Particles ~ 30 fps

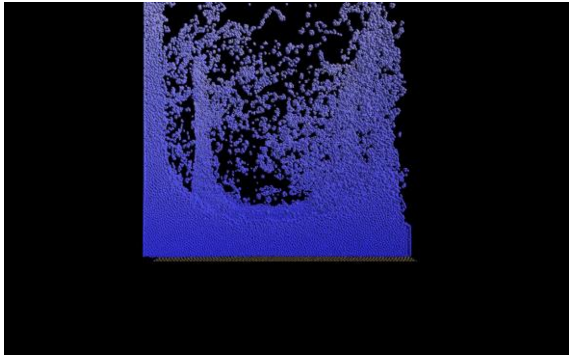
Demo



27K Particles ~ 30 fps



42K Particles ~ 15 fps



125K Particles ~ 4 fps

Final State

- PBF Simulation
  - Parallelized advance (CPU)
  - Fast parallelized neighborhood search
  - Moving Boundaries
- Rendering
  - Instanced rendering
  - Dynamic particle coloring

Implementation Details

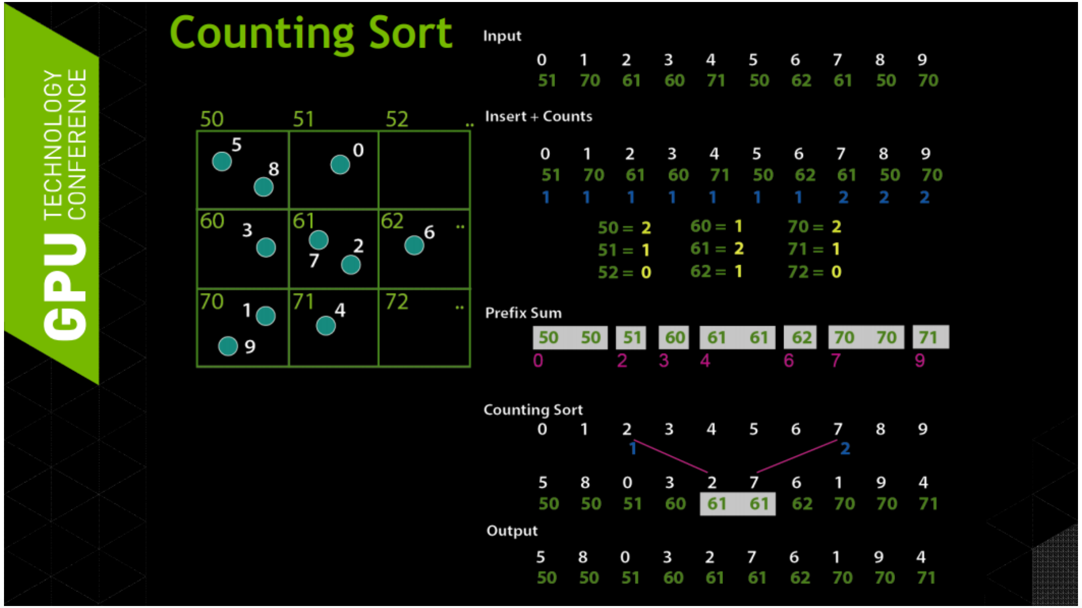
Multithreading

- Standard std::Threads
- Synchronized through barriers
- Responsible for one chunk of particles
- No pool or shutdown

Implementation Details

Neighborhood search

- Atomic increase
- Prefix Sum sequential



Counting Sort

Input

0	1	2	3	4	5	6	7	8	9
51	70	61	60	71	50	62	61	50	70

Insert + Counts

0	1	2	3	4	5	6	7	8	9
51	70	61	60	71	50	62	61	50	70
1	1	1	1	1	1	1	2	2	2

50 = 2	60 = 1	70 = 2
51 = 1	61 = 2	71 = 1
52 = 0	62 = 1	72 = 0

Prefix Sum

50	50	51	60	61	61	62	70	70	71
0		2	3	4		6	7		9

Counting Sort

0	1	2	3	4	5	6	7	8	9
		1					2		
5	8	0	3	2	7	6	1	9	4
50	50	51	60	61	61	62	70	70	71

Output

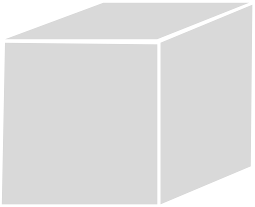
5	8	0	3	2	7	6	1	9	4
50	50	51	60	61	61	62	70	70	71

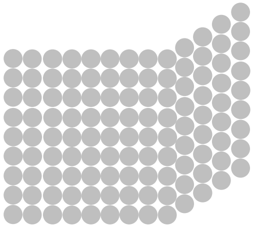
Slide from "Fast Fixed-Radius Nearest Neighbors: Interactive Million-Particle Fluids – Rama C. Hoetzlein, Graphics Devtech, Nvidia" presentation in 2014

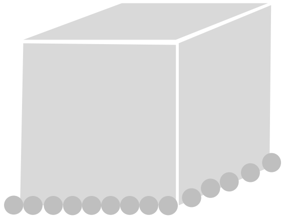
Implementation Details

Simulation Boundary

- Simple AABB
- Boundary Particles
- Best Combined



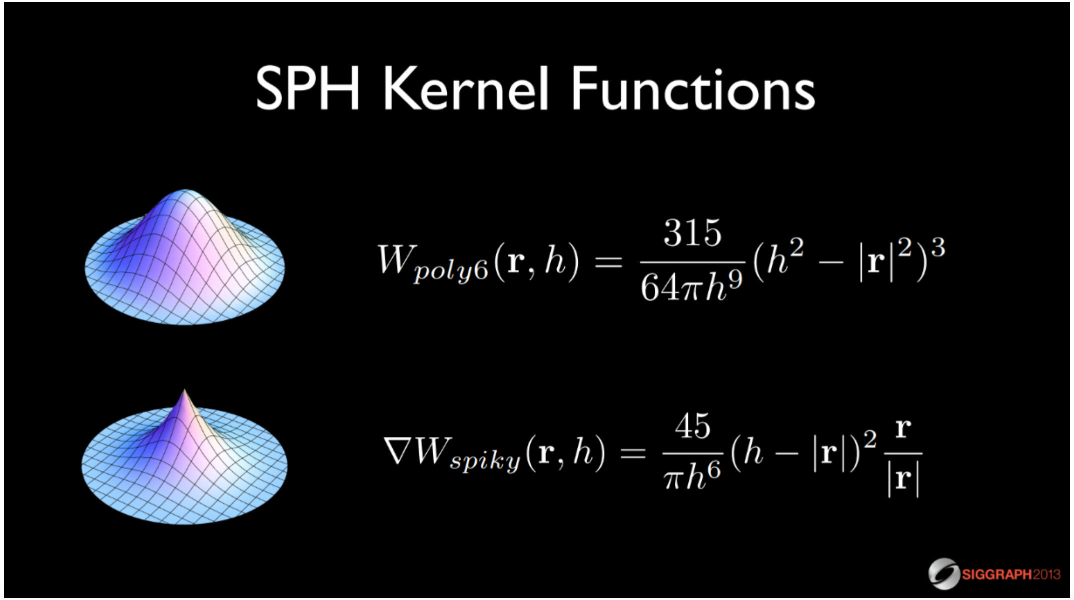




Implementation Details

SPH Kernel Functions

- Expensive
- Precompute
- Replaced by LUT



SPH Kernel Functions

$$W_{poly6}(\mathbf{r}, h) = \frac{315}{64\pi h^9}(h^2 - |\mathbf{r}|^2)^3$$

$$\nabla W_{spiky}(\mathbf{r}, h) = \frac{45}{\pi h^6}(h - |\mathbf{r}|)^2 \frac{\mathbf{r}}{|\mathbf{r}|}$$

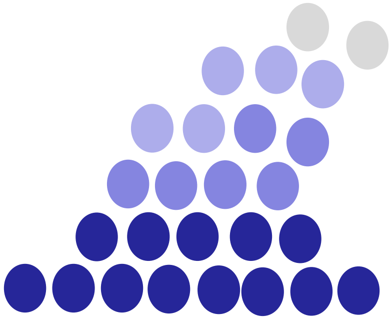
SIGGRAPH2013

M. Macklin – Position Based Fluids, Presentation Slides for SIGGRAPH2013.

Implementation Details

Dynamic Particle Coloring

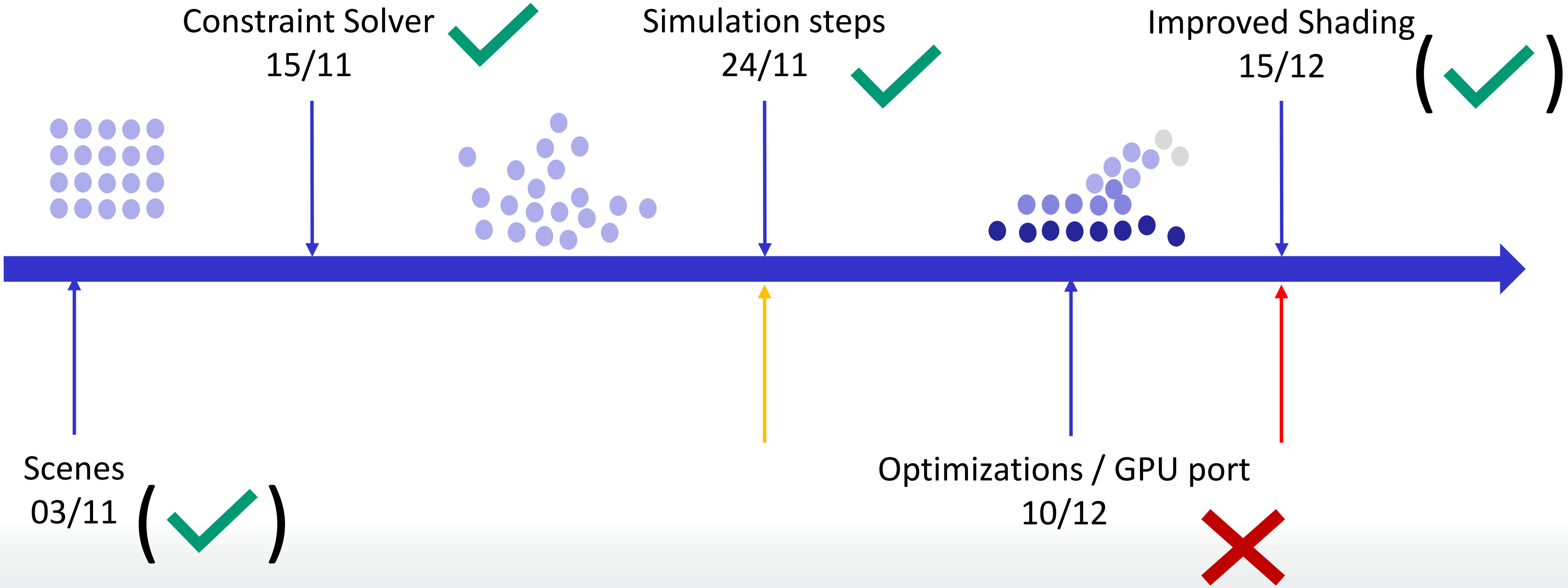
- Trade off between realism and real-time performance
- Float color gradient from blue to white [0, 1]
- Weighted mixture of particle velocity and height
- Bright wave tops, darker deep water



Lessons Learned

- Libigl / Geometry Course Simulator Framework
  - Easy to start, hard to change
  - Rewrite time consuming
- Position Based Fluids
  - Simplifications don’t make it simple to get right
- Realtime is really difficult to achieve
  - any computation is too much

Timeline



Constraint Solver
15/11 ✓

Simulation steps
24/11 ✓

Improved Shading
15/12 (✓)

Scenes
03/11 (✓)

Optimizations / GPU port
10/12 ✗