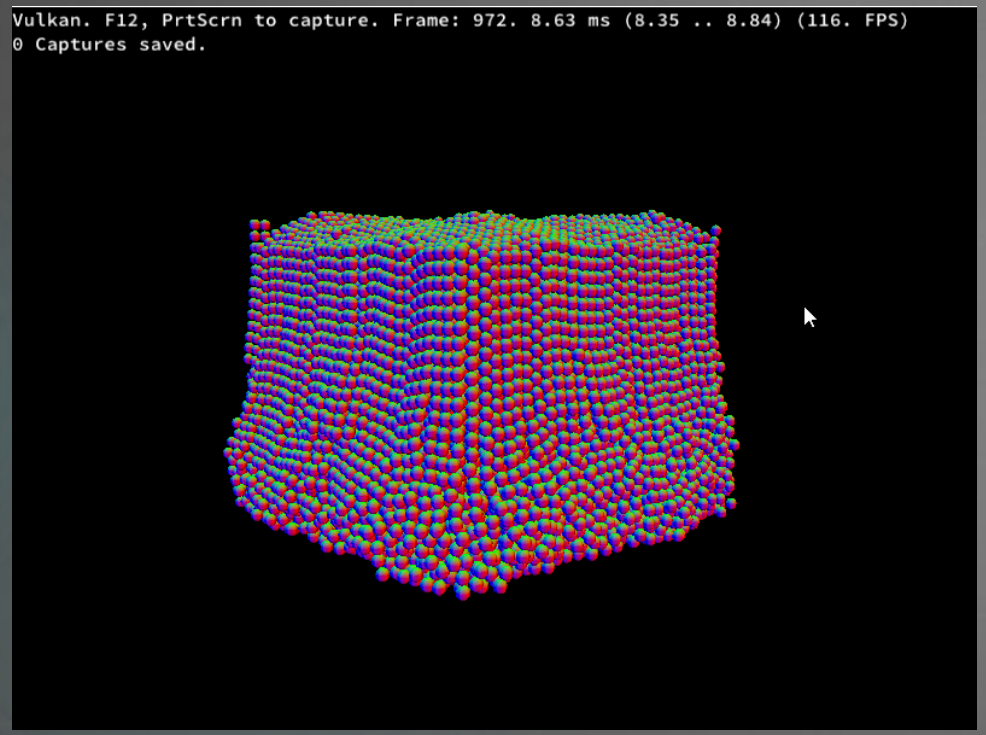
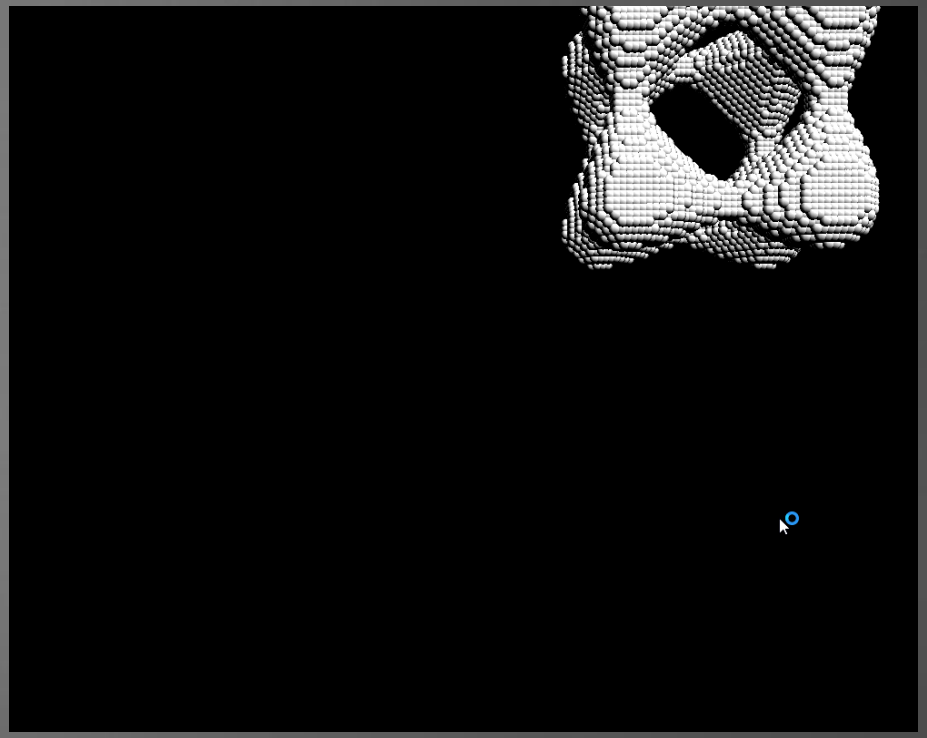
Real-time Particle-based Snow Simulation with Vulkan





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Brief Description

- A real-time particle-based snow simulator
- Use Vulkan for acceleration and visualization
- Compare performance of using CPU, CUDA and Vulkan

Why Vulkan

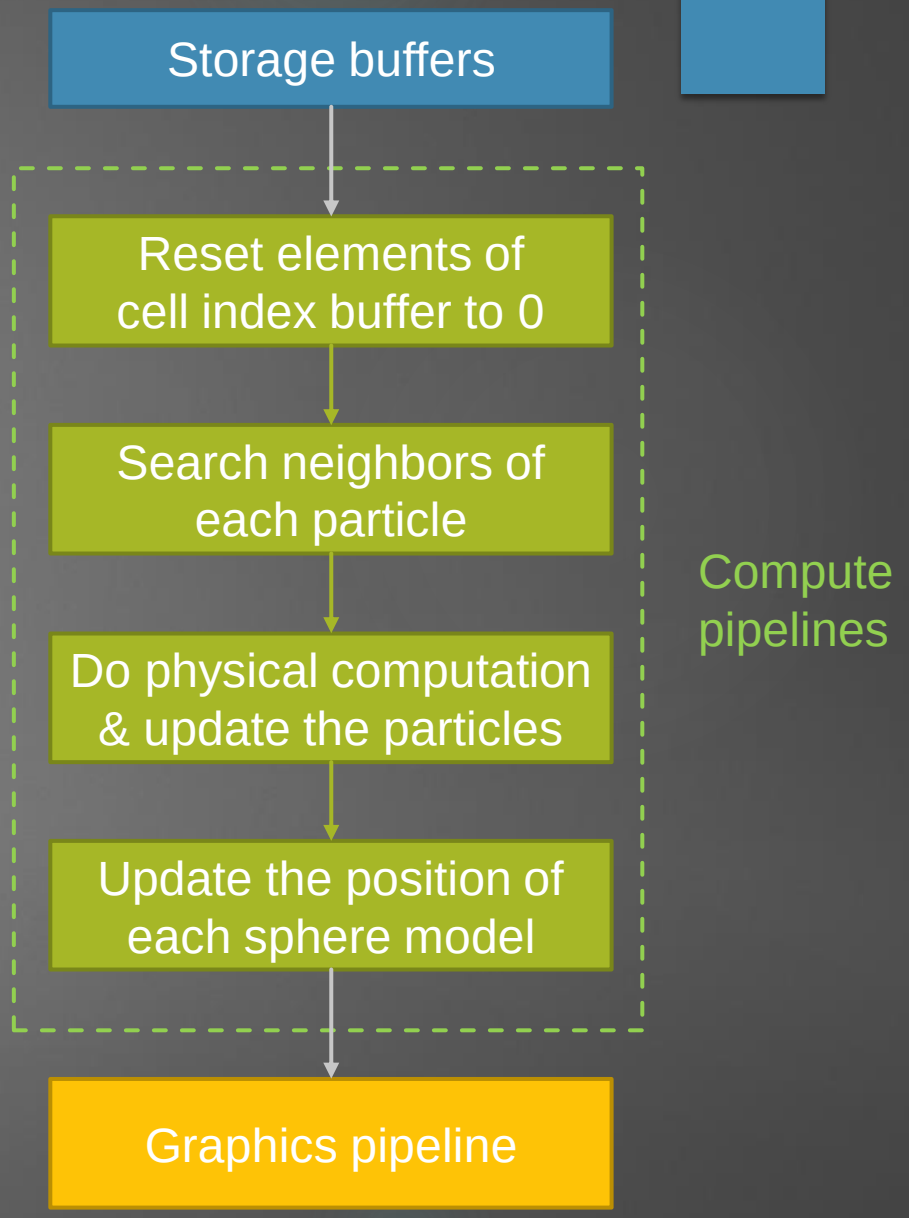
- Interested in learning a new graphics API
- Vulkan offers higher performance and more balanced CPU/GPU usage

Technical Overview

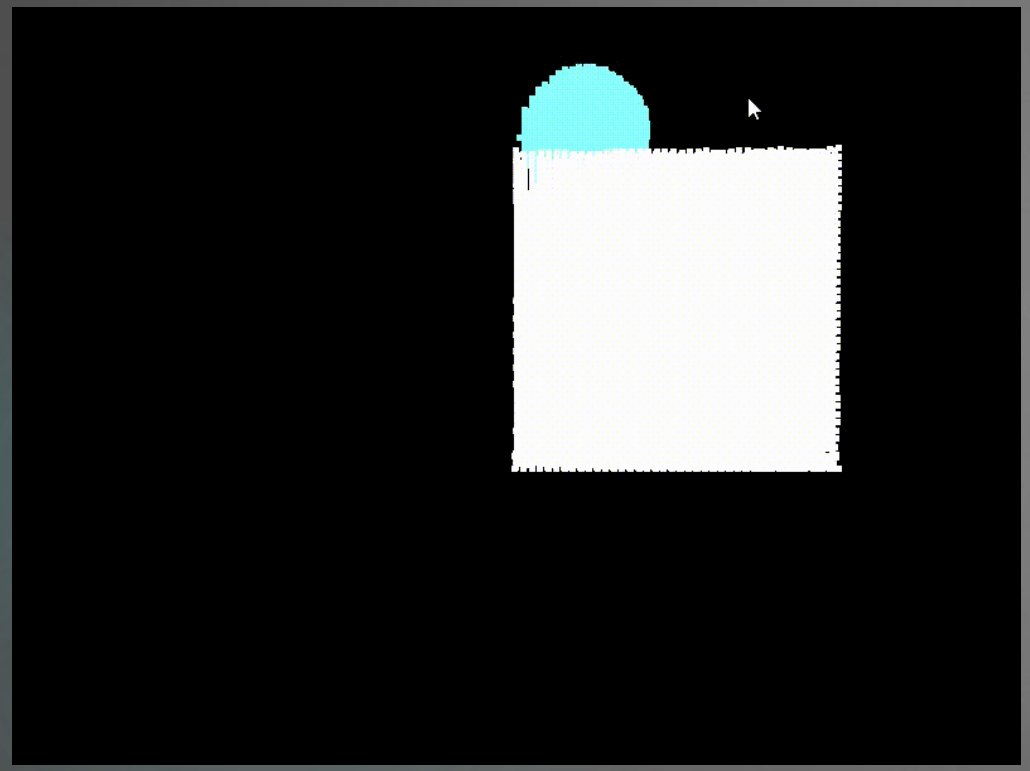
It is a discrete element method and captures compression and bonding between snow particles to model the realistic behavior of snow.

Advantages:

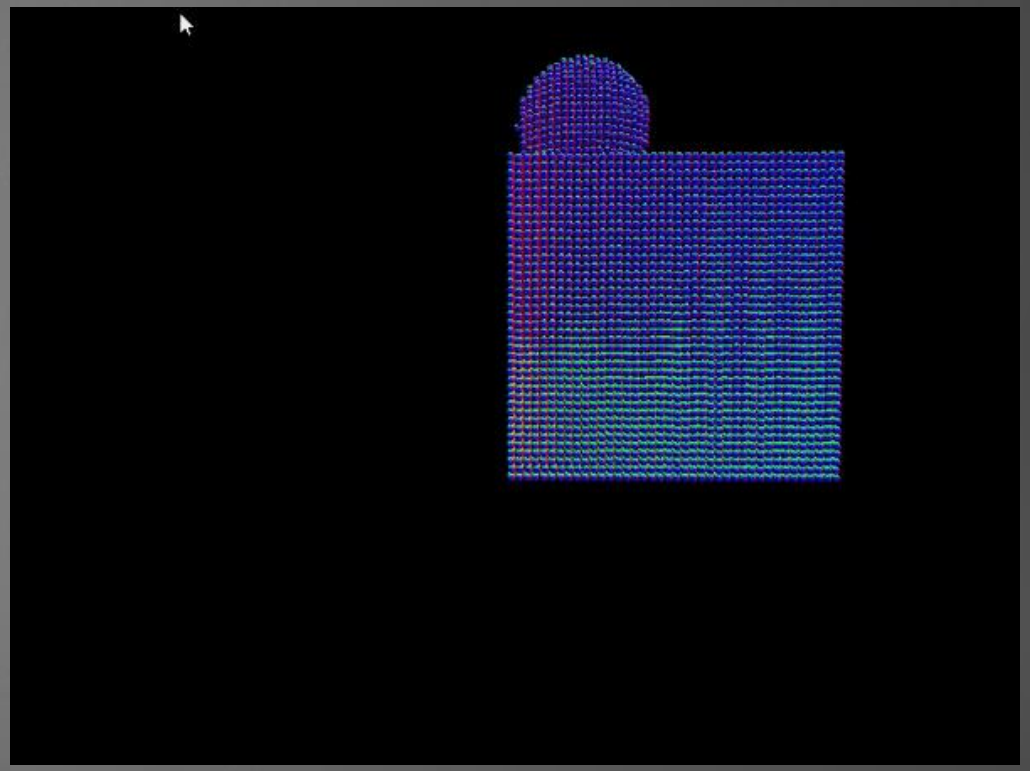
- **It is real-time, computationally inexpensive to simulate snow dynamics.**
- **It can be easily incorporated in the existing unified particle-based frameworks.**



Results & Analysis

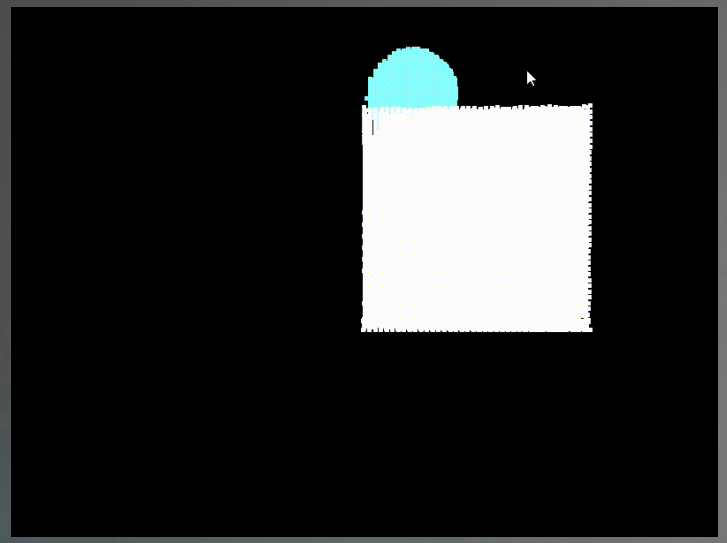


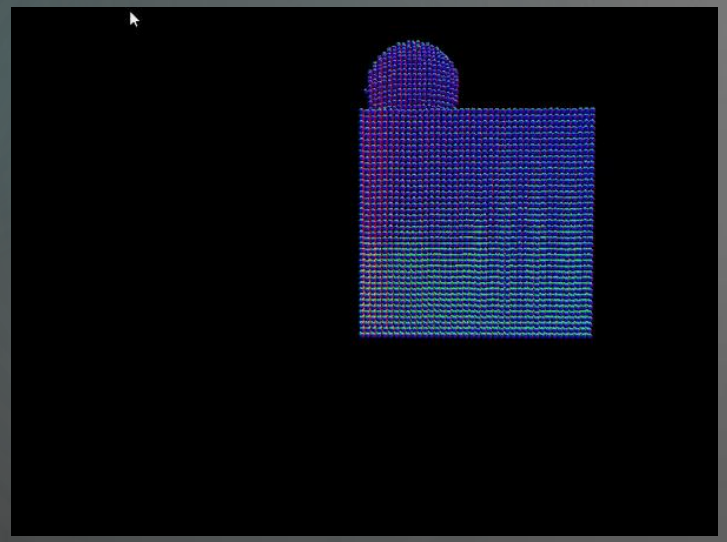
Show particles as points

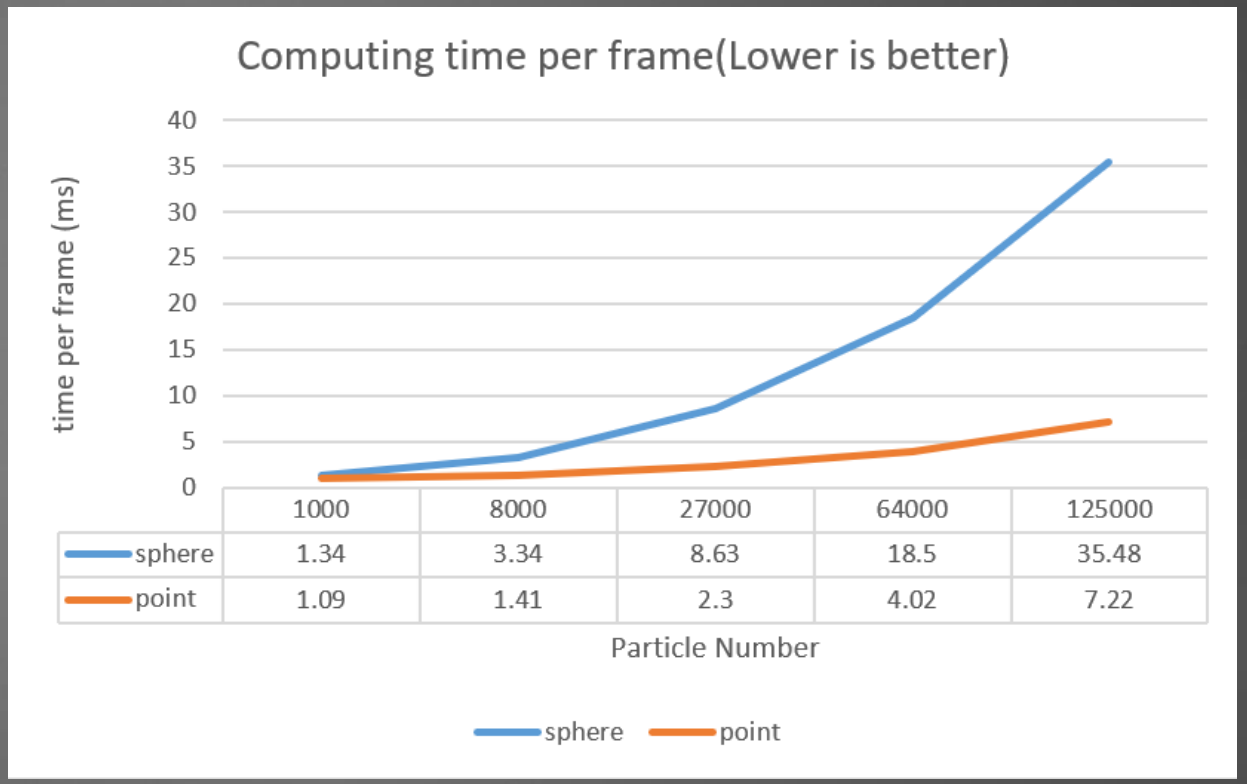


Show particles as sphere models

Results & Analysis

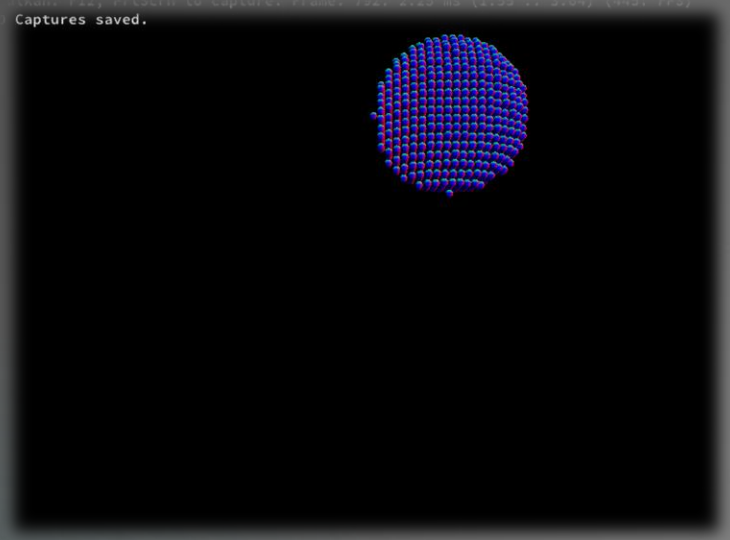


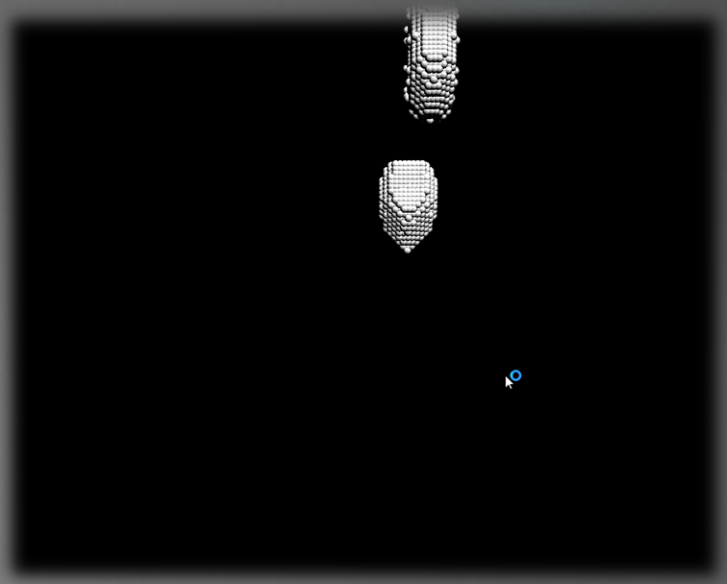




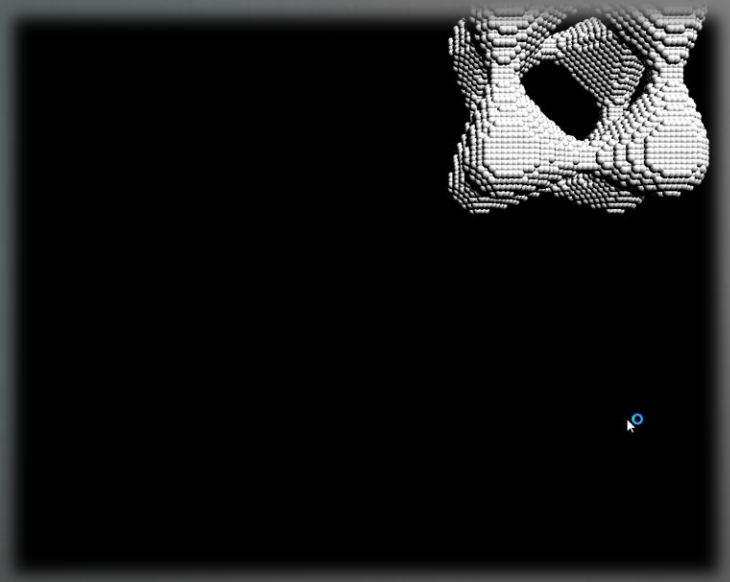
Results & Analysis

Sphere

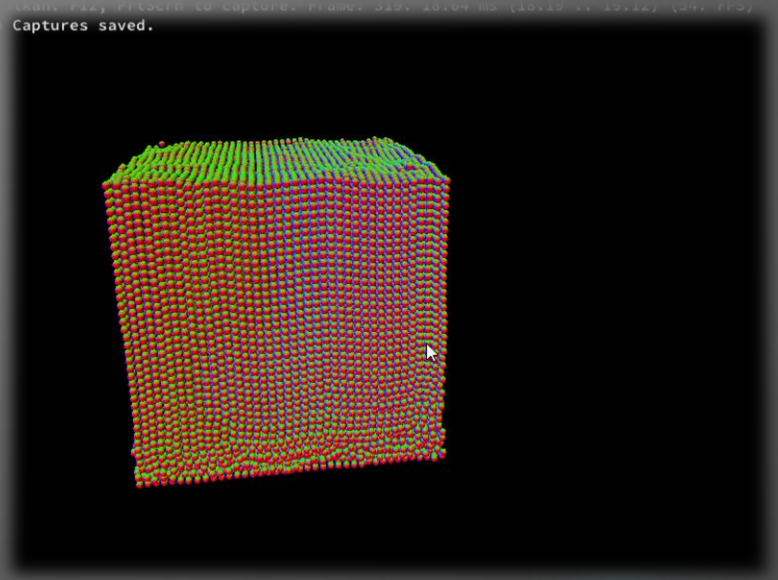




Torus
&
Heart



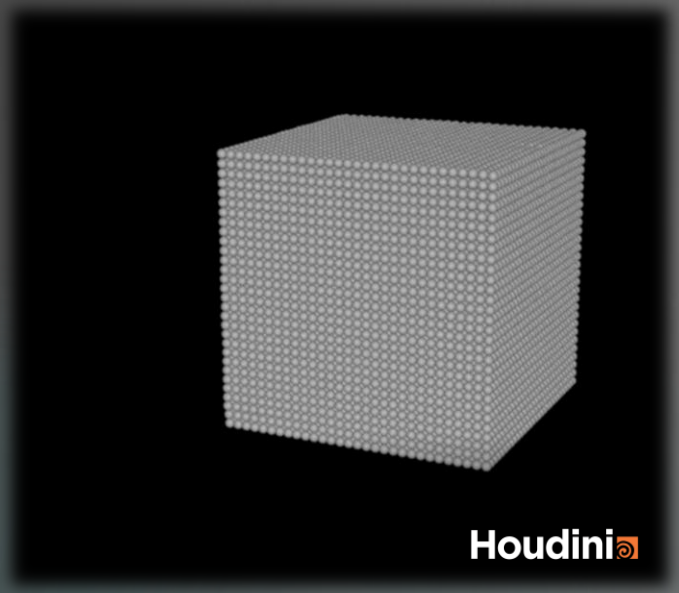
Tanglecube



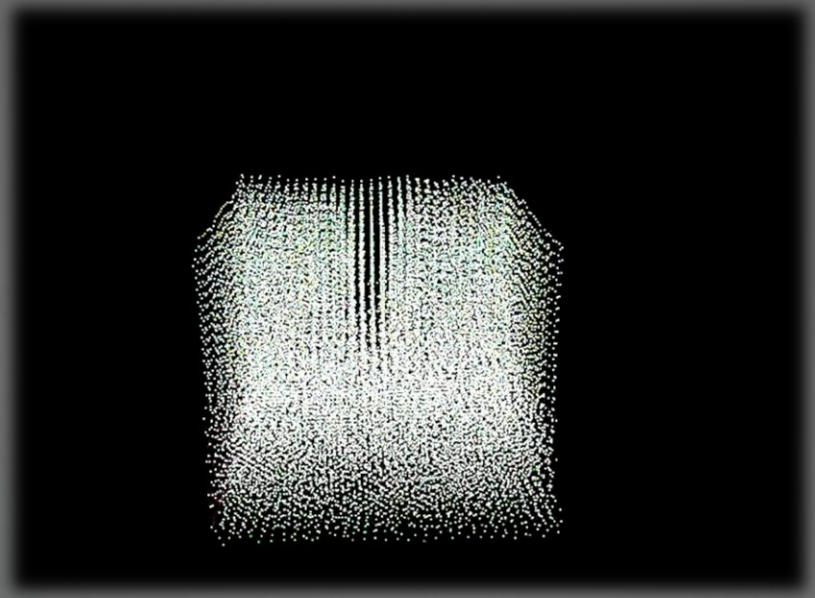
Big Cube

Results & Analysis

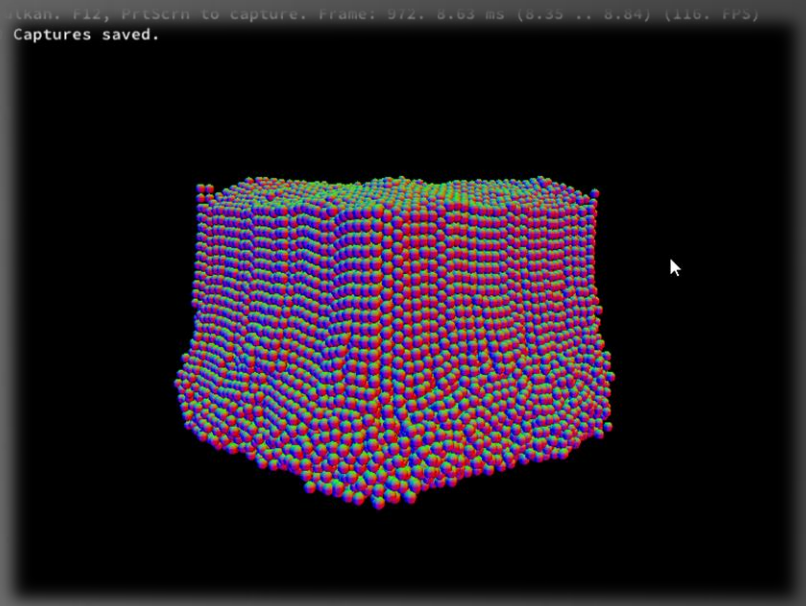
CPU + Houdini



CUDA + OpenGL (only render points)

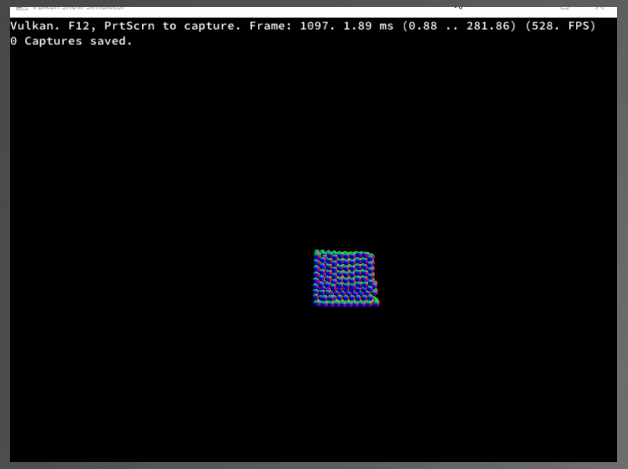


Vulkan

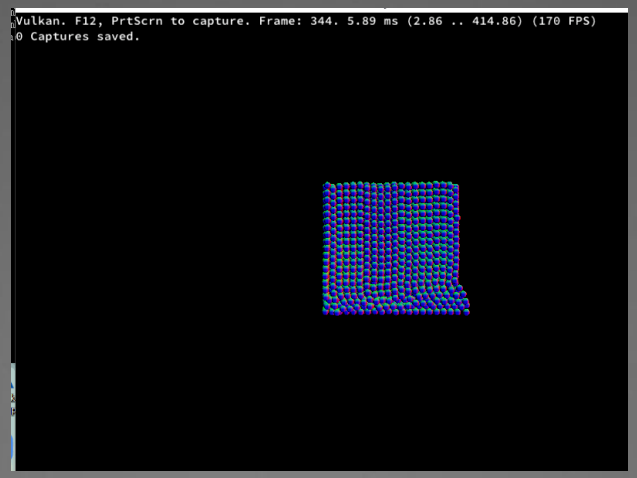


	CPU (without rendering)	CUDA + OpenGL	Vulkan
Computing time per frame (ms)	29,600	29.9	2.3

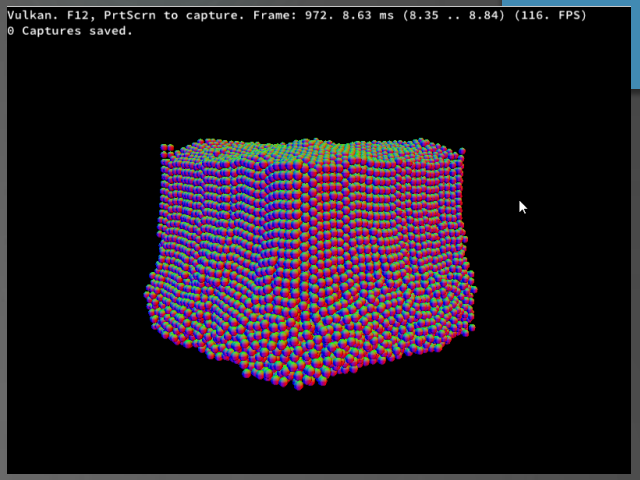
Results & Analysis



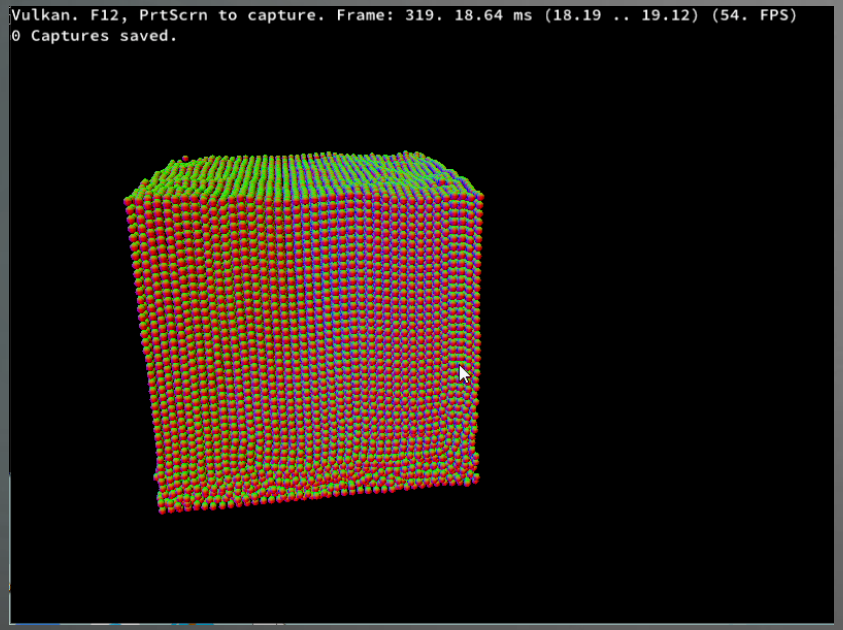
1K Particles (180K Vertices), 740fps



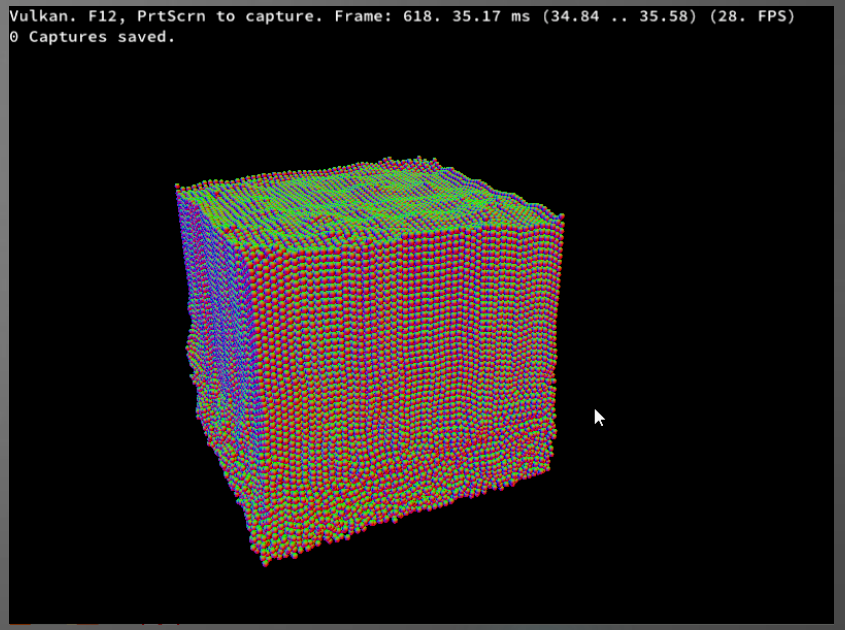
8K Particles (1.44M Vertices), 299fps



27K Particles (4.86M Vertices), 115fps



64K Particles (11.52M Vertices), 54ps



125K Particles (22.5M Vertices), 28ps

Results & Analysis

Shortcomings

For simulation methods:

- **Cannot handle interaction of snow with other material points.**
- **Only simulate soft dry snow.**

For implementation in Vulkan:

- **The code can be refactored and encapsulated further.**
- **Efficiency can be improved further.**
- **We learnt Vulkan from the scratch, which took us too much time.**

Credits

- **Real-time particle-based snow simulation on the GPU**
  https://www.diva-portal.org/smash/get/diva2:1320769/FULLTEXT01.pdf
  https://www.diva-portal.org/smash/get/diva2:1118073/FULLTEXT02
- **A material point method for snow simulation**
  https://www.math.ucla.edu/~jteran/papers/SSCTS13.pdf
- **Vulkan Tutorial**
  https://vulkan-tutorial.com/Introduction
- **Vulkan API**
  https://www.khronos.org/registry/vulkan/specs/1.2-extensions/html/vkspec.html
- **Nvidia: use GPU to simulate fluid**
  https://developer.nvidia.com/gpugems/gpugems/part-vi-beyond-triangles/chapter-38-fast-fluid-dynamics-simulation-gpu
- **tinyobjloader**
  https://github.com/tinyobjloader/tinyobjloader
- **RenderDoc**
  https://renderdoc.org/

Thank For Listening!