

# Real-time Particle-based Snow Simulation with Vulkan

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## Goals and objectives:

The primary focus of this project is to simulate snow efficiently and in real-time.

Based on a 2019's paper: Real-time particle-based snow simulation on the GPU, we are going to achieve a simulator that enables us to simulate snow dynamics in real-time.

Our project has following goals:

1. Achieve a real-time, particle-based method to simulate snow dynamics on the GPU.
2. Use Vulkan compute shader to accelerate the simulation and visualize snow particles in real time with Vulkan as well.
3. Compare the performance of using CPU, CUDA and Vulkan compute shader for attributes computation.

## Motivation:

Based on our interest in simulation, we chose this topic, and this is also a good opportunity for us to explore a new graphics API, Vulkan.

We have done some physical simulation projects before, such as water and colloidal objects, but if you use the CPU for calculation, it often takes a long time to simulate a few seconds of movement, and only offline rendering can be achieved. Using CUDA can speed up and achieve real-time effects, but if visualization is performed at the same time, such as using OpenGL or Vulkan, because it involves frequent data copying, reading and writing, it will also greatly affect efficiency. So we consider using Vulkan's compute pipeline to accelerate the calculation, and use Vulkan for visualization, hoping to improve performance.

## Third-parties:

Vulkan, GLM, Eigen, tiny-obj

## Schedules:

### Milestone 1 – Nov 18th:

- Learn Vulkan
- Write a Vulkan visualizer

**Milestone 2 – Nov 30th:**

- Dive into the references and this paper
- Implement the physics and math calculation part and achieve an off-line simulator with CPU

**Milestone 3 – Dec 7th:**

- Continue to implement the physics and math part
- Use CUDA and OpenGL/Vulkan to acceleration and visualization (for comparing with the performance Vulkan compute pipeline + graphics pipeline)
- Use Vulkan compute shader to accelerate the simulation

**Final – Dec 13:**

- Continue working on Vulkan compute shader
- Testing and bug fixing
- Optimizations

**References:**

- Real-time particle-based snow simulation on the GPU  
<https://www.diva-portal.org/smash/get/diva2:1320769/FULLTEXT01.pdf>
- Nvidia: use GPU to simulate fluid  
<https://developer.nvidia.com/gpugems/gpugems/part-vi-beyond-triangles/chapter-38-fast-fluid-dynamics-simulation-gpu>
- NVIDIA Vulkan Ray Tracing Tutorial  
[https://nvpro-samples.github.io/vk\\_raytracing\\_tutorial\\_KHR/#introduction](https://nvpro-samples.github.io/vk_raytracing_tutorial_KHR/#introduction)
- A demo reference example:  
<https://experiments.withgoogle.com/fluid-particles>
- Vulkan Tutorial  
<https://vulkan-tutorial.com/Introduction>