Fast Volume Rendering with Spatiotemporal Reservoir Resampling

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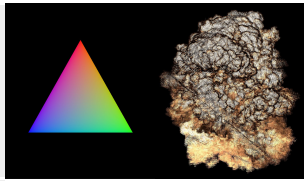
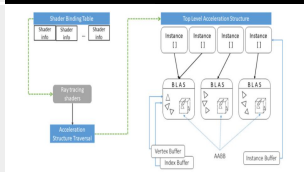
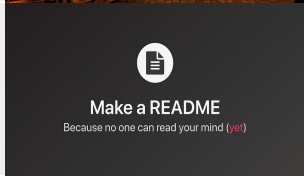
Penn Engineering

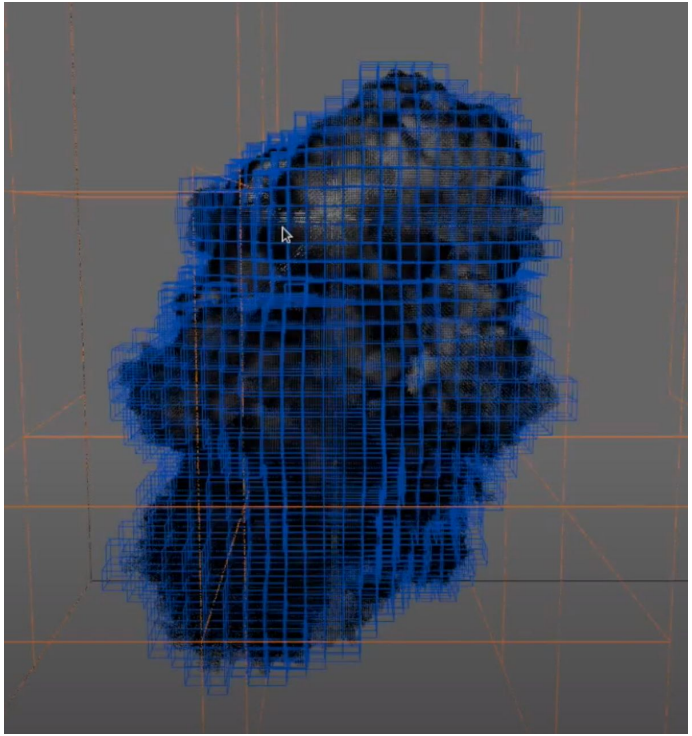
Milestones

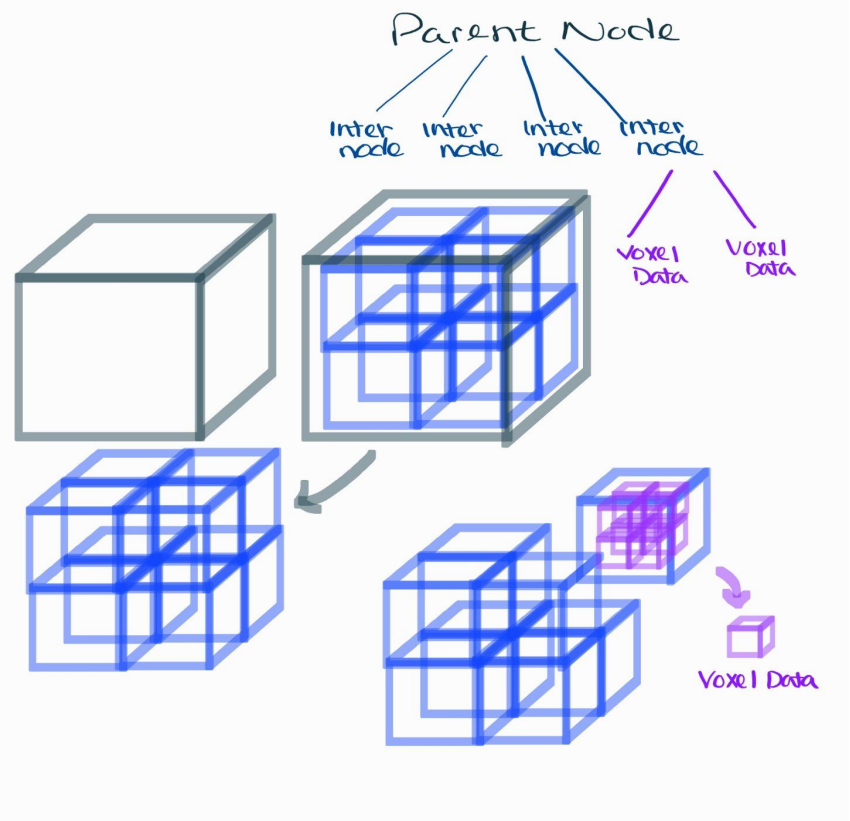
- Milestone 1
  - Build Vulkan -- CUDA Interop project code
- Milestone 2
  - Read and understand Volume + ReSTIR algorithm; develop toy example
- Milestone 3
  - Implement entire Volume + ReSTIR algorithm; concrete example
- Final Deliverable
  - Debug & final code; add more complex assets for visualization, more examples. Make it Cool!

Overview of Project

01	Project Setup Steps	• Basic Vulkan Pipeline • Vulkan Pipeline with Vertex/Index Buffers • OpenVDB Integration	
02	Exploring Vulkan	• Vulkan Ray Tracing Shaders • Vulkan TLAS & BLAS • Vulkan with OpenVDB Assets	
03	Exploring ReSTIR and VDB with ReSTIR	• Reservoirs, Lights, and other Structs • ReSTIR Algorithm • Adaptation of Algorithm for Volume Rendering	
04	Last Minute Touch Ups	• ReadME • Extend GUI's Interactivity • Final Code Refactor	

Overview OpenVDB

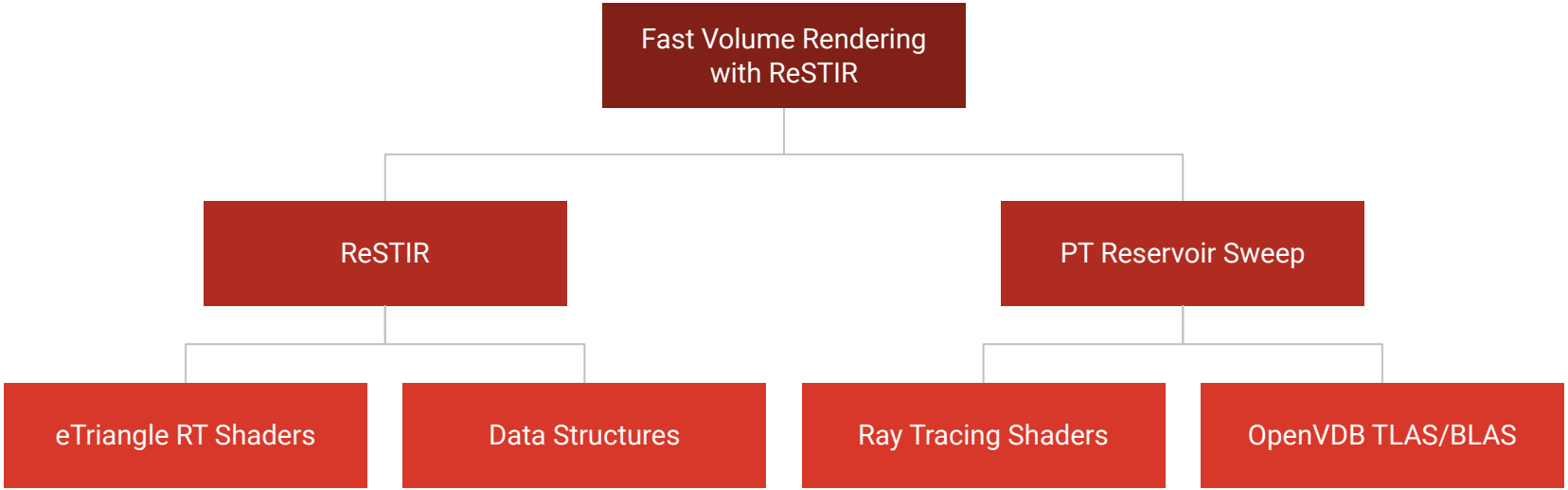




The Power of VDB

- Fast random and sequential data access.
- Memory efficient.
- Adaptive resolution.
- Dynamic

Overview ReSTIR



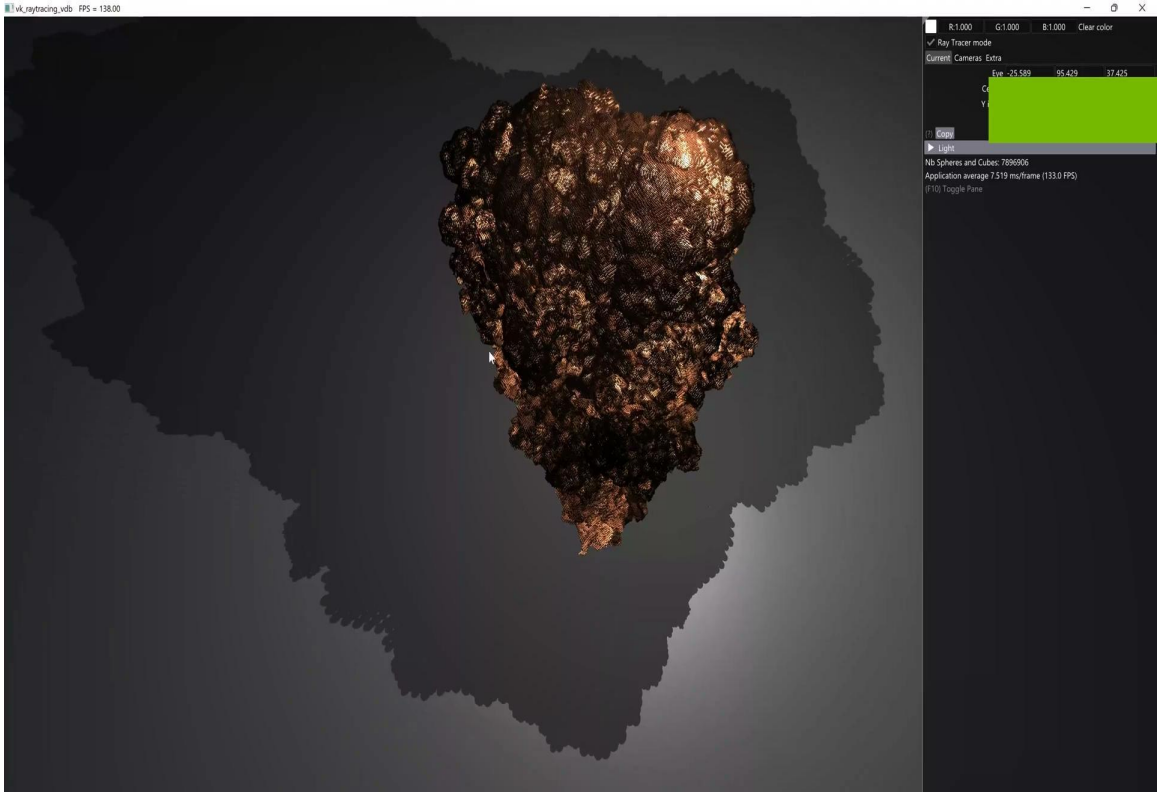
What We Have Completed

- Vulkan Rasterized Pipeline with Volumetric Assets. (milestone 2)
- Vulkan Path Tracing Pipeline with Volumetric Assets.
- Vulkan Raytraced Restir Pipeline with GLTF. (Creating the Scene)

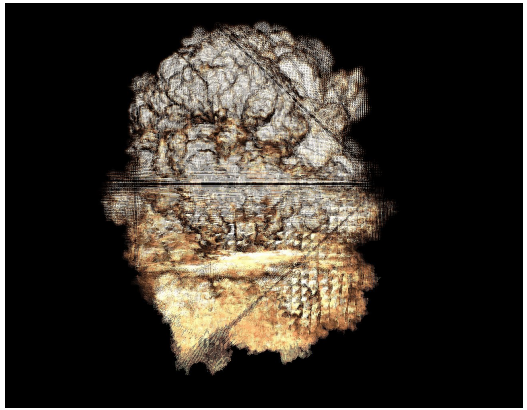
What We Have Left

- Integrating Restir Pipeline with with Volumetric Assets.

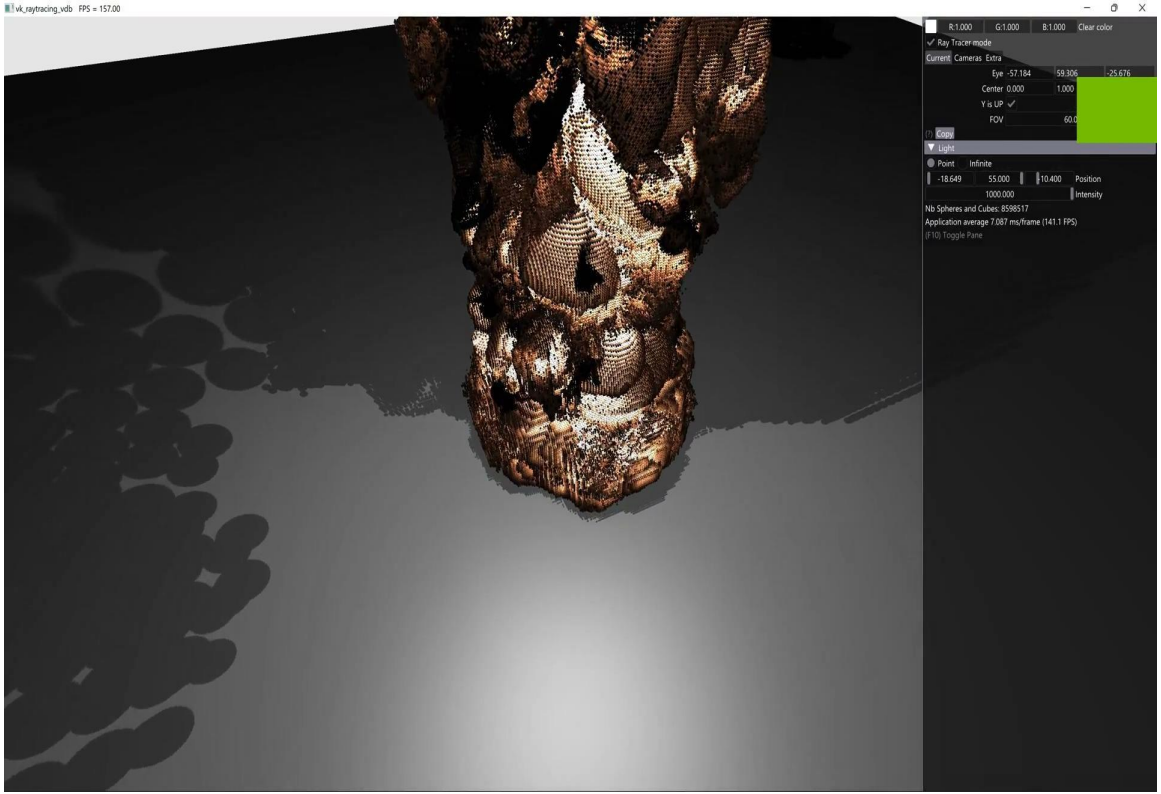
Path Traced Volume Rendering



- **Asset:** Explosion
- **Voxel Count:** 7,896,906
- **FPS:** 133.0

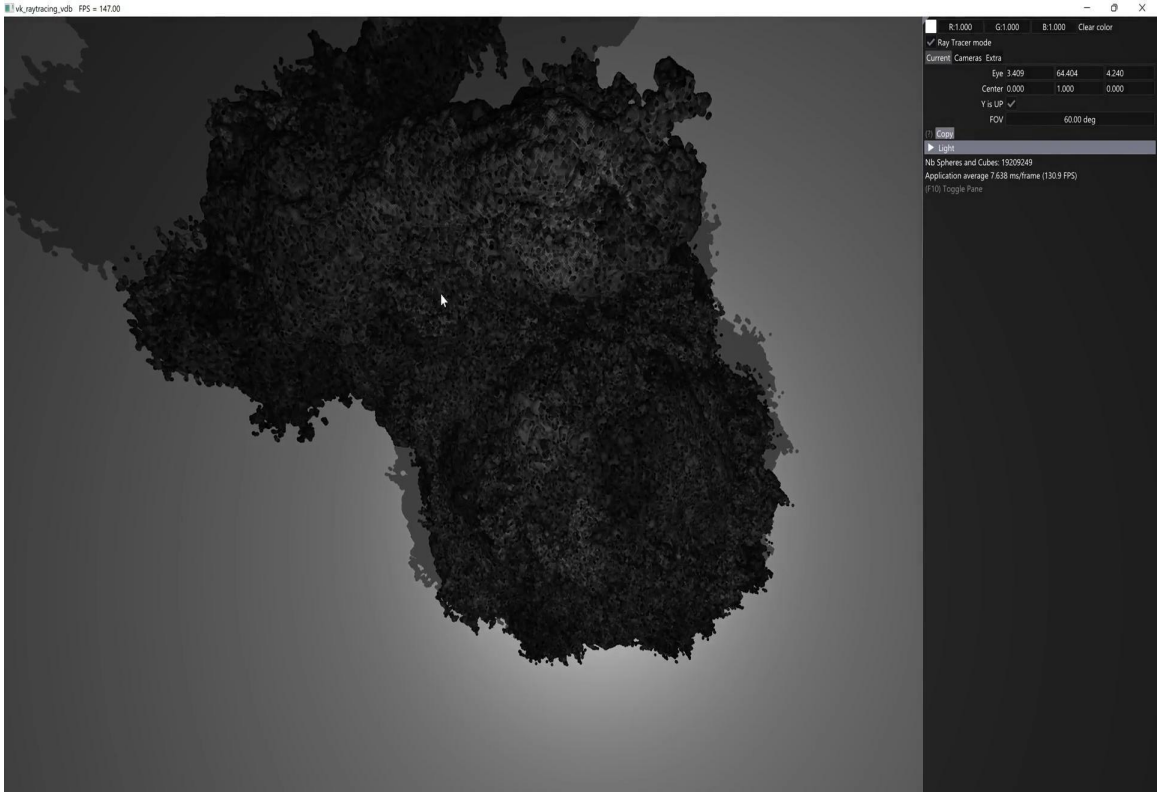


Path Traced Volume Rendering

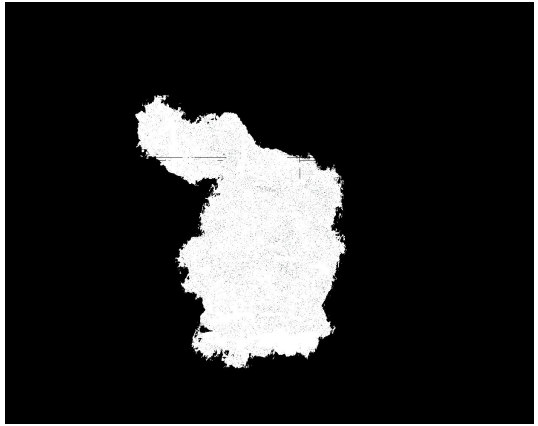


- **Asset:** Fire
- **Voxel Count:** 8,598,517
- **FPS:** 147.1

Path Traced Volume Rendering



- **Asset:** Rabbit
- **Voxel Count:** 1,209,249
- **FPS:** 130.9



ReSTIR with GLTF Scene

ReSTIR with GLTF Scene

Challenges

- Switching Vulkan framework from vk-bootstrap to nvpro libraries
  - vk-bootstrap does not well support Vulkan ray tracing
- Complicated Vulkan hardware ray tracing pipeline (VK_KHR_ray_tracing)
  - Vulkan API has changed drastically this year
  - ray generation shader, ray intersection shader, ray miss shader, …

Questions and Suggestions

- Intersection Shader works with our vulkan raytraced pipeline but not with Restir Pipeline.

References

[1] Volume Rendering

[2] Volume Rendering (Nvidia)

[3] Ray Tracing Gems II

[4] Vulkan Ray Tracing with Intersection Shaders

[5] VK-Bootstrap

[6] OpenVDB

[7] Importance Resampling for Global Illumination

References

[8] Vulkan Ray Tracing Tutorial

[9] NVPRO Vulkan Mini Path Tracer

[10] Khronos Best Practices for Hybrid Rendering

[11] Spatiotemporal reservoir resampling for real-time ray tracing with dynamic direct lighting (SIGGRAPH 2020)

[12] Fast Volume Rendering with Spatiotemporal Reservoir Resampling (SIGGRAPH 2021)