Fast Volume Rendering with Spatiotemporal Reservoir Resampling

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Volume Rendering + ReSTIR

Background: Many visual effects are volumetric in nature. Fluids, clouds, fire, smoke, fog, and dust are difficult to model with geometric primitives. Volumetric models are better suited for creating such effects. These models assume that light is emitted, absorbed, and scattered by a large number of particles in the volume.

This method targets extending ReSTIR to volumetric path tracing. As ReSTIR builds on RIS, we begin by developing an RIS estimator for the volume rendering equation. Volume rendering involves higher-dimensional integrals than the direct surface illumination. Visibility alone forms an integral along primary rays. Thus, we cannot just sample light positions; we must sample entire paths. In this Project we target section, a path integral representation of the volume rendering equation, describe how we can generate candidate paths, and explain how to estimate the volume rendering equation using RIS.

- Technical contributions:
  - A generalization of resampled importance sampling (RIS);
  - An efficient importance sampling estimator for the volumetric path integral;
  - A robust resampling method for temporal reuse.

- ReSTIR is originally for direct illumination sampling from many lights

Volume Rendering + ReSTIR

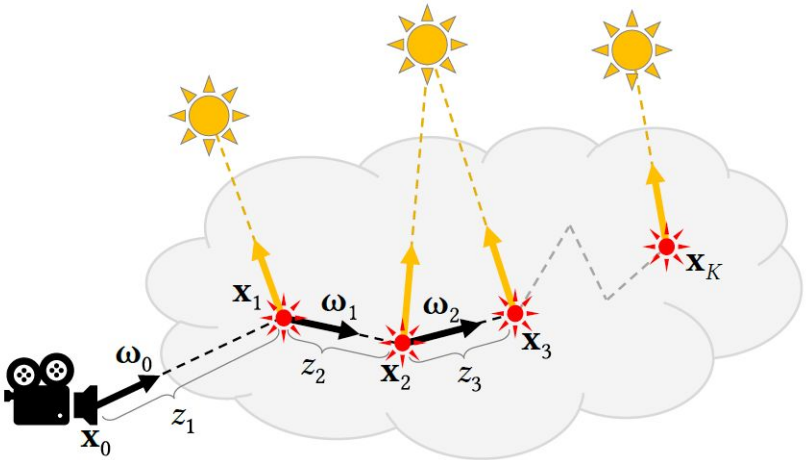

Fig. 3. *A random walk with K vertices generates 2K candidate paths for later reuse: K are scattering paths that terminate at a light (yellow) with next event estimation and the remaining K are emission paths terminating in the media due to volumetric emission (red).*

Why this Matters

- Smoke, fire, clouds, and other participating media are vital in virtual scenes; modern movies, games, and simulations rely heavily on media for realism and ambiance.
- A heavily researched area in the graphics industry right now.
- Will holistically summarize our learning in CIS 565 Course.
- The cool results excites us to take up the challenge!!
- Contribution to the open-source community with a fast novel volume rendering algorithm

Project Plans

Platforms:

- Vulkan + CUDA Interop

3rd-party project dependencies:

- GVDB/OpenVDB for loading volume rendering assets
- TinyGLTF/TinyOBJ for loading scene structures

Goals and Outcomes

Real-time volume rendering application with ReSTIR.

Schedule

- 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!

References

- [1] Fast Volume Rendering with Spatiotemporal Reservoir Resampling (SIGGRAPH 2021)
- [2] Spatiotemporal reservoir resampling for real-time ray tracing with dynamic direct lighting (SIGGRAPH 2020)
- [3] Hoetzlein, R.K. GVDB: Raytracing Sparse Voxel Database Structures on the GPU. High Performance Graphics (2016)