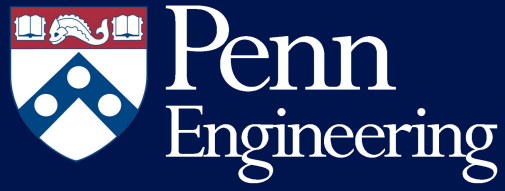
World Space ReSTIR in Vulkan

Jichu Mao Zhiyi Zhou

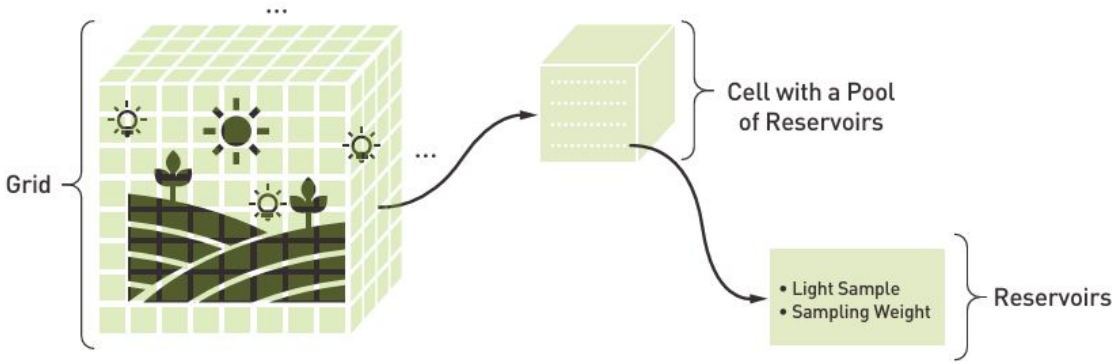
CIS 5650 - Final Project

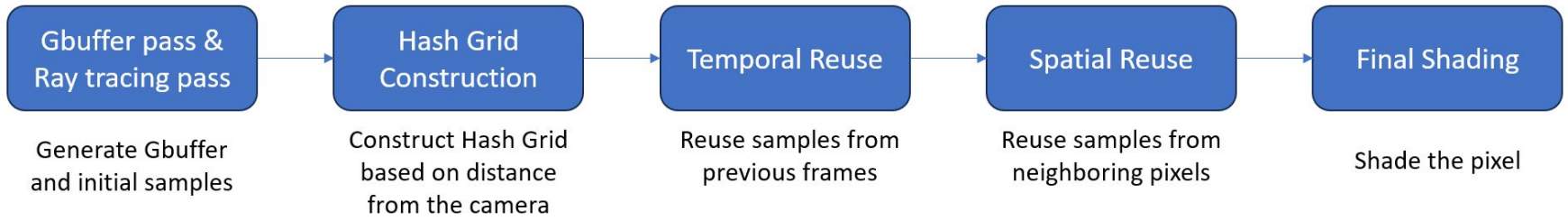
Milestone 1



Overview

- **Goal:** Implement a real-time global illumination renderer based on world-space ReSTIR in Vulkan
- Our project is based on Vulkan's Ray Tracing Extension, which allows us easily find intersections between rays and the scene.
- Subdivide the scene into many hash cells that store samples so that we can reuse these samples according to their geometry properties(normal, position).





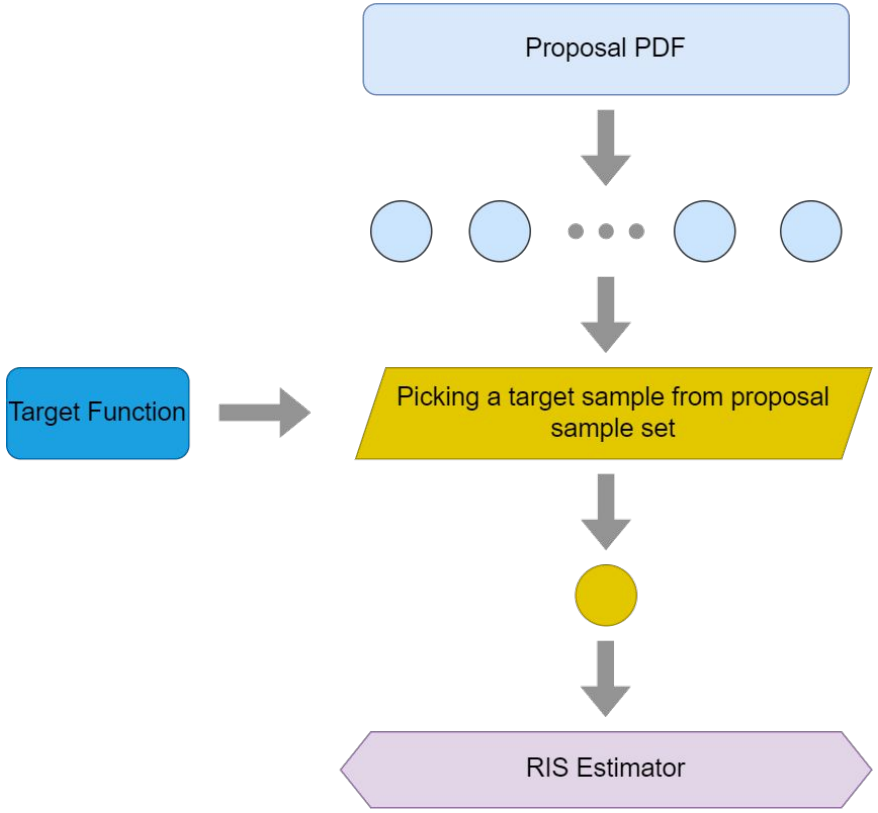
Progress

Milestone 1 (Nov 04 - 13)

- Basic Vulkan Ray-Tracing Pipeline Setup in Vulkan, implement light source importance sampling for both environment map and mesh lights
- Hash Grid Data Structure Setup
- Research on RIS(Resampled Importance Sampling), Reservoir-based sample Algorithm, and Denoise techs

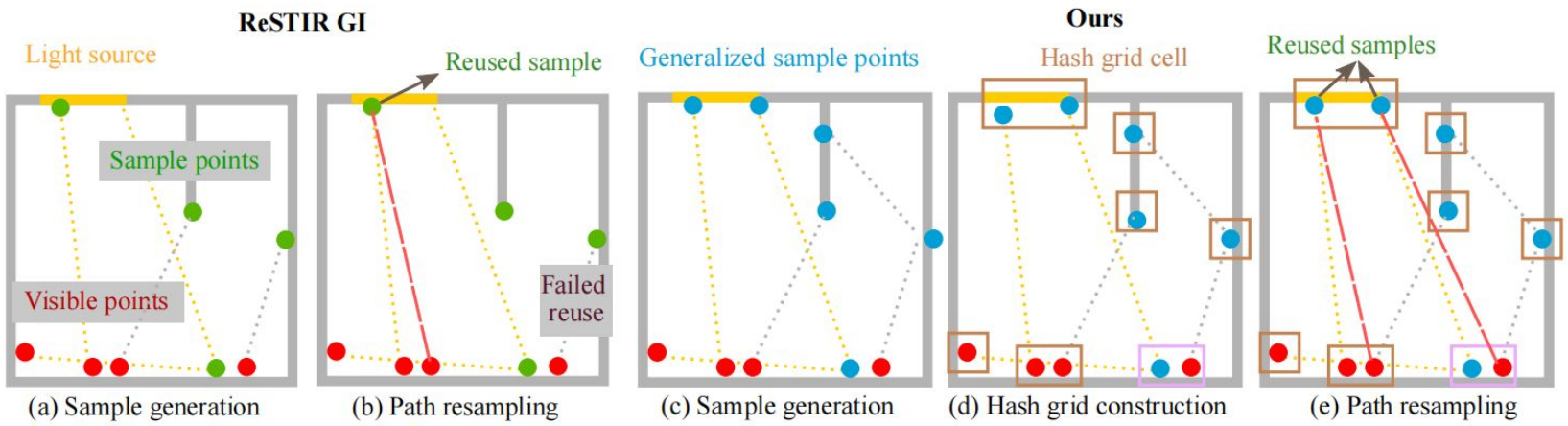
ReSTIR

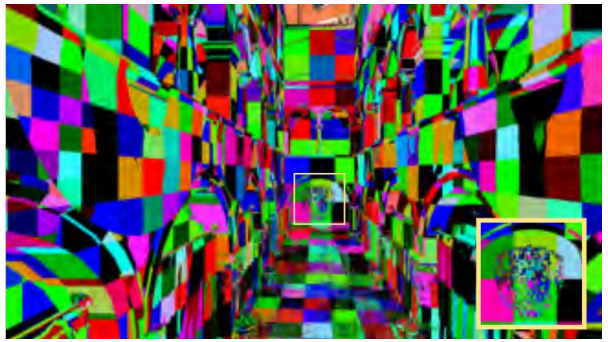
- RIS: Resampled importance sampling. Draw **n** samples from a proposal distribution and select one based on a weighting function. This approach is progressively unbiased as **n** approaches infinity.
- WIS: Weighted Reservoir Sampling. The reservoir efficiently stores and manages samples without requiring all of them to remain in memory(we only need some statistical properties).
- Temporal / Spatial reuse: Reuse samples from neighboring pixels and previous frames, reservoir structure can help us to combine different reservoirs from different pixels and frames.



Paper

- Pure **ReSTIR GI** Operates in **screen space**. It optimizes global illumination sampling for primary rays and uses spatiotemporal resampling to manage indirect illumination. The reservoirs are tied to **screen-space pixels**.
- We extend it to **world space**. It divides the scene into a **3D grid**, with reservoirs distributed across these grid cells.
- To construct the grid, we use a hash function based on the world position and surface normal to map these cells, allowing us to locate sample points with similar geometric properties.





Penn Engineering

Difficulties and Next Step

- Increased Workload: Past ReSTIR projects involved three people due to the heavy workload, and now, with just two of us, the challenge is greater.

- Math-Intensive: Requires a strong math background, demanding significant time to study RIS, Reservoir , ReSTIR and the related ReGIR papers.

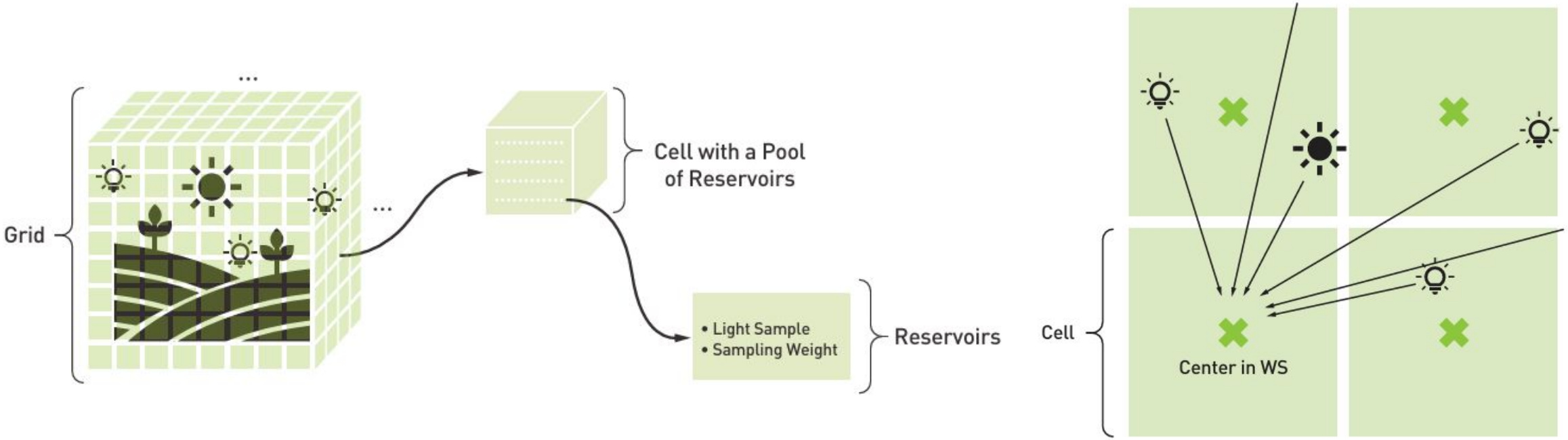
Plan for Milestone 2(Nov 14 - 25)

- Implement Reservoir based resampled importance sampling(RIS).
- Complete hash grid construction.
- Start working on temporal / spatial reuse.

Overview

What is GRID-BASED RESERVOIRS(ReGIR)?

ReGIR (Reservoir Grid Importance Resampling) is an algorithm designed for **efficiently rendering scenes with many light sources** in real-time ray tracing. It builds upon existing techniques such as ReSTIR (Reservoir Spatiotemporal Importance Resampling) and applies them to world-space sampling using a grid-based structure to optimize light sampling for secondary rays.



Milestone Presentations – Do

- Strictly stick to time limits – N minutes is N x 60 seconds!
  - Default length will be 5 minutes, but may change – Will be posted on Ed Discussion
- **Show progress since last milestone**
- Videos, screenshots and demos
- Include goals for next milestone
- Know your audience
  - i.e. your fellow students, not the instructor or TAs
- Add presentation to your GitHub repo.

Penn Engineering

Penn Engineering

Milestone Presentations – Do

- Use social media – Great time to show off your work
- **Get in touch with original authors** – They really like it
  - And do this earlier than later
- See the Cesium Presenter's Guide (or your favorite company) for tips on presenting
- Be sure to present as a team; for a great example, see http://www.youtube.com/watch?v=OTCuYzAw31Y

Penn Engineering

Penn Engineering

Milestone Presentations – Don't

Doing any of these may result in grade penalties

- Don't exceed time limits for presentations
- Don't include code/math equations in your presentation
  - Exceptions: Something cool, good to know, or required for another part of your presentation.
  - If you need to walkthrough the code/math, don't include it

Penn Engineering

Penn Engineering