Advanced Computer Graphics Fall 2024 Image Rendering Project Midterm Report

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Abstract

This is a midterm progress report of my Advanced Computer Graphics Fall 2024 project. I have chosen the topic of image rendering. This report will outline my goals for this project (and the technical points I intend to implement), a schedule for the project, a description of completed aspects so far, external tools used, and visual results demonstrating what I have so far. Furthermore, a plan for remaining technical tasks will be given.

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1 Goals and Technical Details

1.1 Goal

My goal for this project is to write a CPU-based renderer using the path tracing algorithm, implementing all of the basics requirements as outlined as well as the following bonus technical functionalities:

(1) using the Surface Area Heuristic during Bounding Volume Hierarchy construction
(2) a Principled BSDF
(3) homogeneous volume rendering with subsurface scattering and volumetric lighting
(4) a normal map texture and a bump map texture
(5) multiple importance sampling
(6) HDR skylight environment lighting

1.2 Technical Details

I am using the Rust programming language, and the only external libraries I've used are for linear algebra purposes, random number generation, and image encoding. In the future, I may import a library for loading/manipulating OBJ files.

As of writing this report (November 25), my path tracer has path tracing with global illumination and the following functionalities:

(1) diffuse and specular materials
(2) simple BVH construction
(3) transmissive (glass) material
(4) solid color texture, image texture, checkerboard pattern texture
(5) importance sampling with Russian roulette
(6) motion blur and depth-of-field
(7) emissive material (area light)
(8) anti-aliasing

These completed features so far achieve global illumination with good looking diffuse, glossy, and glass materials. With the textures and shapes I've written, some simple scenes can be assembled, including a modified Cornell box. Currently, the rendering is done on a single CPU thread. For 1000 samples per pixel at resolutions around HD resolutions, simple scenes involving only a few quads and spheres take 20 to 30 minutes to render. Another current limitation is that due to area lights being relatively small, renders with area lights are noisy even at 1000 samples per pixel.

2 Project Schedule

2.1 What I've done so far

From November 14 to November 24, I've got:

(1) sphere structure
(2) camera structure
(3) diffuse, specular, refractive materials
(4) solid color, checkered, image textures
(5) Russian roulette
(6) motion blur, depth of field
(7) BVH
(8) quad structure
(9) emissive material (area light)

2.2 My remaining schedule

Here's an optimistic schedule of the term:

Week of November 25: alpha shadow, point lights, rendering homogeneous volumes

Week of December 2: Surface Area Heuristic, principled BSDF

Week of December 9: normal and bump maps, HDR skylight environment

Week of December 16: multiple importance sampling, preparing for presentation

3 Figures

Here are some visual demos of what I have so far. They are rendered at 1000 samples per pixel on my laptop. Each figure shows off a cool aspect that I've implemented so far.

Figure 1 demonstrates the three basic materials, and motion blur. Details to pay attention to: the motion blur on the moving balls, the reflections on the three large spheres demonstrating each type

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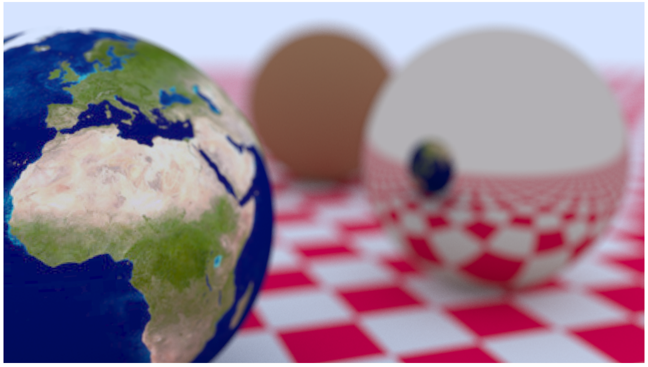

Figure 3: A scene with Earth and some spheres.

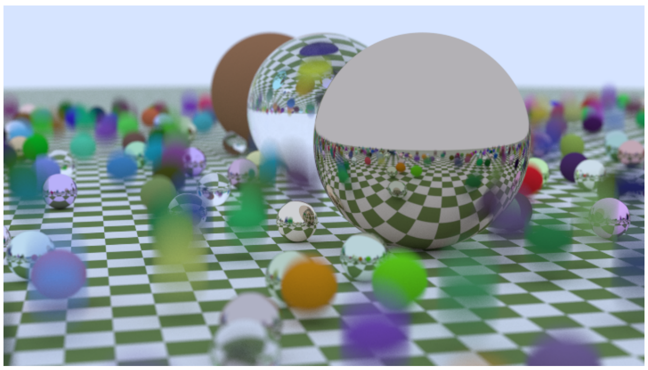

Figure 1: A scene adapted from Ray Tracing in One Weekend.

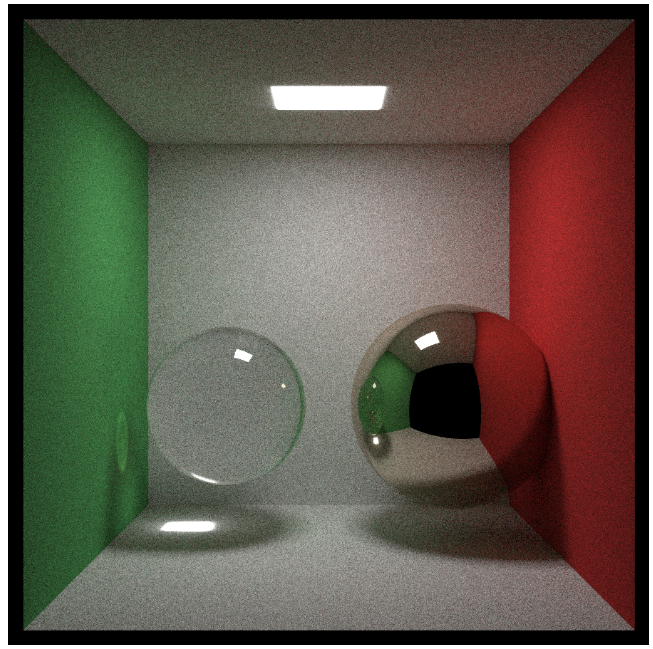

Figure 2: A modified Cornell box scene.

of material. It also shows off the checker pattern texture on the ground.

Figure 2 is a modified version of the Cornell box. It demonstrates a glossy sphere and a glass sphere inside the Cornell box interacting with an area light and the surrounding walls (which are diffuse material).

Figure 3 shows off the image texture with a map of the Earth projected onto the sphere and depth-of-field effects (notice how the Earth is in focus, while the reflective and diffuse spheres are not in focus).

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