Assignment 3:
Basic Ray Tracing

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1 Introduction

In this assignment, I modified interaction.cpp, bvh_tree.h, integrator.cpp, integrator.h and bsdf.cpp to realize basic ray tracing.

2 Implementation Details

For compilation, I downloaded clangd and upgraded cmake. I used "cmake -B build -G Ninja -DCMAKE_POLICY_VERSION_MINIMUM="3.5" -DCMAKE_EXPORT_COMPILE_COMMANDS=ON" at the root directory and successfully compiled it. The result is as follows.

According to the formula $p_0+u\cdot(p_1-p_0)+v\cdot(p_2-p_0) = o+t\cdot d$,

$$u = \frac{[d\times(p_2-p_0)]\cdot[u\cdot(p_1-p_0)+v\cdot(p_2-p_0)-t\cdot d]}{(p_1-p_0)\cdot[d\times(p_2-p_0)]}$$
$$v = \frac{d\cdot\{(p_1-p_0)\times[u\cdot(p_1-p_0)+v\cdot(p_2-p_0)-t\cdot d]\}}{(p_1-p_0)\cdot[d\times(p_2-p_0)]}$$
$$t = \frac{(p_2-p_0)\cdot\{(p_1-p_0)\times[u\cdot(p_1-p_0)+v\cdot(p_2-p_0)-t\cdot d]\}}{(p_1-p_0)\cdot[d\times(p_2-p_0)]}$$

I calculated u, v and t through these formulas and added checks on these parameters.

Then I realized the AABB intersection, I confirmed the entering and exiting time of the ray and judged whether the intersection was valid.

After completing triangle and AABB intersection, the result of intersection test is as follows.

```
[==========] Running 7 tests from 2 test suites.
[----------] Global test environment set-up.
[----------] 1 test from AABB
[ RUN      ] AABB.AxisAligned_EnterExit_PositiveAndNegativeDirs
[       OK ] AABB.AxisAligned_EnterExit_PositiveAndNegativeDirs (0 ms)
[----------] 1 test from AABB (2 ms total)

[----------] 6 tests from TriangleIntersect
[ RUN      ] TriangleIntersect.Basic
[       OK ] TriangleIntersect.Basic (0 ms)
[ RUN      ] TriangleIntersect.MissCases
[       OK ] TriangleIntersect.MissCases (0 ms)
[ RUN      ] TriangleIntersect.TimeWindow_RejectionAndClamping
[       OK ] TriangleIntersect.TimeWindow_RejectionAndClamping (0 ms)
[ RUN      ] TriangleIntersect.TriangleInXZPlane_Hit
[       OK ] TriangleIntersect.TriangleInXZPlane_Hit (0 ms)
[ RUN      ] TriangleIntersect.DegenerateTriangle_ReturnsFalse
[       OK ] TriangleIntersect.DegenerateTriangle_ReturnsFalse (0 ms)
[ RUN      ] TriangleIntersect.MultiTriangleMesh_HitCorrectTriangle
[       OK ] TriangleIntersect.MultiTriangleMesh_HitCorrectTriangle (0 ms)
[----------] 6 tests from TriangleIntersect (12 ms total)

[----------] Global test environment tear-down
[==========] 7 tests from 2 test suites ran. (21 ms total)
[  PASSED  ] 7 tests.
```

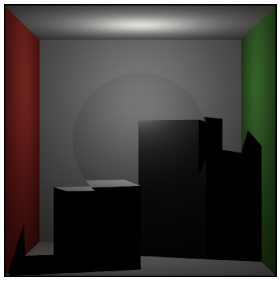
In bvh_tree.h, I set up a stop criteria based on parameters CUTOFF_DEPTH, span_left and span_right and sorted the nodes in [span_left, span_right) according to their centroid's 'dim'-th dimension with function 'std::nth_element'. The result of bvh test is as follows.

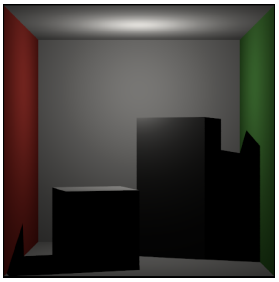
```
[==========] Running 3 tests from 1 test suite.
[----------] Global test environment set-up.
[----------] 3 tests from BVH
[ RUN      ] BVH.BasicConstruction
[       OK ] BVH.BasicConstruction (0 ms)
[ RUN      ] BVH.SingleObject
[       OK ] BVH.SingleObject (0 ms)
[ RUN      ] BVH.EmptyTree
[       OK ] BVH.EmptyTree (0 ms)
[----------] 3 tests from BVH (5 ms total)

[----------] Global test environment tear-down
[==========] 3 tests from 1 test suite ran. (10 ms total)
[  PASSED  ] 3 tests.
```

In integrator.cpp, I completed the IntersectionTestIntegrator class, realizing functions like adding offsets for anti_aliasing, updating ray direction, occlude detection and assigning color.

In BSDF.cpp, I modified PerfectRefraction::sample and set the 'interaction.wi' to the direction of the "in-coming light" after refraction or reflection.

After completing all must tasks, the results are as follows.





To implement multiple light sources, I added position and flux parameters for the new light source in integrator.h and calculated its color contribution in integrator.cpp, the results are as follows.

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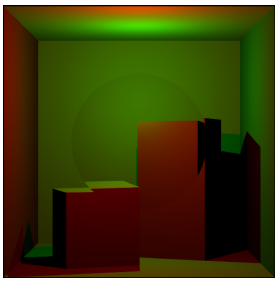
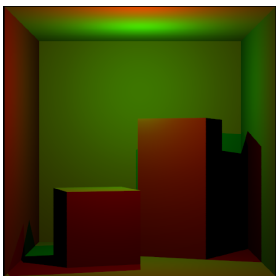
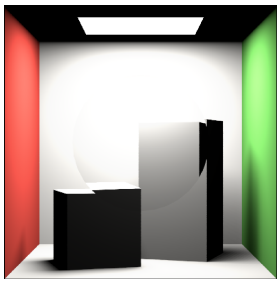
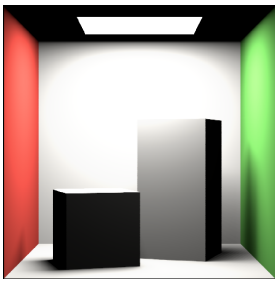

I set a rectangle area light source in the center of the ceiling, took 256 sample points from it, and calculated their color contributions to the scene to render soft shadow, the results are as follows.

3 Results

The result is a program for basic ray tracing with multiple light sources and rectangular area lights with soft shadow generation.