Advanced Topics in Computer Graphics I

Universität Bonn
Institut für Informatik II
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Sheet R03 - Whitted-Raytracing

Hand in your solutions via eCampus by Tue, 06.05.2025, **12:00 p.m.**. Compile your solution to the theoretical part into a single printable PDF file. For the practical part, hand in a single ZIP file containing only the exercise* folder within the src/ directory. Please refrain from sending the entire framework.

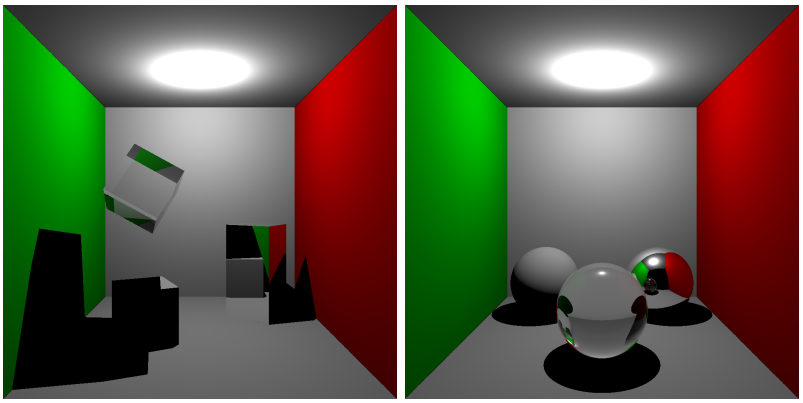

Figure 1: Cornell Box scene rendered with Whitted raytracing. To obtain these renderings, run `./bin/exercise03_WhittedRaytracing -s data/exercise03_WhittedRaytracing/cornell_box_cubes.xml` and `./bin/exercise03_WhittedRaytracing -s data/exercise03_WhittedRaytracing/cornell_box_spheres.xml` from the project root, respectively.

Assignment 1) Whitted-Raytracer *(8 Pts)*

In this exercise, we implement a raytracer based on the Whitted algorithm[1]. The framework is similarly structured to the last exercise. We now use the `XMLSceneLoader` to load scene representations from xml files instead of defining them manually in the C++ code. The ray generator that implements the Whitted raytracing algorithm is defined in the `whittedraygenerator.{cpp,cu,cuh,h}` files. A point and directional light source is implemented in the `lightsources.{cpp,cu,cuh,h}` files. An opaque BSDF modeling diffuse and perfect specular reflections, as well as a refractive BSDF, modeling reflection and transmission at the interface between two media (e.g. air and glass) is implemented in the `bsdfmodels.{cpp,cu,cuh,h}` files.

a) Compute the diffuse reflections of the light sources on opaque materials in `whittedraygenerator.cu`. Generate a ray towards to light source using the `EmitterVPtrTable::sampleLight()` method. Determine the visibility of the light source using the `traceOcclusion()` method. Evaluate the BSDF at the surface interaction towards the light direction using the `BSDFVPtrTable::evalBSDF()` method. Accumulate the contribution of the light source in the `output_radiance` variable. Note that only diffuse BSDF components contribute here, since the probability that a given light direction corresponds to a perfect specular reflection is zero.

4 Pts

b) In `bsdfmodels.cu`, generate a reflection ray for the specular component of the opaque BSDF in `__direct_callable__opaque_sampleBSDF()`, as well as reflection and transmission rays for the refractive BSDF in `__direct_callable__refractive_evalBSDF()`.

Hints: The surface normals point outwards. You can use Schlick's approximation for the Fresnel term to compute the amount of light reflected or transmitted

4 Pts

If you finished all tasks successfully your results should look like the ones in Figure 1.

Theoretical Assignment

Assignment 2) Reflection Equation

(5 + 1 Bonus Pts)

Consider the simple scene from the first sheet as it is shown in Figure 2. Again, we're given the radiance of the sun $L_s = 20.045 \frac{MW}{m^2 sr}$ and the direction v having an angle of 45° to the table. You can again assume that the radiance is constant over the whole surface of the sun.

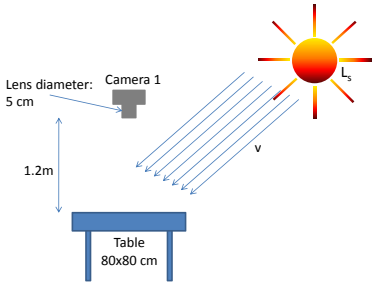

Figure 2: Toy example for radiometric quantities

Now, assume that the table plate is perfectly diffuse with 50% albedo. A camera having a lens of 5cm diameter has been placed 1.2m above the center of the table looking exactly downwards. Calculate the irradiance and the radiant power at the camera lens assuming that everything else around the table is perfectly black. Furthermore, you can for simplicity assume that the table covers the same solid angle from all points of the lens and that the irradiance is constant over the camera lens. Use tools like Maple or WolframAlpha[1] for solving the integrals.

For a rough approximation you will get 5 points and for a complete solution you will get an additional bonus point.

References

[1] Turner Whitted. An improved illumination model for shaded display. In *Proceedings of the 6th annual conference on Computer graphics and interactive techniques*, page 14, 1979.

Good luck!

[1] `https://www.wolframalpha.com`