Homework 2
Physically based rendering

ADVANCED COMPUTER GRAPHICS 2023/24

1 Introduction

The goal of this homework is to get familiar with path tracing and the use of different light sources and materials in physically based rendering. Your task is to extend the path tracing framework provided with the homework and implement a basic path tracing algorithm (section 3), spherical lights (section 4) and the Oren-Nayar material (section 5). The homework also has some optional extensions. The homework is worth 10 % of the final grade (1-week extension: 7 %, 2-week extension: 5 %).

2 The path tracing framework

For implementation of the homework you may use the provided framework, or you may write your own. The provided framework is developed in C# and includes basic math and support for easier implementation of a path tracer. It is loosely based on the PBRTv3 rendering framework,[1] developed by authors of the book Physically Based Rendering.[2]

Optional: You can create your own Path tracing framework to implement the homework.

3 Implementation of path tracing

Implement the main path tracing method in the framework (within PathTracer.cs), which uses probabilistic evaluation for stopping and importance sampling for choosing ray directions.

Optional: Provide appropriate support for light sampling with specular materials, such as the provided SpecularReflection.cs.

4 Lights

Extend the framework with support for spherical light sources. The user must be able to set the radius of the sphere and the emission spectrum. Implement uniform light sampling for light rays emitting from the sphere. For your convenience, an example (disk) light source is provided in Disk.cs, which you can use as a template.

5 Materials

Implement the Oren-Nayar microfacet reflection model. The Oren-Nayar BRDF is defined as

$$f_r(\omega_o, \omega_i) = \frac{k_d}{\pi}(A + B\max(0, \cos(\phi_i - \phi_o))\sin\alpha\tan\beta),$$
$$A = 1 - \frac{\sigma^2}{2(\sigma^2 + 0.33)},$$
$$B = 0.45\frac{\sigma^2}{\sigma^2 + 0.09},$$
$$\alpha = \max(\theta_i, \theta_o),$$
$$\beta = \min(\theta_i, \theta_o),$$

[1] `https://github.com/mmp/pbrt-v3`
[2] `http://www.pbr-book.org/`

where k_d is albedo, σ is the roughness parameter, and (ϕ_i, θ_i) and (ϕ_o, θ_o) are the spherical parametrizations of ω_i and ω_o, respectively. For your convenience, an example (Lambertian) reflection model is provided in Lambertian.cs, which you can use as a template.

Optional: Implement a new transmitting BSDF material (Glass) with support for specular transmission for transparency and caustics. Use Fresnel's equations for determining the amount of transmitted light and Implement Snell's Law for refraction. You can look at the implementation of SpecularReflection.cs.

Optional: Implement a new anisotropic BRDF material (Aluminum). You can find the appropriate BRDF properties online.[3]

6 Outputs

The expected outputs of this homework are example renderings (images), displaying the implemented features.

7 Grading

This assignment is worth 10 points:

- 4 points for the implementation of path tracing,
- 3 points for the spherical light, and
- 3 points for the Oren-Nayar material.

[3] `https://www.merl.com/brdf/`