CSC4140 Assignment 6

Computer Graphics

April 30, 2022

Ray Tracing II

This assignment is 8% of the total mark.

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This assignment represents my own work in accordance with University regulations.

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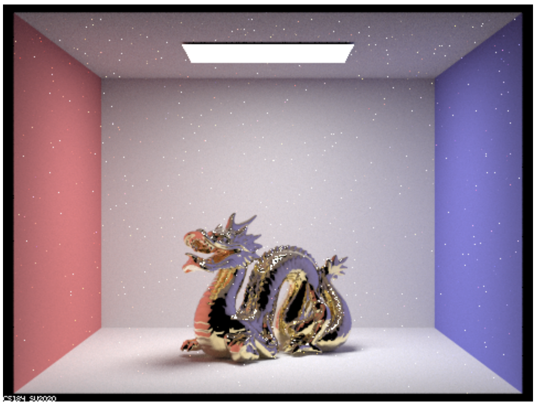
1 Overview

This project implements microfacet BRDF, environment lighting, and a thin-lens camera model to demonstrate depth of field.

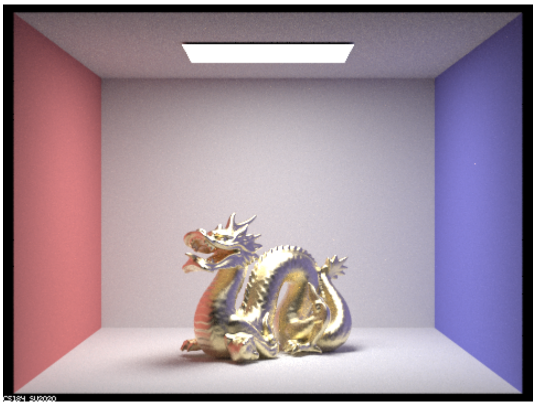
2 Implement and Results

2.1 Part 1: Microfacet Material

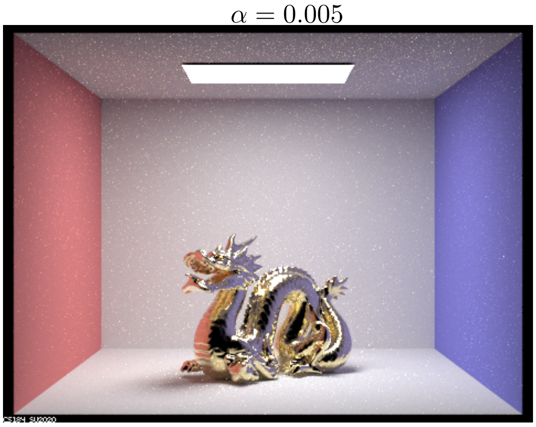
With α decreasing (smoother suface), the objects become shininer and white specks on the image increase.



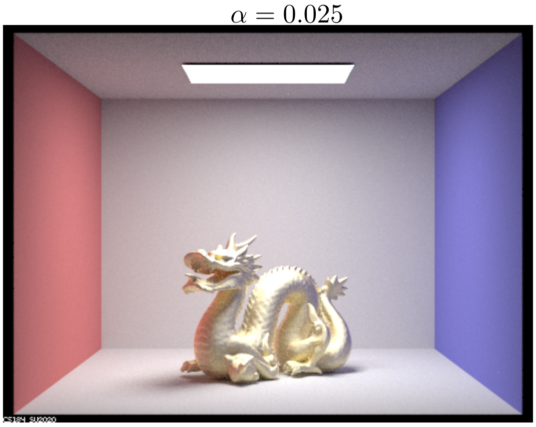
$\alpha = 0.005$



$\alpha = 0.025$



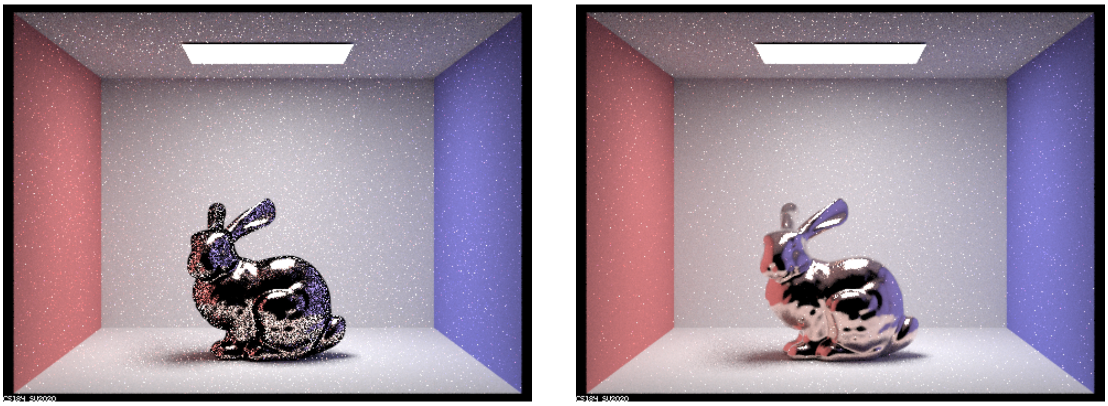
$\alpha = 0.05$



$\alpha = 0.5$

Figure 1: Microfacet BRDF with different α

Command: ./pathtracer -t 1 -s 256 -l 4 -m 3 -r 480 360 ../dae/sky/CBdragon_microfacet_au.dae

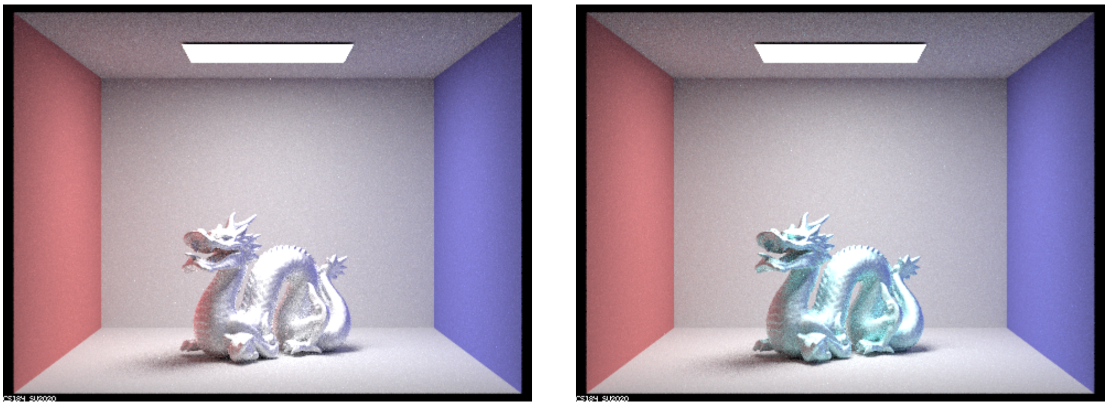


Cosine hemisphere sampling | Importance sampling

Figure 2: Cosine hemisphere VS importance sampling
Command: ./pathtracer -t 8 -s 64 -l 1 -m 5 -r 480 360 ../dae/sky/CBbunny_microfacet_cu.dae

Importance sampling generates a less noisy image compared to cosine hemisphere sampling. Also, bunny generated by importance sampling looks brighter in generally. That's because the provided hemisphere sampling is perfect for importance sampling diffuse BRDF, but here we use microfacet BRDF with Beckmann distribution.

I choose silver (Ag) and iron (Fe) material to render with microfacet BRDF. At 0.614 μm (red), 0.549 μm (green), and 0.466 μm (blue),for silver, the η and k values are: $\eta = (0.059193, 0.059881, 0.047366), k = (4.1283, 3.5892, 2.8132)$. For iron, the η and k values are: $\eta = (2.8851, 2.9500, 2.6500), k = (3.0449, 2.9300, 2.8075)$



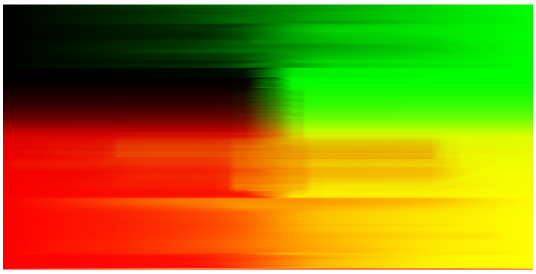
Silver | Iron

Figure 3: Different materials
Command: ./pathtracer -t 8 -s 64 -m 5 -r 480 360 ../dae/sky/CBdragon_microfacet_au.dae

2.2 Part 2: Environment Light

Environment light can simulate realistic lighting environment. The light source is thought to be "infinitedly far away" and supplies incident radiance from all direcitons, which is very similar to sunlight. We use a texture map to define the intensity of incoming light. In uniform sampling, a random direction is sampled from the sphere surrounding the hit point. In importance sampling, sampled direction is more closer to where the incoming radiance is the greatest. The result will be less noisy and closer to reality. For .exr file, I choose ennis:

ennis

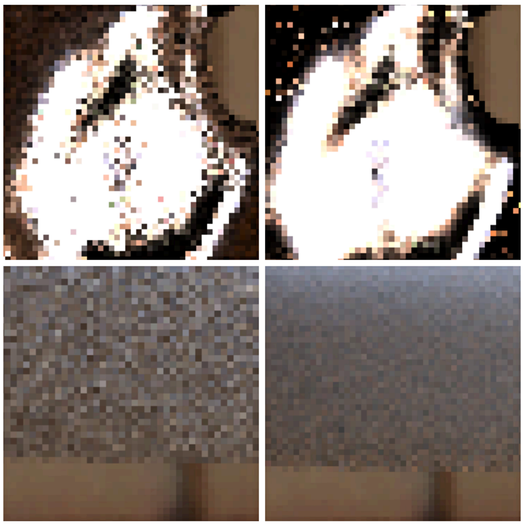


probability_debug

Uniform sampling

Importance sampling

We can see that the image generated by uniform sampling is more noisy than importance sampling when zoomming in. Black dots are more prominent on the bunny face and the tray has more "mosica".



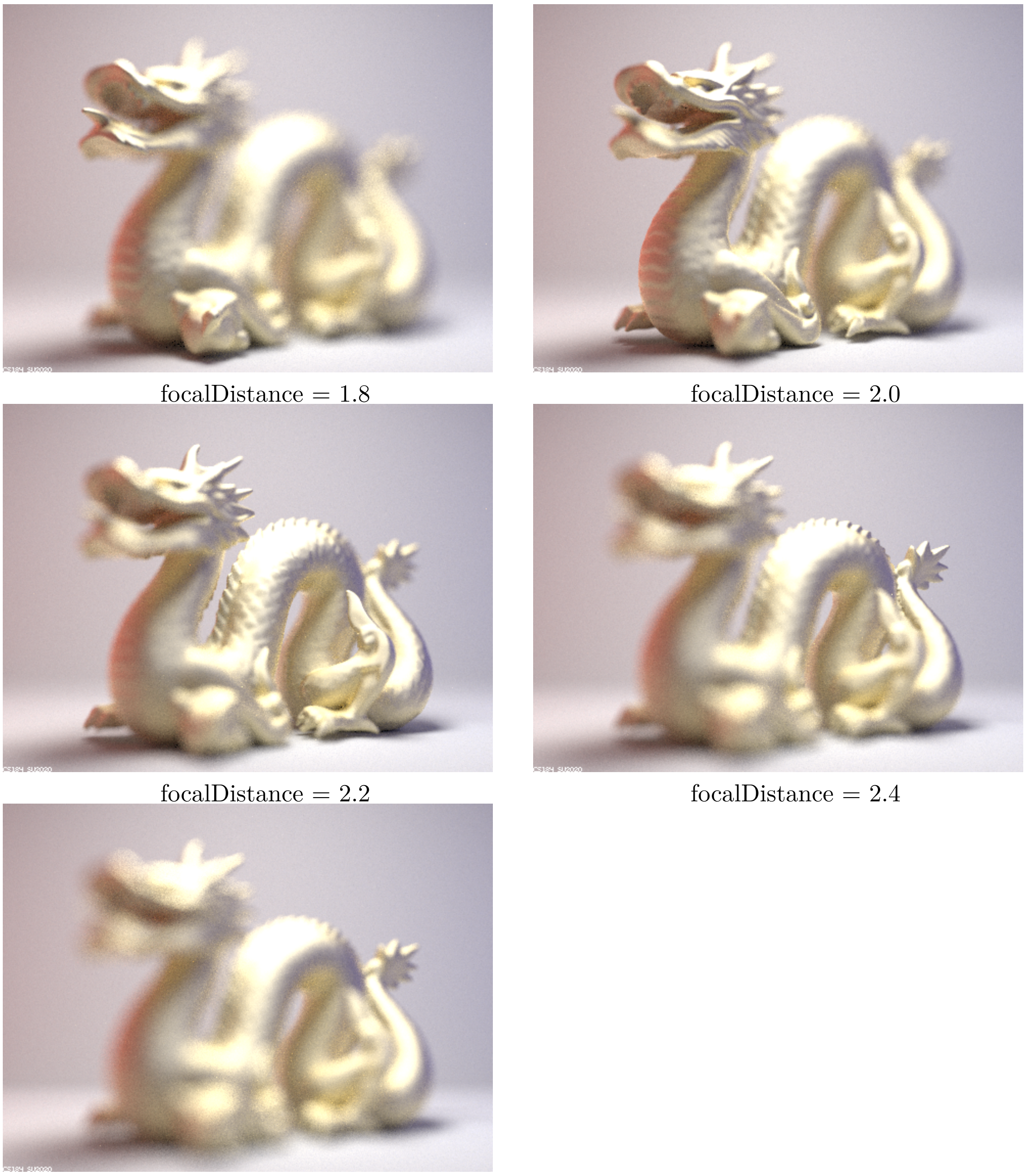
Zoom in (left: uniform sampling, right: importance sampling)

Figure 4: Uniform sampling VS Importance sampling based on Microfacet
Command: ./pathtracer -t 8 -s 4 -l 64 -e ../exr/ennis.exr ../dae/sky/bunny_microfacet_cu_unlit.dae

2.3 Part 3: Depth of Field

Pinhole camera model: it has linear perspective, but the camera aperture is described as a point and no lens is used to focus the light.

Thin-lens camera model: render images with blur due to depth of field, but it is a fairly rough approximation of actual camera lens systems, involving elements such as the Thin Lens equation, focus distance, lens radius(>0).



focalDistance = 1.8

focalDistance = 2.0

focalDistance = 2.2

focalDistance = 2.4

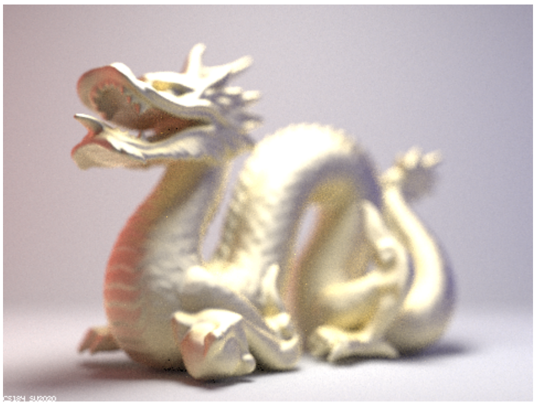
focalDistance = 2.6

Figure 5: Comparsion between different focalDistance

Command:./pathtracer -t 4 -s 256 -l 4 -m 5 -r 480 360 -b 0.125 -d 1.8 ../dae/sky/CB-dragon_microfacet_au.dae

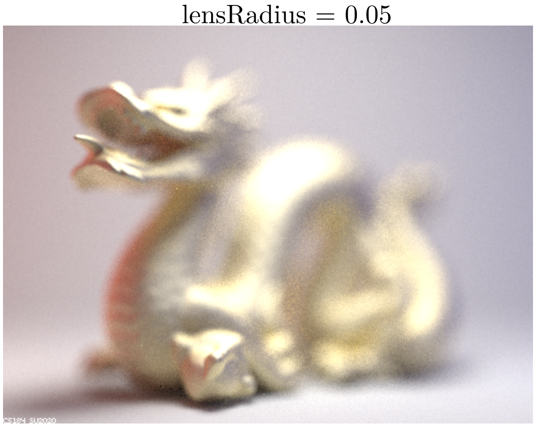
With lensRadius fixed at 0.125, the image focused at a further distance as focalDistance increases.

lensRadius = 0.025



lensRadius = 0.05

lensRadius = 0.075



lensRadius = 0.15

lensRadius = 0.2

Figure 6: Comparsion between different lensRadius

Command: ./pathtracer -t 4 -s 256 -l 4 -m 5 -r 480 360 -b 0.15 -d 1.8 ../dae/sky/CB-dragon_microfacet_au.dae

With focalDistance fixed at 1.8, image becomes more blur as lensRadius increases.