CSC4140 Assignment VI

Computer Graphics

May 1, 2022

Ray Tracing II

This assignment is 8% of the total mark.

Strict Due Date: 11:59PM, May 1^{st}, 2022

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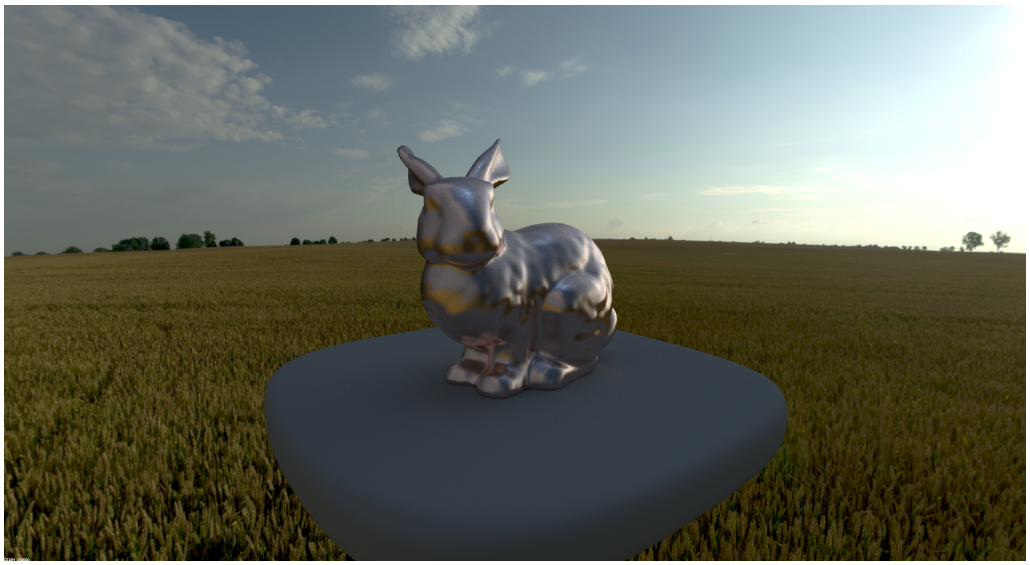
This assignment represents my own work in accordance with University regulations.

Signature:

Overview

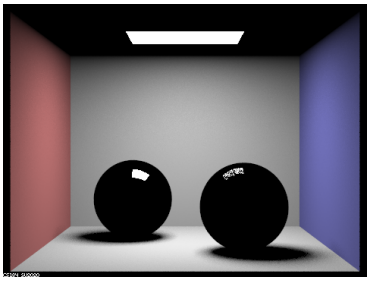
In this project, I have completed **Parts 1, 2, 3, and 4**. This project adds the simulation of **reflected and refracted light**, as well as support for ambient light and depth of field to the previous one (Assignment 6). The simulation of refracted and reflected light and the **simulation of microfacet** are based on the simulation of the physical laws of light, while choosing the appropriate approximation formula to calculate these physical models can greatly reduce the computational effort. When dealing with **environmental light**, in addition to simple uniform sampling, importance sampling is also implemented to reduce the error, which in turn reduces the time cost of rendering the same quality images. Finally, for the simulation of **depth of field**, a simple lens camera is used instead of the small-aperture camera model.

All images can be found in the `images/` folder in the `docs/` directory.

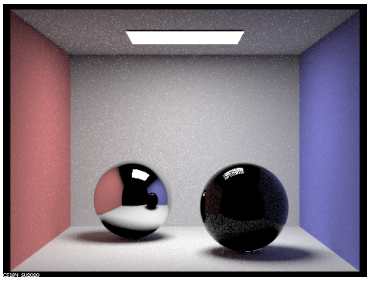


Part 1. Mirror and Glass Materials

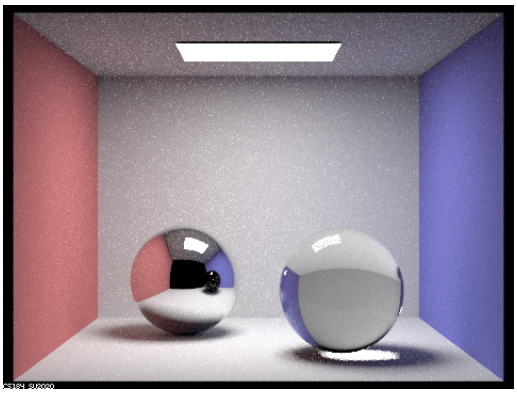
(a) m = 0



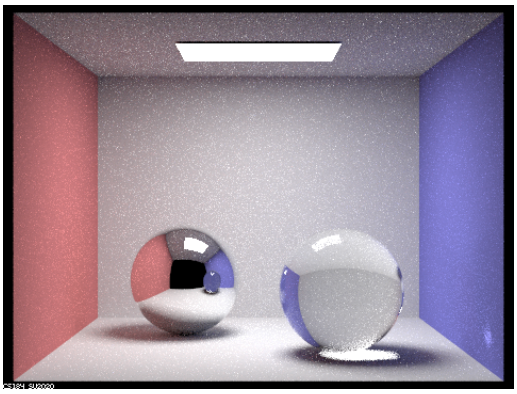
(b) m = 1



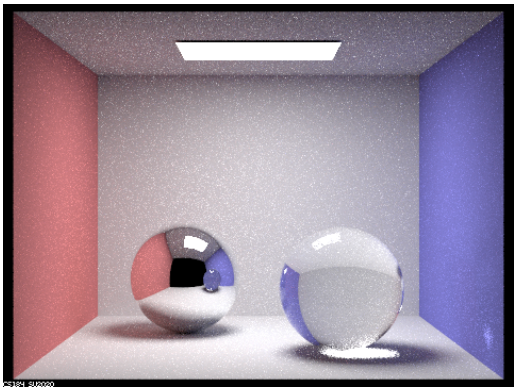
(c) m = 2



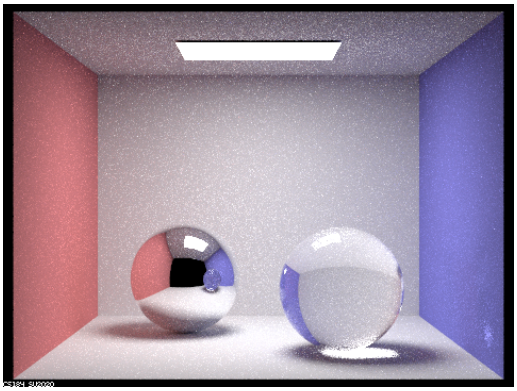
(d) m = 3



(e) m = 4



(f) m = 5



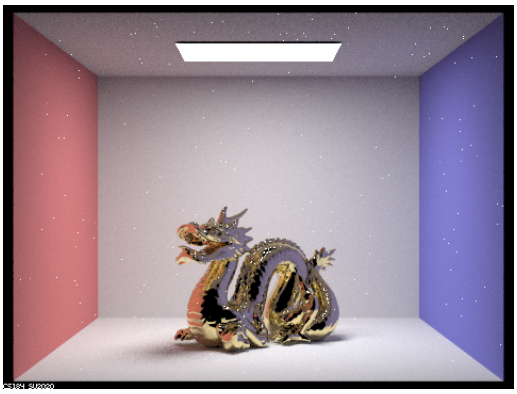
(g) m=100

The light bounds refers to:

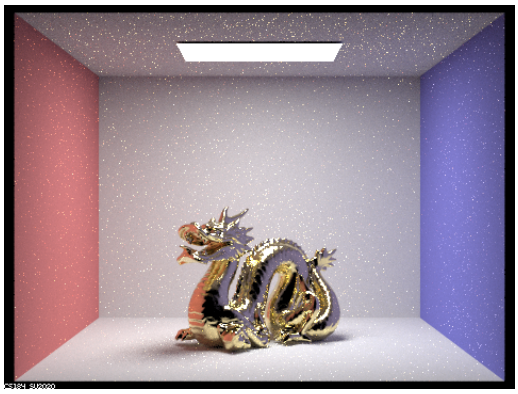
- m=0: only the light source.
- m=1: only the surface bounce light.
- m=2: mirror material could reflect lights.
- m=3: refraction appears. (the first time refrection happened on both sides)
- m=4: refraction of light source hit the wall surface.

- m=5: no new path: the environment became brighter.
- m=100: nearly the same as 'm=5', which indicates m more than 5 is not necessary.

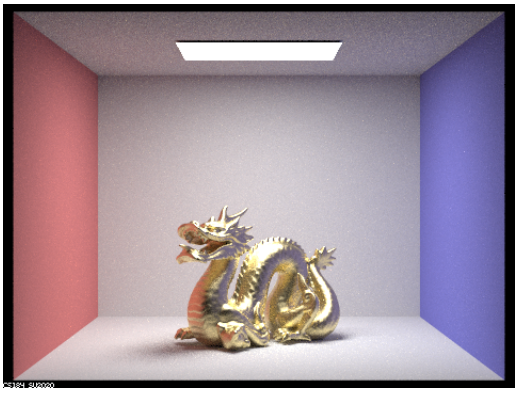
Part 2. Microfacet Material



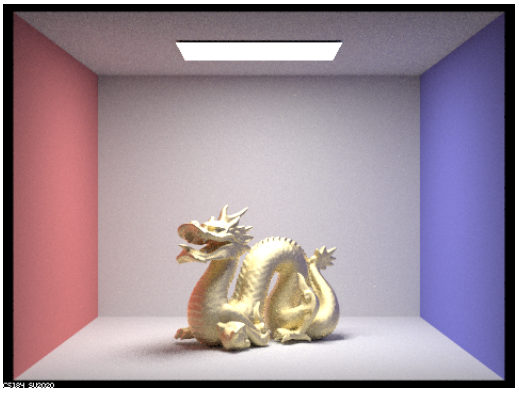
(h) alpha = 0.005



(i) alpha = 0.05



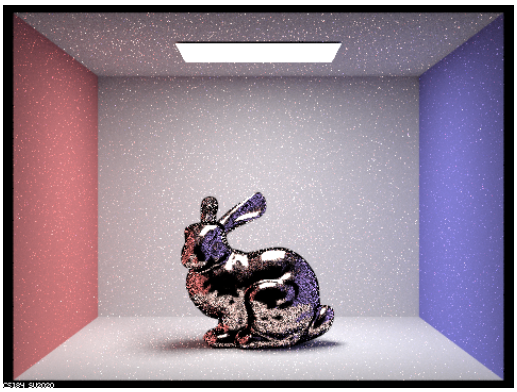
(j) alpha = 0.25



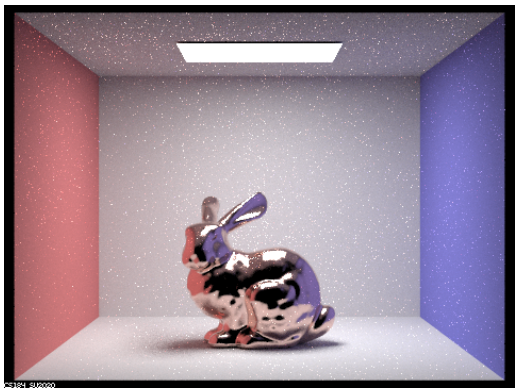
(k) alpha = 0.5

Figure 1: CBdragon_microfacet_au.dae under different alpha

As we can see from the comparison in these images, the alpha value mainly affects the degree of diffuse reflection of light. Specifically, the larger the alpha value, the more diffuse and less smooth the surface is.



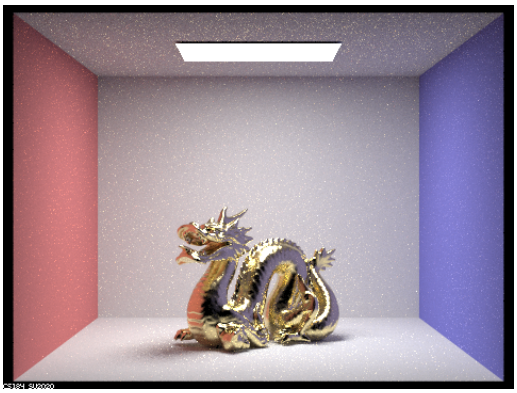
(a) Cosine Weighed Hemispherical Smapling



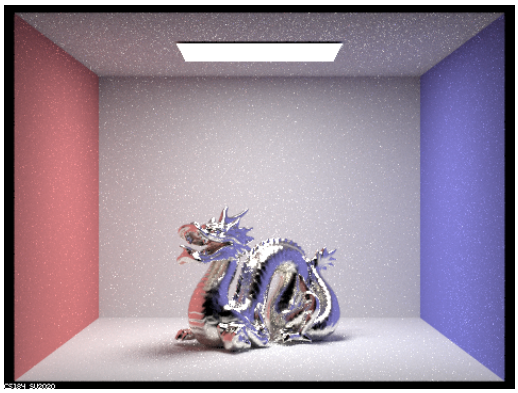
(b) Importance Smapling

From the figures we see clearly sampling by importance performs better than uniformly by comparing the noise level and brightness.

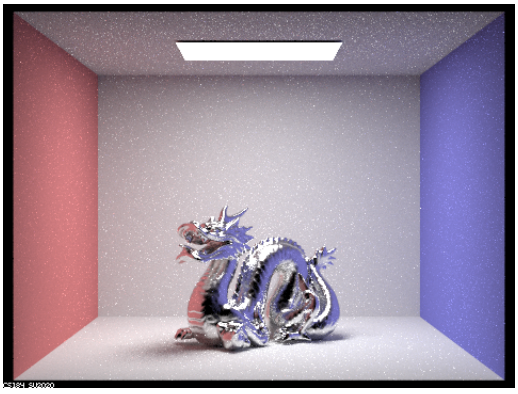
Here are some comparison of rendered scenes from various material.



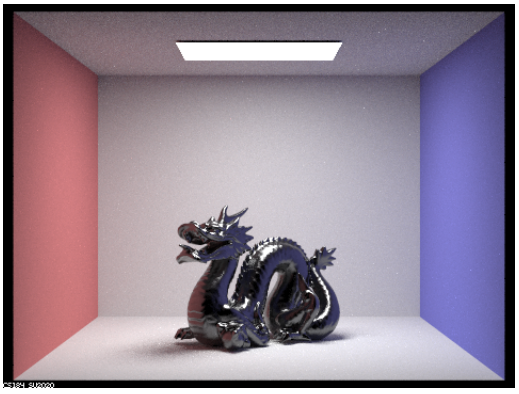
(c) Gold (Au)



(d) Silver (Ag)



(e) Zinc (Zn)



(f) Carbon (C)

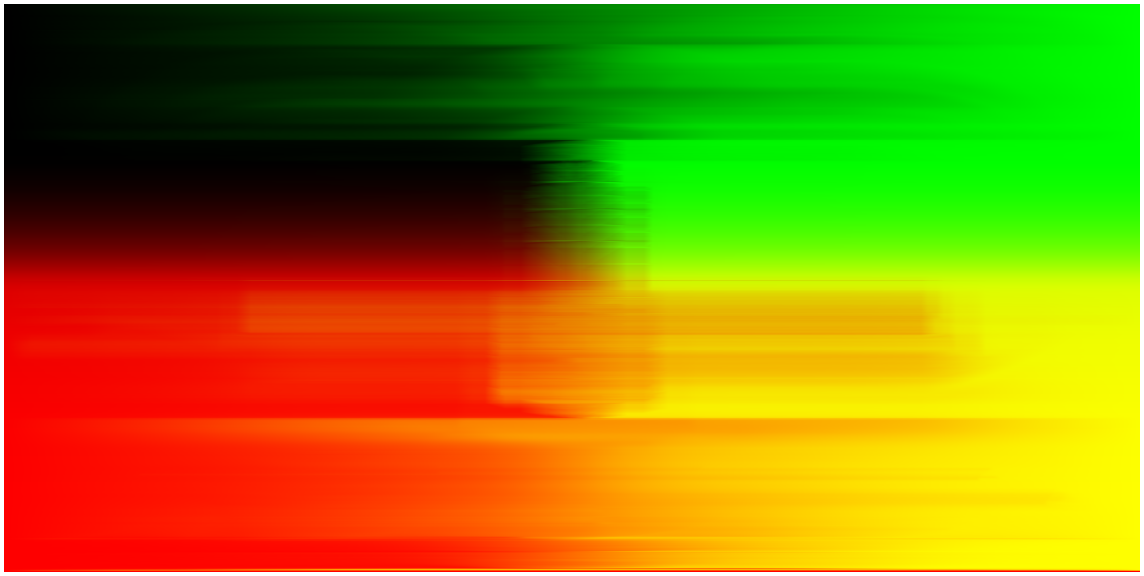
Figure 2: CBdragon of different materials (alpha = 0.1)

Part 3. Environment Light

The simulation of ambient light helps us to reduce the estimation of the number and location of light sources. Under the assumption of constant distant object occlusion relations, the intensity of ambient light is only related to its brightness at the pixel level, which facilitates importance sampling (we no longer need to enumerate individual light sources, but see them as a whole). Specifically, it relies on a panoramic image instead of a sampling of the environment.

In the rest of this section, I will use the `ennis.exr` file as the environment map.

(a) exr



(b) propability_debug

Figure 3: ennis.exr and propability_debug.png

On the `bunny_unlit.dae` model:

(a) Uniform

(b) Importance

From the figures we see clearly sampling by importance performs better than uniformly by comparing the noise level.

On the `bunny_microfacet_cu_unlit.dae` model:

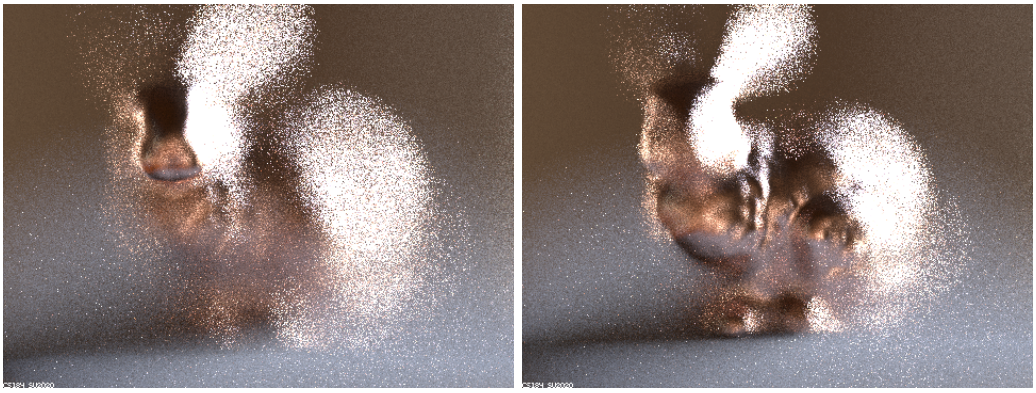
(c) Uniform

(d) Importance

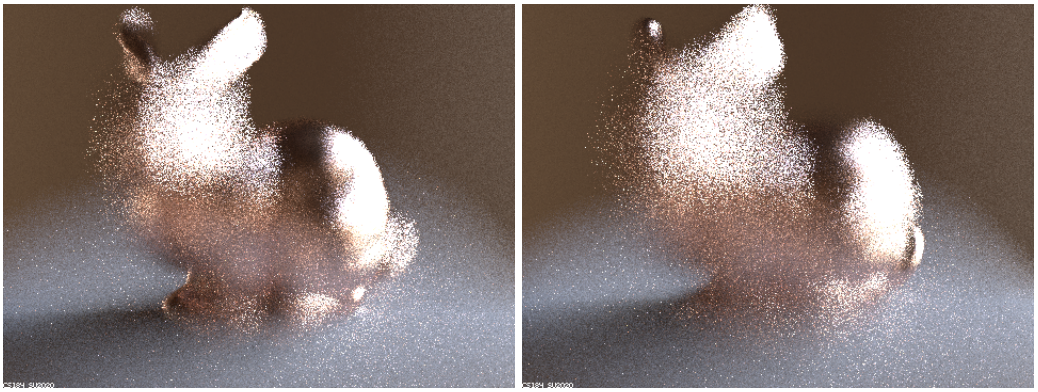
From the figures we see clearly sampling by importance performs better than uniformly by comparing the noise level.

Part 4. Depth of Field

Lens imaging is the result of convergence of light rays, from a point of light back to a point. Small-aperture imaging, on the other hand, has no convergence. But it is also point-to-point, from a point and then to a point. So they are both the same in this respect. These indicate that using lens camera requires more sampling to gain a acceptable quality.



(e) 2.1 (f) 2.2

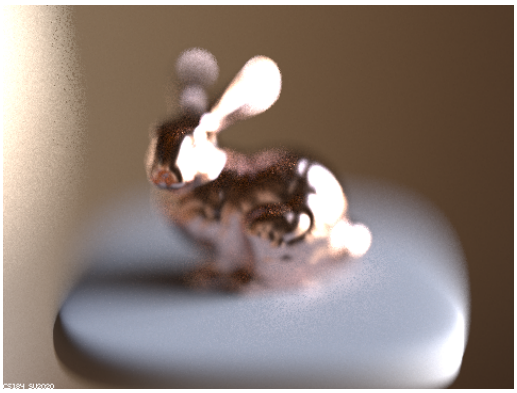


(g) 2.5 (h) 2.5

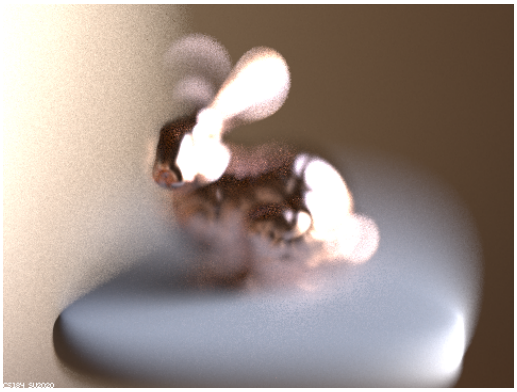
Figure 4: Different Focal Distances, (radius=1.0)

(a) 0 (Pinhole)

(b) 0.3



(c) 0.6



(d) 1

(e) 2

Figure 5: Different Lens Radius(Focal Distances = 3.2)