CS 184: Computer Graphics and Imaging, Spring 2023

Project 3: Pathtracer 2

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Overview

In this project, we implemented reflection and reflaction as well as depth of focus using the thin lens camera model. In Part I, reflection was straightforward, while refraction required more computation and case checking to determine whether refraction or total internal reflection occurred. We encountered minor problems with the PDF of refraction, which should be 1 since refraction angle is unique, and with glass BSDF, forgetting to take the absolute value of cosine theta. This allowed us to render refractive and reflective materials such as glass and metal. For Part IV, computation of the correct vectors was relatively straightforward, with a minor error in forgetting to add the position of the camera to the ray origin. This part allowed us to render with focus on various depths of the scene, which gives a nice visual effect.

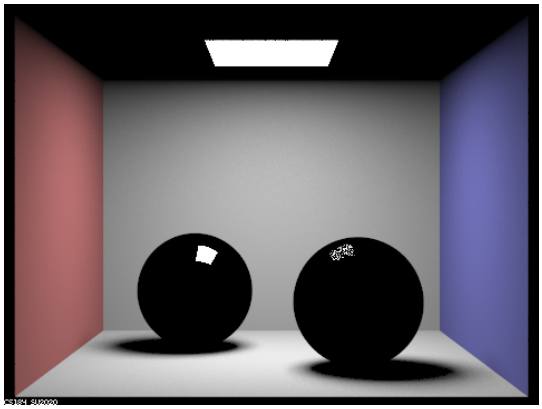
Part I: Mirror and Glass Materials

When max ray depth is 0, the only thing we see is the light coming from light sources since this is zero bounce radiance. When we increase it by 1, the walls are lit up, but not the ceiling since it can't reach the light with one additional bounce. For the mirror sphere, we see the reflection of everything in the previous image, which is just the light. For the glass sphere, we see some reflection of everything in the previous image, as well as refraction, but in this case refraction hasn't had anything yet so it's still black.

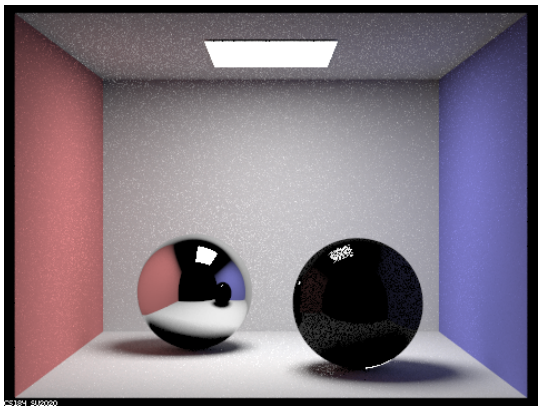
When max ray depth goes up to 2, we see the mirror sphere still reflects the previous image with max ray depth 1. We can see the reflection of the cornell box and the other sphere. For the glass sphere, it is still the same as the previous image because the rays that were refracted have not a chance to exit the sphere yet which means there's no color/radiance. When max ray depth goes up to 3, we see the mirror sphere still reflects the previous image with max ray depth 2. We can see that the ceiling in this reflection is lit up now. For the glass sphere, the refracted rays have finally had a chance to exit the sphere, which means the refraction is working.

After one more bounce, we can see the effects of the refraction in the glass ball reflected in the mirror ball. This makes sense because it takes one extra bounce from when a feature first appears in the camera to see it as a reflection in the mirror ball. Due to this, from depth 4 to depth 5 we can see that the light reflected on the mirror ball can be seen more noticeably in the reflection of the mirror ball, although the rest of the scene does not change much. Finally at a depth of 100, light bounces around the room significantly more so we can see that the light refracted through glass ball is much more spread out over the surface, and since we have sufficiently many bounces this is reflected in the mirror ball as well.

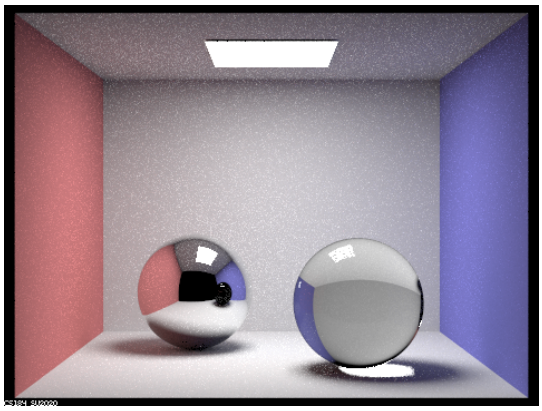
Spheres: 256 samples per pixel, 4 per light, max ray depth 0; dae/sky/CBspheres.dae.



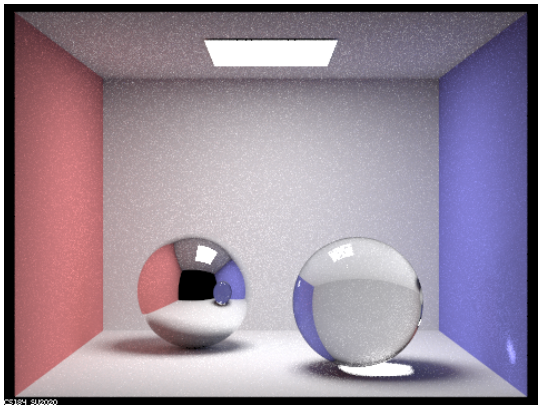
Spheres: 256 samples per pixel, 4 per light, max ray depth 1; dae/sky/CBspheres.dae.



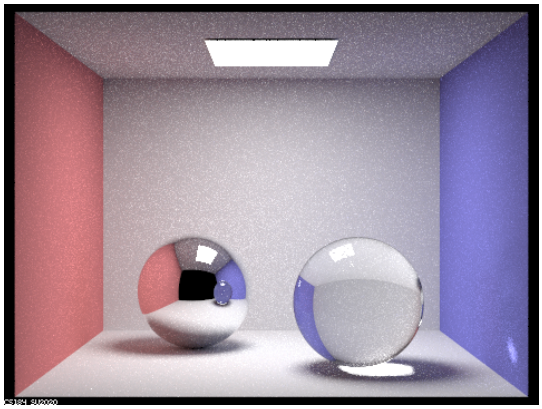
Spheres: 256 samples per pixel, 4 per light, max ray depth 2; dae/sky/CBspheres.dae.



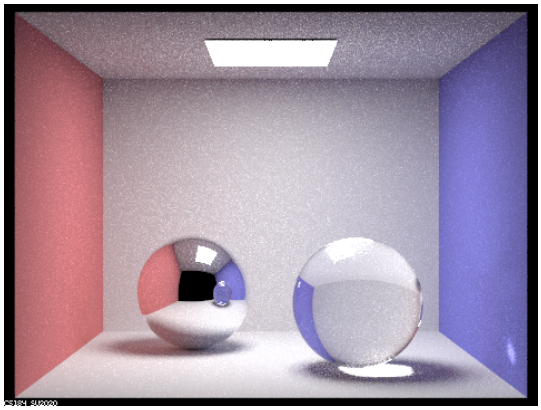
Spheres: 256 samples per pixel, 4 per light, max ray depth 3; dae/sky/CBspheres.dae.



Spheres: 256 samples per pixel, 4 per light, max ray depth 4; dae/sky/CBspheres.dae.



Spheres: 256 samples per pixel, 4 per light, max ray depth 5; dae/sky/CBspheres.dae.

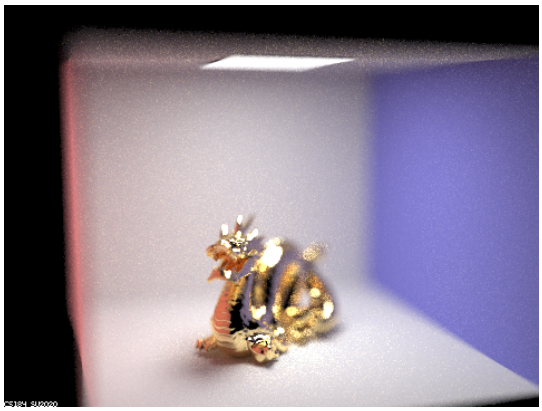


Spheres: 256 samples per pixel, 4 per light, max ray depth 100; dae/sky/CBspheres.dae.

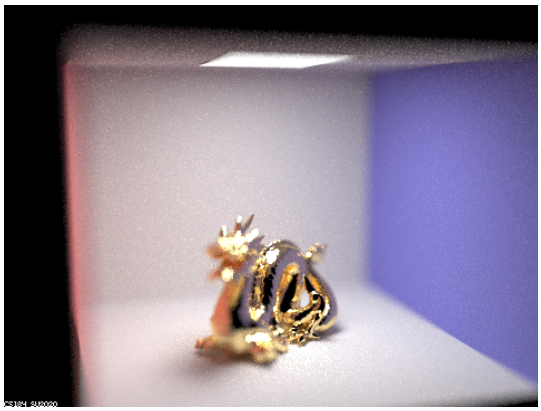
Part IV: Depth of Field

The pinhole model assumes no reflective nor refractive material between the camera and the scene, and therefore all rays that sample a point must travel directly from the camera to the scene. However, for a thin lens model, light can refract from the scene through the lens to the camera, which means the scene at the camera is now an integral over many different rays. When an object is at the point of focus, this can be seen as an average of views of the object at different angles. However when the object is not in focus, then the rays converge either in front or behind the object, which causes the pixel to produce an average of the scene in near proximity of the object. This produces a blur of objects that are further away from the focal distance.

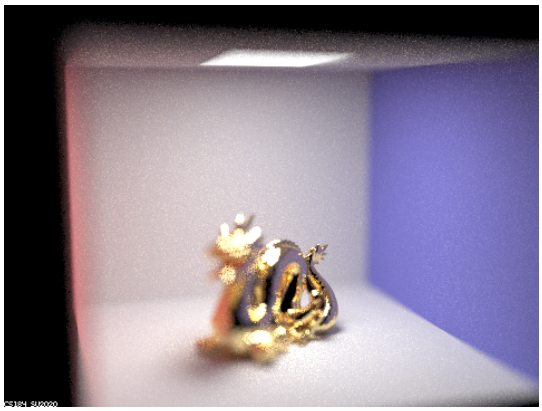
The photos below all have 256 samples per pixel, 4 per light, and aperture width 0.23.



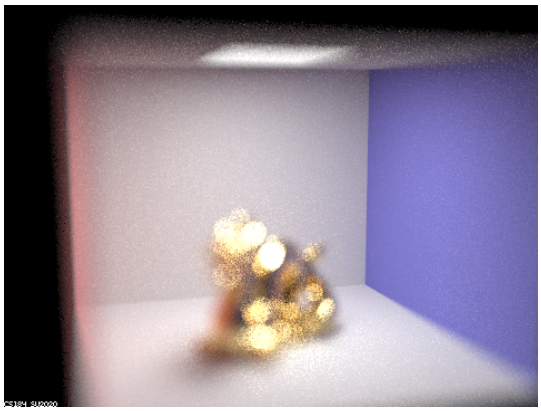
Dragon: depth 3.65; dae/sky/CBdragon.dae.



Dragon: depth 3.98; dae/sky/CBdragon.dae.

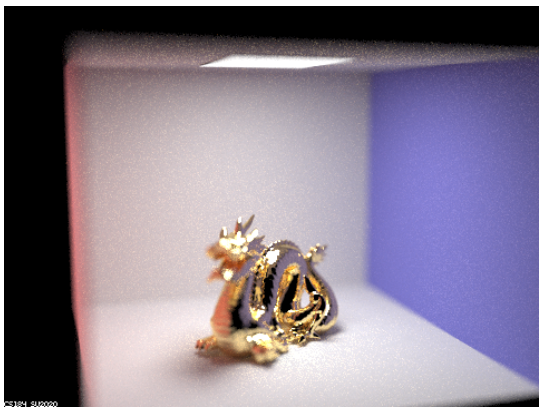


Dragon: depth 4.22; dae/sky/CBdragon.dae.

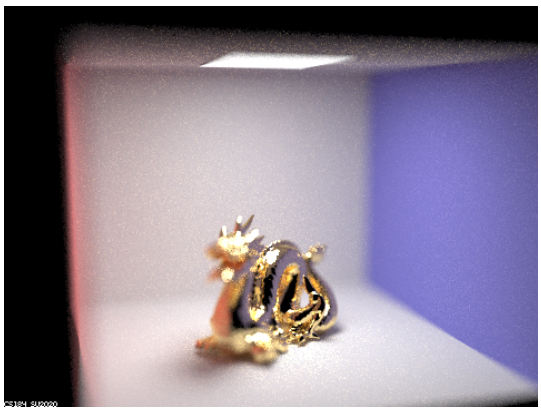


Dragon: depth 5.08; dae/sky/CBdragon.dae.

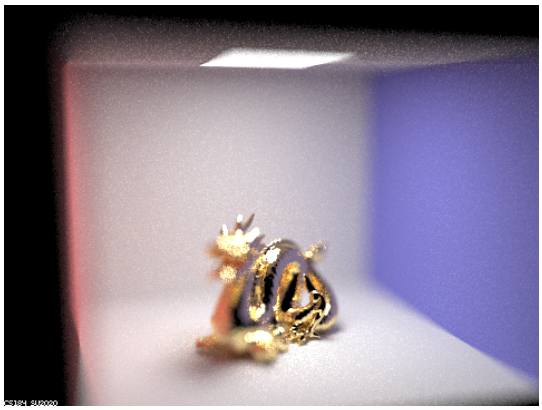
The photos below all have 256 samples per pixel, 4 per light, and focal depth 3.98.



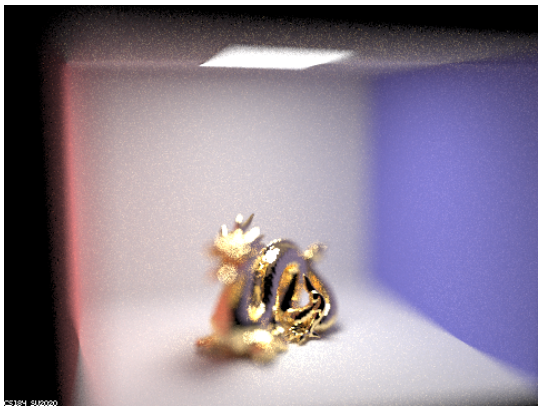
Dragon: aperture 0.16; dae/sky/CBdragon.dae.



Dragon: aperture 0.24; dae/sky/CBdragon.dae.



Dragon: aperture 0.32; dae/sky/CBdragon.dae.



Dragon: aperture 0.40; dae/sky/CBdragon.dae.