The Chinese University of Hong Kong, Shenzhen

CSC4140

Computer Graphics

CSC4140 Assignment 7

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May 1, 2022

Contents

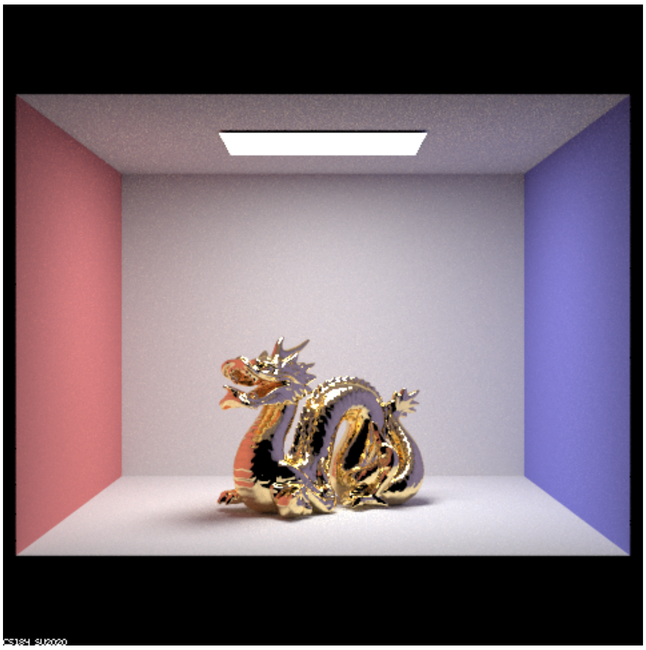
1 Choose Part

In my assignment 7, I choose to complete Part 1, 3, 4. I also tried to implement Part 2, but there seems to have some problems in my code, I have no enough time to fix it right now, but I will try later.

2 Mirror and Glass Materials

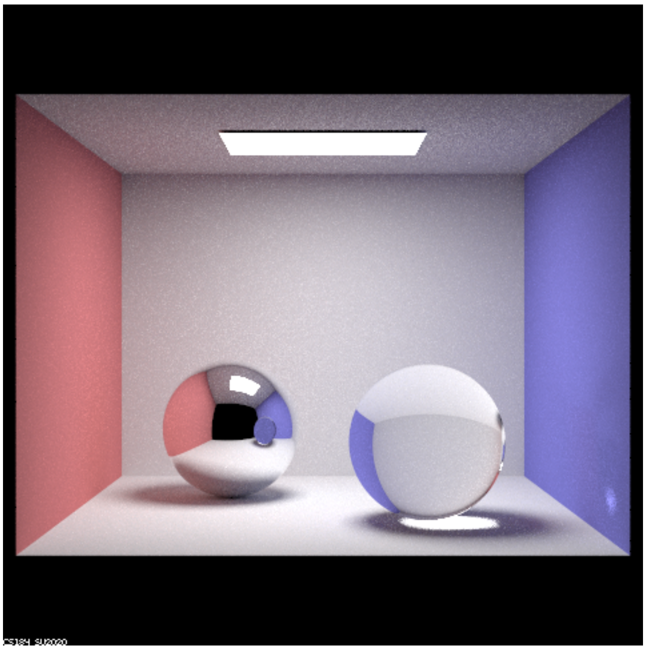
2.1 Reflect and Mirror Material

The result of CBdragon.dae with mirror material is shown here:



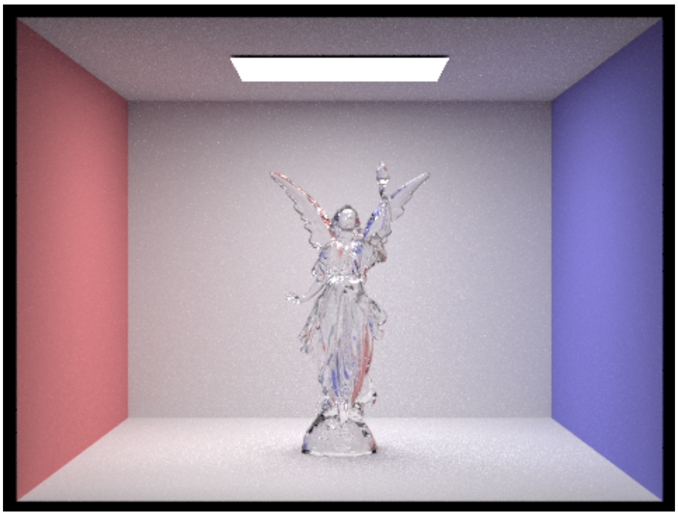
2.2 Refract

The result of CBspheres_refract.dae is shown here, the material in the model only reflect or refract, not like real glass.



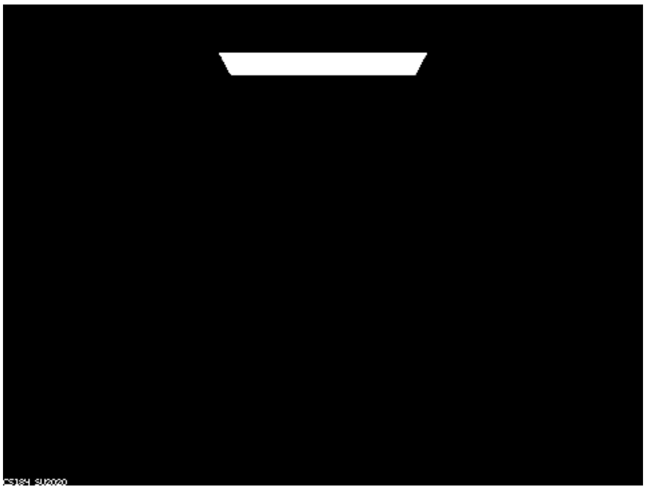
2.3 Glass Material

The glass material combine reflection and refraction together, with Fresnel term to calculate the fraction of each of the two effects. The result of CBlucy.dae is shown here:

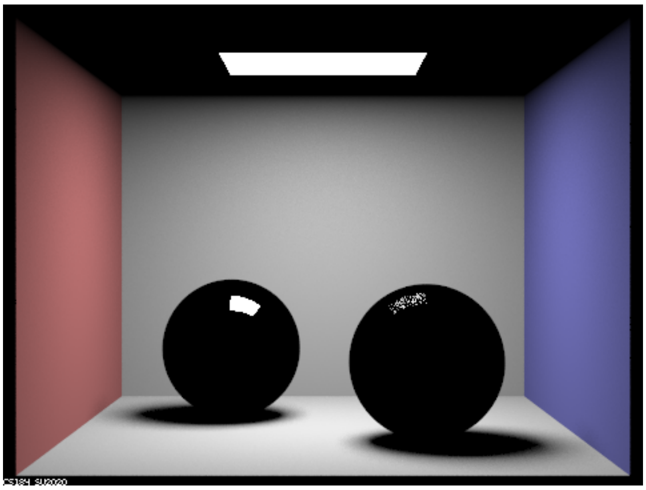


And the following is a sequence of six images of file CBspheres.dae rendered with max_ray_depth set to 0, 1, 2, 3, 4, 5, and 100, the model in the file include both mirror and glass material, with different max ray depth, the bounce of the rays in the scene can be seen clearly.

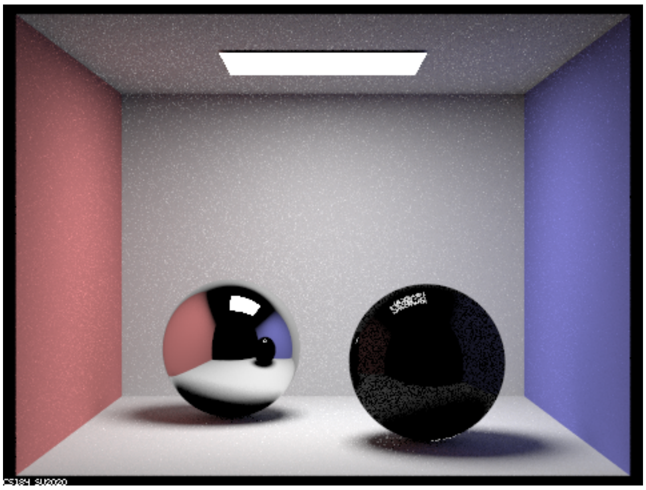
The first is 0 bounce, only the light source can be seen.



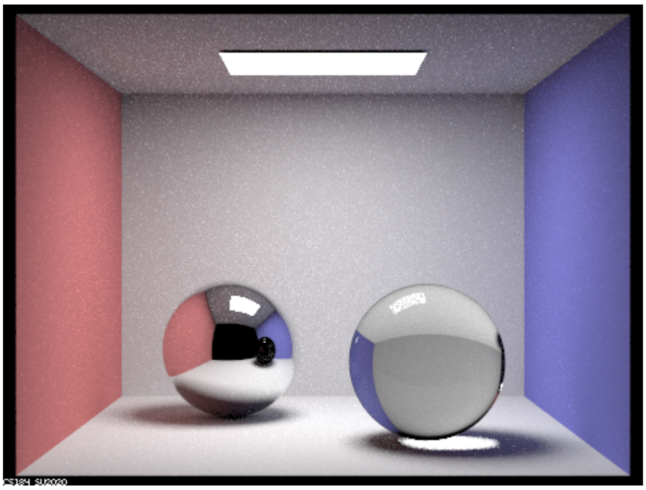
The second is 1 bounce, the border of the box can be seen, but the two balls are still almost black, because the light from object excluding the light source need one bounce to get radiance from light source, and one more bounce to arrive at the material, so that the camera can observe it.



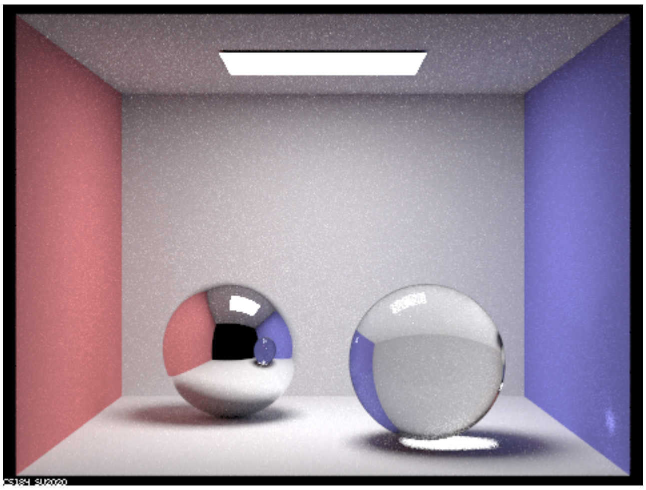
In the 2 bounce, the mirror material can be seen now, but the glass cannot. It's because that the light is refracted into the glass ball, it needs one more bounce to go out to be seen by the camera.



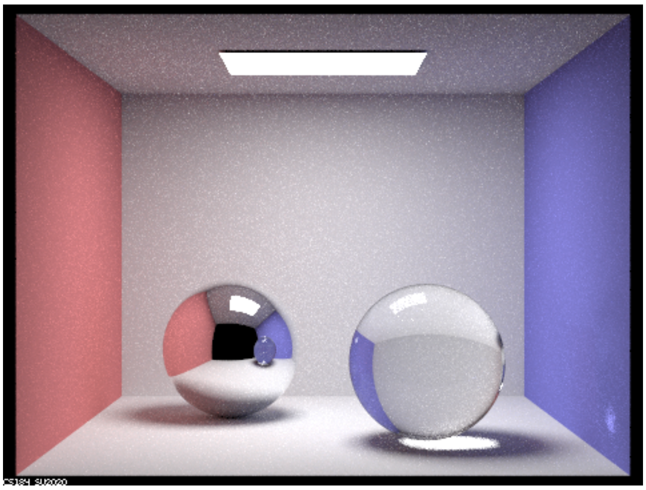
And this is the result of three bounce, both material can be seen correctly



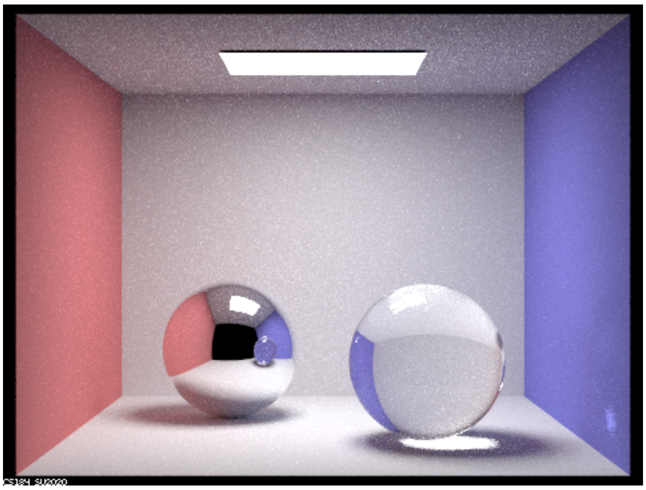
The result of 4 bounce:



For the four and five bounce, the difference between the first three scenes is the facula on the right(blue) wall, this is also because of the number of bounce.



The last one is 100 bounce. It can be seen that the material in the scene is very close to the real mirror and glass in our daily life.

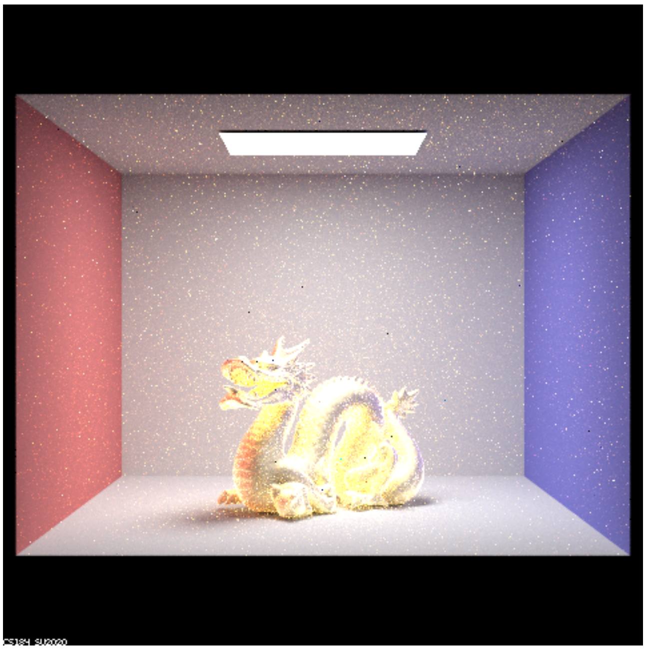


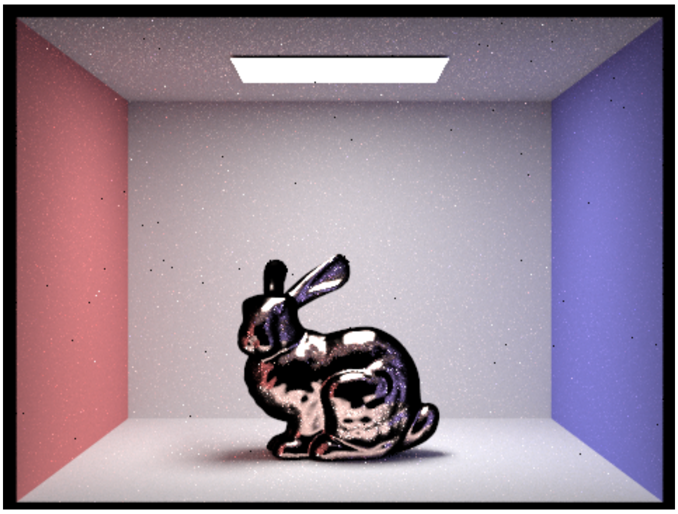
3 Microfacet Material

I choose to implement part 1, so this part can be ignored when grading.

But I have also tried to implement the microfacet material, although there's some problems in my code, I'll fix it later.

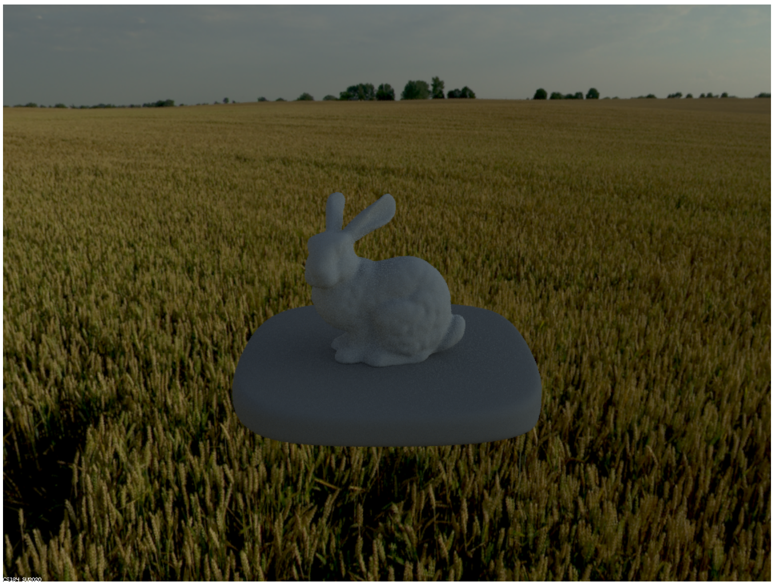
Here is some result of this part:





4 Environment Light

For the environment light, the object recieve incoming light from a texture map, which is parameterized by theta and phi. And this part is rendered successfully, this is the result of field.exr:



And the results in the following will use environment file **uffizi.exr**.

4.1 EnvironmentLight::sample_dir()

The function is used to convert the world's ray to the parameter theta and phi, and then to the x and y in the environment texture. So that the environment map can be shown in background, but the light in the texture is not used yet, which will be implemented in the following tasks.

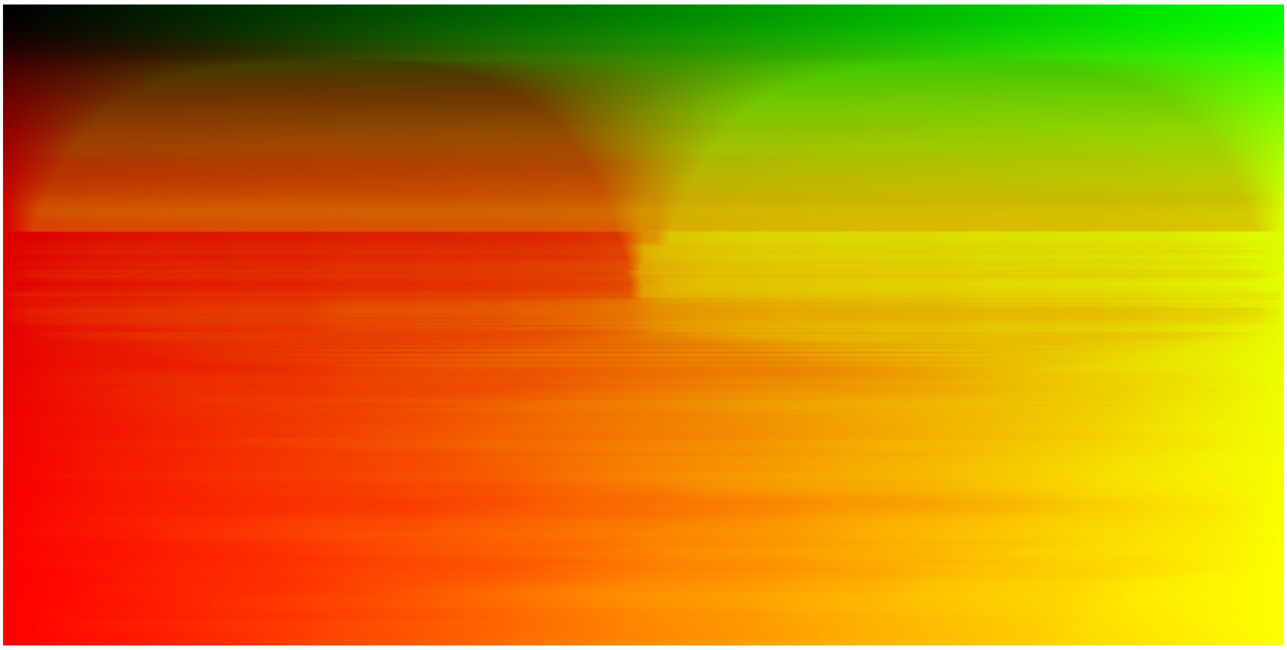
4.2 Uniform sampling

In this task, the light in the texture map is sampled uniformly on a sphere with $pdf = \frac{1}{4\pi}$, the sampled radiance value is returned so the model can recieve the light from the environment map now, but the noise is huge if the sample rate is not high, because now the light is sampled uniformly.

4.3 Importance sampling

The importance sampling includes many statistical calculation to reduce the noise. The light energy in the environment map is not distributed uniformly in almost all of the cases, most of the energy provided by an environment light source is concentrated in the directions toward bright light sources, thus the sampling method prefers to select the direction which is towards the direction where the incoming radiance is greatest.

The task will calculate how the radiance distribute on each pixel of the texture map, and each pixel corresponds to a solid angle direction. After calculating the marginal and conditional distribution, it will generate a file: probability_debug.png, representing the radiance distribution of the map:



And after changing the sample method to importance sampling by sampling direction using the probability map and calculating the proper pdf, It can be observed that the noise is reduced a lot.

5 Depth of Field

In this part, the camera is no longer an ideal pin hole, it will have its radius and act as an thin lens.

Since the point on the image is able to recieve radiance from any points of the thin lens, we need to sample the origin of the camera ray on the thin lens. This is done by two random value ranging in [0, 1) one of which will be multiplied be 2π to sample a random point on a 2d disk.

To get another point on the ray, two properties of the thin lens is used:

1. Rays from the same point on the plane of focus will always be focused to the same point on the image plane, no matter where they pass through the lens.

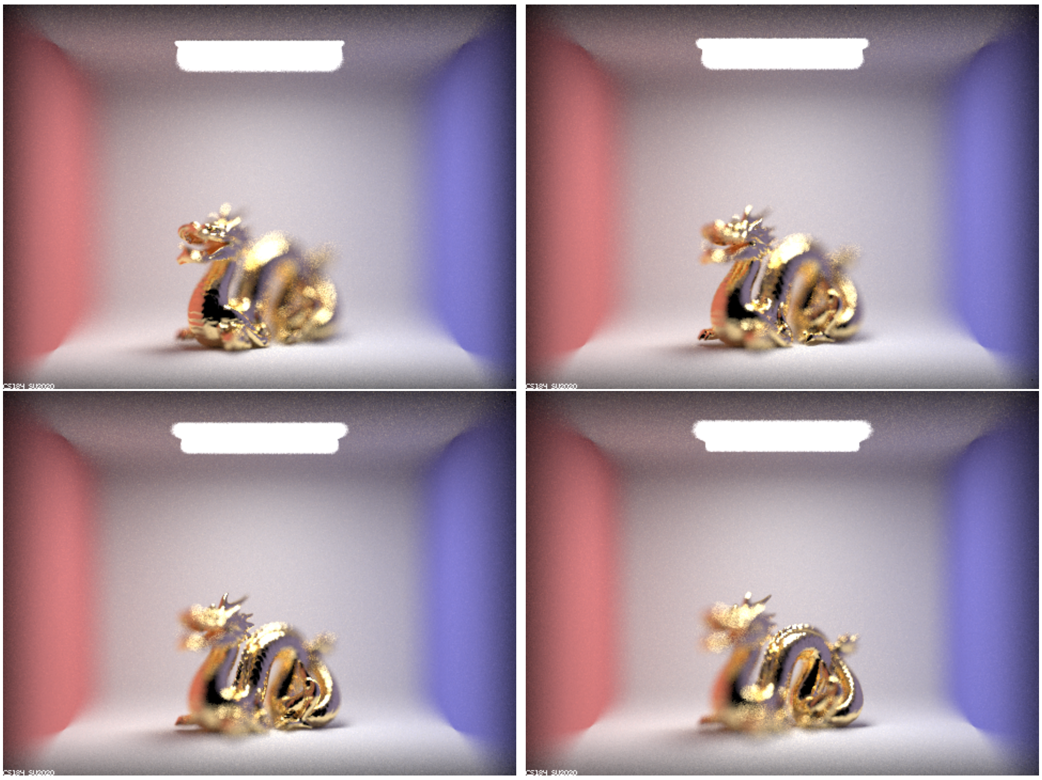
2. The ray passing though the lens' center won't change direction.

Thus, the intersaction point of the ray originated from the center of the lens (the ray in Assignment 6, part 1) and the plane of focus is also the point on the ray we want to sample.

Then, the origin, the direction of the sampled ray is obtained, after doing the camera to world conversion and setting near, far clips as in Assignment 6, return the ray.

The result shown here all use 256 samples/pixel, 4 samples/light, max ray depth = 12:

The following sequence of pictures is using lens radius = 0.6, focal distance = 4.6(left, row 1), 4.7(right, row 1), 4.8(left, row 2), 4.9(right row 2):



The following sequence of pictures is using focal distance = 4.5, lens radius = 0.4(left, row 1), 0.6(right, row 1), 0.8(left, row 2), 1.0(right row 2):