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CS 549: Computer Vision
Assignment 1

Question 1

1. Comparing Heights

While we do not know that whether the ground plane is perfectly even, that means we do not know whether A, B step their foots on the same height while standing, making the comparison not very plausible.

If we assume they were on the standing on the same ground plane. In the image provided, both A and B have their heads above the horizon. To determine who is taller, we need to compare the ratios of their head-to-toe distances ($a_1 + a_2$ for A and $b_1 + b_2$ for B) to their head-to-horizon distances (a_2 for A and b_2 for B). The person with the larger ratio is taller, who is possibly B.

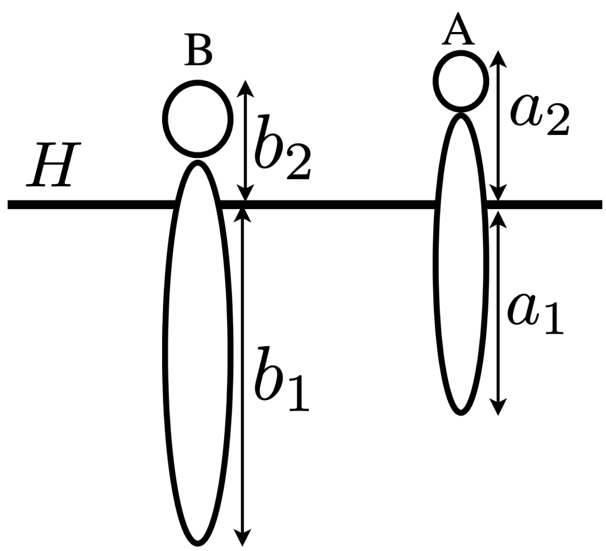

Figure 1: Compare Height

2. Calculating Heights

- Height of the camera above the ground:
  The height of the camera can be found by creating a proportion using the height of person A (which we know) and the distances to the horizon line:
  Camera height $= \frac{a_1}{a_1+a_2} \cdot h$
- Height of person B in feet:
  To find the height of person B, we will use the ratio of the segments that person A and B subtend with respect to the horizon, knowing A's height:
  Height of $\mathrm{H_B} = \frac{a_1}{a_1+a_2} \cdot h \cdot \frac{b_1+b_2}{b_1} = \frac{a_1 h(b_1+b_2)}{b_1(a_1+a_2)}$
- Distance from the camera to person B:
  This will involve using the focal length of the camera and the height of B. Assuming the camera is level with person A's feet and using the thin lens formula and similar triangles, we hav $b_2 = \frac{fH_B}{D}$
  Plug in what we have for H_B, that gives: $D = \frac{fH_B}{b_2} = \frac{fa_1 h(b_1+b_2)}{b_1 b_2(a_1+a_2)}$

Question 2

1. Rectangle

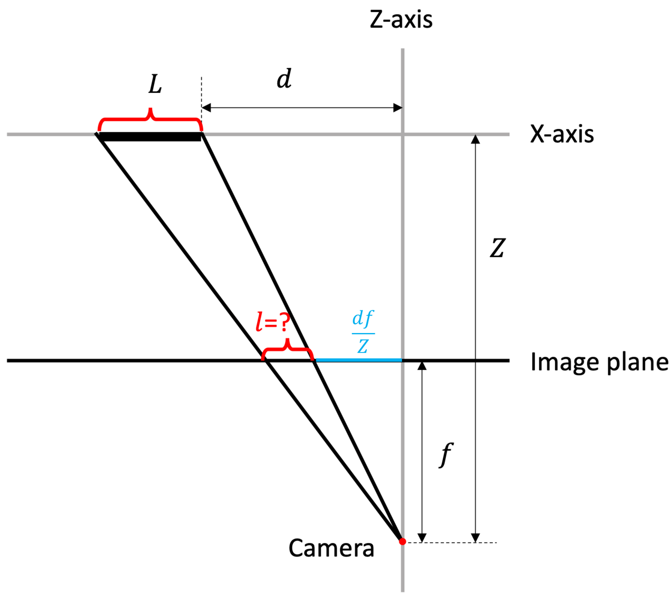

Figure 2: Geometric Analysis

According to the figure 2, by similar triangle, we have:

$$\frac{f}{Z} = \frac{\frac{df}{Z}}{d}$$

$$\frac{f}{Z} = \frac{l + \frac{df}{Z}}{L + d}$$

That gives:

$$l + \frac{df}{Z} = \frac{f(L + d)}{Z}$$

Therefore,

$$l = \frac{fL}{Z}$$

The l is invariant w.r.t. d to origin.

2. Cylinder

The notations we use to solve the problem is as depicted in Fig. 3 below.

Similarly, noticing the similar triangles in blue and yellow, we have:

$$\frac{r}{a} = \frac{Z}{\sqrt{Z^2 + (d + a)^2}}$$

$$\frac{r}{b} = \frac{Z}{\sqrt{Z^2 + (d - b)^2}}$$

Solve the above equation gives:

$$aZ = r\sqrt{Z^2 + (d + a)^2}$$

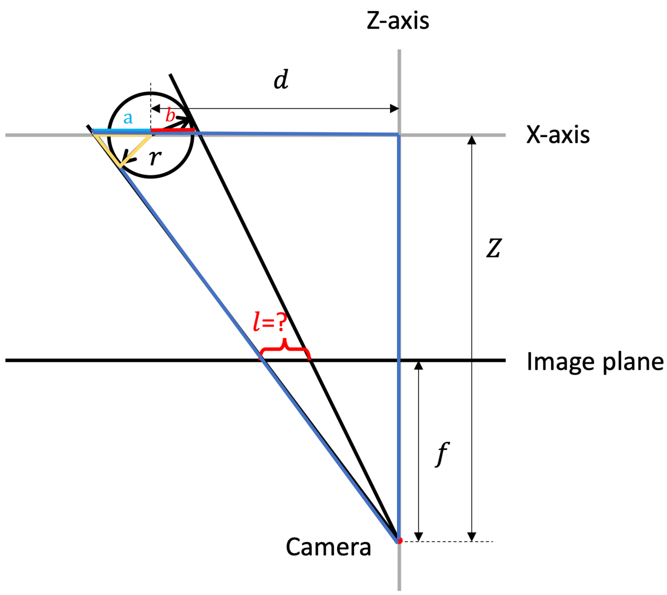

Figure 3: Notations for cylinder scenario

$$a^2Z^2 = r^2Z^2 + (d+a)^2$$

$$a = \frac{r(-Z\sqrt{Z^2+d^2-r^2} - dr)}{-Z^2+r^2}$$

Similarly for b:

$$bZ = r\sqrt{Z^2+(d-b)^2}$$

$$b = \frac{r(Z\sqrt{Z^2+d^2-r^2} - dr)}{-Z^2+r^2}$$

From (1), we know that $l = \frac{fL}{Z}$, plug in $L = a + b$ gives:

$$l = \frac{fL}{Z} = \frac{2fr\sqrt{Z^2-r^2+d^2}}{Z^2-r^2}$$

That gives:

$$\frac{\partial l}{\partial d} = \frac{2dfr}{(Z^2-r^2)\sqrt{Z^2-r^2+d^2}}$$

Which is exactly how l changes w.r.t. d

Question 3

3.1 Ball

3.2 Bunny

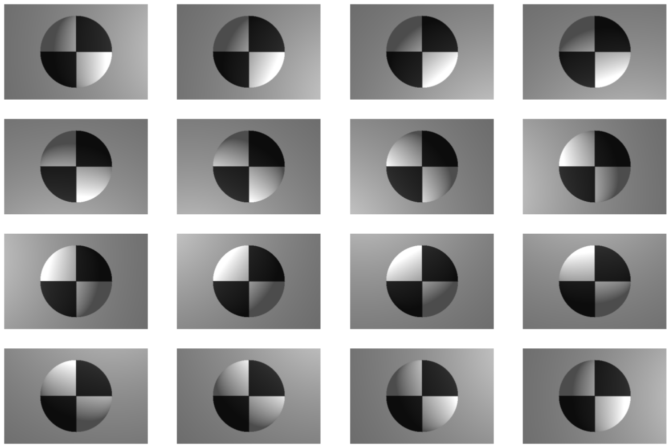

Figure 4: specular0_move_point

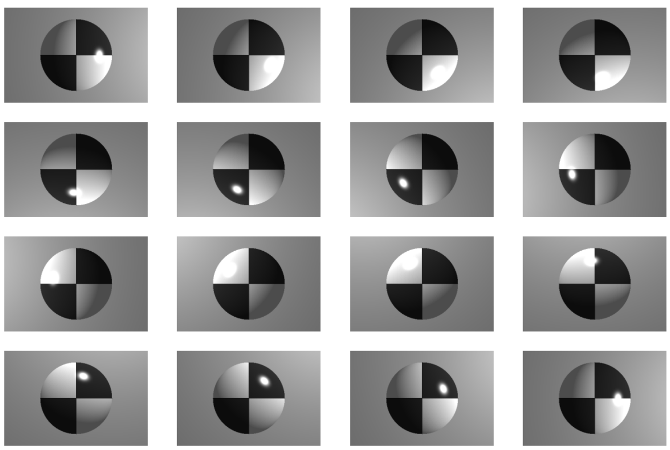

Figure 5: specular1_move_point

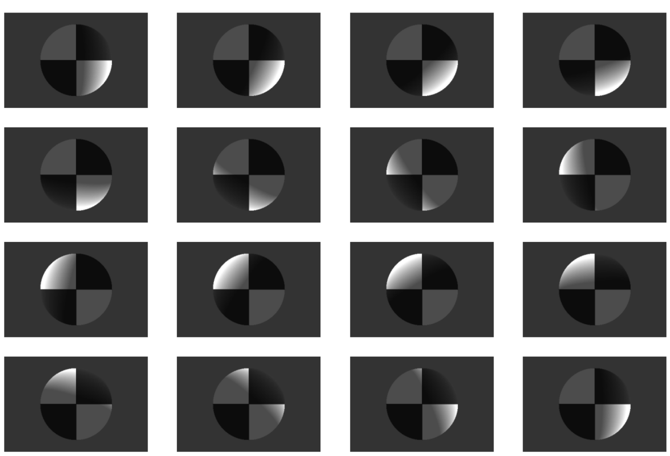

Figure 6: specular0_move_direction

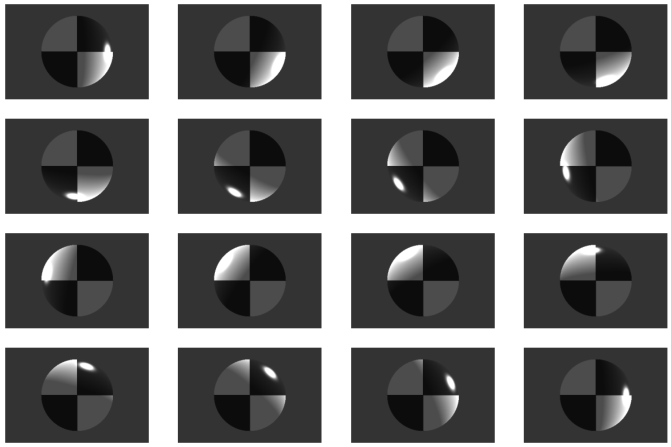

Figure 7: specular1_move_direction

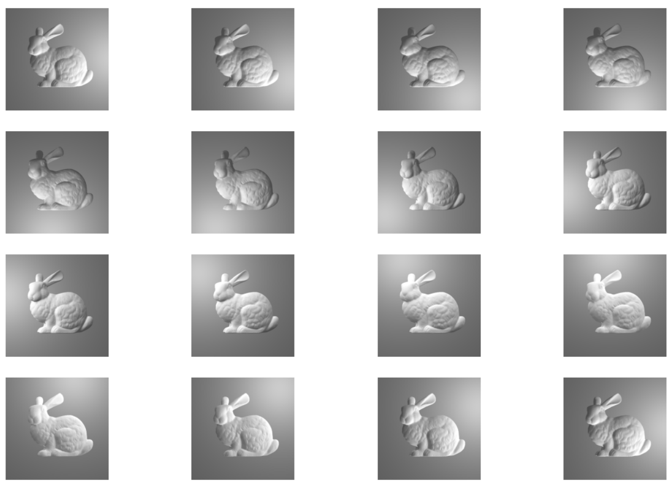

Figure 8: specular0_move_point

Figure 9: specular1_move_point

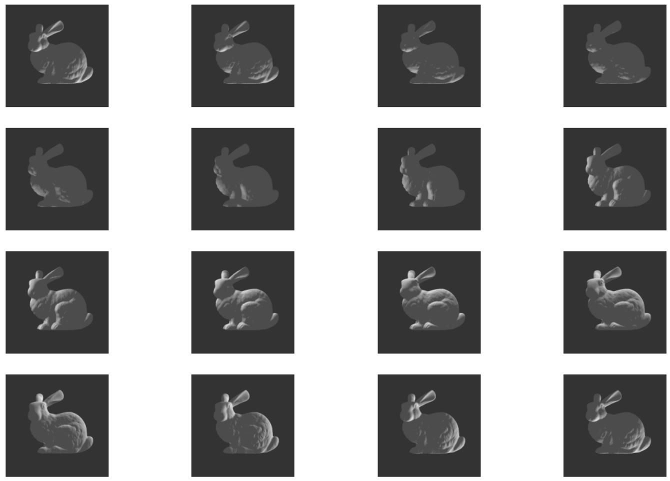

Figure 10: specular0_move_direction

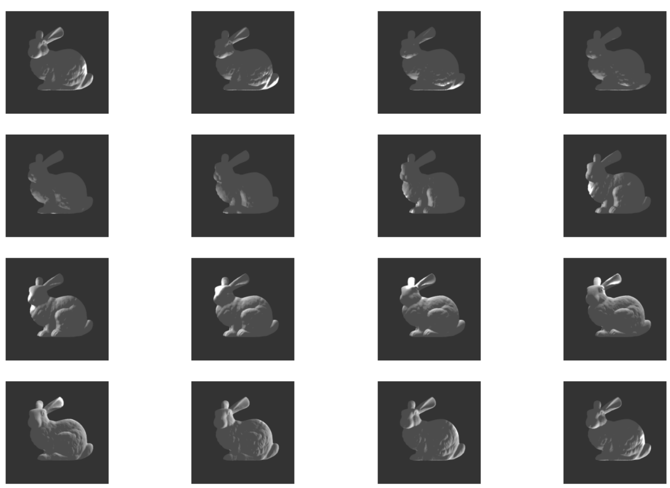

Figure 11: specular1_move_direction