Homework Assignment

Computer Graphics

Assignment 2

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Contents

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1 Exercise 2

The vector towards the directional light source: $l = \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix}$.

The position of the camera: $c = \begin{pmatrix} 4 \\ 6 \\ 7 \end{pmatrix}$.

Given a plain $y = 0$ we have the normal $n = (0, 1, 0)^T$

1.1 Task 1

We know that the reflected ray r is:

$$\begin{aligned} r &= 2n \cdot \langle n, l \rangle - l \\ &= 2 \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \cdot \langle \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix} \rangle - \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix} \\ &= 2 \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \cdot 2 - \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix} \\ &= \begin{pmatrix} 0 \\ 4 \\ 0 \end{pmatrix} - \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix} \\ &= \begin{pmatrix} -1 \\ +2 \\ -2 \end{pmatrix} \end{aligned}$$

So: $c - kr = p$

$$\begin{pmatrix} 4 \\ 6 \\ 7 \end{pmatrix} - k \begin{pmatrix} -1 \\ +2 \\ -2 \end{pmatrix} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

Since y is on the plain $y = 0$ we have $y = 0$ and we can solve the system:

$$\begin{cases} 4 - k(-1) = x \\ 6 - k(2) = 0 \\ 7 - k(-2) = z \end{cases}$$

$$\begin{cases} 4 + k = x \\ 6 - 2k = 0 \\ 7 + 2k = z \end{cases}$$

$$\begin{cases} 4 + k = x \\ k = 3 \\ 7 + 2k = z \end{cases}$$

$$\begin{cases} x = 4 + 3 = 7 \\ k = 3 \\ z = 7 + 2 \cdot 3 = 13 \end{cases}$$

So the intersection point is: $p = \begin{pmatrix} 7 \\ 0 \\ 13 \end{pmatrix}$

1.2 Task 2

$$k = 2 \qquad I = 1 \qquad P_s = \frac{1}{2} \qquad P_d = \frac{1}{2}$$

- **Specular term**

$$\begin{aligned} I_s &= p_s \cdot (\cos\alpha)^k \cdot I \\ &= \frac{1}{2} \cdot 1^2 \cdot 1 \\ &= \frac{1}{2} \end{aligned}$$

- **Diffuse term**

$$\begin{aligned} I_d &= p_d \cdot cos\phi \cdot = p_d \cdot \langle n, l \rangle \cdot I \\ &= \frac{1}{2} \cdot \langle \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 2 \\ 2 \end{pmatrix} \rangle \cdot 1 \\ &= \frac{1}{2} \cdot = 1 \end{aligned}$$

- **Total light**
  The attenuation in directional light is none i.e $attenuation = 1$

$$I_{tot} = (I_s + I_d) \cdot attenuation = (\frac{1}{2} + 1) \cdot 1 = 1,5$$

2 Exercise 3

The Phong lighting model is an empirical model to describe the illumination of the points representing an object. According to this model, the color of every pixel is modulated by the cosine of the angle between the normal vector and the light direction (Lambert's cosine law) as shown in fig. 1.

But we notice that some objects does not follow the Phong illumination model and apper flat. An example is the full moon: ignoring the shading artifacts caused by craters, it appears as a white disk with constant brightness rather than a sphere shaded according to the Phong illumination.

This effect is due to the roughness of the surface. When rays hit the surface, they are reflected in random directions, including the direction of the camera. As shown in fig. 2, increasing the surface roughness makes the object appear flatter.

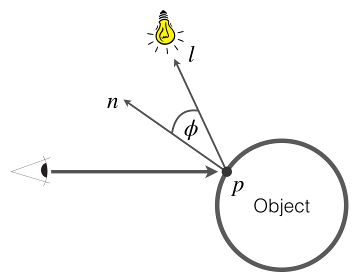

Figure 1: Lambert's cosine law

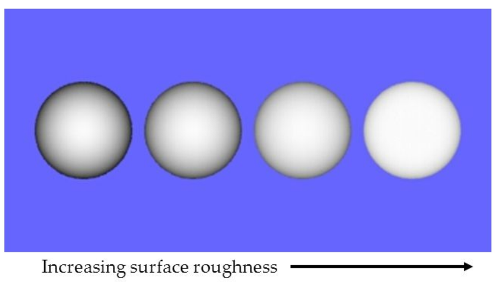

Figure 2: Effects of surface roughness variations

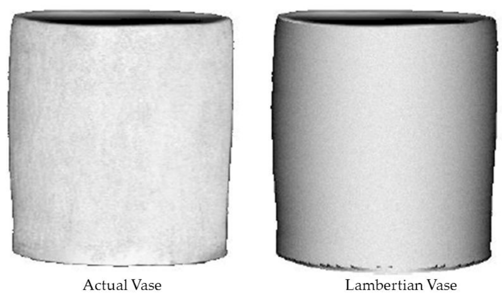

Figure 3: Real vase vs vase obtained through the Lambertian model

In fig. 3 we note that the lambertian model doesn't work correctly with rough materials.

To render rough objects more accurately, the Oren-Nayar model is often used, which takes into account surface roughness (fig. 4).

When the roughness is set to 0 the Oren-Nayar model simplifies to the Lambertian model.

Figure 4: Oren-Nayar model