Algo 4: Light

Introduction to Computer Graphics, Fall 2022

Due:

1 Lighting calculation

1.1 Lighting components In the following ingredients, select out which ones are used for which part of lighting calculation. (Suppose you already acquire the intersection position. And ingredient 1 and 2 are only for the intersection surface.)

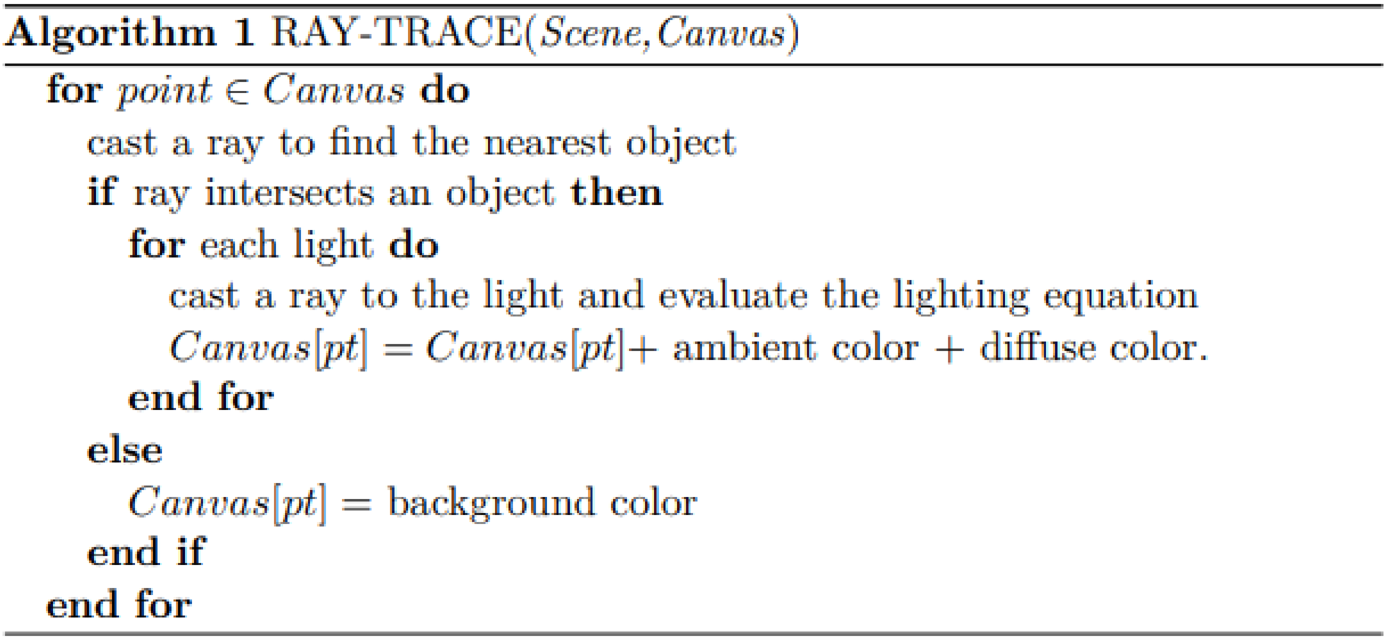
Ingedients:

- (1) Surface normals
- (2) Surface color
- (3) Light sources
- (4) Camera position

Lighting components:

- (a) Ambient Light 2
- (b) Diffuse 1,2,3
- (c) Specular 1,2,3,4
- (d) Reflection 1,4
- (e) Texture mapping 1,3

2.2 Raytracing pipeline In the following pseudo code, what needs to be changed / added to make this a full-fledged raytracer?



Algorithm 1 RAY-TRACE($Scene, Canvas$)

```
for $point \in Canvas$ do
  cast a ray to find the nearest object
  if ray intersects an object then
    for each light do
      cast a ray to the light and evaluate the lighting equation
      $Canvas[pt] = Canvas[pt] +$ ambient color + diffuse color.
    end for
  else
    $Canvas[pt] =$ background color
  end if
end for
```

specular component

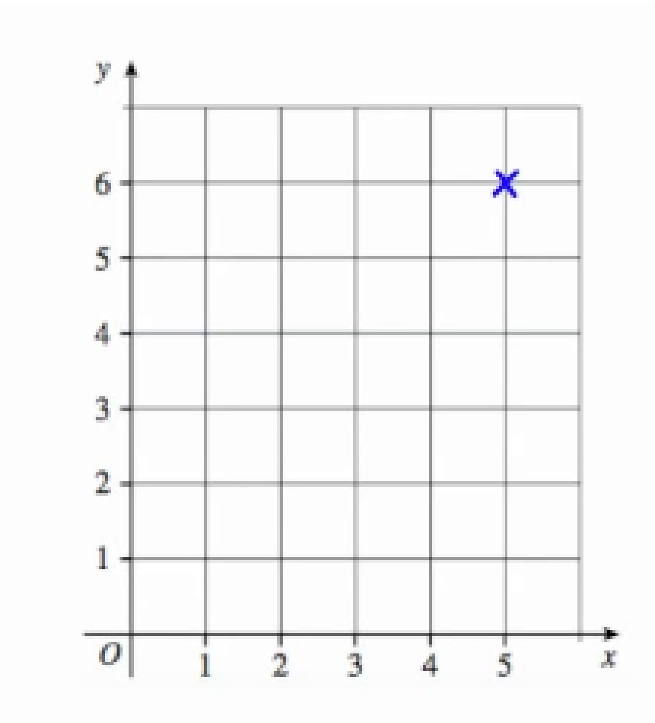
2 Reflection equation

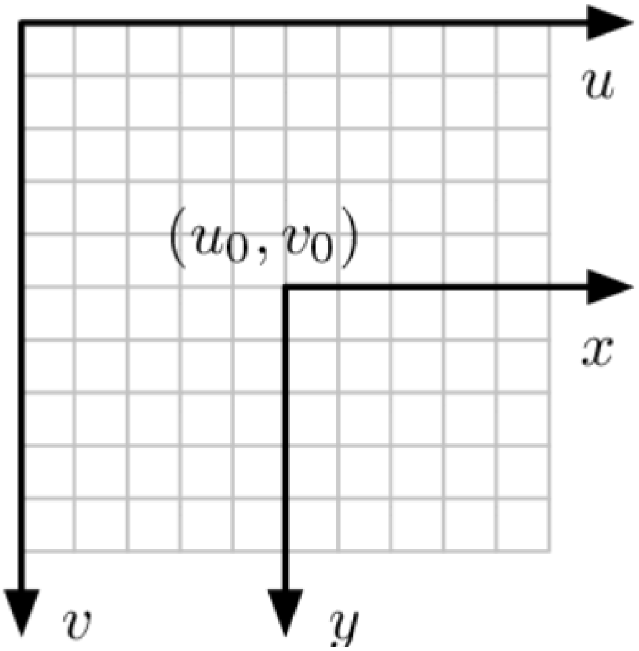
Calculating the reflected direction of light on surface is an important part of implementing lighting. Given the light direction L, normal N, write down the function for getting reflection direction. (L is from light source to intersection point)

$$R = L - 2N * (N \cdot L)$$

3 Texture coordinates

In most cases, your shape's texture coordinates may have different coordinates than the texture images. In the case below, surface coordinates originates from left bottom while the texture image from left top. In order to make the image show on the surface without any change in orientation, you need to build a mapping between these two coordinate systems.





3.1 Suppose image has a size of (w, h) and surface has a size of (s, t). What's the location of a pixel (u, v) on the surface when the texture image covers the whole image?

$$(\frac{u*s}{w}, h-\frac{v*t}{h})$$

3.2 From question 1. Suppose that you want to repeat the texture m times horizontally and n times vertically. What's the location of pixel (u, v) on the surface now? (Multiple positions, express in a way you feel best!)

$$(\frac{(u+m_i*w)*s}{m*w}, h-\frac{(v+n_j*h)*t}{n*h})$$

4 Shadow generation

In the normal process of adding shadows, you need to do the intersection again in the scene from the previous intersection point. Here is the problem, do you have to detect intersections with the previous intersected object itself? Why?

Yes. For a object with complicated geometry, self shadowing is possible. etc

5 Falloff function

Falloff is the effect of lighting intersity gradually fading from center to boundary. Think about the case of a spot light. To make it simple, we set the spot light to falloff right from the center. We use a falloff function to calculate the magnitude of falloff. It works like this:

$$I_f(x) = I * (1 - \mathcal{F}(x, b))$$

where I is the full light intensity, I_f is the light intensity after applying falloff, $\mathcal{F}$ is the falloff function, x is current position from center and b is boundary position.

Although any falloff function is allowed, we typically want a function range from 0 to 1 and is smooth at the boundaries. With this standard, which falloff function below do you think is best?

- (a) $\mathcal{F}(x, b) = \sin\left(\frac{x}{b} * 0.5\pi\right)$
- (b) $\mathcal{F}(x, b) = \frac{x}{b}$
- (c) $\mathcal{F}(x, b) = -2 * \left(\frac{x}{b}\right)^3 + 3 * \left(\frac{x}{b}\right)^2$
- (d) $\mathcal{F}(x, b) = 0.5 * \cos\left(\frac{x}{b} * \pi\right) + 0.5$

(c)