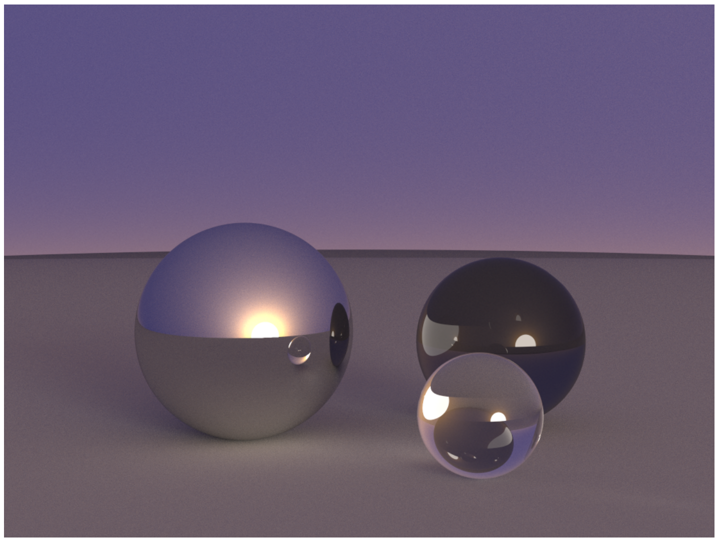
Master 1 IMAGINE

GASC Thibault

Ray Tracing Project : Step 1 and 2



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I Introduction

The ray tracing is used in 3D computer graphics. It is a technique for modeling light transport for use in a wide variety of rendering algorithms for generating images.

II STEP ONE :

1 Intersections with objects

A Ray/Sphere

To compute the intersection between the ray and spheres, I used the analytic solution. Let's consider the ray, which can be expressed using this function :

$$O + td \tag{1}$$

Where O the origin of the ray and D its direction, and the equation for a sphere which is :

$$x^2 + y^2 + z^2 = R^2 \tag{2}$$

Where x, y and z are the coordinates of a point and R the radius of the sphere. Let's consider that x, y and z are the coordinates of point P, we can write this following equation :

$$P^2 - R^2 = 0 \tag{3}$$

Now we can substitute equation 1 in equation 2 in order to replace P by the equation of the ray. So now, we have this equation :

$$(O + td)^2 - R^2 = 0 \tag{4}$$

By developing, we found a quadratic function with t as the unknown:

$$D^2t^2 + 2Odt + (O^2 - R^2) = 0 \tag{5}$$

Now that we have this equation, we can compute the solutions of this equation in order to find the intersection point.

To illustrate that, let me show you by using a table.

Δ	$= 0$	> 0	< 0
t	$= \frac{-b}{2a}$	$t_1 = \frac{-b-\sqrt{\Delta}}{2a}$ and $t_2 = \frac{-b+\sqrt{\Delta}}{2a}$	t is undefined
intersection	one intersection	two intersections $\rightarrow$ keep the min	no intersection

Table 1: Table representing the different solution

Then, to compute the normal of the sphere, we have to compute the intersection point (with the t that we have computed) and to normalize the vector formed by the intersection point and the center of the sphere.

Afterwards, in the function which is called *computeIntersection()*, we browse the sphere array in order to find the nearest intersection. When we have this intersection, we get the index of the object that we have intersected, we specify the type of intersect object, namely sphere or square. And then, in the function which is named *rayTraceRecursive()*, we have to change the color of the objects by using this variable of type of *Vec3* : objects[index]*.material.diffuse_material*.

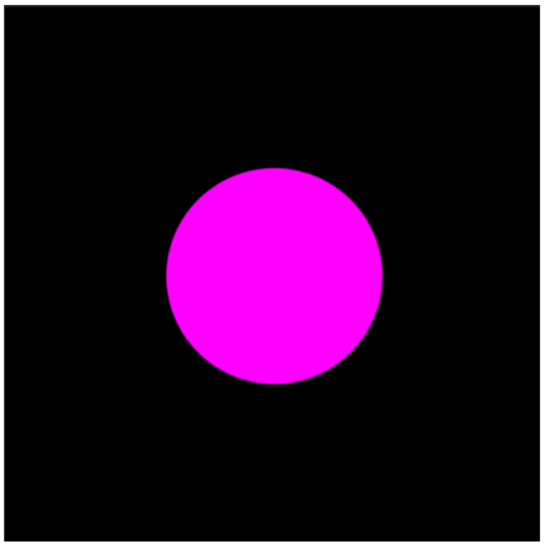

Figure 1: Result of ray tracing on sphere

B Ray/Square

For this intersection, we need the equation of a plane, namely :

$$x \cdot n - D = 0 \tag{6}$$

Where n the normal, and D the distance between the plane and the center (0,0,0), which is defined by $D = a \cdot n$. If we replace x by the equation of the ray (cf. equation 1), we get :

$$(O + td) \cdot n - D = 0 \tag{7}$$

And then, by rearranging the terms, we get :

$$t = \frac{D - O \cdot n}{d \cdot n} \tag{8}$$

To illustrate that, I will also use a table.

	intersection
$t > 0$	intersection in front of the camera
$t < 0$	intersection behind the camera
t undefined	ray confused with the plane
t infinity	ray is parallel and distinct from the plane

Table 2: Table representing the different t

And then proceed as for the spheres, i.e, we get the index of the object, the type of the object (sphere or square) and we change the color.

After all that, we can apply these two calculations on the Cornell's box.

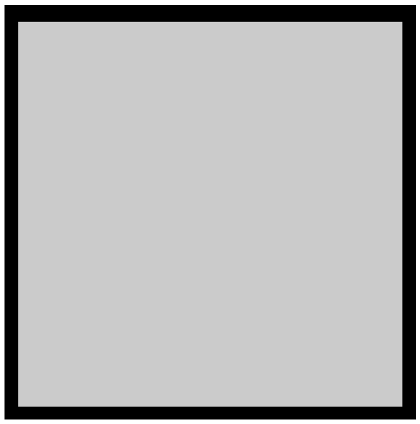

Figure 2: Result of ray tracing on square

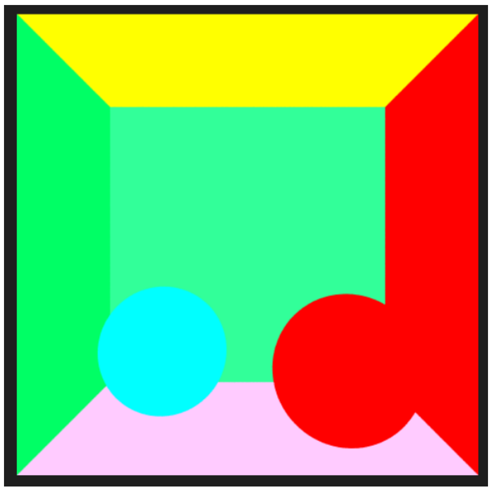

Figure 3: Result of ray tracing on Cornell's box

III STEP TWO :

1 Phong illumination

Now that we have display the Cornell box, we have to add Phong illumination. To do that, we have to use the following formula :

$$I = I_a K_a + \sum_{l}^{nb\_light} I_{ld} K_{ld} (L_l \cdot N) + I_{ls} K_{ls} (R_l \cdot V)^n \tag{9}$$

Where :

- $I_{a/d/s}$ is the intensity of the ambient/diffuse/specular light
- $K_{a/d/s}$ is the reflection coefficient of ambient/diffuse/specular light
- N is the normal
- L is the vector between the intersection point and the light position
- R is the direction of light reflection
- V is the vector of the view

To compute this intensity, we need to compute the direction of light reflection by using the following formula :

$$R = 2(N \cdot L)N - L \tag{10}$$

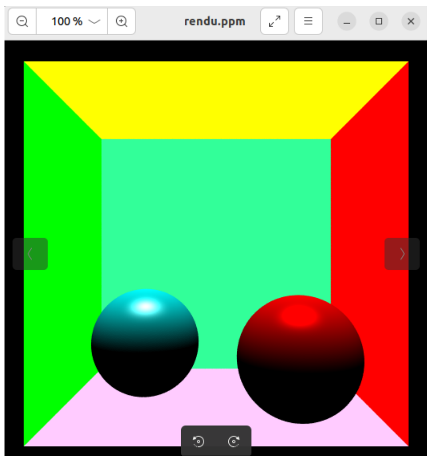

Figure 4: Result of ray tracing on Cornell's box with Phong illumination

I tried to made shadow in the spheres but no result. I didn't have more time to go on about it.