CSC 240 Computer Graphics
Day 21: Ray Tracing 2

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Final Projects - Past Years

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Q. Could you explain question 2 again?

“What does it mean if one of the solutions for $t$ is negative and the other is positive?”

A. We have a parameterized ray equation. The $t$ parameter measures the distance traveled along the ray from the starting point. If it is negative, the point is behind the camera.
Your Questions

Q. Why we only consider the smallest positive t? How about refraction and transmission (recursive ray tracing)?
A. The smallest positive t gives the first contact point of the ray. From there, we generate new rays for reflection and transmission.

Q. What does it mean to have one zero and not two?
A. The ray just grazes the surface (tangent contact) rather than piercing the sphere.
Q. Can you explain how knowing the refraction index tells you the light bends down in question 3?

A. Snell’s law says $N_1 \sin \theta_1 = N_2 \sin \theta_2$.

Rewrite this as $\frac{\sin \theta_1}{\sin \theta_2} = \frac{N_2}{N_1} = 1.5$.

In other words, $\sin \theta_1 > \sin \theta_2$, so $\theta_1 > \theta_2$
Q. Could you reexplain the second question "Why do we also need to solve for $u$ and $v$?"

A. Mathematically, we solved for the intersection of the ray with the plane containing our triangle.

$$
x_0 + tx_d = a_x + u(b_x - a_x) + v(c_x - a_x)
$$

$$
y_0 + ty_d = a_y + u(b_y - a_y) + v(c_y - a_y)
$$

$$
z_0 + tz_d = a_z + u(b_z - a_z) + v(c_z - a_z)
$$

What we don’t know is whether the intersection point is inside the triangle or not. The values of $u$ and $v$ tell us that.

Q. I don't quite understand the triangle plane equation and the reflection equation. Can you explain more on them?

A. The plane equation is a parametric equation in two variables.

$$
\vec{p} = \vec{A} + u(\vec{B} - \vec{A}) + v(\vec{C} - \vec{A})
$$
Q. Can you explain a bit about the formula for the mirror reflection?

A. Yes! Let’s do an example. The equation: \( \vec{R} = \vec{E} - 2(\vec{E} \cdot \hat{N})\hat{N} \)

Suppose we have a ray along the \(-z\) axis striking a 45° surface.

\[ \vec{E} = (0,0,-1), \quad \hat{N} = (0, \sqrt{2}/2, \sqrt{2}/2), \quad \vec{E} \cdot \hat{N} = -\sqrt{2}/2 \]

\[ \vec{R} = (0,0,-1) + \sqrt{2} \left( 0, \sqrt{2}/2, \sqrt{2}/2 \right) = (0,0,-1) + (0,1,1) = (0,1,0) \]

Q. Do we need to know all this math to code a scene or does three.js do it for us?

A. Three.js uses a traditional polygon-based rendering pipeline rather than ray tracing. However, Blender does ray tracing, and it takes care of all the math for you. ;-)
Other Questions?
Lab 14: Bézier Curves in Blender