CSCI 461: Computer Graphics

Middlebury College, Spring 2025

Lecture 08: Translucency

By the end of today's lecture, you will be able to:

- identify the difference between ray casting, ray tracing, and path tracing.
- cast rays through **refractive** materials,
- implement a **subsurface scattering** technique,
- identify sources of bias in some computer graphics algorithms.


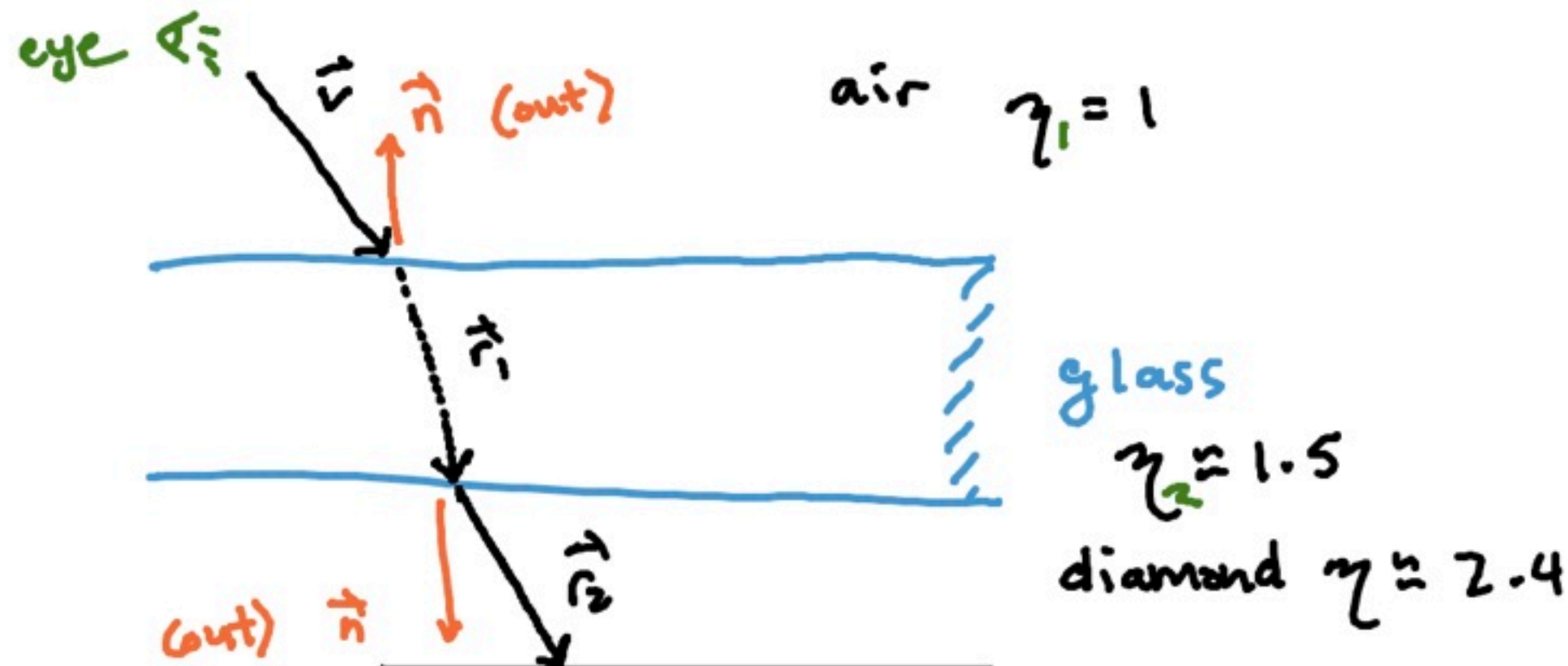Our main goal is to discuss how light goes *through* materials.

This is our last lecture on ray tracing. You might hear terms like "ray tracing", "ray casting", "path tracing." What's the difference?

name	what it does	lighting
Ray Caster	camera rays only	direct
Ray Tracer	camera rays + deterministic secondary rays	direct
Monte Carlo Ray Tracer	camera rays + multiple random secondary rays	indirect
Path Tracer	camera rays + single random secondary ray	indirect

For more on ray tracing, see the following books.
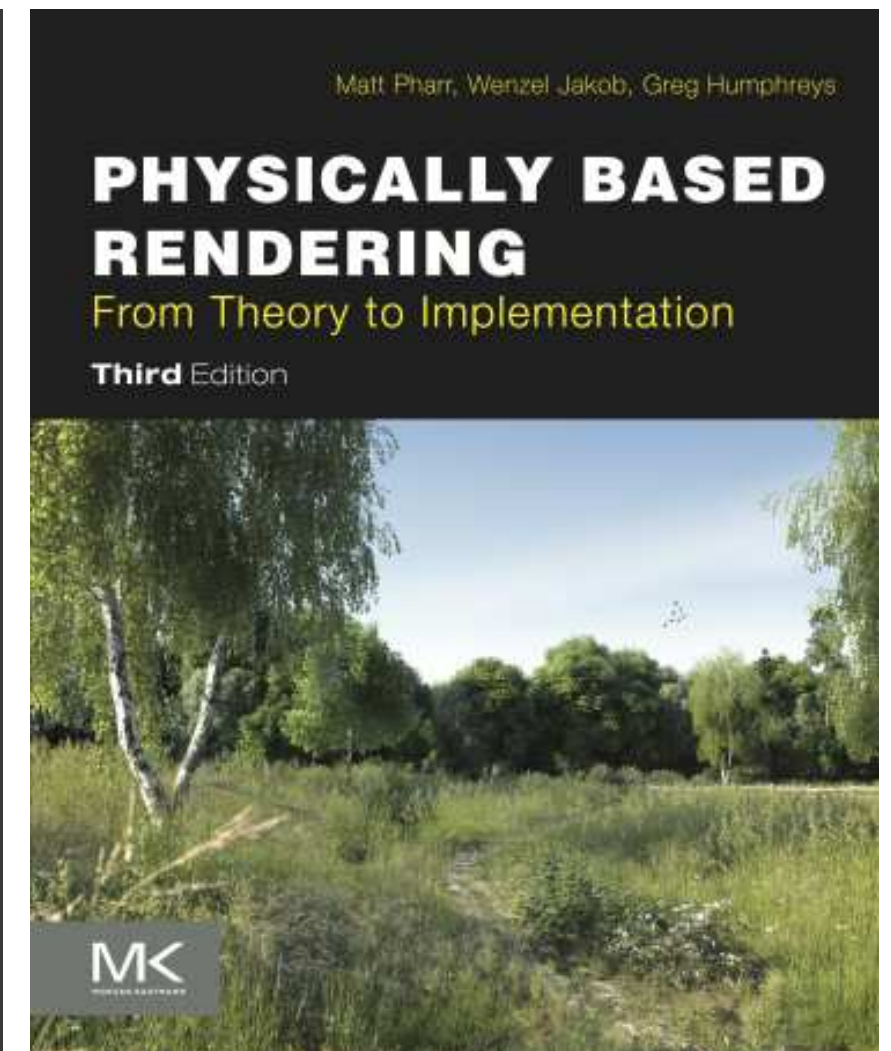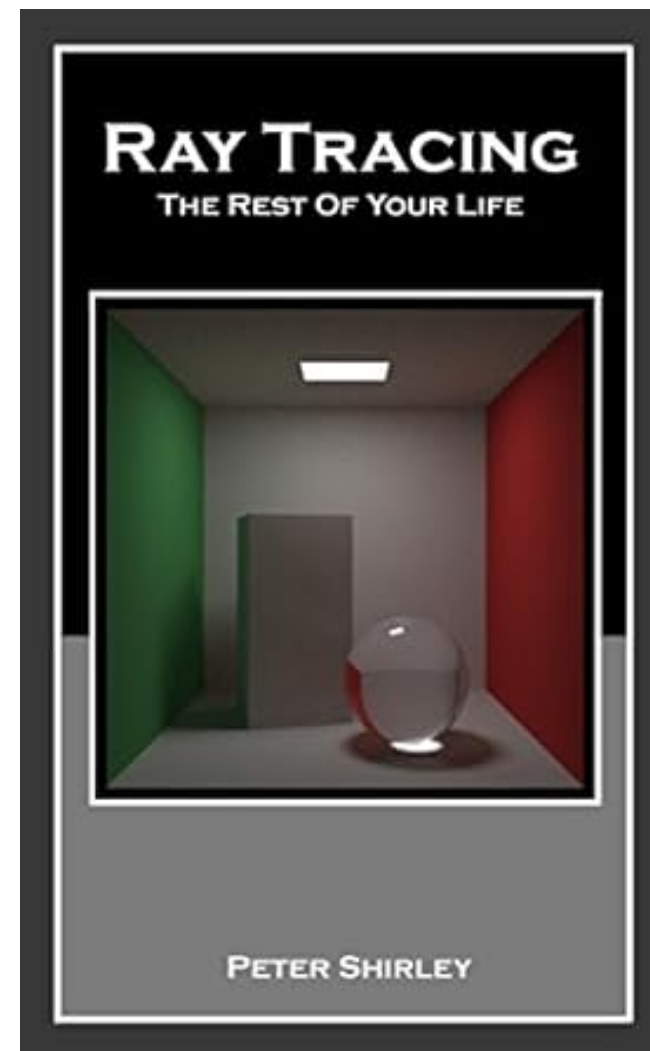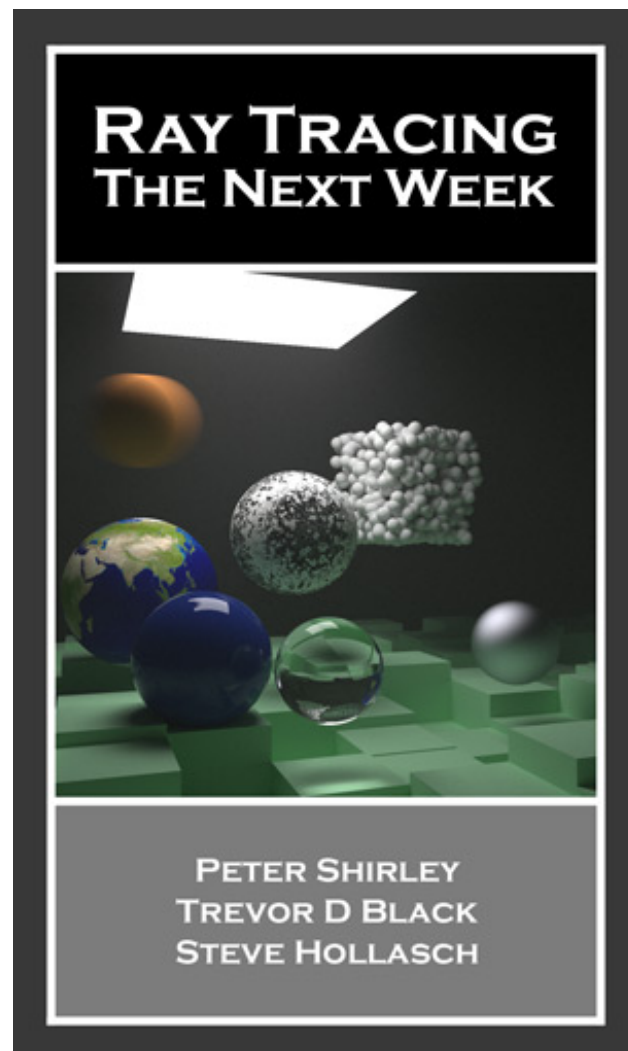
What if we want to render a crystal giraffe? We can model it as glass, which is refractive. Refractive materials *bend* rays.

eye $\vec{v}_?$

$\vec{v}$ $\vec{n}$ (out)

air $\eta_1 = 1$

$\vec{r}_1$

glass $\eta_2 \approx 1.5$

diamond $\eta \approx 2.4$

(out) $\vec{n}$

$\vec{r}_2$
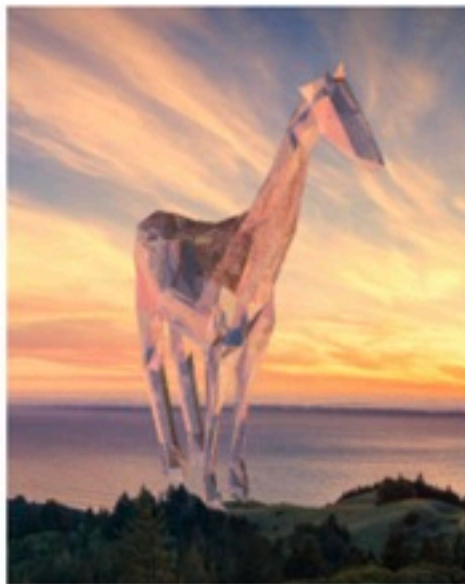
$$\vec{u} = \frac{\eta_1}{\eta_2}\left(\vec{v} - (\vec{v} \cdot \vec{n})\vec{n}\right) - \vec{n}\sqrt{1 - \left(\frac{\eta_1}{\eta_2}\right)^2 (1 - (\vec{v} \cdot \vec{n})^2)}$$

↑ direction of refraction ray

↑ what if this is < 0?

↑ points into material ① (η_1)

cast a reflection ray.

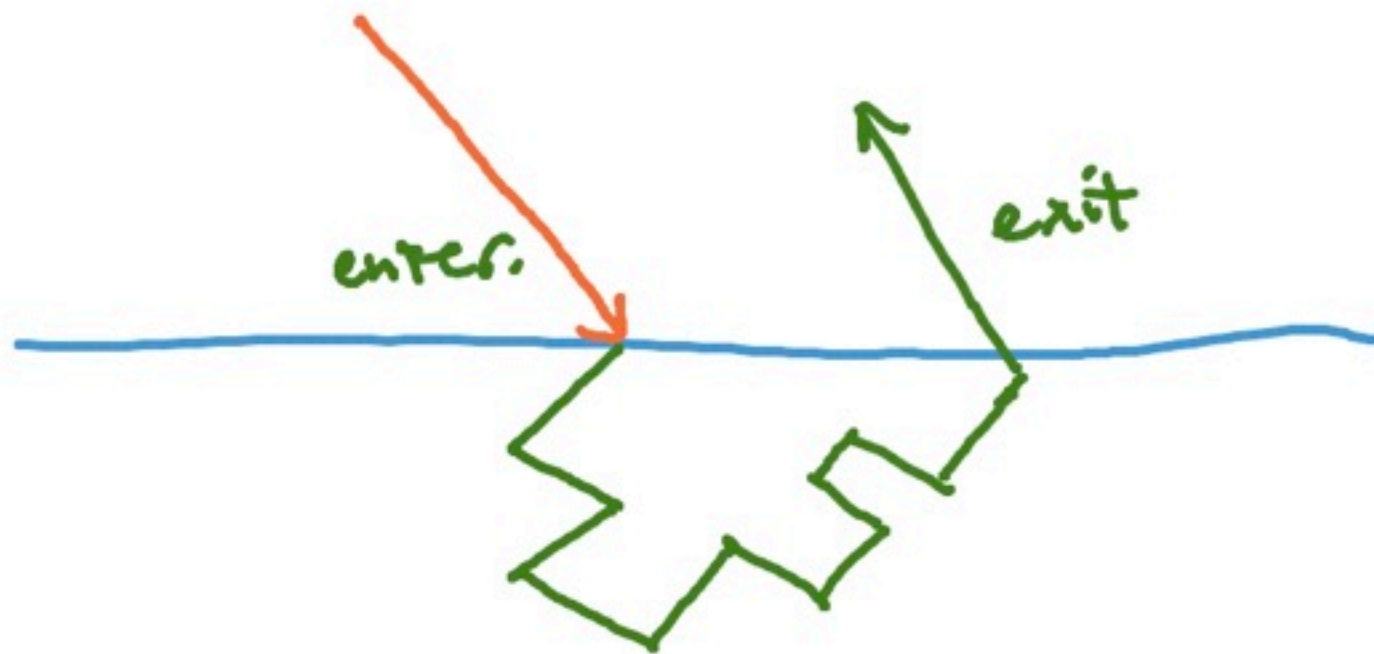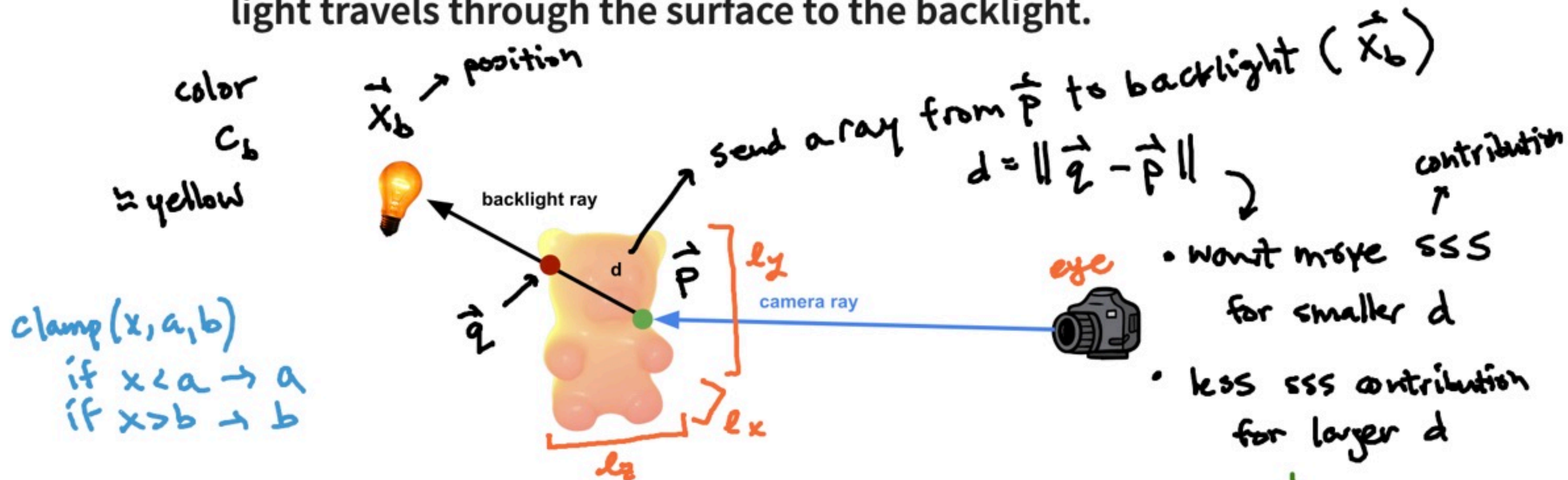← total internal reflection (TIR)

5

What if we want to render gummy bears? Notice that the color from the background gummy bears influences the color in the foreground gummy bears.

Subsurface Scattering: light may also enter a material, scatter and exit at a different point.

We can model subsurface scattering by estimating how much light travels through the surface to the backlight.

color $c_b \simeq$ yellow

$\vec{X_b} \to$ position

Send a ray from $\vec{P}$ to backlight $(\vec{X_b})$

$d = \| \vec{q} - \vec{P} \|$

backlight ray

contribution

- won't move SSS for smaller d
- less SSS contribution for larger d

$\vec{P}$

$\vec{q}$

ℓ_y

camera ray

eye

ℓ_x

ℓ_z

clamp(x, a, b)
if $x < a \to a$
if $x > b \to b$

color $= \alpha\, c_{phong} + (1-\alpha)\, c_{sss}$

SSS contrib $\sim \dfrac{1}{d}$

$S = \exp\left(-\gamma \left(\dfrac{d}{\ell_{scale}}\right)^2\right)$

constant

$c_{sss} = c_b\, k_m\, \beta\, s\, \text{clamp}\left(\vec{v} \cdot \vec{l_b},\, 0, 1\right)^m$

$m \to$ some constant

some constant

vector from $\vec{P}$ to eye

$\vec{l_b} = \dfrac{\vec{P} - \vec{X_b}}{\| \vec{P} - \vec{X_b} \|}$

8

Do a Google Image search for subsurface scattering. What else can we model?

Anti-Racist Graphics Research (SIGGRAPH 2021)

That's it for ray tracing! Next week: rasterization.

Course grading policy update: lowest assignment grade will receive a grade of "C" (complete).

This is kind of like "dropping" the lowest assignment grade, but in a way that maintains the breakdown of the final letter grade.