Introduction to Ray Tracing

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Ray Tracing

Rajesh Sharma

Course Outline

-✔- Intro, Model, Sampling
-✔- Rays, Intersections
-✔- Scene, Recursion
-✔- Materials, BRDF
-✔- BRDF-2
-✔- Systems View: Integrators, Accelerators, BRDF-3
-- Soft Shadows, Wrap up, Learn more

Eric Haines

Eric Haines is an expert in computer graphics. Currently he is with NVIDIA Corporation as a Distinguished Engineer. He co-authored the book *Real-Time Rendering*, currently in its fourth edition.

He created the Massive open online course *Interactive 3D Graphics* in 2013 with Udacity. He authored a chapter in the book *An Introduction to Ray Tracing* by Andrew Glassner (ed), 1989. He has published a number of articles in computer graphics, some of which are included in the *Graphics Gems* series. He also maintains the Graphics Gems code repository.

Haines was on the editorial board of the *Journal of Graphics Tools* until 2012, at which time he helped found the *Journal of Computer Graphics Techniques*. He was the editor of the online forum of experts in ray tracing, *Ray Tracing News* (1988-2010)[4]

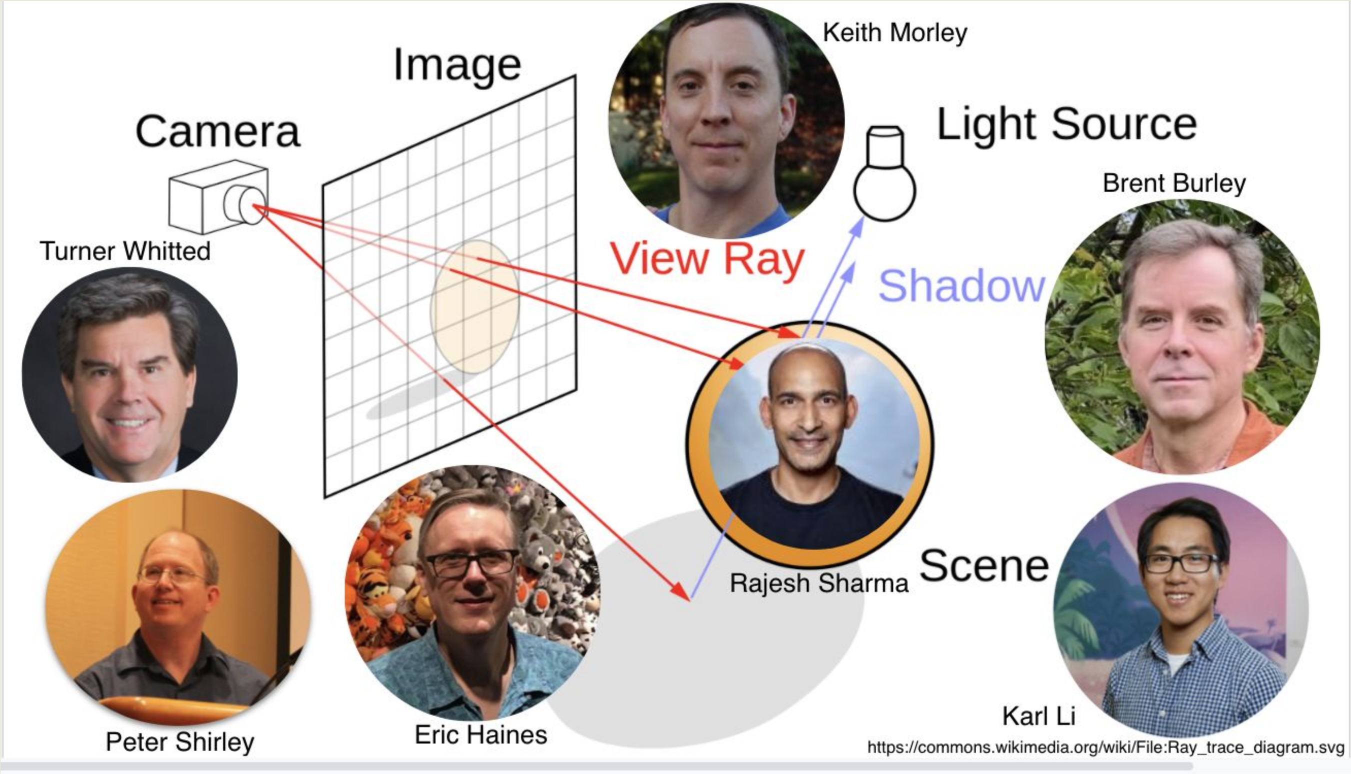
Today

- Guest: Eric Haines
- Recap
- Soft Shadows (Area Lights)
- BRDF Sampling
- Wrap up
- Further Learning

Housekeeping

- Link to today's slides and shaderToys:
  - Log in to your google drive
  - Google drive folder: https://bit.ly/3viTHez
  - Code: https://www.shadertoy.com/user/xarmalarma
- Use the chat to ask questions, help others
- After the lecture: @xarmalarma, #siggraph2021

Thanks to the Guests!



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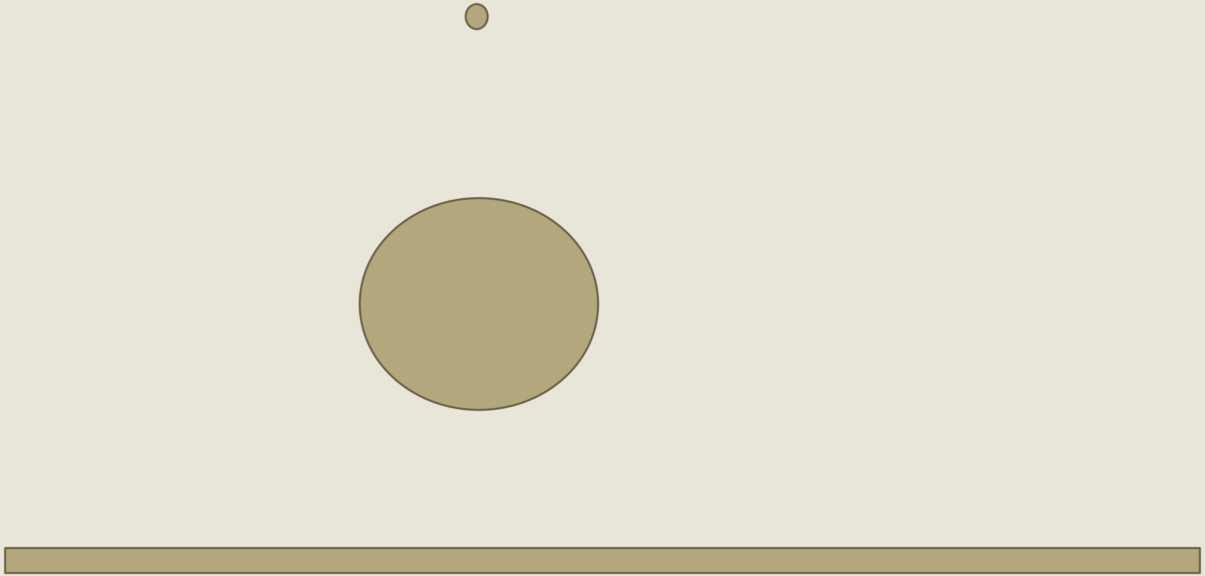
SIGGRAPH 2021

Shadows

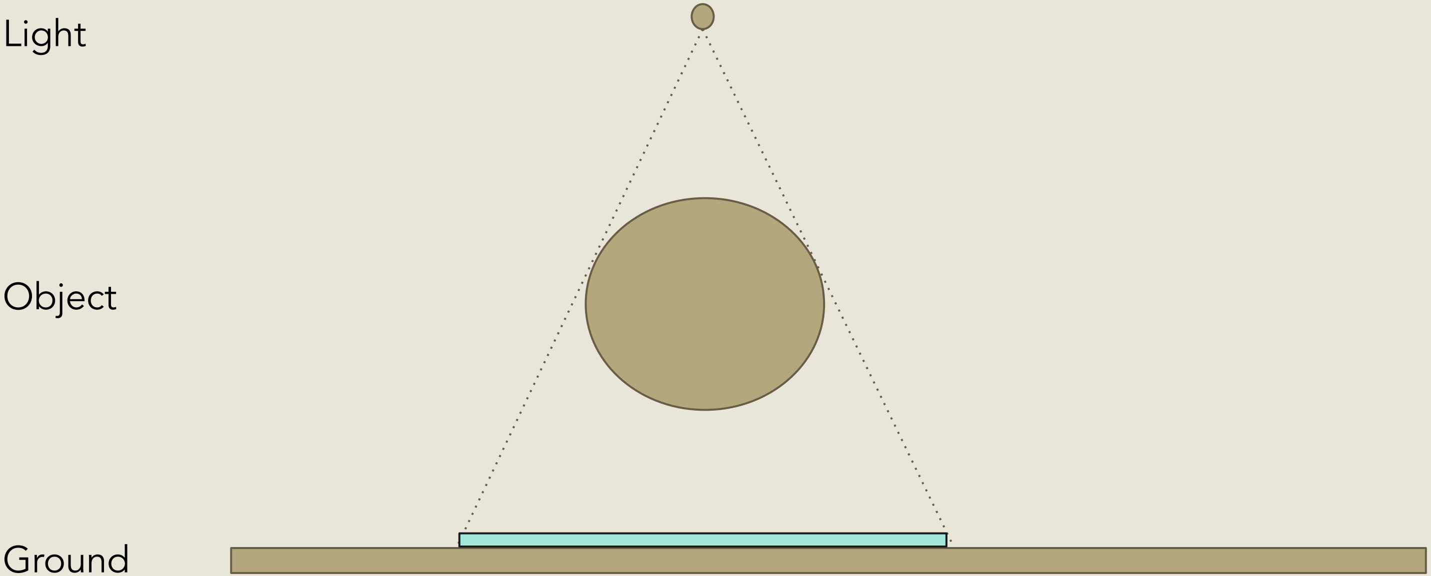
Light

Object

Ground



Shadows



Shadows

Light

Object

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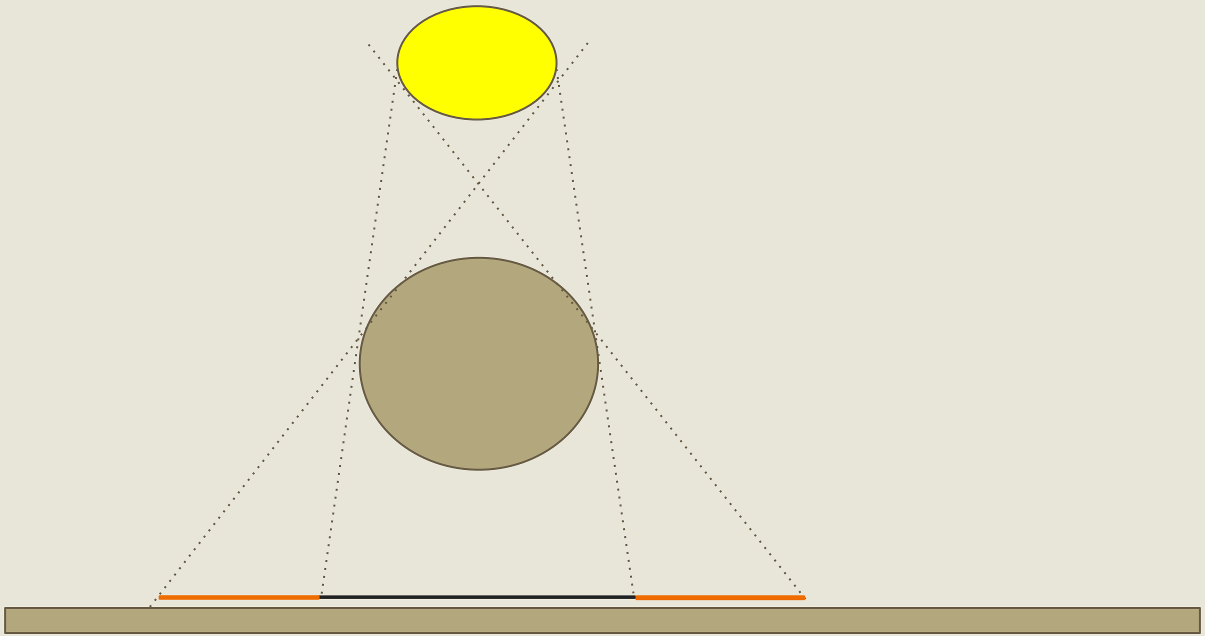
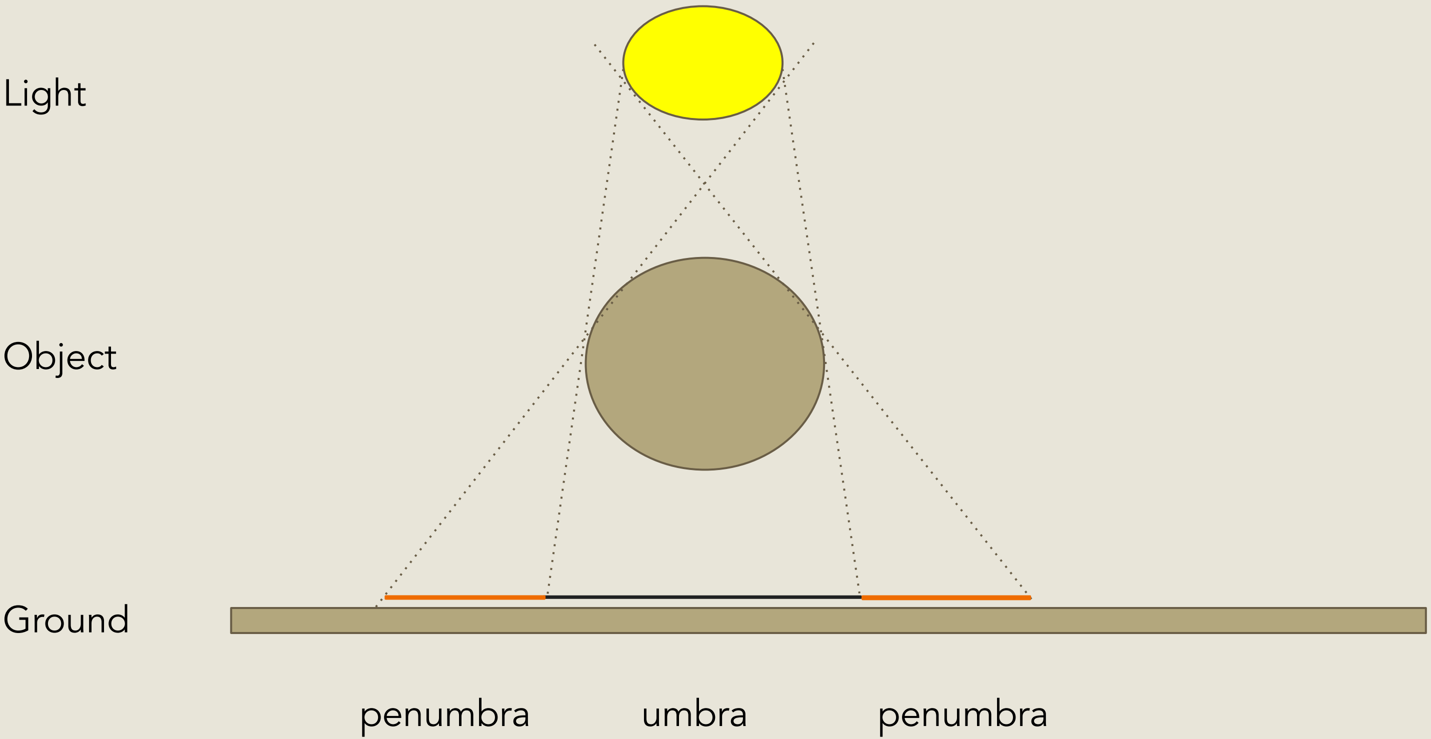


Shadows

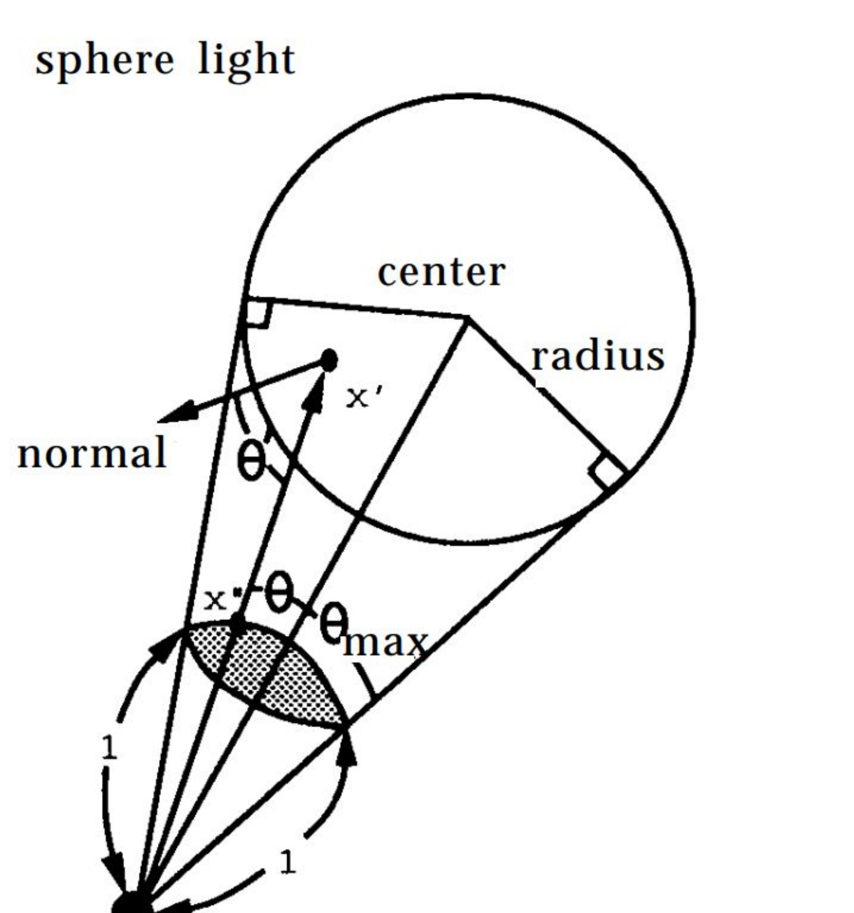


Sampling the Spherical Light

Light contribution is proportional to the visible area

```
vec3 SampleCone(vec2 u, float cosThetaMax) {
    cosTheta = (1-u[0]) + u[0] * cosThetaMax;
    sinTheta = sqrt(1 - cosTheta * cosTheta);
    phi = u[1] * 2 * Pi;
    return vec3(cos(phi) * sinTheta,
                sin(phi) * sinTheta,
                cosTheta);
}
```

From the PBRT book



Shirley & Wang -- 1993

General Sampling Strategy

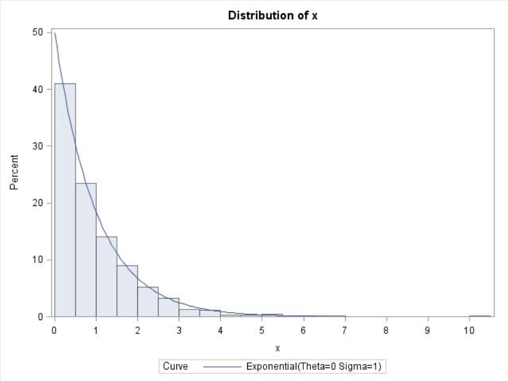
If you know the cumulative distribution function (CDF) of a probability distribution, then you can *always* generate a random sample from that distribution.

The *inverse CDF* technique for generating a random sample uses the fact that a continuous CDF, F, is a one-to-one mapping of the domain of the CDF into the interval (0,1). Therefore, if U is a uniform random variable on (0,1), then $X = F^{-1}(U)$ has the distribution F.

Example:

The exponential distribution has probability density (PDF): $f(x) = e^{-x}, x \geq 0$,
CDF (cumulative distribution) is the integral of the density: $F(x) = 1 - e^{-x}$.

This function can be inverted by solving for x in the equation $F(x) = u$.
The inverse CDF is: $x = -\log(1-u)$.



Summary

Light coming in * Light Going to Viewer * angle to the normal

Over multiple samples/bounces

If objects were emitting light, we would add that too

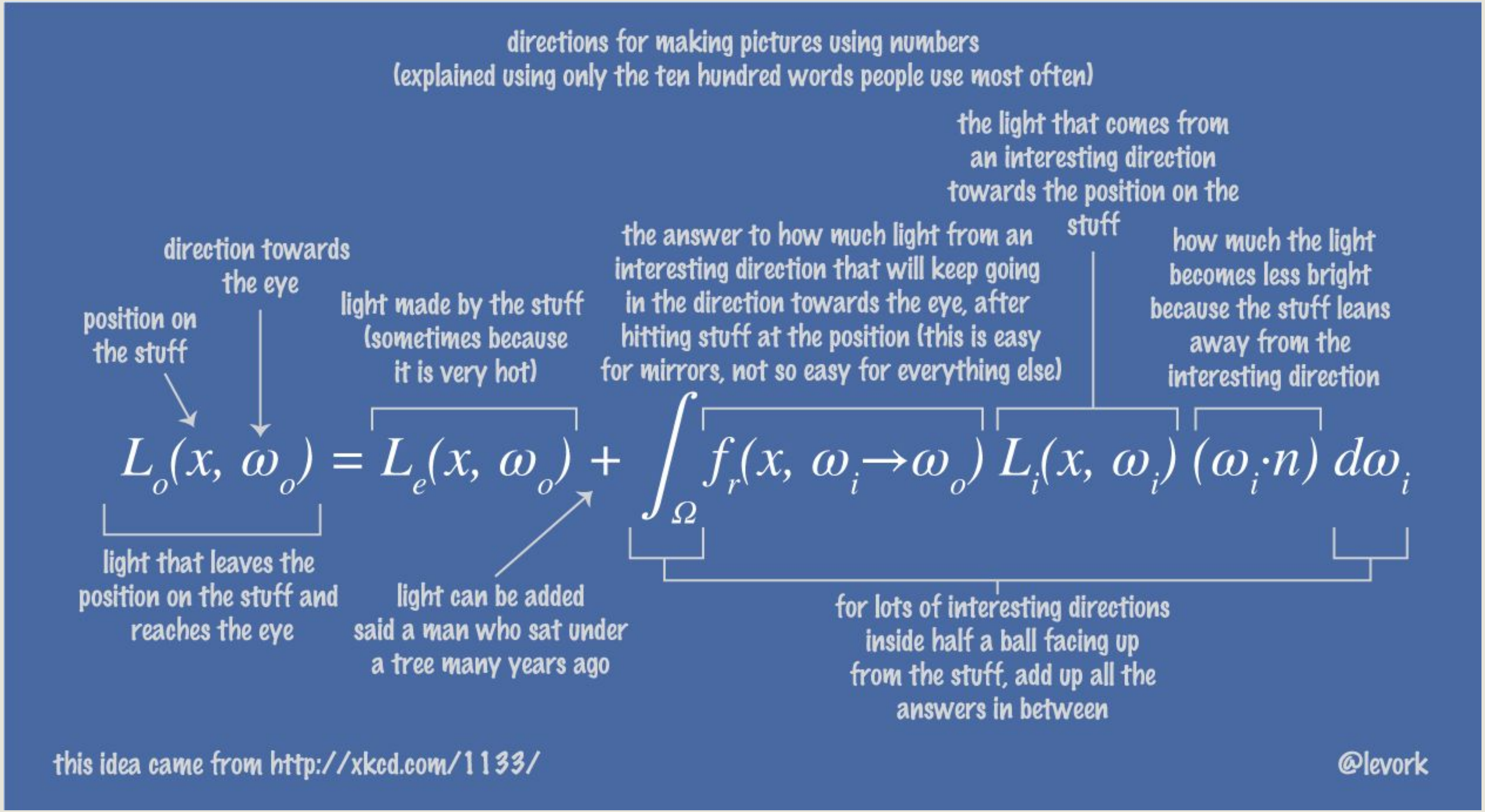
Emitted Light + MultipleSamples [Light coming in * Light Going to Viewer * angle to the normal]

Summary

Emitted Light + MultipleSamples [Light coming in * Light Going to Viewer * angle to the normal]

$$L_r(x, \omega_r) = L_e(x, \omega_r) + \int_\Omega L_r(x', -\omega_i)\, f(x, \omega_i, \omega_r) \cos\theta_i \, d\omega_i$$

Rendering Equation Explained (Thanks to Julian Fong @ Pixar)



Learning More

- Peter Shirley's Ray Tracing Series
- PBRT Book
- Embree, OptiX, Vulkan, DirectX
- Papers, Conferences (SIGGRAPH)

QUESTIONS?

- Chat
- #xarmalarma