Subsurface Scattering

Last Time?

Retro-Reflectance Intuition

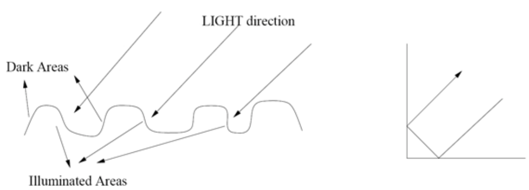
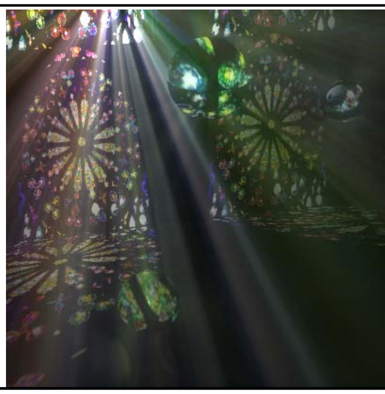


Figure 5: Showing retroreflection from a very rough surface (left). Only areas with normals close to the light direction are well lit, so there is a strong retroreflective peak. On the right, we see a corner reflector (the inside corner of 3 planes is the 3D analog) which produces the same effect.

Dusty Surfaces

- Viewed perpendicular to the surface, there is little scattering off the dust.
- At grazing angles, there is increased scattering with the dust making the surface appear brighter.
- Similarly, the earth viewed from space appears brighter near the edges, because of increased scattering of the atmosphere.

Light Rays in a Dusty Room



Annie Ding, MIT
6.837 Final Project
December, 2004

Participating Media

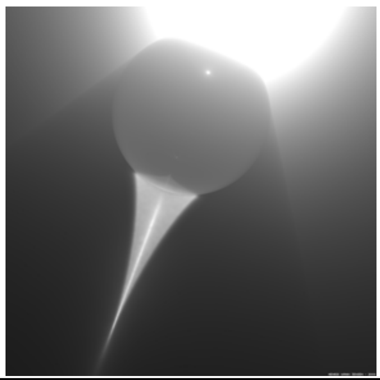
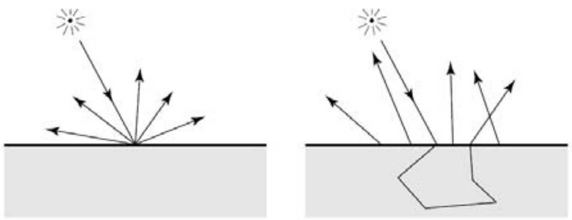


Image by Henrik Wann Jensen

BRDF vs BSSRDF



Images from "A Practical Model for Subsurface Light Transport"
Jensen, Marschner, Levoy, & Hanrahan SIGGRAPH 2001

Subsurface Scattering Variables

Name	Symbol	Units	Description
Scattering Coeff.	σ_s	$(\text{length})^{-1}$	Probability of scattering per unit length
Absorption Coeff.	σ_a	$(\text{length})^{-1}$	Probability of absorbtion per unit length
Phase Function	$p(x, \vec{\omega}', \vec{\omega})$		Angular distribution of scattering
Extinction Coeff.	σ_t	$(\text{length})^{-1}$	$\sigma_a + \sigma_s$
(Scattering) Albedo	A		σ_s / σ_t
Optical Depth	$\tau(0, d)$		$\int_0^d \sigma_t dx$
Transmittance	$t(0, d)$		$e^{-\tau(0,d)}$

Albedo, A

- When A = 1, no absorption occurs and light is only transmitted or scattered. This is an ok approximation for snow or clouds.

Sampling a BSSRDF

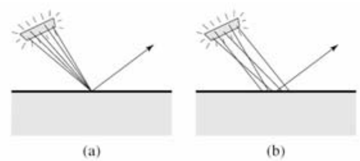


Figure 7: (a) Sampling a BRDF (traditional sampling), (b) sampling a BSSRDF (the sample points are distributed both over the surface as well as the light).

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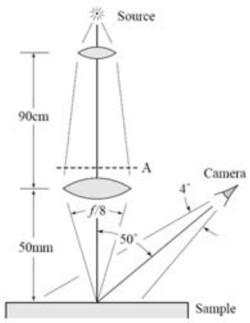
Jensen, Marschner, Levoy, & Hanrahan SIGGRAPH 2001

BSSRDF Measurement



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SIGGRAPH 2001

Single Scattering

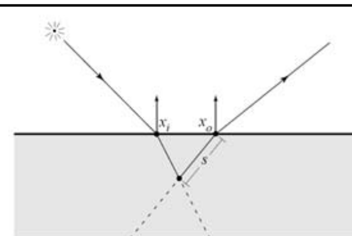

Figure 4: Single scattering occurs only when the refracted incoming and outgoing rays intersect, and is computed as an integral over path length s along the refracted outgoing ray.

Images from "A Practical Model for Subsurface Light Transport"
Jensen, Marschner, Levoy, & Hanrahan SIGGRAPH 2001

Dipole Approx. for Diffuse Scattering

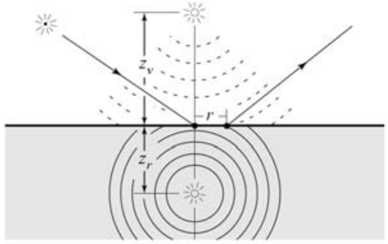

Figure 3: An incoming ray is transformed into a dipole source for the diffusion approximation.

Images from "A Practical Model for Subsurface Light Transport"
Jensen, Marschner, Levoy, & Hanrahan SIGGRAPH 2001

Results

SIGGRAPH2005

Real vs. CG

slide from presentation by
J.P. Lewis and George Borshukov