Subsurface Scattering

Retro-Reflectance Intuition

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

Participating Media

Annie Ding, MIT
6.837 Final Project
December, 2004

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scattering Coeff.</td>
<td>( \sigma_s )</td>
<td>(length)(^{-2})</td>
<td>Probability of scattering per unit length</td>
</tr>
<tr>
<td>Absorption Coeff.</td>
<td>( \sigma_a )</td>
<td>(length)(^{-1})</td>
<td>Probability of absorption per unit length</td>
</tr>
<tr>
<td>Phase Function</td>
<td>( p(\xi, 2\xi, \theta) )</td>
<td></td>
<td>Angular distribution of scattering</td>
</tr>
<tr>
<td>Extinction Coeff.</td>
<td>( \sigma_e )</td>
<td>(length)(^{-1})</td>
<td>( \sigma_a + \sigma_s )</td>
</tr>
<tr>
<td>Albedo</td>
<td>( \alpha )</td>
<td></td>
<td>( \int \frac{\gamma}{\gamma + \rho_{\alpha}} )</td>
</tr>
<tr>
<td>Optical Depth</td>
<td>( \tau(\xi, \theta) )</td>
<td></td>
<td>( e^{-\tau(\xi, \theta)} )</td>
</tr>
<tr>
<td>Transmittance</td>
<td>( \tau(0, \theta) )</td>
<td></td>
<td>( e^{-\tau(0, \theta)} )</td>
</tr>
</tbody>
</table>

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

Albedo, A

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

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

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).

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

BSSRDF Measurement

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

Real vs. CG slide from presentation by J.P. Lewis and George Borshukov