Fast Subsurface Scattering

(even real time)

J.P. Lewis and George Borshukov

Subsurface Scattering

- Prehistory:
  - Hanrahan and Krueger, Siggraph 1993
  - Pharr and Hanrahan, Siggraph 2000
- Jensen, Marshner, Levoy, and Hanrahan, A Practical Model for Subsurface Light Transport, Siggraph 2001
- Jensen and Buhler, A Rapid Hierarchical Rendering Technique for Translucent Materials, Siggraph 2002

Jensen 2001

- Diffuse reflectance:

$$\frac{\alpha'}{4\pi}\left[(\sigma_{tr}d_r+1)\frac{e^{-\sigma_{tr}d_r}}{\sigma'_t d_r^3}+z_v\,(\sigma_{tr}d_v+1)\frac{e^{-\sigma_{tr}d_v}}{\sigma'_t d_v^3}\right]$$

Fast Subsurface Scattering

- In essence:

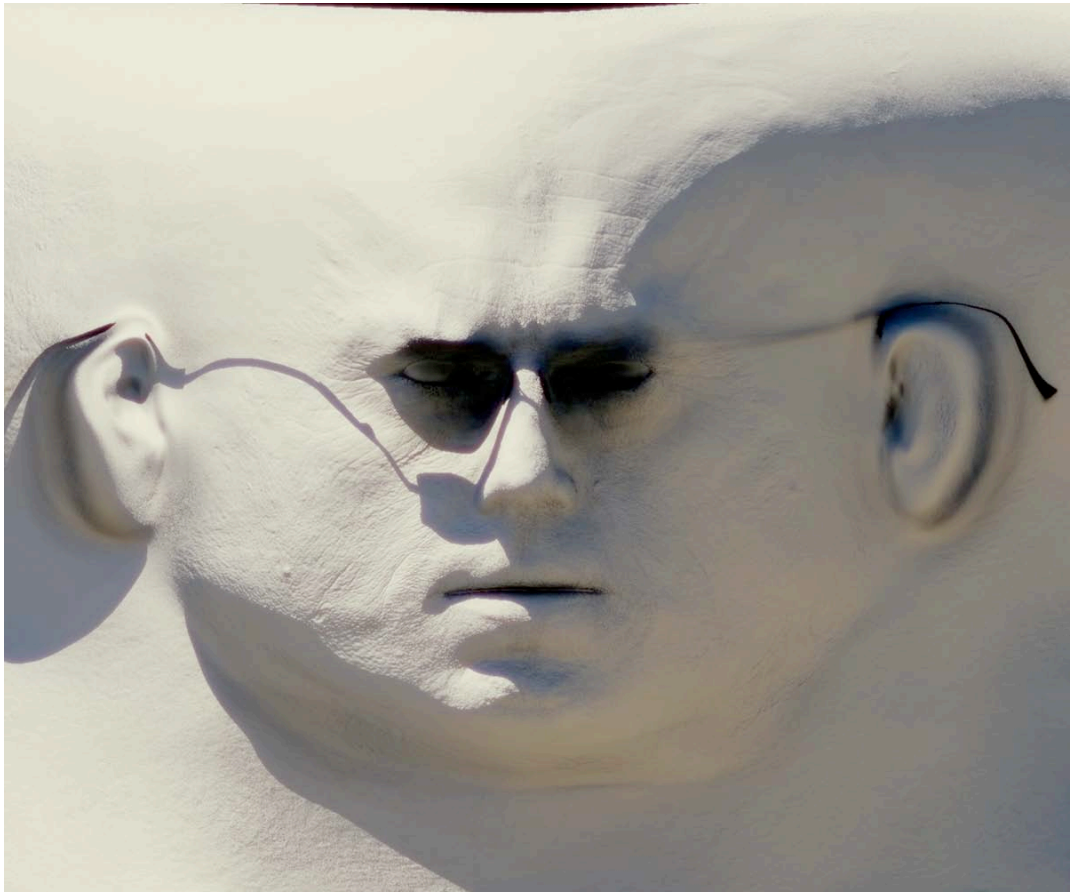
  *convolve the illumination with a profile that simulates diffusion/scattering (**rapid_falloff**)*

  Borshukov and Lewis, “Realistic Human Face Rendering for *The Matrix Reloaded*”, Siggraph 2003 sketch

Fast Subsurface Scattering

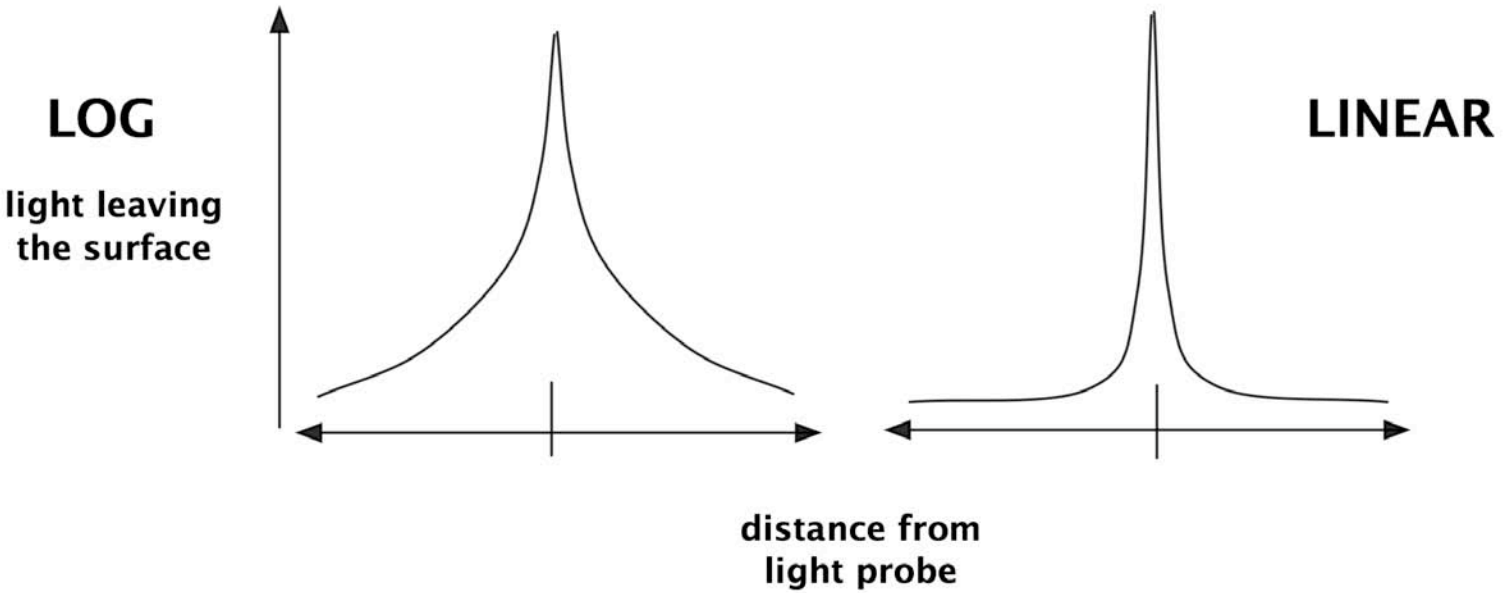
- Process:
  - Render
  - Save illuminated surface to texture (diffuse only!)
  - Filter the illuminated texture with rapid_falloff
  - Cheap re-render

Fast Subsurface Scattering



Light map

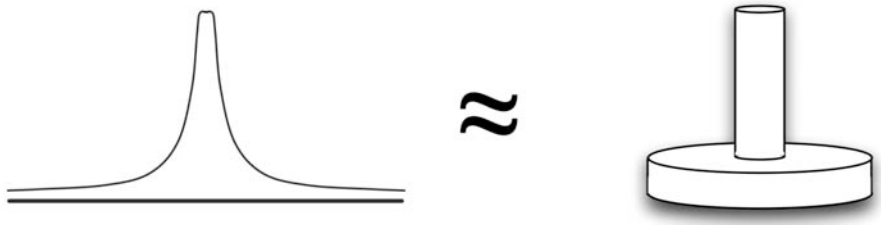
What is rapid_falloff() ?



Intuitive explanation

SIGGRAPH2005

- Rapid_falloff ~ spike + broad area
  - Spike keeps the result from looking blurred
  - Broad area does the scattering



- (Or, physics analogy: Green's function: a kernel that is convolved with the given data (r.h.s.) to produce the solution. Green's function for diffusion…)

What is rapid_falloff() ?

- Various approximations:
  - is the skin like a sheet, a slab, or more like an volume? We simulate the result of 3D process in 2D
  - BRDF may/may not include homogeneous subsurface scattering (e.g. Hanrahan and Krueger)
  - make up for finite kernel size
- Our choice: $1/(c+radius)^{power}$
  - c: avoid division by zero
  - adjust power for desired appearance. Start with ~2

Making it look good

- Use for diffuse only
- Use a spike+base / rapid falloff kernel, not a regular blur (some people haven't)
- Falloff slower in the red channel
- Make sure there is pore-like detail in the texture / normals

Results

SIGGRAPH2005

Real vs. CG

Results

Look for color bleeding into the shadows (macro, micro)

Results

Results

- (See Borshukov presentation this afternoon for movies and additional images, details)

GPU Implementation

- Sander, Gosselin, Mitchell, “Real-Time Skin Rendering on Graphics Hardware”, Siggraph 2004 Sketch
- Real-Time Skin Rendering, ATI presentation at Game Developer Conference 2004 (also demo at ATI booth)

Real time on the PS3

- See George Borshukov's presentation at 3PM
- (The images are amazing…)

Fast Subsurface Scattering

- Advantages:
  - Fast (real-time demonstrated)
  - Looks great
- Disadvantages:
  - Not as accurate, no physically-interpretable parameters
  - Cannot do thick translucent skin region (ears)