BRDF Rendering

CS 563 Advanced Topics in Computer Grahpics

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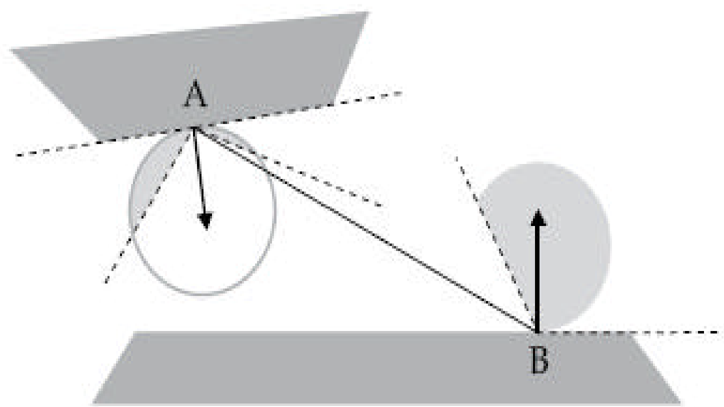
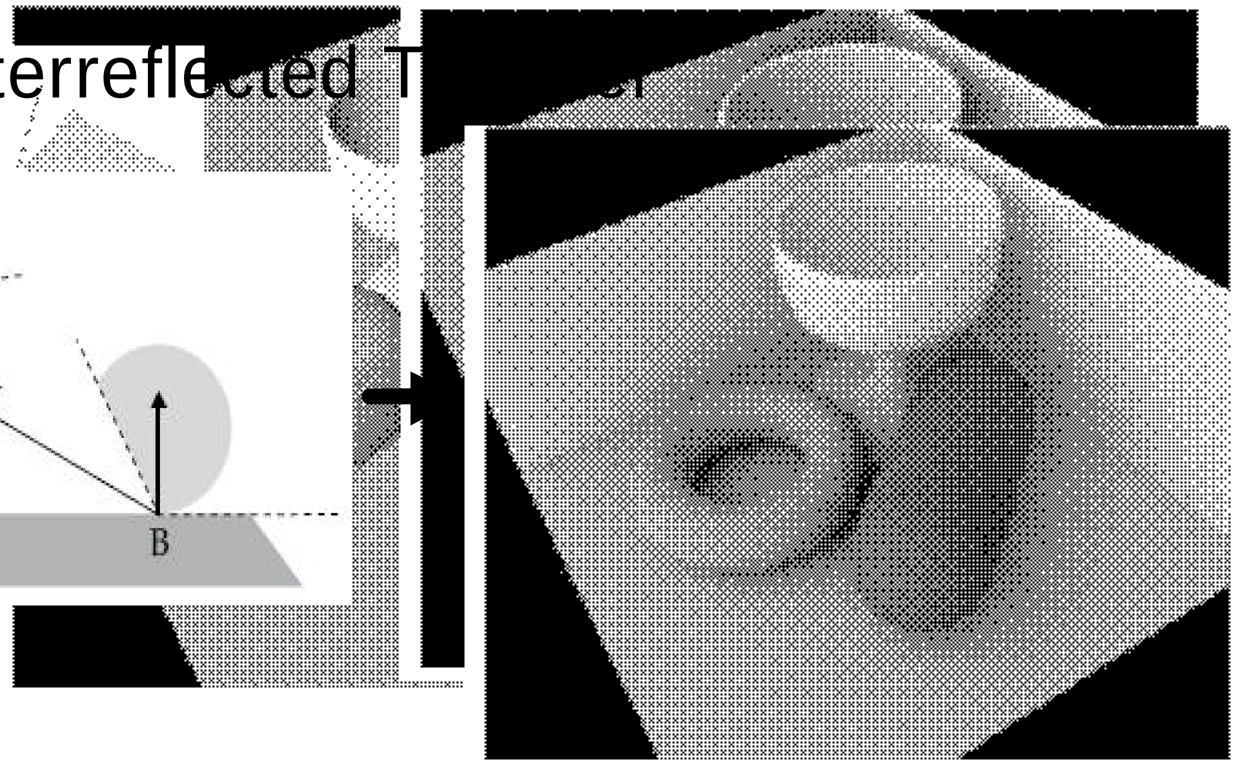
Feb, 11, 2005

Lighting Diffuse Surface

- Diffuse Unshadowed Transfer
- Shadowed Diffuse Transfer
- Diffuse Interreflected Transfer

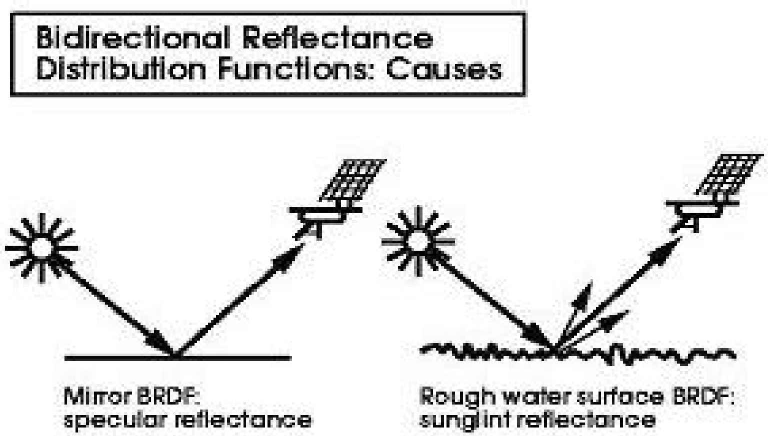




Phong Model

- Phong model
  - $L_{tot} = L_{amb} + L_{diff} + L_{spec}$
    $= f\,(?\ ,\ ?\ ,\ ?\ ,\ V_x,\ V_y,\ V_z,\ time)$
  - No way to describe different materials.

- Why the surface of different materials are different?



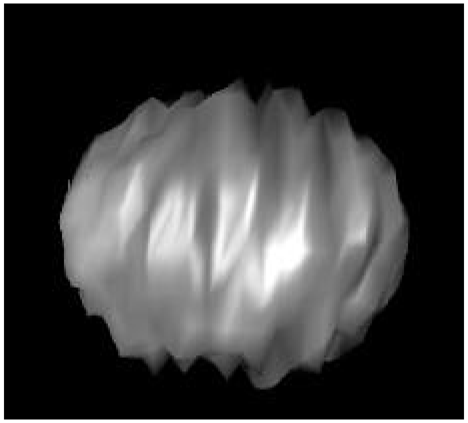
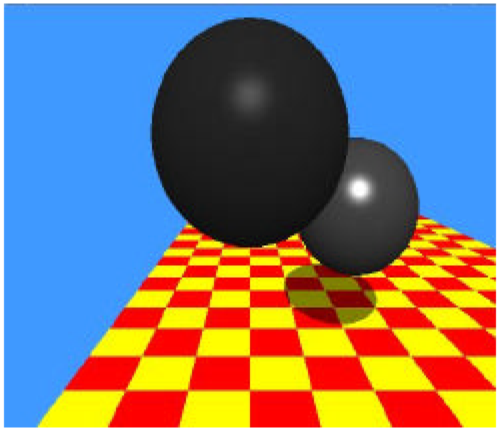
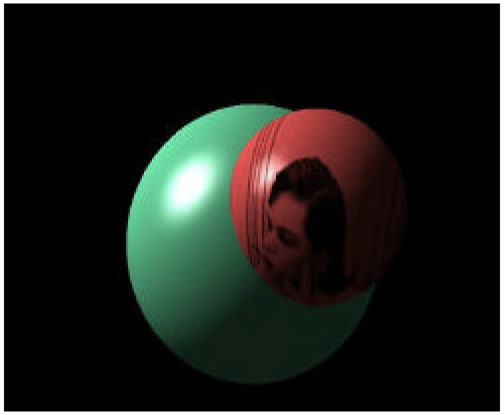
Discussion Topics

- Why we use BRDF?
  - Phong model is powerless for the material presentation
  - No previous lighting model can deal with the anisotropic surfaces
- What is BRDF?
  - Bidirectional Reflectance Distribution Function

    --- M. Shibayama, CL Wiegand, 1985, “Remote Sensing Environment”
- How to render a surface with BRDF?
  - Data Sampling
  - Monte Carlo Integration
  - Data compression

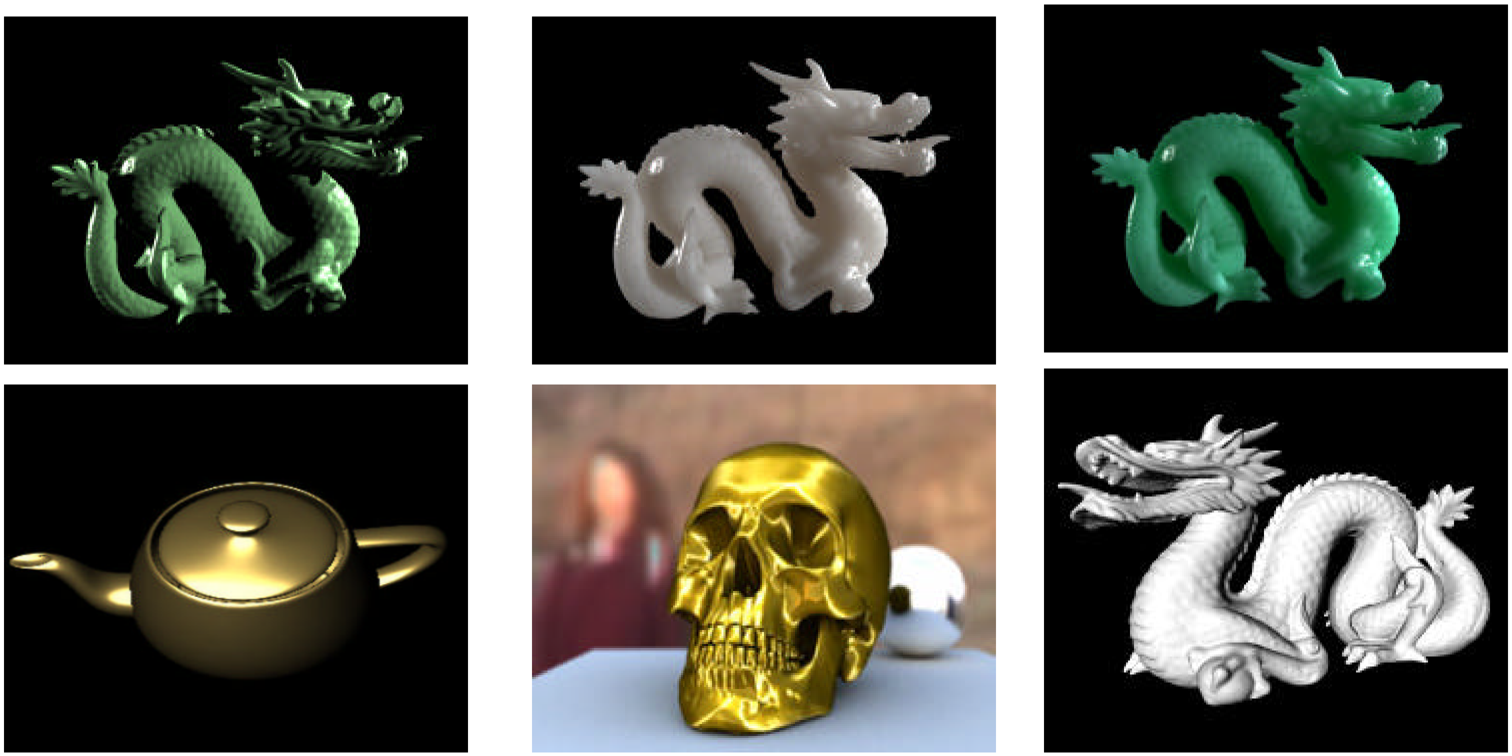
Why we use BRDF?

- Phong model for diffusion surface

Result of the BRDF

- BRDF (BSSRDF) model for the same object



- We have known the reason we prefer to BRDF.

What is BRDF?

- BRDF is a lighting model

$$L_o = \sum_{j=1}^{n} BRDF \quad (q_i^{\,j}, f_i^{\,j}, q_r, f_r) L_i^j \cos \; q_i^{\,j}$$

- The relationship between BRDF and Phong
  - Phong lighting model can be looked at as a special case of general BRDF based lighting.

$$I_{out} = I_{in}\left(k_d(\mathbf{L} \bullet \mathbf{N}) + k_s(\mathbf{R} \bullet \mathbf{V})^n\right)$$

- --- Phong

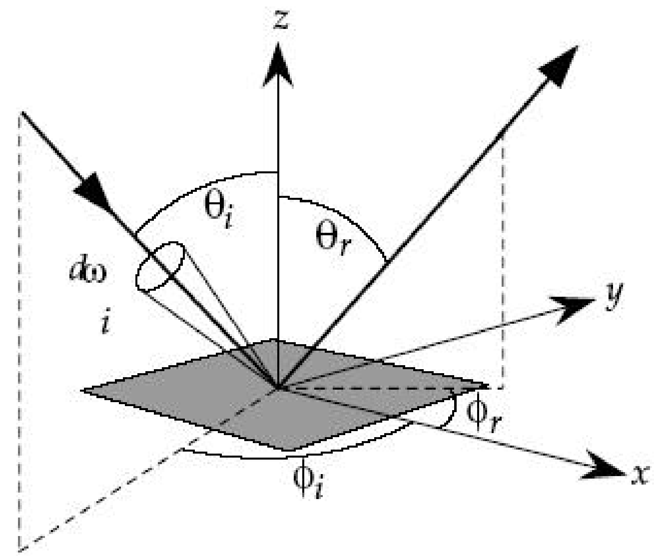
$$L_o = L_i Refl(\mathbf{L}, \mathbf{V})$$

- --- BRDF

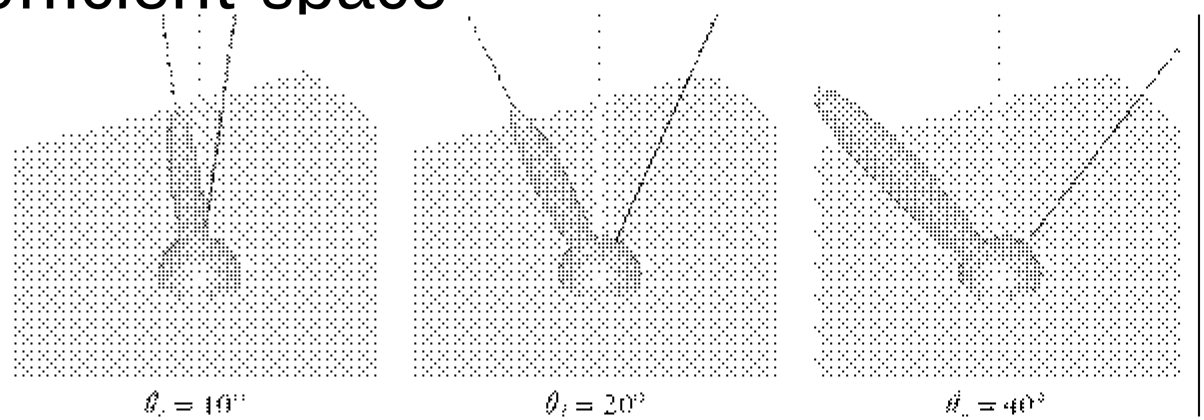
Render With BRDF

- Physical lighting model

$$L_o = BRDF(\theta_i, \phi_i, \theta_r, \phi_r) L_i \cos\theta_i$$



- Coefficient space



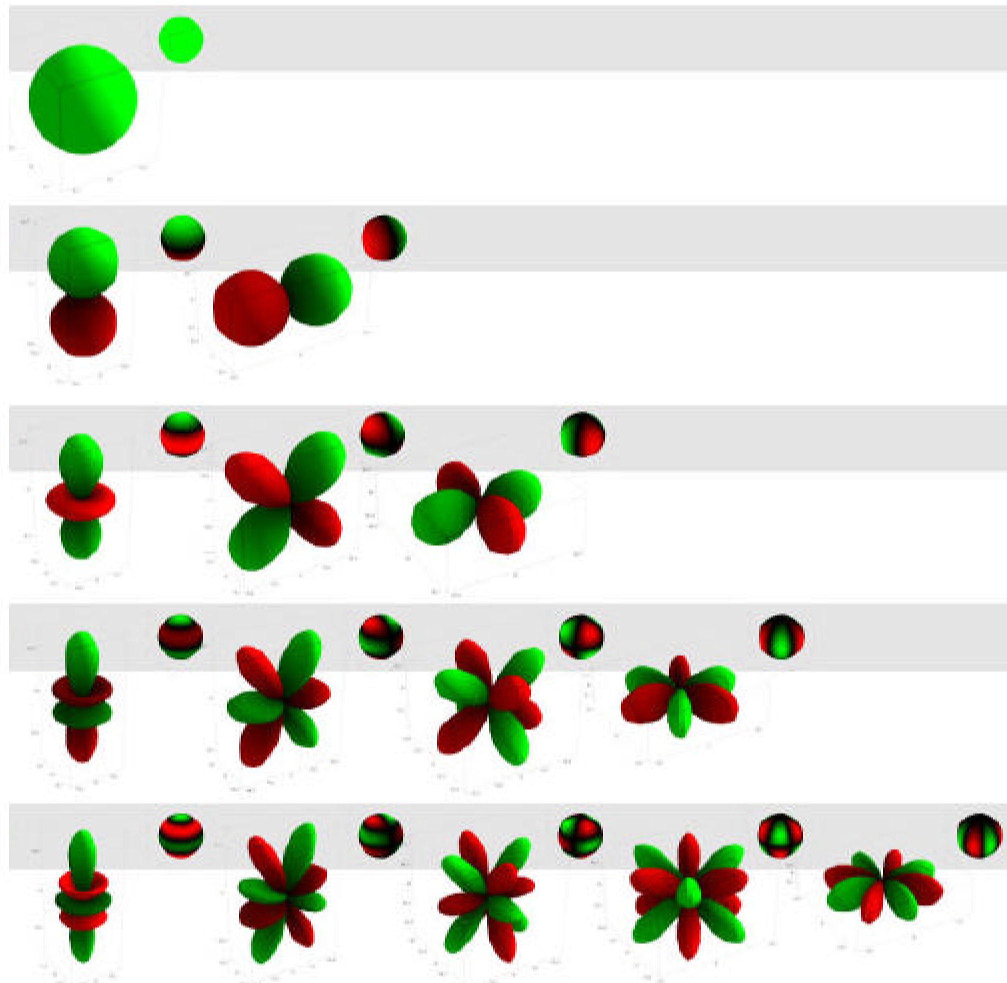
$\theta_i = 10^\circ$ $\theta_i = 20^\circ$ $\theta_i = 40^\circ$

Lighting models

- Different Lighting models

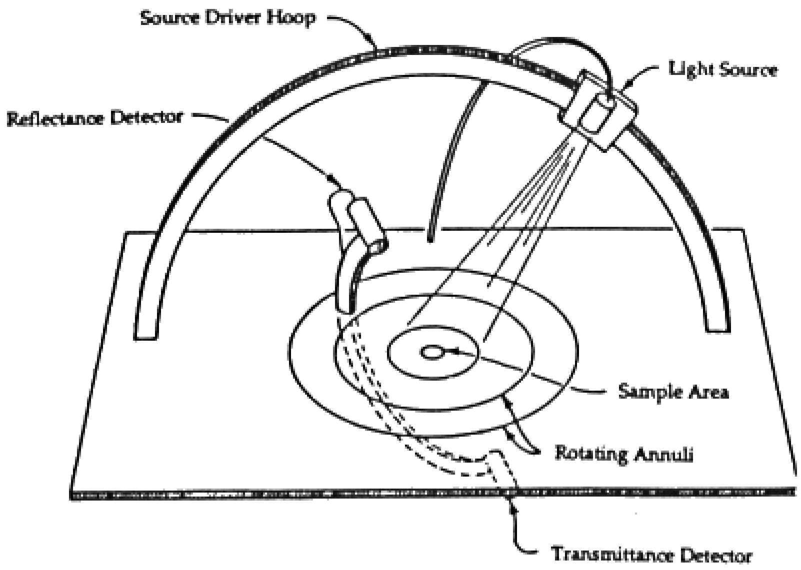
$$y_l^m(\theta,\varphi) = \begin{cases} \sqrt{2}K_l^m \cos \\ \sqrt{2}K_l^m \sin \\ K_l^0 P_l^0(\cos \end{cases}$$

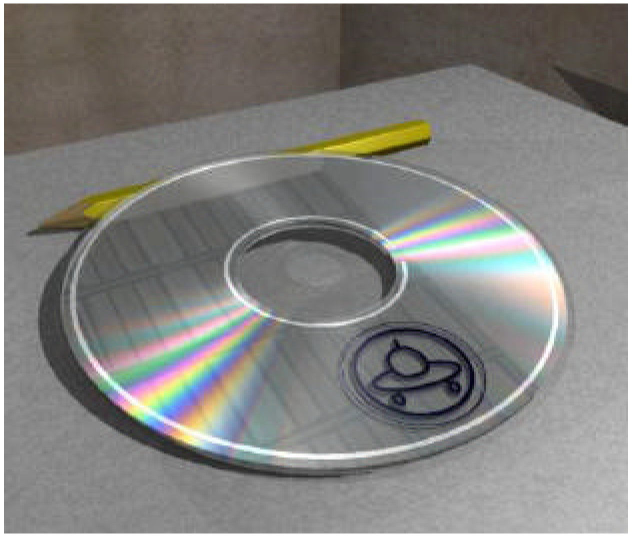
$$K_l^m = \sqrt{\frac{(2l+1)}{4\pi}\frac{(l}{(l}}$$



Coefficient Acquisition

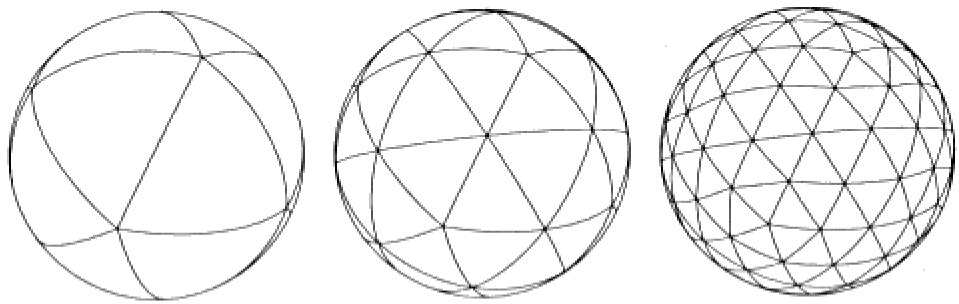
- Monte Carlo Integration
  - Lighting models
- Real data sampling





Data Sampling

- 3-D BRDF data sampling



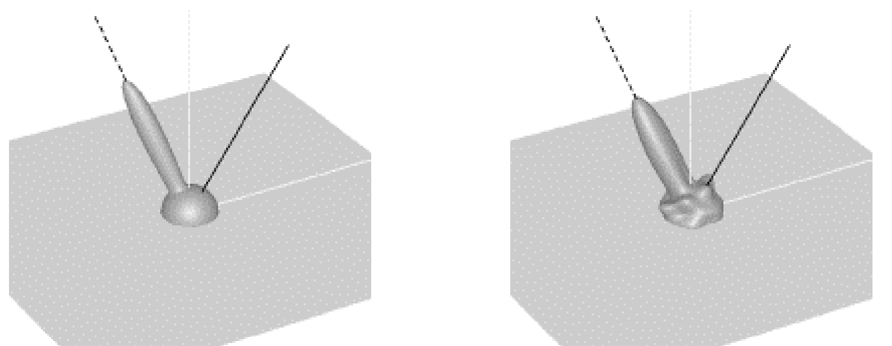
- Coefficient Matrix for BRDF

$$L_o = \sum_{j=1}^{n} BRDF\,(q_i^{\,j}, f_i^{\,j}, q_o, f_o) L_i^j \cos q_i^{\,j}$$

- Interpolation

Coefficient compression

- Sysmatric Simplification
  - $L_o = BRDF(q_i, 0, q_r, f_r - f_i) L_i \cos q_i$
- DCT transformation



Full BRDF High-frequency components removed

- Wavelet transformation

Map 4-D to 2-D

- Graphics Hardware only provide support for 2D textures

$$\mathrm{BRDF}(\theta_i, \phi_i, \theta_r, \phi_r) = G(\theta_i, \phi_i) \cdot H(\theta_r, \phi_r)$$

$$L_o = G(\theta_i, \phi_i) \cdot H(\theta_r, \phi_r) L_i \cos\theta_i$$

- Normalized-Decomposition approach

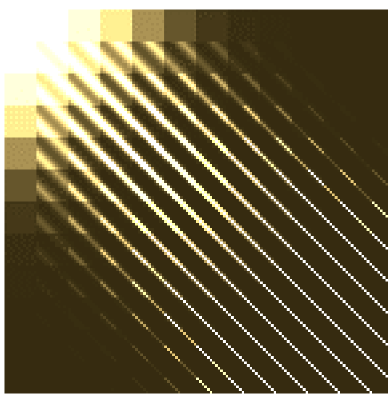
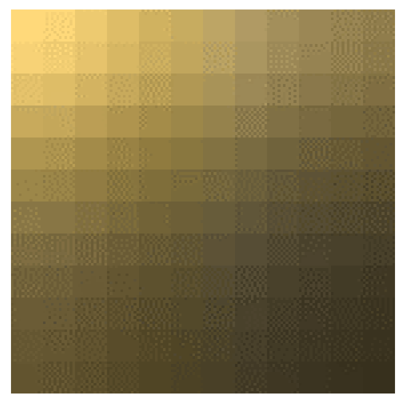


Image of the sampled “true” BRDF matrix.

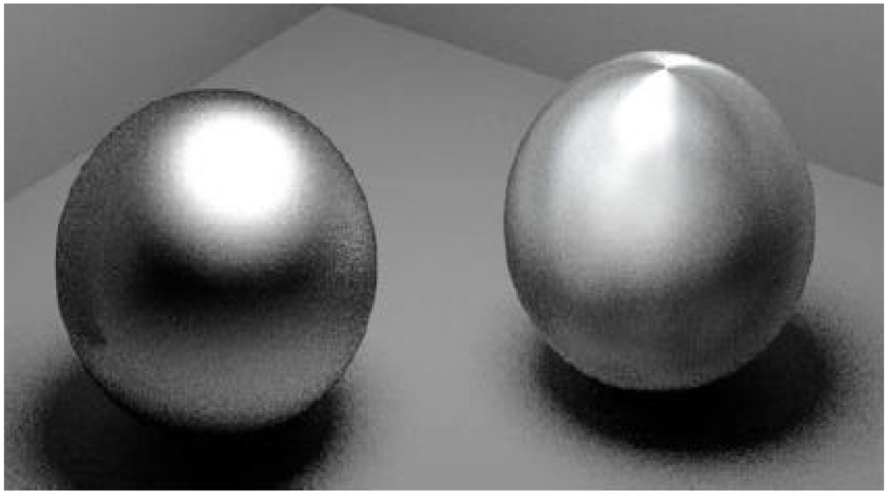


The “approximate” BRDF matrix reconstructed using G * H.

Anisotropic BRDF

- Anisotropic Shading
  - No Sysmatric Simplification

- Anisotropic Reflecting



Specular

- Integrating Over Milligeometry
- Approximate by Phong Specular term

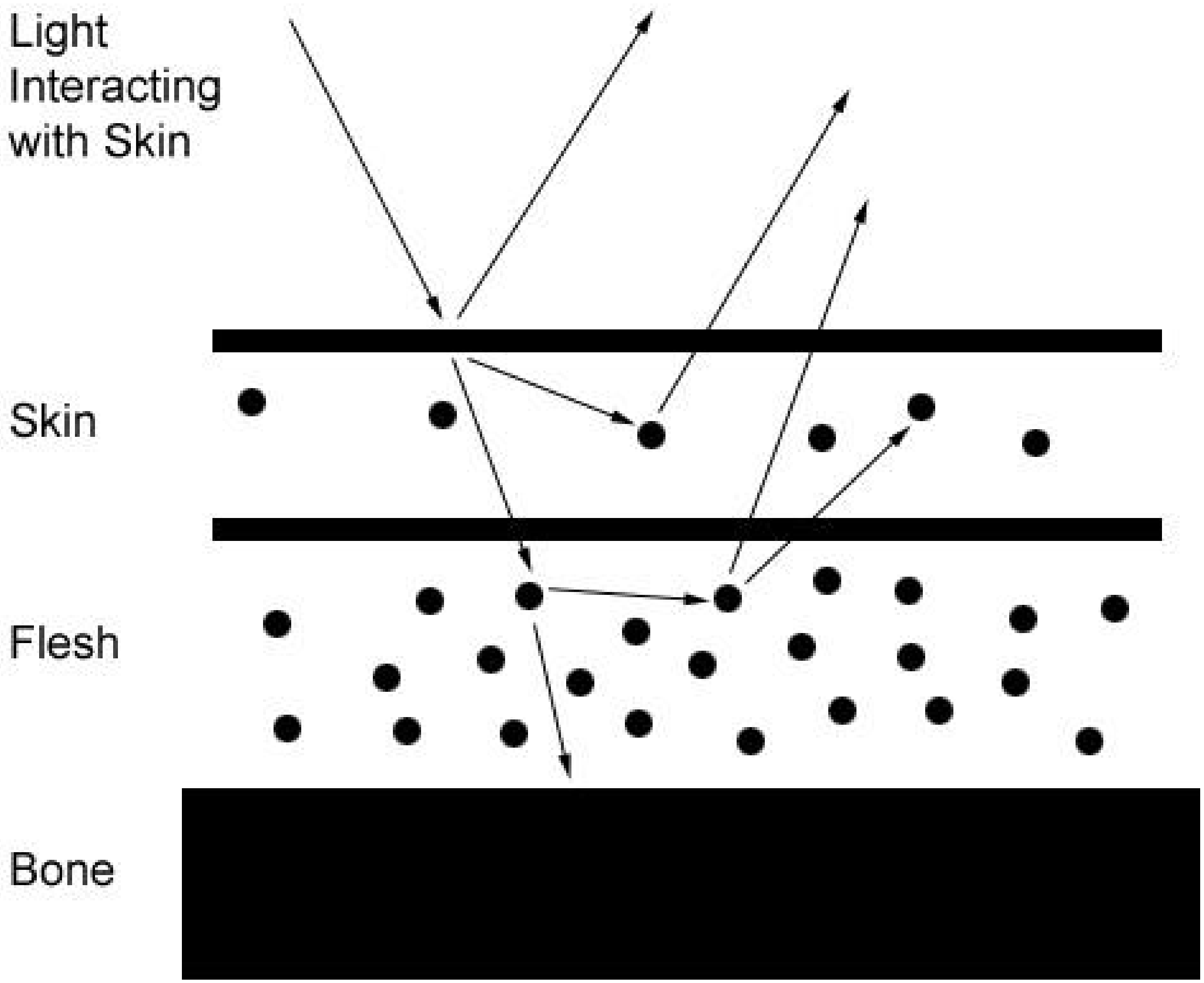
BSSRDF

- The bidirectional surface scattering distribution function

BRDF

BSSRDF

BSSRDF



BSS.....ssss....RDF

- What is the next step?

The End

Thank you

Reference

- [1] Robin Green, “Spherical Harmonic Lighting: The Gritty Details”
- [2] Stephen H. Westin, James R. Arvo, Kenneth E. Torrance, “Predicting Reflectance Functions from Complex Surfaces”
- [3] www.nvidia.com
- [4] Szymon Rusinkiewicz, “A Survey of BRDF Representation for Computer Graphics”
- [5] NVIDIA Corporation, Chris Wynn, “An Introduction to BRDF-Based Lighting”
- [6] NVIDIA Corporation, Chris Real-Time BRDF-based Lighting using Cube-Maps Wynn, “”