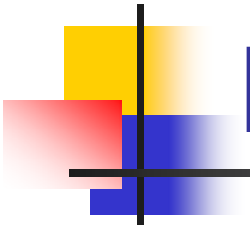
CS598 Spring 2005 Advanced Graphics Rendering and Animation

1/21/2005



Radiance & Irradiance

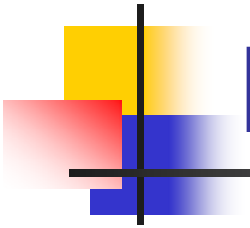
- Radiance [W/m^2 sr]
  - Amount of energy per unit time per unit (foreshortened) area per unit steradian
- Irradiance [W/m^2]
  - Amount of energy per unit time per area

BRDF(Bidirectional Reflectance Distribution Function)

- 4-dimensional distribution
  - 2 angles for incident direction
  - 2 angles for outgoing direction
- In isotropic surface, 3 dimensional distribution

$$\frac{dL(\theta_r \varphi_r)}{dE(\theta_i \varphi_i)}$$

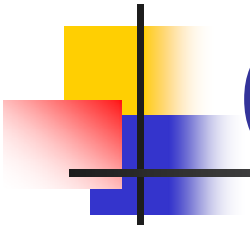
$$\int_{\Omega} \frac{dL \cos\theta_r}{dE} dw_r \leq 1$$



How to represent BRDF

- Physical based model
- Empirical model
- Data-driven model

Physical based model (Cook-Torrance model)



- Assumptions
  - Surface is covered with symmetric V-grooves
  - Each microfacet is a perfect mirror
  - No interreflections inside V-groove
- Factors
  - D: surface orientation distribution
  - G: modeling occlusion and shadowing
  - F: Fresnel term (should depend on wave length)

Cook-Torrance model 2

$$D = \frac{1}{4m^2 \cos^4 \beta} e^{-\{(\tan \beta)/m\}^2}$$

$$G = \min\{1, \frac{2(N \bullet H)(N \cdot V)}{V \cdot H}, \frac{2(N \bullet H)(N \cdot L)}{V \cdot H}\}$$

$$F_\lambda = \frac{1}{2}\{\frac{\tan^2(\theta_i - \theta_t)}{\tan^2(\theta_i + \theta_t)} + \frac{\sin^2(\theta_i - \theta_t)}{\sin^2(\theta_i + \theta_t)}\}$$

$$f_{CT} = \frac{F_\lambda}{\pi} \frac{DG}{(N \cdot V)(N \cdot L)}$$

N : *surface normal*

V : *viewing direction*

L : *incident direction*

H : *halfway vector*

m : *roughness*

β : *angle between N and H*

θ_i : incoming direction

θ_r : *refraction* direction

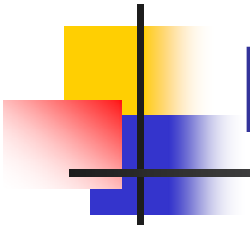
Empirical model

- Physical model is complicated
- Make up a simple model
- Estimate its parameters by minimizing difference between the model and the observation
- Ward's model

$$\frac{1}{\sqrt{\cos\theta_i \cos\theta_r}} \frac{\exp[-(\tan^2\delta)/\alpha^2]}{4\pi\alpha^2}$$

δ : same as β

α : parameter



Data-driven model

- Model may not fit weird materials well
- Take a lot of data with various lighting and camera directions (Gonioreflectometer)
- Huge amount of data - 4D distribution
- Apply PCA (principal component analysis) to reduce its amount