CG Programming II (VGP 352)

Agenda:

- Discuss last week's assignment.
- BRDFs
  - What are they?
  - How is it used?

BRDF

- Bidirectional reflectance distribution function
  - Notation is $f(\omega_o, \omega_i)$.

    "...describes the ratio of reflected radiance exiting from a surface in a particular direction (defined by the vector ω_o) to the irradiance incident on the surface from direction ω_i over a particular waveband."
  - Our previous lighting models (i.e., Phong and Blinn) are *subsets* of a BRDF.

BRDFs in Lighting

- The lighting reflected out at a particular angle is:

$$L(\omega_o) = f(\omega_o, \omega_i) L(\omega_i)(n \cdot \omega_i)$$

  - $L(\omega_o)$ is the outgoing light intensity.
  - $L(\omega_i)$ is the incoming light intensity.
    - Factors in the intensity of the light, falloff from directional light, etc.

Where do we get *f*?

- Numerous sources.
  - Complex camera & light setups can be used to sample a BRDF.
  - Analytic methods can be used to derive a BRDF.
    - Once such method is Fresnel reflectance.

Fresnel Reflectance

- Dielectric materials (e.g., glass, plastic, *not* metal) exhibit a strong Fresnel factor.
- When the material is viewed from a shallow angle, it is more reflective.
  - This means that at shallow angles (i.e., N•V close to 1.0) the surface is more specular.
  - At step angles (i.e., N•V close to 0.0) the surface is more diffuse.

Fresnel Reflectance (cont.)

- The book and Nvidia paper contain full derivation, but we'll use:

$$F = 1/2 \frac{(g-c)^2}{(g+c)^2}\left(1+\frac{\left[c(g+c)-1\right]^2}{\left[c(g-c)+1\right]^2}\right)$$

Where $c = v \cdot h$ and $g = \sqrt{n^2 + c^2 - 1}$. *n* is the index of refraction of the material.

Fresnel Reflectance (cont.)

- How is F used?
  - It can be used as a weight of the specular factor vs. the diffuse factor.
  - Calculate the final color as:

$$K = F \times S + (1 - F) \times D$$

How does this relate to BRDFs?

- The Fresnel term is an important factor in some common analytic BRDFs.
  - Cook-Torrance is the one that we will use.

Cook-Torrance

- Based on “microfacets”.
  - Think of a surface as being made up of many, many *tiny* sub-surfaces that face in semi-random directions.
  - The distribution of normal directions of these surfaces affect how specular or diffuse a surface a appears.
  - These microfacets can also obscure each other → self shadowing.

Cook-Torrance (cont.)

- Cook-Torrance BRDF:

$$f(\omega_o, \omega_i) = K_d f_d + K_s f_s(\omega_o, \omega_i)$$

$$f_d = 1/\pi$$

$$f_s = 1/\pi \frac{F \times D(n \cdot h) \times G(n \cdot \omega_i, n \cdot h, n \cdot \omega_o)}{(n \cdot \omega_i)(n \cdot \omega_o)}$$

  - F is the Fresnel term, D is the distribution of microfacet directions, and G is self-shadowing (geometry) factor.

D

- Several models for D exist.
- We'll use the Beckmann Distribution:

$$D(n \cdot h) = \frac{1}{m^2 (n \cdot h)^4} \exp\left(\frac{-1 - (n \cdot h)^2}{(n \cdot h)^2 m^2} \right)$$

m is a constant on [0, 1] that controlls the smoothness of the surface.

G

- The model for G used by Cook & Torrance is:

$$G(n\cdot\omega_i, n\cdot h, n\cdot\omega_o) = min\left(1, \frac{2(n\cdot h)(n\cdot\omega_o)}{\omega\cdot h}, \frac{2(n\cdot h)(n\cdot\omega_i)}{\omega\cdot h}\right)$$

  - In the denominators, either ω_i or ω_o can be used.

For next time...

- Cook-Torrance doesn't work very well for metals, so we'll look at some other BRDFs that do.
- Cook-Torrance also ignores surface anisotropy, so we'll look at some other BRDFs that take this into consideration.

Questions?

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