CS461: Lighting

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part II

Luxo Jr., Pixar Films
Lighting types

Ambient

Spot

Point

Directional
Material types

- Diffuse (matte)
- Specular (shiny)
- Translucent
Phong lighting model

Luminance

\[ I = \begin{pmatrix} I_r \\ I_g \\ I_b \end{pmatrix} \]

\[ I = I_a + I_d + I_s \]
Phong lighting model

Luminance

\[ I = \begin{pmatrix} I_r \\ I_g \\ I_b \end{pmatrix} \]

\[ L_i = \begin{bmatrix} L_{ira} & L_{iga} & L_{iba} \\ L_{ird} & L_{igd} & L_{ibd} \\ L_{irs} & L_{igs} & L_{ibs} \end{bmatrix} \]

each light is broken into ambient, diffuse and specular components, with each of those broken into the three channels

material = \[
\begin{bmatrix}
    k_{ra} & k_{ga} & k_{ba} \\
    k_{rd} & k_{gd} & k_{bd} \\
    k_{rs} & k_{gs} & k_{bs}
\end{bmatrix}
\]

each surface has material properties or **reflection coefficients** (0 <= k <= 1), which tells us how much of the light reflects off of the surface
Principle vectors of the Phong illumination model

all vectors should be normalized
Ambient lighting

Use the material ambient reflection coefficient to determine the luminance of the light bouncing off of the surface.

\[ I_a = k_a L_a \]

\( L_a \) could be the contribution of a particular light, or a global value.
Diffuse lighting

**Lambert’s Law**
the amount of reflected light is proportional to the \( \cos(\theta) \)

\[
I_d = k_d (\hat{l} \cdot \hat{n}) L_d
\]

- \( L_d \) — diffuse component of the light
- \( k_d \) — diffuse reflection coefficient

\[
I_d = k_d \max(0, (\hat{l} \cdot \hat{n}) L_d)
\]

\[
I_d = \frac{k_d}{a + bd + cd^2} \max(0, (\hat{l} \cdot \hat{n}) L_d)
\]
Specular lighting

As the angle between \( \mathbf{v} \) and \( \mathbf{r} \) grows, the amount of specular highlight falls off rapidly.
Specular lighting

Phong’s model

the amount of reflected light is proportional to \( \cos^\alpha(\phi) \)

\( \alpha \) — the shininess coefficient

\[
I_s = k_s \ \max(0, (\hat{r} \cdot \hat{v})^\alpha L_s)
\]
Calculating $r$

\[ r \approx \hat{l} + 2(\hat{l} \cdot \hat{n})\hat{n} \]

\[ \cos(\theta) = \hat{l} \cdot \hat{n} \]
Specular lighting

Blinn-Phong’s model

the amount of reflected light is proportional to $\cos^\alpha(\psi)$

$h$ — the halfway vector, halfway between $l$ and $v$

$$\hat{h} = \frac{\hat{l} + \hat{v}}{|\hat{l} + \hat{v}|}$$

$I_s = k_s \max(0, (\hat{n} \cdot \hat{h})^\alpha L_s)$
The Phong lighting model is given by the equation:

\[ I = I_a + I_d + I_s \]

where:

- \( I_a \) is the ambient component
- \( I_d \) is the diffuse component
- \( I_s \) is the specular component

The components are calculated as follows:

\[ I = k_a L_a + k_d \max(0, \hat{l} \cdot \hat{n}) L_d + k_s \max(0, \hat{n} \cdot \hat{h})^\alpha L_s \]

where:

- \( k_a \) and \( k_d \) are the ambient and diffuse coefficients, respectively.
- \( k_s \) is the specular coefficient.
- \( L_a \), \( L_d \), and \( L_s \) are the ambient, diffuse, and specular lighting components.
- \( \hat{l} \), \( \hat{n} \), and \( \hat{h} \) are the unit vectors for light, surface normal, and view direction, respectively.
- \( \alpha \) is an exponent for the specular component.
Implementing shading