CS461: Lighting

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Local vs global illumination

Local illumination
surfaces are lit only from the light rays coming
directly from the source in the ceiling
[note that this example does include shadows]

Global illumination
light bounces around the room adding
indirect lighting

Global illumination

shadows

bounce light

color change

reflections
Point light source lighting

Our idealized light is a point source radiating in all directions.
Light bulbs have area

point source

That surface makes for softer light

this is the point of shades on lamps
Shadows from lights with area

More area == softer shadows

fig 6.8, Interactive Computer Graphics, 7e, Angel and Shreiner
Directional lighting

Distant light sources can be modeled as having parallel rays.
Spot lights

Point light sources with angular restriction

*typically, spots are modeled has having* **falloff** *towards the edges*
Ambient light

Light evenly coming from all directions

*Hack that models a well designed room full of light*
Lighting types

- Ambient
- Spot
- Point
- Directional
Material types

Diffuse (matte)

Specular (shiny)

Translucent
**Phong lighting model**

\[
I = I_a + I_d + I_s
\]

Luminance

\[
I = \begin{pmatrix}
I_r \\
I_g \\
I_b
\end{pmatrix}
\]
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
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
Principle vectors of the Phong illumination model

All vectors should be normalized.
Diffuse lighting

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

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

\( L_d \) — 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

$$I_S = k_s \max(0, (\hat{r} \cdot \hat{v})^\alpha L_s)$$
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 can be expressed as:

\[ I = I_a + I_d + I_s \]

And more specifically:

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