1 Administrivia

Announcements

Assignment

Read Chapter 6.

From Last Time

RoomView lab.

Outline

1. Real world lighting.

2. A lighting model.

3. Types of shading.

4. The Phong reflection model.
2 Lighting in the Real World

1. Viewer, lights, objects.

2. Light properties?


4. How do lights and materials interact?

5. The rendering equation. Calculation for each point in a scene.

6. Need a balance between accuracy and efficiency.

7. Local vs. global lighting. The graphics pipeline.

3 A Lighting Model

1. General illumination function for a light source: $I(x, y, z, \theta, \phi, \lambda)$.

2. Types of modeled light sources:
   
   (a) Ambient light

   (b) Point sources

   (c) Spotlights

   (d) Distant light sources
3.1 Color Sources

1. Illumination function is a continuous function of wavelength.

2. Complex computation, vision model.

3. Luminance function:

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

3.2 Ambient Light

1. Uniform light — “background” light.

2. Model:

\[
\mathbf{I}_a = \begin{bmatrix} I_{ar} \\ I_{ag} \\ I_{ab} \end{bmatrix}
\]

3.3 Point Sources

1. Emits light equally in all directions.

2. Assume point source at \( \mathbf{p}_0 \). Color vector:

\[
\mathbf{I} (\mathbf{p}_0) = \begin{bmatrix} I_r (\mathbf{p}_0) \\ I_g (\mathbf{p}_0) \\ I_b (\mathbf{p}_0) \end{bmatrix}
\]

3. Illumination at \( \mathbf{p} \) due to \( \mathbf{p}_0 \)? Depends upon square of distance:

\[
\mathbf{I} (\mathbf{p}, \mathbf{p}_0) = \frac{1}{\|\mathbf{p} - \mathbf{p}_0\|^2} \mathbf{I} (\mathbf{p}_0)
\]

4. High contrast harshness due to shadow effects: umbra, penumbra.

5. In practice, replace inverse square term with

\[
a + bd + cd^2
\]

where \( d \) is the distance and \( a, b, \) and \( c \) are constants chosen to soften.
3.4 Spotlights

1. Simple spotlight: point source with light emitted only through narrow range of angles.

2. Consider the source at \( p_s \) to be restricted by the cone described by \( l_s \) and \( \theta \).

3. For accuracy, distribution within the cone is modeled by \( \cos^\epsilon \phi \).

3.5 Distant Light Sources

1. Re-calculting the \( p_0 - p \) vector.

2. If the distance is “large” how much does the vector change?

3. Replace source location with source direction:

(a) Near source: \( p_0 = \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \) (a point)

(b) Far source: \( p_0 = \begin{bmatrix} x \\ y \\ z \\ 0 \end{bmatrix} \) (a vector)

4 Shading

1. Flat shading: each point on a polygon assigned same color.

2. Gouraud (smooth) shading: assign colors individually to vertices, interpolate.

5 The Phong Reflection Model

1. Consider an object point, \( p \) and a light source \( p_i \).
2. Important vectors:

(a) \( l \): vector to light source.

(b) \( n \): surface normal.

(c) \( v \): vector to COP.

(d) \( r \): reflection vector.

3. The light from source to object can be described by:

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

(therefore wrong but, in practice, right)

4. Using material properties, distance from viewer, orientation of surface and direction of source a reflection matrix can be constructed:

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

5. (Simplified) Illumination at \( p \):

\[
I = I_a + I_d + I_s = L_a R_a + L_d R_d + L_s R_s
\]

A global ambient term may be “thrown” in.