Light

Tom Kelliher, CS 320

Apr. 9, 2003

1 Administrivia

Announcements

Assignment

Read Chapter 6.

From Last Time

3-D maze project discussion.

Outline

1. Real world lighting.
2. A lighting model.
3. Types of shading.
4. The Phong reflection model.

Coming Up

More light on light.

2 Lighting in the Real World

1. Viewer, lights, objects.

2. Light properties?

3. Material properties: Translucence, reflectance (specularity), scattering (diffusion). Examples? Color of an object.

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 $\mathbf{p}_s$ to be restricted by the cone described by $\mathbf{l}_s$ and θ.
3. For accuracy, distribution within the cone is modeled by $cos^e\phi$.

3.5 Distant Light Sources

1. Re-calculating the $\mathbf{p}_0$–$\mathbf{p}$ vector.
2. If the distance is "large" how much does the vector change?
3. Replace source location with source direction:

   (a) Near source: $\mathbf{p}_0 = \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$ (a point)

   (b) Far source: $\mathbf{p}_0 = \begin{bmatrix} x \\ y \\ z \\ 0 \end{bmatrix}$ (a vector)

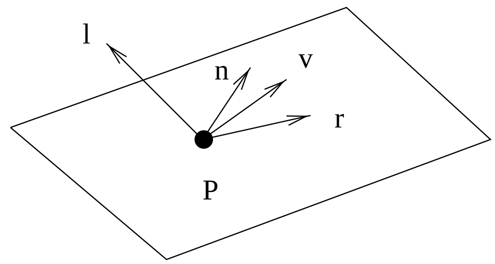
4 Shading

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, $\mathbf{p}$ and a light source $\mathbf{p}_i$.

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:

$$\mathbf{L}_i = \begin{bmatrix} L_{ira} & L_{iga} & L_{iba} \\ L_{ird} & L_{igd} & L_{ibd} \\ L_{irs} & L_{igs} & L_{ibs} \end{bmatrix}$$

   (theoretically 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:

$$\mathbf{R}_i = \begin{bmatrix} R_{ira} & R_{iga} & R_{iba} \\ R_{ird} & R_{igd} & R_{ibd} \\ R_{irs} & R_{igs} & R_{ibs} \end{bmatrix}$$

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.