More Light on Light

Tom Kelliher, CS 320

Apr. 11, 2003

1 Administrivia

Announcements

Projects due Wednesday.

Assignment

Read Chapter 6.

From Last Time

Introduction to light.

Outline

1. Derivation of Phong lighting model.

2. Computing normal vectors.

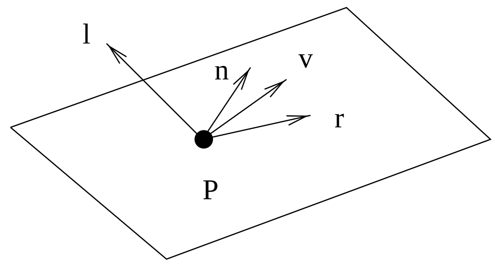
Coming Up

Project day.

2 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 source, 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 $\mathbf{p}$:

$$I = I_a + I_d + I_s = L_a R_a + L_d R_d + L_s R_s$$

   A global ambient term may be "thrown" in.

2.1 Ambient Reflection

Same at each point on a surface:

$$I_a = R_a L_a$$

Repeat for each color.

2.2 Diffuse Reflection

1. Diffuse surface brightest at noon, dimmest at dawn, dusk.
2. Lambert's law: we see only the vertical component of light:

$$R_d \propto \cos\theta$$

3. If $\mathbf{l}$ and $\mathbf{n}$ are normalized:

$$\cos\theta = \mathbf{l} \cdot \mathbf{n}$$

So:

$$I_d = \frac{R_d}{a + bd + cd^2}(\mathbf{l} \cdot \mathbf{n}) L_d.$$

2.3 Specular Reflection

1. Specular reflection produces highlights.
2. The smoother the surface (higher shininess) the narrower the range of reflection angles.
3. Reflectivity proportional to angle between viewer ($\mathbf{v}$) and perfect reflection ($\mathbf{r}$):

$$R_d \propto \cos^\alpha \phi,$$

   where α is the shininess term:

   (a) < 100 for objects with broad highlights.

   (b) 100 to 500 for most metallic objects.

4. Assuming normalized vectors:

$$I_s = \frac{R_s}{a + bd + cd^2}(\mathbf{r} \cdot \mathbf{v})^\alpha L_s$$

2.4 The Phong Model

Computed for each light source and each color:

$$I = \frac{1}{a + bd + cd^2}(R_d L_d(\mathbf{l} \cdot \mathbf{n}) + R_s L_s(\mathbf{r} \cdot \mathbf{v})^\alpha) + R_a L_a.$$

3 Introduction to Computation of Normals

1. Outward facing normal must be specified for each vertex.
2. Analytic surfaces: cross product of partial differentials
3. Polygonal surfaces:
   (a) Points of continuity.

   (b) Points of discontinuity.