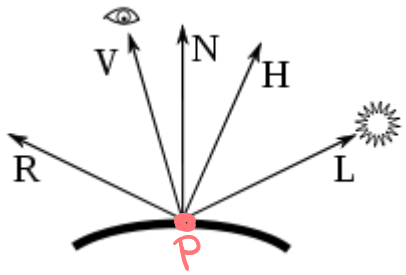
Shading and the Phong Reflection Model



$$I_{\mathrm{p}} = k_{\mathrm{a}} i_{\mathrm{a}} + \sum_{m \in \text{ lights}} \left(k_{\mathrm{d}} (\hat{L}_m \cdot \hat{N}) i_{m,\mathrm{d}} + k_{\mathrm{s}} (\hat{R}_m \cdot \hat{V})^{\alpha} i_{m,\mathrm{s}} \right)$$

This equation models the reflection of light from a specific point on a surface. All of the vectors used in the model are unit length vectors pointing outward from the point.

What does the N vector tell you? normal vector
What does the L vector tell you? vector to light
What does the V vector tell you? vector to eye (viewer)
What does the R vector tell you? reflection vector

All are unit length and point away from vertex P

The H vector is the *halfway vector* between L and V. It is used in the Blinn-Phong reflection model…but not the Phong reflection model.

I_p is the total illumination in three different wavelengths Red, Green, and Blue. The illumination in each wavelength, or channel, is described by a number in the range [0,1]. It is composed of a sum of three terms:

The Ambient Term

The ambient term is a component-wise product of two RGB values $k_a i_a$ The value i_a is the incoming light to the surface and $k_a$describes how much light reflected.

What is the source of the light in this term? indirect, scattered light

What would we see if the incoming light was blue and the surface green?

$i_a = (0,0,1)$ and $k_a = (0,1,0)$ component-wise
reflected $= (0,0,1) \cdot (0,1,0) = (0,0,0)$

$L \cdot N = \frac{\cos\theta}{\|L\| \|N\|} = \frac{\cos\theta}{1}$ unit length

The Diffuse Term

The diffuse term is $k_d(\hat{L}_m \cdot \hat{N})i_{m,d}$

What does the term $\hat{L}_m \cdot \hat{N}$ measure? How aligned L's N are

Under what conditions is diffuse reflection strongest? when $\theta = 0$, $L = N$

What kind of material does this term model? Non-shiny (matte) paper ... cloth

The Specular Term

The specular term is $k_s(\hat{R}_m \cdot \hat{V})^{\alpha} i_{m,s}$

What does the term $\hat{R}_m \cdot \hat{V}$ measure? If the view is aligned w/ reflect direction

Under what conditions is specular reflection strongest? $R = V$

What happens to specular highlights when the shininess exponent α increases? Get smaller (theoretically brighter)

If you wanted a surface to look rougher, how would you change the values of the parameters in the specular term? Lower α

What kind of material does the specular term model? shiny

Open Questions

How could you change the equation so that the model includes attenuation (the reduction in illumination as the distance to the light increases)? Use $1/(a d_i^2 + b d_i + c)$ factor for diffuse & specular for each light i

d_i = distance to light i

Suppose you had a scene with no specular surfaces…and no moving lights. How could you use pre-processing to achieve a higher frame-rate?

Can precompute shading (ambient + diffuse)

Doesn't depend on view.

Why is modeling 3 wavelengths sufficient to produce realistic images?

We'll find out when we discuss color