

Illumination and Shading

Illumination

- Illumination models
 - Light and surfaces
 - Local illumination versus Global illumination
 - Phong reflection model
 - Ambient reflection
 - Diffuse reflection
 - Specular reflection
 - Light attenuation
- Polygonal shading
 - Flat Shading
 - Gourand Shading
 - Phone Shading

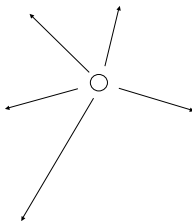
Illumination Model

- Also called reflection model or lighting model.
- Describe the interaction between the light sources and the surfaces.
- local illumination models versus global illumination models.
- Local models are ad-hoc, but is fast and easy.
- Global models are more accurate, but much more expensive.

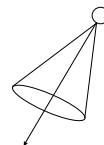
Light Sources

- Point sources
- Spotlights
- Distant light

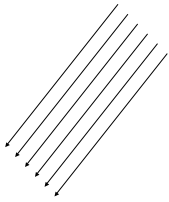
Point Source



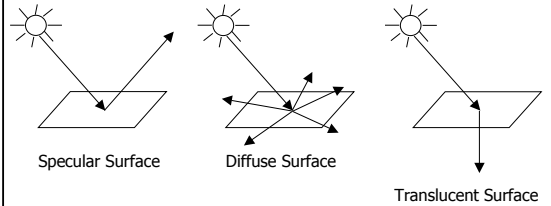
Spotlights



Distant light

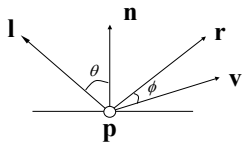


Surface types



Phong Reflection Model

- An efficient approximation of physical reality.
- Supports three types of material-light interactions.
 - Ambient
 - Diffuse
 - Specular

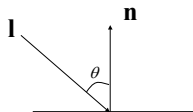


Ambient Reflection

- $I_a = k_a L_a$
- $0 \leq k_a \leq 1$

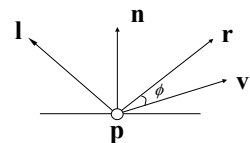
Diffuse Reflection

- $I_d = k_d L_d \cos \theta$
- $\cos \theta = \mathbf{l} \cdot \mathbf{n}$
- $I_s = k_d L_d (\mathbf{l} \cdot \mathbf{n})$



Specular Reflection

- $I_s = k_s L_s \cos^2 \phi$
- $\cos \phi = \mathbf{r} \cdot \mathbf{v}$
- $I_s = k_s L_s (\mathbf{r} \cdot \mathbf{v})^2$



Phong Model

- $I = I_a + I_d + I_s$
 $= k_s L_s (\mathbf{r} \cdot \mathbf{v})^\alpha + k_d L_d (\mathbf{l} \cdot \mathbf{n}) + k_a L_a$

- With light attenuation by distance

$$I = 1/(a+bd+cd^2) (k_d L_d (\mathbf{l} \cdot \mathbf{n}) + k_s L_s (\mathbf{r} \cdot \mathbf{v})^\alpha) + k_a L_a$$

Polygonal Shading

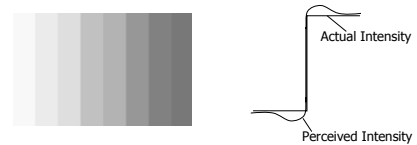
- Flat shading
- Gourand shading
- Phong shading

Flat Shading

- `glShadeModel(GL_FLAT)`
- Constant intensity shading, i.e. the intensity is constant for each polygon.
- Very simple to implement, however, it may introduce intensity discontinuities by Mach band effect.

Mach Band Effect

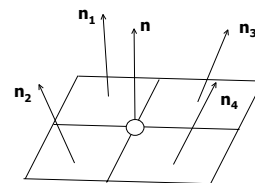
- The human visual system is very sensitive to small differences in light intensity.
- Because of a property known as lateral inhibition.



Gourand Shading

- `glShadeModel(GL_SMOOTH)`
- Interpolative intensity shading.
- Calculate intensity at each vertex of the polygon and interpolate the other intensity values.

Normal vector calculation



Phong shading

- Evaluate the intensity at each pixel.
- The normals are interpolated.
- Often done off-line.
- $\mathbf{n}_c = (1-\alpha)\mathbf{n}_a + \alpha\mathbf{n}_b$
- $\mathbf{n}_c = \mathbf{n}_c / |\mathbf{n}_c|$

