

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

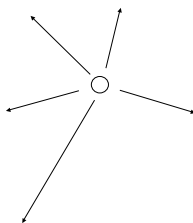
Illumination Model

- 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.

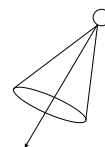
Light Sources

- Point sources
- Spotlights
- Distant light

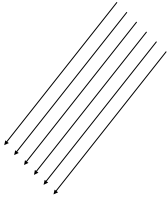
Point Source



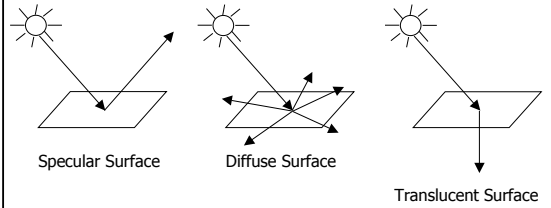
Spotlights



Distant light

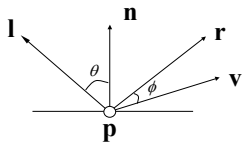


Surface types



Phong Reflection Model

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



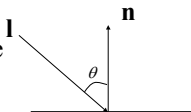
Ambient Reflection

- $I_a = k_a L_a$
- $0 \leq k_a \leq 1$
- *Background light: uniform illumination*
- *View direction independent*

Diffuse Reflection

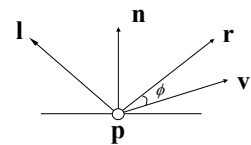
- $I_d = k_d L_d \cos \theta$
- $\cos \theta = \mathbf{l} \cdot \mathbf{n}$
- $I_s = k_d L_d (\mathbf{l} \cdot \mathbf{n})$

- Angle of incidence
- View independent



Specular Reflection

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



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

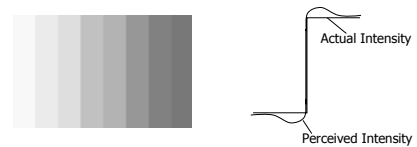
- Flat shading
- Gourand shading
- Phong shading

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

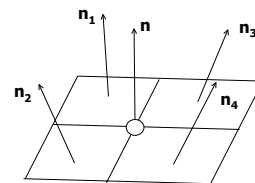
- The human visual system is very sensitive to small differences in light intensity.
- Because of a property known as lateral inhibition.



Gourand Shading

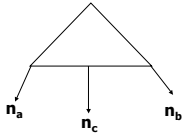
- `glShadeModel(GL_SMOOTH)`
- Interpolative intensity shading.
- Calculate intensity at each vertex of the polygon and interpolate the other intensity values.

Normal vector calculation



Phong shading

- Evaluate the intensity at each pixel.
- The normals are interpolated.
- Often done off-line.
- $n_c = (1-\alpha)n_a + \alpha n_b$
- $n_c = n_c / |n_c|$



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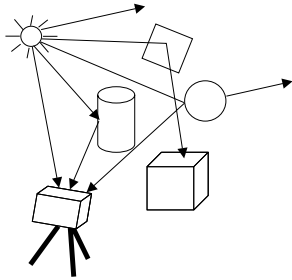
Global Illumination

- Shading is conducted by considering the interaction between all objects in the environment.
- More accurate rendering with more cost.
- Often done in off-line.
- Two main approaches:
 - Ray Tracing
 - Radiosity

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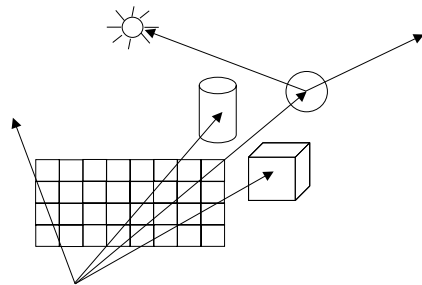
Ray Tracing



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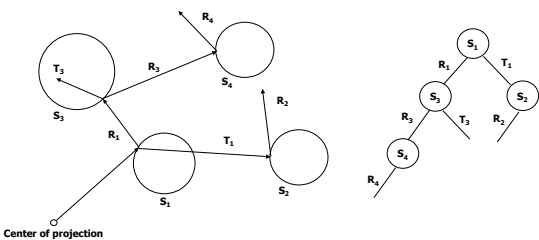
Ray Tracing



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Ray Tracing Tree



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Ray Tracing

- The intensity assigned to a pixel is then determined by accumulating the intensity contributions, starting at the bottom (terminal nodes) of its ray-tracing tree.
- Surface intensity from each node in the tree is attenuated by the distance from the “parent” surface (next node up the tree) and added to the intensity of the parent surface. Pixel intensity is then the sum of the attenuated intensities at the root node of the ray tree.

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