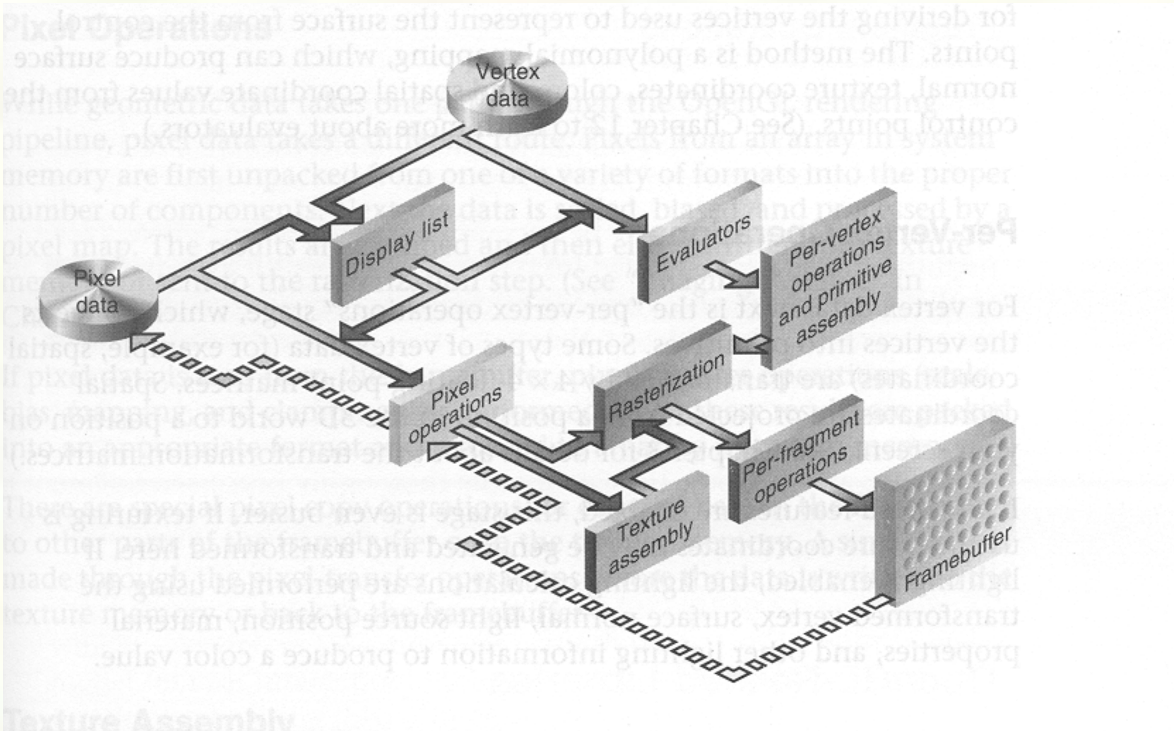
CS 378: Computer Game Technology

Basic Rendering Pipeline and Shading

Spring 2012

Rendering

- Recall the standard graphics pipeline:



Normal Vectors

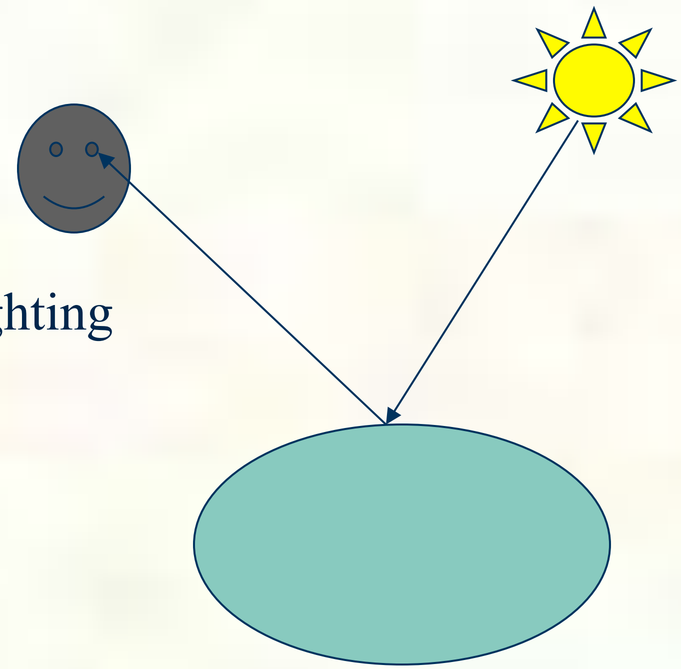
- The intensity of a surface depends on its orientation with respect to the light and the viewer
  - CDs are an extreme example
- The surface normal vector describes the orientation of the surface at a point
  - Mathematically: Vector that is perpendicular to the tangent plane of the surface
    - What's the problem with this definition?
  - Just "the normal vector" or "the normal"
  - Will use N to denote

Local Shading Models

- Local shading models provide a way to determine the intensity and color of a point on a surface
  - The models are local because they don't consider other objects at all
  - We use them because they are fast and simple to compute
  - They do not require knowledge of the entire scene, only the current piece of surface

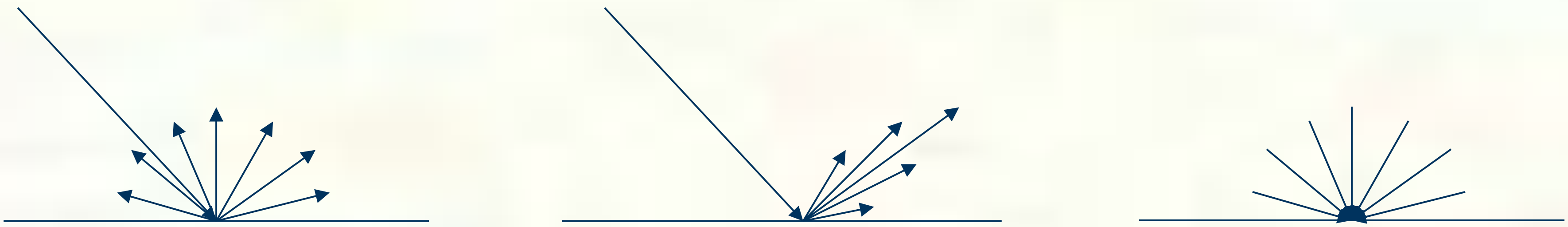
Local Shading Models (Watt 6.2)

- What they capture:
  - Direct illumination from light sources
  - Diffuse and Specular components
  - (Very) Approximate effects of global lighting
- What they don’t do:
  - Shadows
  - Mirrors
  - Refraction
  - Lots of other stuff …



"Standard" Lighting Model

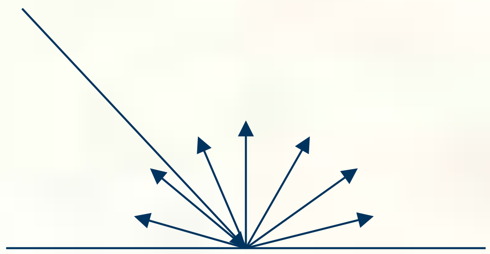
- Consists of several simple terms linearly combined:
  - Diffuse component for the amount of incoming light reflected equally in all directions
  - Specular component for the amount of light reflected in a mirror-like fashion
  - Ambient term to approximate light arriving via other surfaces



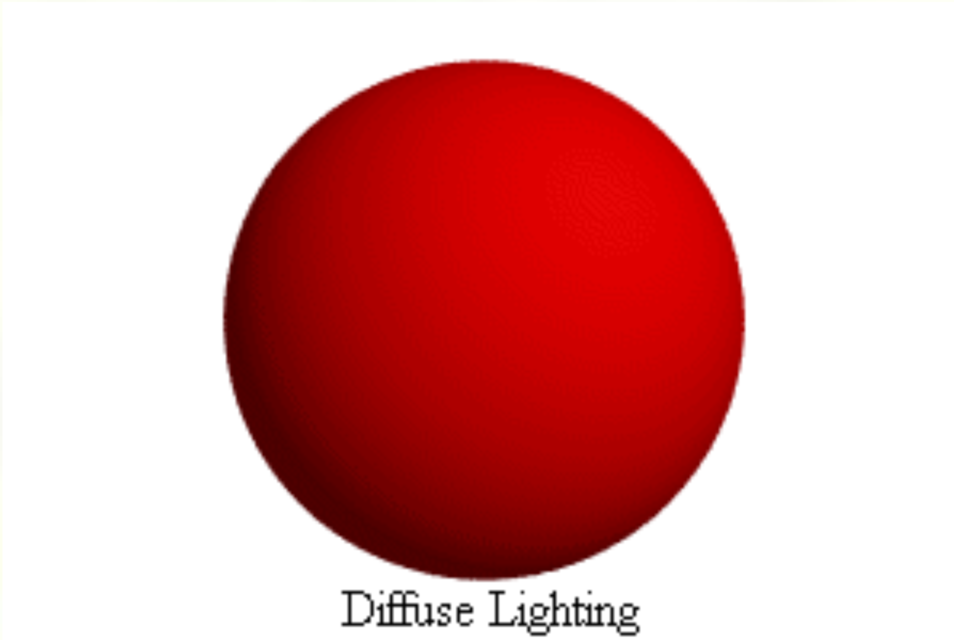
Diffuse Illumination

- Incoming light, Ii, from direction L, is reflected equally in all directions $k_d I_i (\boldsymbol{L} \bullet \boldsymbol{N})$
  - No dependence on viewing direction
- Amount of light reflected depends on:
  - Angle of surface with respect to light source
    - Actually, determines how much light is collected by the surface, to then be reflected
  - Diffuse reflectance coefficient of the surface, kd
- Don't want to illuminate back side. Use

$$k_d I_i \max(\boldsymbol{L} \bullet \boldsymbol{N}, 0)$$



Diffuse Example

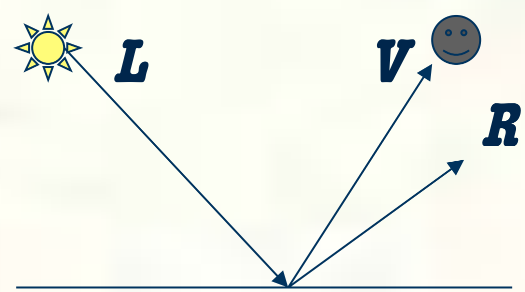


Where is the light source?

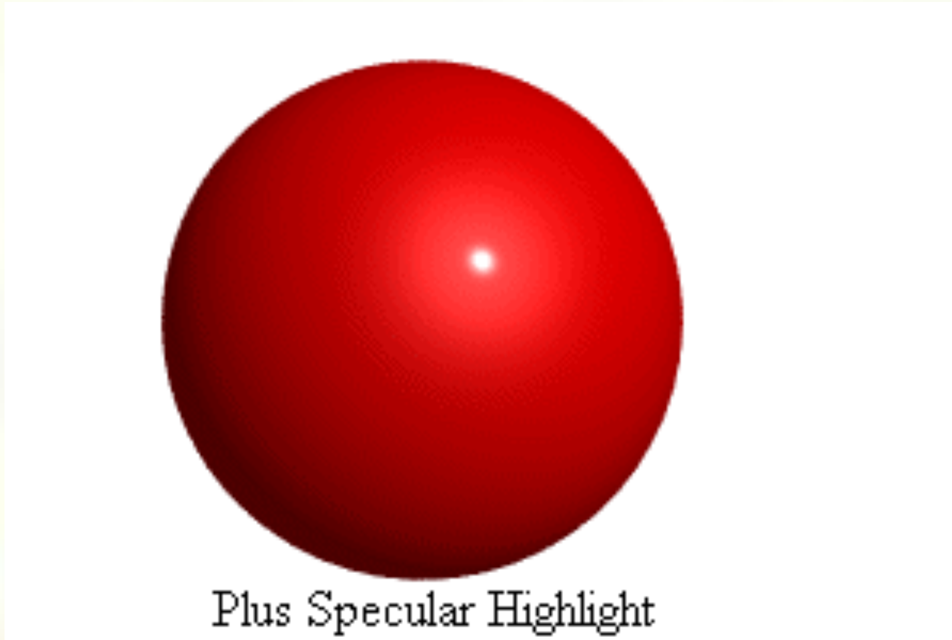
Specular Reflection (Phong Model)

- Incoming light is reflected primarily in the mirror direction **R**
  - Perceived intensity depends on the relationship between the viewing direction **V** and the mirror direction **R**
  - Bright spot is called a specular highlight
- Intensity controlled by:
  - The specular reflectance coefficient k_s
  - The parameter n controls the apparent size of the specular highlight
    - Higher *n,* smaller highlight

$$k_s I_i (\mathbf{R} \bullet \mathbf{V})^n$$



Specular Example



Putting It Together

- Global ambient intensity, I_a:
  - Gross approximation to light bouncing around of all other surfaces
  - Modulated by ambient reflectance k_a
- Emitted term I_e – no reflected light, comes from object
- Just sum all the terms
- If there are multiple lights, sum contributions from each light
- Several variations, and approximations …

$$I = I_e + k_a I_a + \sum_{\text{lights } i} I_i \left(k_d (\mathbf{L}_i \bullet \mathbf{N}) + k_s (\mathbf{R}_i \bullet \mathbf{N})^n \right)$$

Flat shading

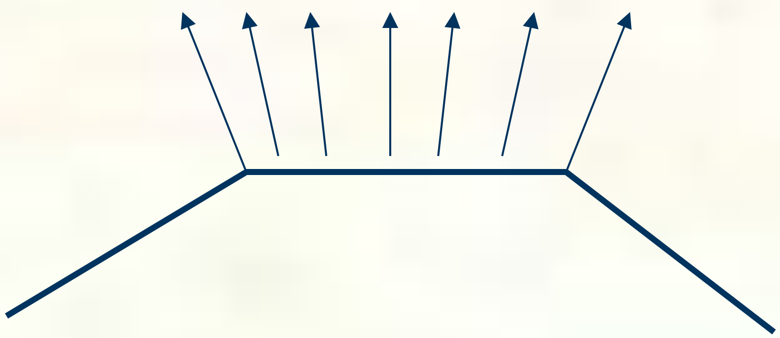
- Compute shading at a representative point and apply to whole polygon
  - OpenGL uses one of the vertices
- Advantages:
  - Fast - one shading value per polygon
- Disadvantages:
  - Inaccurate
  - Discontinuities at polygon boundaries

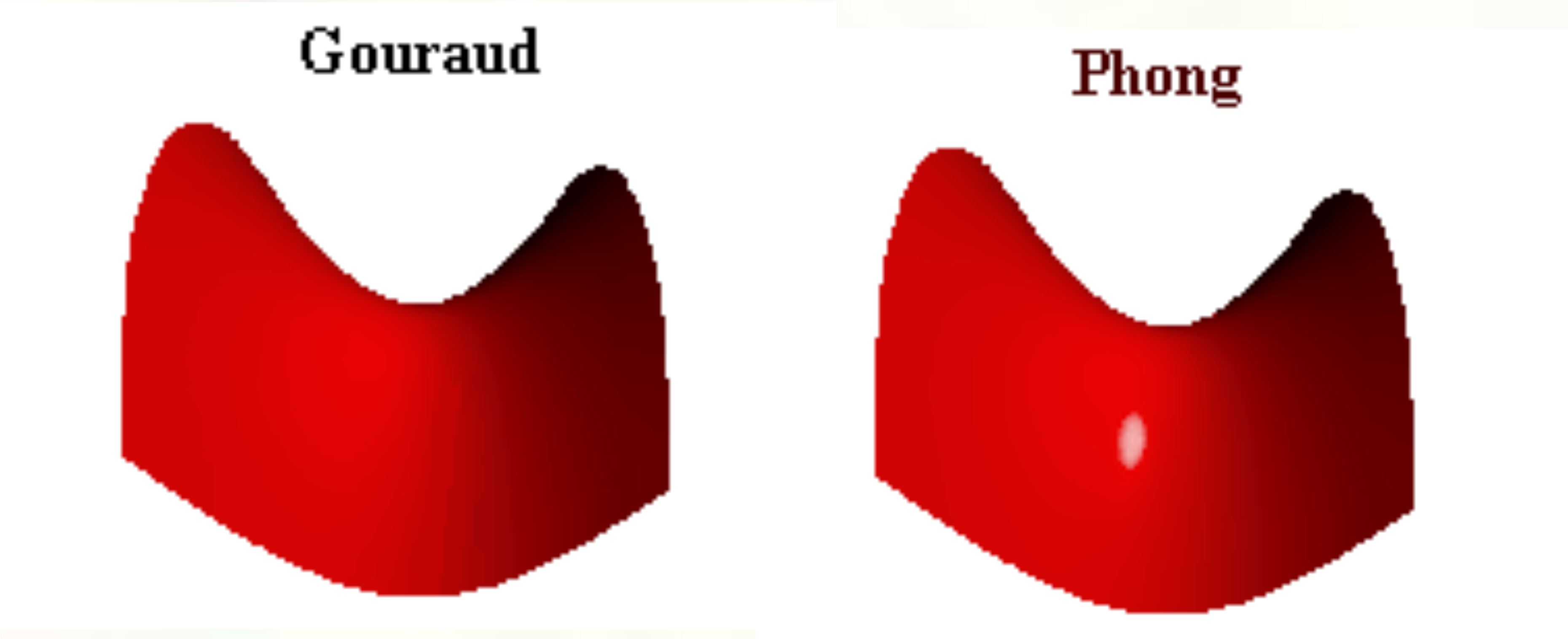
Gourand Shading

- Shade each vertex with it's own location and normal
- Linearly interpolate across the face
- Advantages:
  - Fast - incremental calculations when rasterizing
  - Much smoother - use one normal per shared vertex to get continuity between faces
- Disadvantages:
  - Specular highlights get lost

Phong Interpolation

- Interpolate normals across faces
- Shade each pixel
- Advantages:
  - High quality, narrow specular highlights
- Disadvantages:
  - Expensive
  - Still an approximation for most surfaces
- Not to be confused with Phong's shading model




Gouraud
Phong