Specular Reflection
Lecture 17

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Outline

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1. Specular Reflection
2. The Specular Calculations
   - The Phong Lighting Model
   - The Blinn Lighting Model
3. Assignment

Specular Reflection

- Specular reflection is different.
- The specular reflection represents the “shininess” of the surface.
- Thus, the color of the specular reflection is typically the color of the light source (which is usually white).

Specular Reflection

Specular Reflection

```
vec3 specular(1.0f, 1.0f, 1.0f);
GLuint spec_loc = glGetUniformLocation(program, "specular");
glUniform3fv(spec_loc, 1, specular);

GLfloat shiny = 20.0f;
GLuint shiny_loc = glGetUniformLocation(program, "shiny");
glUniform1f(shiny_loc, 1, shiny);
```

- We pass the specular light and the “shininess” as uniform variables the shaders.
- Note that `shiny` is a **`float`**, not a **`vec3`**.

Outline

Specular Reflection

- Specular reflections takes into account
  - The specular light (intensity of reflection)
  - The shininess of the material (narrowness of reflection)
  - Orientation of the surface (normal vector **N**)
  - Direction of the light source (light vector **L**)
  - Direction of the viewer (view vector **V**)

Outline

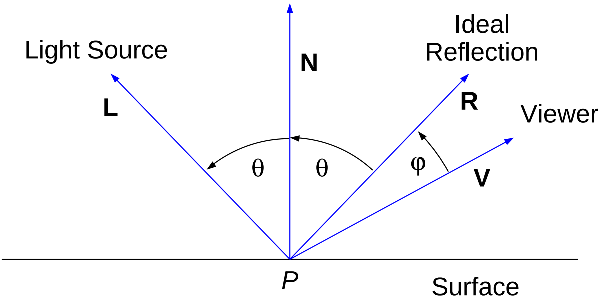
Blinn and Phong Lighting

- There are two standard lighting models for specular reflection.
  - Phong lighting model
  - Blinn lighting model
- The Phong model is more intuitive, but the Blinn model is more efficient.
- The results are very similar, but not identical.

Phong Lighting Model

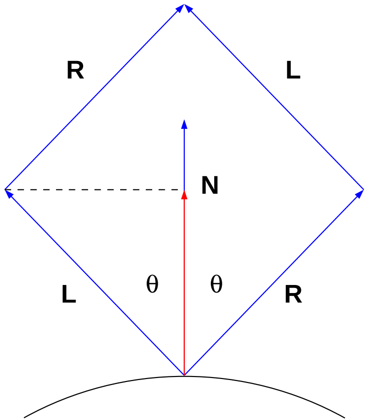
- In the Phong model, the intensity of the reflection is a function of the angle between direction **V** to the viewer and the ideal direction **R** of reflection from the light source off the surface.

Phong Lighting Model



Phong Lighting Model

- To compute **R**, note that **R** + **L** equals twice the projection of **L** onto **N**.



Phong Lighting Model

- The projection of **L** onto **N** is

$$\left(\frac{\mathbf{L}\cdot\mathbf{N}}{\mathbf{N}\cdot\mathbf{N}}\right)\mathbf{N} = (\mathbf{L}\cdot\mathbf{N})\mathbf{N}.$$

- Therefore,

$$\mathbf{R} + \mathbf{L} = 2(\mathbf{L}\cdot\mathbf{N})\mathbf{N}$$

so

$$\mathbf{R} = -\mathbf{L} + 2(\mathbf{L}\cdot\mathbf{N})\mathbf{N}.$$

Computing Specular Reflection

- According to the Phong lighting model, the specular reflection is proportional to the cosine of the angle between **V** and **R**, raised to the α power, where α is a positive number.
- This is calculated as

$$(\cos\varphi)^{\alpha} = (\mathbf{R}\cdot\mathbf{V})^{\alpha}.$$

- The larger α, the narrower the cone of reflection.

Computing Specular Reflection

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$$(\cos\varphi)^{\alpha} = (\mathbf{R} \cdot \mathbf{V})^{\alpha}.$$

- The larger α, the narrower the cone of reflection.
- α is called the shininess.

Computing Specular Reflection

- Two other factors are
  - Intensity of the incident light `spec`.
  - Material specular property of the surface `mat_spec`.
- Therefore, the formula for specular reflection is

$$\texttt{spec\_refl} = \texttt{specular} * \max((\mathbf{R} \cdot \mathbf{V}), 0)^{\alpha}.$$

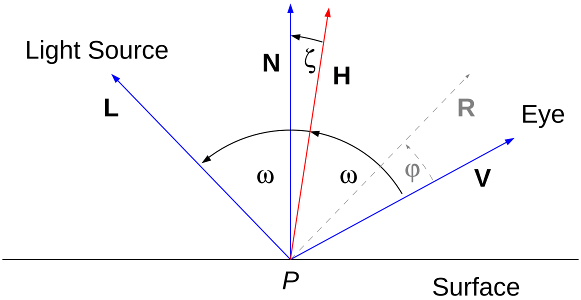
Outline

Blinn Lighting Model

- The Blinn model is more efficient.
- Let **H** be the halfway vector, which is the unit vector halfway between **L** and **V**.
- Then use $\mathbf{H} \cdot \mathbf{N}$ instead of $\mathbf{R} \cdot \mathbf{V}$.

$$\texttt{spec\_refl} = \texttt{specular} * \max((\mathbf{H} \cdot \mathbf{N}), 0)^{\alpha}.$$

Blinn Lighting Model



Blinn Lighting Model

- **H** is computed as
$$\mathbf{H} = \frac{\mathbf{L} + \mathbf{V}}{|\mathbf{L} + \mathbf{V}|}.$$
- How does $\mathbf{H} \cdot \mathbf{N}$ compare to $\mathbf{L} \cdot \mathbf{V}$?
- If **L**, **N**, and **V** are coplanar, then the angle between **H** and **N** is half of the angle between **R** and **V**.
- Pretty much the same results can be obtained by adjusting α.

Blinn Lighting Model

- Why is Blinn lighting more efficient?
- The calculation of **H** uses **L** and **V**, but not **N**.
- Therefore, if the light source is directional and the viewer is "at infinity," then the halfway vector may be computed only once for the entire scene, not once for every vertex.
- The halfway vector would be passed as a uniform variable.

Blinn Lighting Model

- Why is Blinn lighting more efficient?
- The calculation of **H** uses **L** and **V**, but not **N**.
- Therefore, if the light source is directional and the viewer is "at infinity," then the halfway vector may be computed only once for the entire scene, not once for every vertex.
- The halfway vector would be passed as a uniform variable.
- In other situations, the two methods are about equally efficient.

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Assignment

- Assignment 16.
- Read pp. 376 - 387: Fragment Shaders for Different Light Styles.
- Read pp. 387 - 390: Moving Calculations to the Vertex Shader.