Directional and Positional Lights

Lecture 18

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Outline

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Light Sources

Definition (Directional iight source)

A directional light source is "at infinity" in a specific direction. Thus, the light vector is the same for all vertices.

Definition (Positional light source)

A positional light source is at a finite point in space. Thus, the light vector varies from one vertex to another.

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Definition (Positional light source)

A positional light source is at a finite point in space. Thus, the light vector varies from one vertex to another.

- A directional light source is defined by a vector (**vec3** with $w = 1$).
- A positional light source is defined by a point (**vec3** with $w = 1$).

Light Sources

- Which is more efficient, directional or positional?

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- Which is more realistic, directional or positional?

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- Which is more efficient, directional or positional?
- Which is more realistic, directional or positional?
- Which is more important, efficiency or realism?

Outline

Directional Light Sources

- If the light source is directional, then the direction of the light source is given by a (unit) vector **L**.
- Then for every vertex, if **N** is the (unit) normal vector at that vertex, then the intensity of the diffuse light is

$$(\mathbf{N} \cdot \mathbf{L}) * \text{diffuse}.$$

- Added to the ambient light, we compute the shade as

$$\text{vColor} * (\text{ambient} + (\mathbf{N} \cdot \mathbf{L}) * \text{diffuse}).$$

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Positional Light Sources

- Positional light sources are more complicated.
- Let L be the position of the light source, in world coordinates.
- Let P be the position of the vertex, in world coordinates.
- Then the light vector is

$$\mathbf{L} = \text{normalize}(L - P).$$

- The intensity of the diffuse light at point P is

$$(\mathbf{N} \cdot \mathbf{L}) * \text{diffuse}$$

Outline

Shader `in` Variables

- Any variable that passed from the vertex shader to the fragment shader will be smoothly interpolated across the primitive to which it belongs.
- If the primitive is a line, then the interpolation is linear.
- If the primitive is a triangle, then the interpolation is bilinear, which means linear in each of two directions.

Linear Interpolation

- Let a and b be the values at opposite ends of a line segment.
- We want to find a *linear* function $f(t)$ such that $f(0) = 1$ and $f(1) = b$.
- That is, a linear function from the point $(0, a)$ to the point $(1, b)$.
- The slope is

$$m = \frac{b - a}{1 - 0} = b - a.$$

- By the point-slope form, using $(0, a)$,

$$\begin{aligned} y &= (b - a)t + a \\ &= a(1 - t) + bt. \end{aligned}$$

Linear Interpolation

Example

- Write a function that interpolates linearly between the points $(1, 5, 4)$ and $(8, 6, 2)$.

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$$\begin{aligned} f(t) &= (1, 5, 4)(1 - t) + (8, 6, 2)t \\ &= ((1 - t) + 8t, 5(1 - t) + 6t, 4(1 - t) + 2t) \\ &= (1 + 7t, 5 + t, 4 - 2t). \end{aligned}$$

Linear Interpolation of Normal Vectors

Example

- Given two normal vectors $\mathbf{u} = \left(\frac{1}{3}, \frac{2}{3}, \frac{2}{3}\right)$ and $\mathbf{v} = \left(\frac{4}{5}, \frac{3}{5}, 0\right)$, write a function that interpolates linearly between them.

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$$\begin{aligned} f(t) &= \left(\tfrac{1}{3}, \tfrac{2}{3}, \tfrac{2}{3}\right)(1-t) + \left(\tfrac{4}{5}, \tfrac{3}{5}, 0\right) t \\ &= \left(\tfrac{1}{15}\right)\left((5, 10, 10)(1-t) + (12, 9, 0)t\right) \\ &= \left(\tfrac{1}{15}\right)(5 + 7t, 10 - t, 10 - 10t). \end{aligned}$$

Linear Interpolation of Normal Vectors

Example

- Note that for most values of t, the vector $f(t)$ is not a unit vector.
- Its magnitude is

$$\left(\tfrac{1}{15}\right)\sqrt{(5+7t)^2+(10-t)^2+(10-10t)^2}$$

$$=\left(\tfrac{1}{15}\right)\sqrt{225-150t+150t^2}$$

$$=\sqrt{1-\tfrac{2}{3}t+\tfrac{2}{3}t^2},$$

  which is probably not 1.
- Thus, any vector that is passed from the vertex shader to the fragment shader must be renormalized before it is used.

Outline

Assignment

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- Read pp. 373 - 385, Lighting Introduction, Classic Lighting Model.