Normals, Shading wrap up

Dinesh K. Pai

Textbook Chapter 3.6, 14

Today

- Announcements
  - Assignment 2: please show up only at the times you signed up for
  - Lost and Found: umbrella left at last office hour
- Transforming normals
- Lighting and Shading, odds and ends
- Assignment 3
Review: Phong Reflection

- Which feature is modelled by the specular component in the Phong reflection model?
- Which feature is modelled by the diffuse component?

a) A  b) B  c) C  d) All of the above  e) None of the above

Switch to tablet
Normals are not "normal"

Suppose \( \mathbf{n}_{\text{new}} = A \mathbf{p} \)

\[ \mathbf{n}_{\text{new}} = ? = A \mathbf{p} \times \mathbf{n}_{\text{new}} \] \[ \text{Wrong} \]

What exactly is a normal vector?
"Right angles to surface"?

Better:
"Right angles to every tangent vector \( \mathbf{t} \)"

i.e.
\[ \mathbf{n} \cdot \mathbf{t} = 0 = \mathbf{n}_{\text{new}} \cdot \mathbf{t}_{\text{new}} \]

in coordinates
\[ \mathbf{n}^T \mathbf{t} = \mathbf{n}_{\text{new}}^T \mathbf{t}_{\text{new}} = 0 \]

But what is \( \mathbf{t}_{\text{new}} \)?

\[ \mathbf{t}_{\text{new}} = A \mathbf{t} \]

Intuition: tangent vector difference of \( \mathbf{p} \) and \( \mathbf{p}_h \)

\[ \mathbf{t} = \frac{\mathbf{p}_h - \mathbf{p}}{h} \]
From (1) and (2)
\[ m^T t = m_{nw}^T A t \]
This must hold for all tangent vectors \( t \)
So:
\[ m^T = m_{nw}^T A \]
Taking transpose and moving \( A \) to the other side
\[ m_{nw} = A^{-T} m \]

Notation:
\[ A^{-T} \equiv (A^{-1})^T \]

Important and special cases:
- If \( A \) is pure translation, has no effect.
  So you can safely ignore translation part of the matrix

\[(A_{0,0})^{-T} \text{ is called the "Normal Matrix"} \]

THREE.js defines this for you automatically

- If \( A \) is pure rotation (i.e. orthogonal)
  \[ A^{-1} = A^T \]
  \[ A^{-T} = (A^T)^T = A \]

So the wrong matrix \( A \) can still work!

**Watch out: Hidden bugs.**
Lighting and Shading, odds and ends

- Phong shading vs. Gouraud shading
- Phong reflection/illumination vs. Phong shading
- Global illumination and ambient
- Blinn-Phong reflection and the halfway vector
- Toon shading

Phong shading vs. Gouraud shading
- Gouraud == per-vertex normals and illumination. Interpolate vertex colors to fragments
- Phong == Interpolate vertex normals, per-fragment illumination

Phong reflection vs. Phong shading
- P. reflection == an approximation of BRDF, into specular + diffuse + ...

Global illumination and ambient
- Ambient term is a crude approximation of global illumination