CPSC 314
Computer Graphics

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L11

Frames in Graphics, continued..

Today

- Announcements
  - Homework: Read textbook Chapter 5
  - Quiz 1 will post to piazza to save class time
  - Assignment 2 delayed, available later today
  - All grades are made available through Connect>MyGrades
- Lecture
  - Transformation about an auxiliary frame
  - The Eye and “lookAt” matrices

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Frames, contd...

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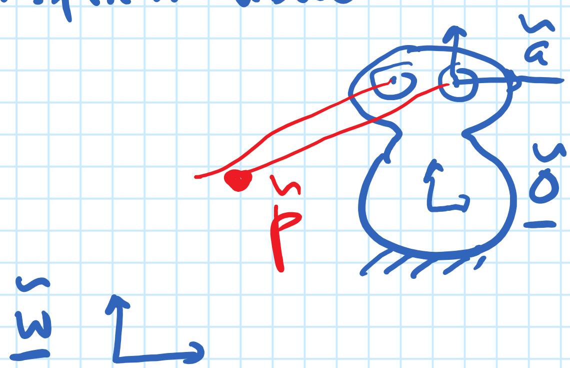
① Transform about an "auxiliary" frame



$$\underline{\tilde{a}} = \underline{\tilde{w}} A \qquad (1)$$

How do I rotate about origin of frame $\underline{\tilde{a}}$?

Simplest case, suppose you know point's coords in $\underline{\tilde{w}}$ (ignore $\underline{\tilde{o}}$ for now)

$$\tilde{p} = \underline{\tilde{w}}\, p_w$$

Plug in Eq. (1) to convert to $\underline{\tilde{a}}$ frame

$$= \underline{\tilde{a}}\, A^{-1} p_w$$

Apply transformation M

$$\tilde{p}' = \underline{\tilde{a}}\, M A^{-1} p_w$$

use Eq (1) to get back to $\underline{\tilde{w}}$

$$= \underline{\tilde{w}} \boxed{A M A^{-1}} p_w$$

This is a "similarity transformation"

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A small generalization. What if, as typical, you know $\breve{p}$ w.r.t. $\underline{\breve{a}}$ and $\underline{\breve{a}}$ w.r.t. Object frame $\underline{\breve{o}}$?

That is, I'm given

$$\underline{\breve{a}} = \underline{\breve{o}}\, A \qquad (2)$$

and

$$\breve{p} = \underline{\breve{a}}\, p \qquad (3)$$

$$\breve{p}' = \breve{a}\, M p$$

Convert to $\breve{o}$ with eq (2)

$$= \underline{\breve{o}}\, A M p$$

convert to $\underline{\breve{w}}$

$$= \underline{\breve{w}}\, O A M p$$

The "look At" matrix

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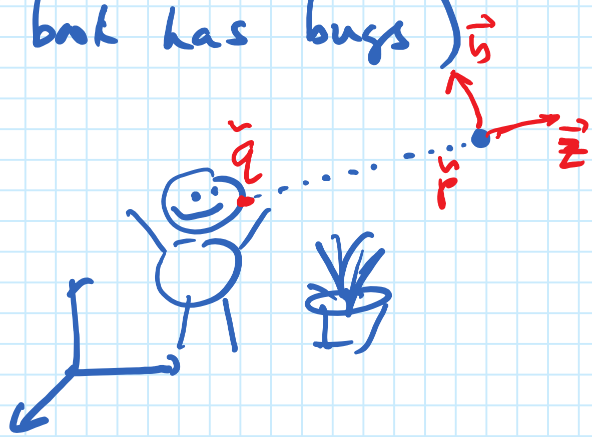
Exists in all flavors of OpenGL

(book has bugs)



$\Uparrow \vec{u}$ "up vector"

input: $\tilde{p}, \tilde{q}, \vec{u}$

output: Eye matrix with $\vec{y}$ as close as possible to $\vec{u}$

$$E = \left[\begin{array}{c|c|c|c} x & y & z & p \end{array}\right]$$

$$\underline{\tilde{w}}\, E = \underline{\tilde{o}}$$

$$\vec{z} = \text{normalize}(\tilde{p} - \tilde{q})$$

$$\vec{x} = \text{normalize}(\vec{u} \times \vec{z})$$

$$\vec{y} = \vec{z} \times \vec{x}$$

(normalization is optional here)

The lookAt or View matrix is E^{-1}

(see Lec. 10)

Issues with Textbook's "lookAt"

- Book description in 5.2.3 has a bug, fixed in online Errata (make this and other corrections in your textbook copy)
  - z = normalize(p - q)
    x = normalize(u × z)
    y = (z × x)
- The book's "lookAt" should be called "eye" matrix. It is the inverse of Three.js's camera.lookAt() method E
  $E^{-1} \equiv$ View Matrix
- The author is aware of these issues, will fix it in future editions

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