CPSC 314
Computer Graphics

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L14
Projection and Depth

Today

- Announcements
  - My office hour is each W 4-5pm in the lab (005)
  - Signup for the next office hour by W 12:00
    https://tinyurl.com/CS314-OfficeHour
  - Reminder: Lecture notes are available on the course web page http://sensorimotor.cs.ubc.ca/cpsc-314/ (under “Lectures” tab)

- Lecture
  - Projection and Depth
Review: OpenGL pipeline

PerspectiveCamera
Eye coords → Clip coords

See p. 106 of text

gluPerspective (which uses glFrustum) in OpenGL

Cont'd:
In Book mean and for are negative. In
https://threejs.org/docs/#api/cameras/PerspectiveCamera
Today: where does this come from?
Basic Geometry of Perspective (L13)

\[ \vec{e} = (\frac{y}{2}) \]

\[ \vec{e} \]

\[ \vec{m} = (\frac{y_m}{2_m}) \]

\[ x_m = -y_m \]

by design

\[ y_m = \frac{-y}{2} \]

because

\[ \frac{y}{2} = \frac{-1}{2} \]

In Vector form (writing \( \vec{P_e} \) as \( \vec{p} \))

\[ \begin{pmatrix} y \\ \frac{1}{2} \\ -2 \end{pmatrix} \rightarrow \begin{pmatrix} -3/2 \\ -1 \\ -2 \end{pmatrix} = -\frac{1}{2} \begin{pmatrix} y \\ 2 \\ -2 \end{pmatrix} \]

so projection achieved by just changing "w"!!

in homogenous ends

\[ \text{General Principle:} \]

Identify all non-zero multiples of homogenous coordinates of a point with itself

\[ \text{eq.} \quad \begin{pmatrix} y \\ \frac{1}{2} \\ -2 \end{pmatrix} \rightarrow \begin{pmatrix} 25y \\ 25y \frac{1}{2} \\ 25 \end{pmatrix} \]

Divide by the "w" up

also called Homogeneous "perspective divide"

"multiplican is easy to see"

So we can delay the perspective division (expensive)

until geometry has been clipped to the View Frustum
Using this new insight into homogeneous we can write the non-linear perspective transform as a matrix.

\[
\text{Attempt 1:} \quad P_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix}
\]

Even though this achieves projection, it loses all depth information. \(3D \rightarrow 2D\)

\[
\text{Attempt 2: Projective Transformation} \quad P_2 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
\]

Unhinging Transform

\[
(y, z) \rightarrow (y, \frac{1}{z}) \rightarrow \left(\frac{-y1}{z}, \frac{-1}{z}, \frac{-1}{z} \right)
\]

View frustum

\[
\begin{pmatrix} 0 \\ 0 \\ 1 \\ 1 \end{pmatrix} \rightarrow \left(\begin{pmatrix} 0 \\ 1 \\ 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ -\frac{1}{f} \\ -\frac{1}{f} \\ 1 \end{pmatrix} \right)
\]

Can be used for hidden surface removal (Ch. 11)