CS174A Lecture 8

Announcements & Reminders

- *10/26/22 and 10/27/22: Office hours, Noon – 1 PM PST, Zoom*
- *10/27/22: Midterm Exam: 6:00 – 7:30 PM PST, in person, in class*
- *11/08/22: Team project proposals due, initial version*
- *11/09/22: A3 due*
- *11/10/22: Midway demo, online zoom*

TA Session This Friday

- ***Team project***
  - First draft of proposal due: 11/08/22
  - What’s expected in the proposal
  - Still looking for teammates? Resolve this Friday
- ***Project assignment #3, due 11/09/22***
- ***Midterm review***

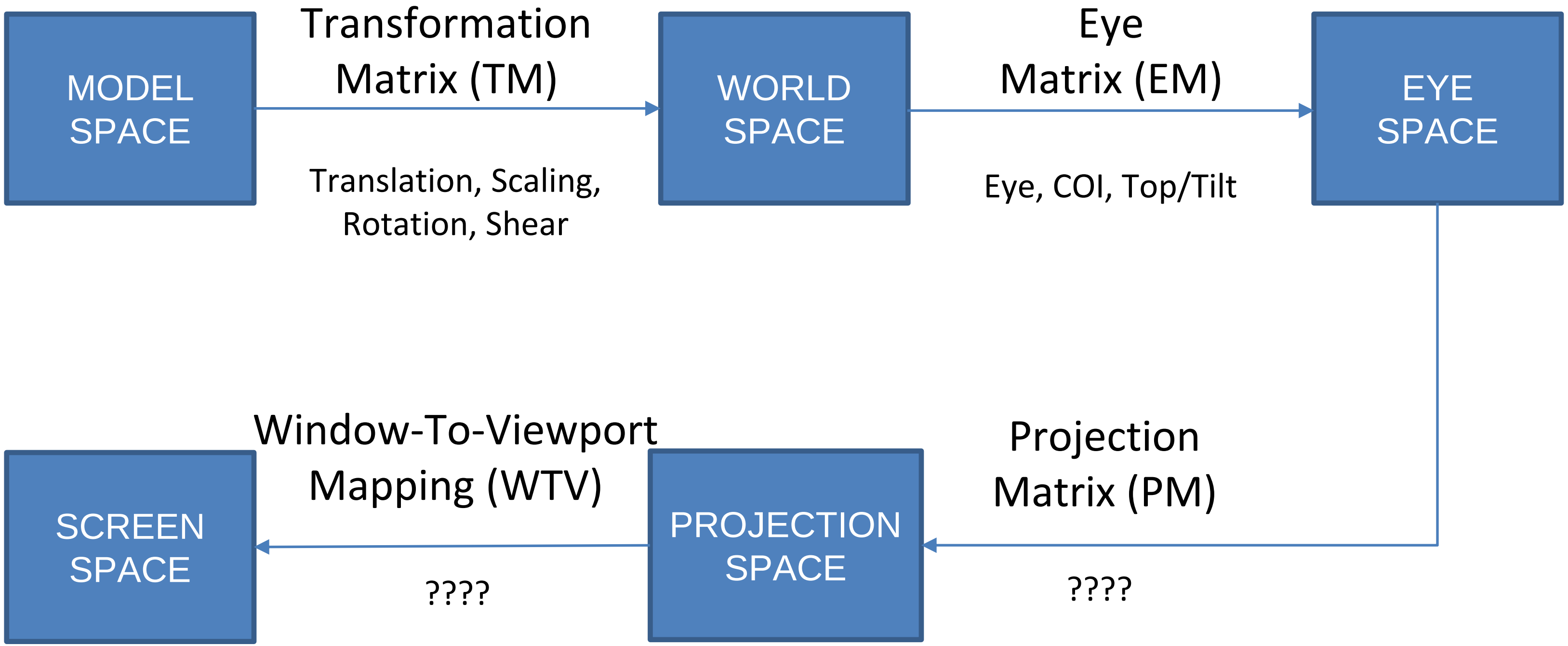
Last Lecture Recap

- ***Spaces:***
  - Model space
  - Object/world space
  - Eye/camera space
  - Projection Space
  - Screen space

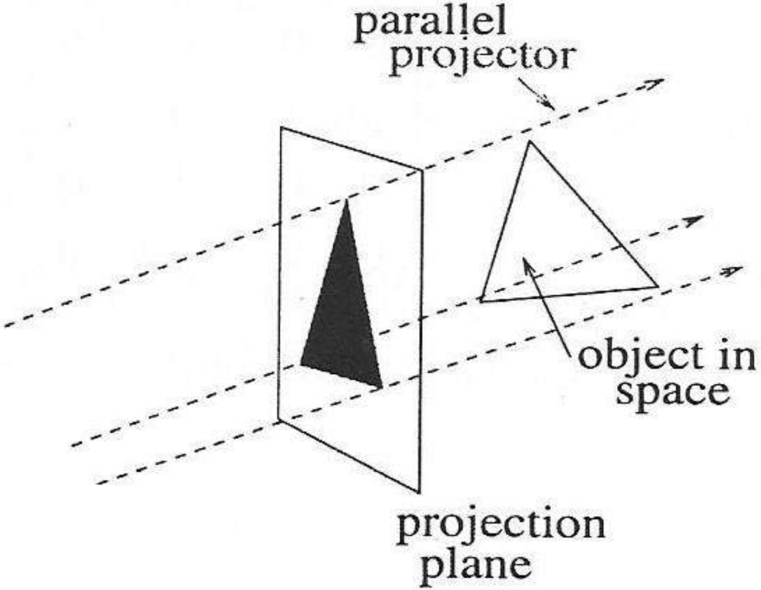
Next Up

- ***Projections: parallel and perspective***
  - Parallel and perspective view volumes
  - Canonical (normalized) view volume
- ***Geometric Calculations***
- ***Midterm***
- ***Hidden Surface Removal***
  - Backface Culling
- ***Lighting***
- ***Flat and Smooth Shading: introduction***

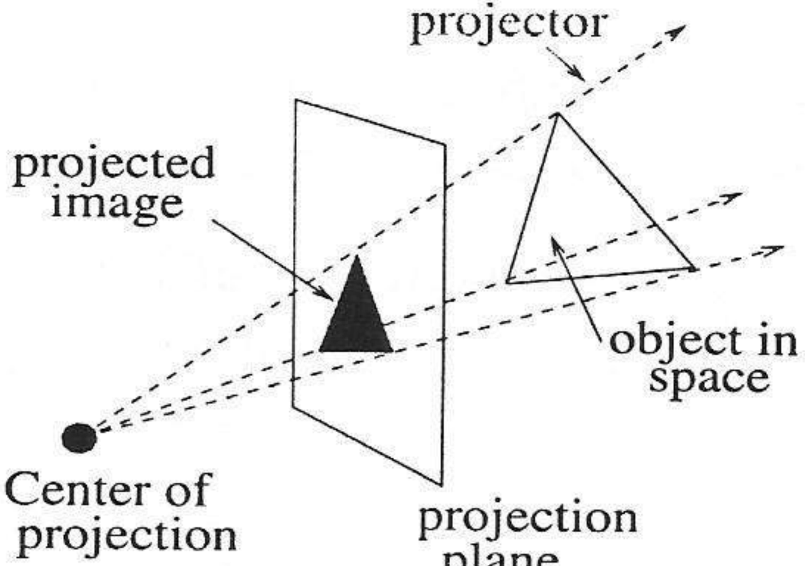
Rendering Pipeline



Orthographic Projections

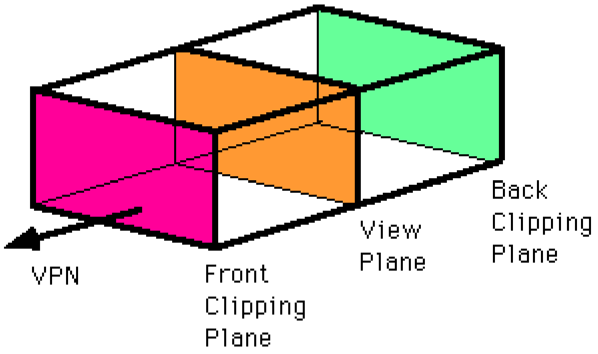


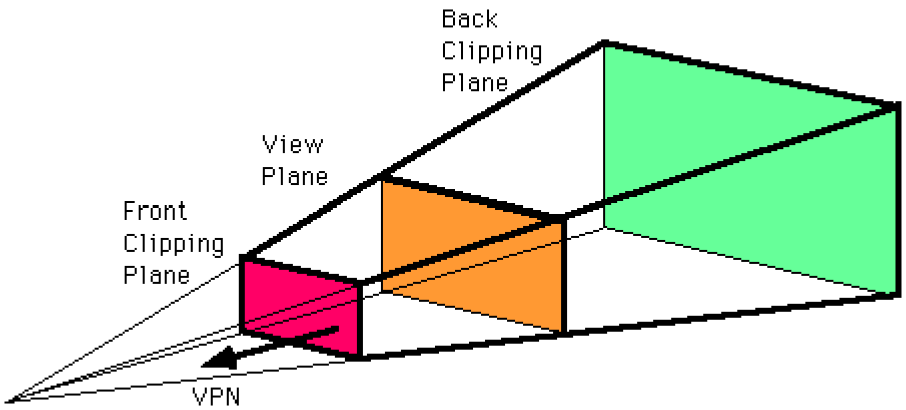
Parallel projection



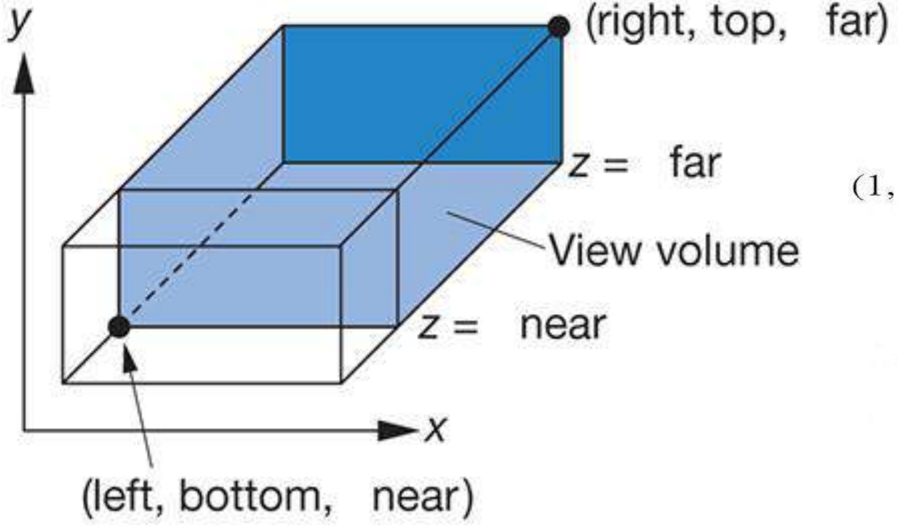
Perspective projection

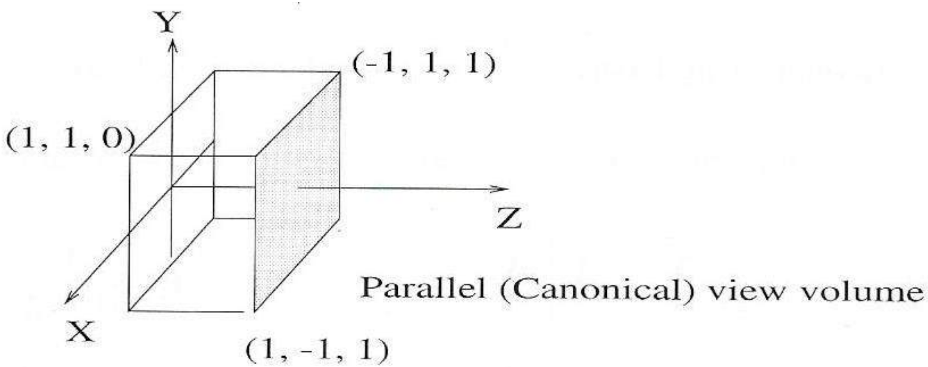
Orthographic Projections
View Volumes





Parallel Projection





Parallel PM = $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

View Volume

$-\frac{W}{2} <= X <= \frac{W}{2}$

$-\frac{H}{2} <= Y <= \frac{H}{2}$

$N <= Z <= F$

Parallel Projection

Parallel PM = $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

View Volume

$-\frac{W}{2} <= X <= \frac{W}{2}$

$-\frac{H}{2} <= Y <= \frac{H}{2}$

N <= Z <= F

Normalized Parallel PM = $\begin{bmatrix} \frac{2}{W} & 0 & 0 & 0 \\ 0 & \frac{2}{H} & 0 & 0 \\ 0 & 0 & \frac{1}{F-N} & -\frac{N}{F-N} \\ 0 & 0 & 0 & 1 \end{bmatrix}$

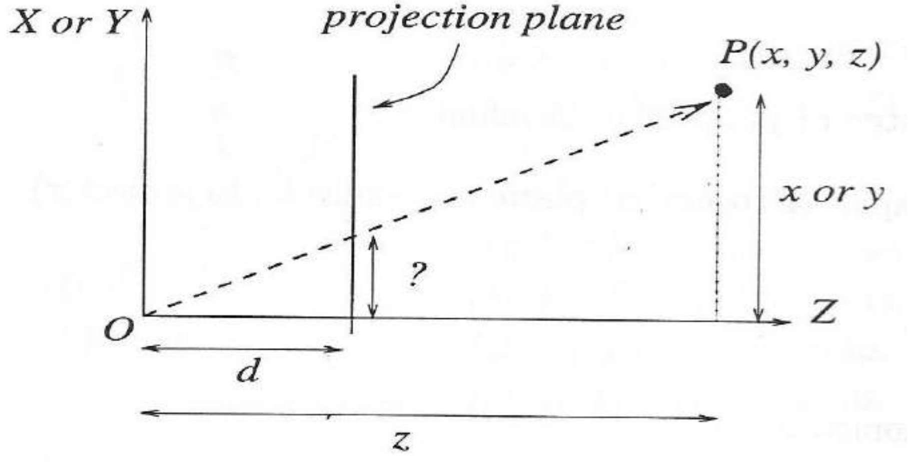
Canonical View Volume

-1 <= X' <= 1

-1 <= Y' <= 1

0 <= Z' <= 1

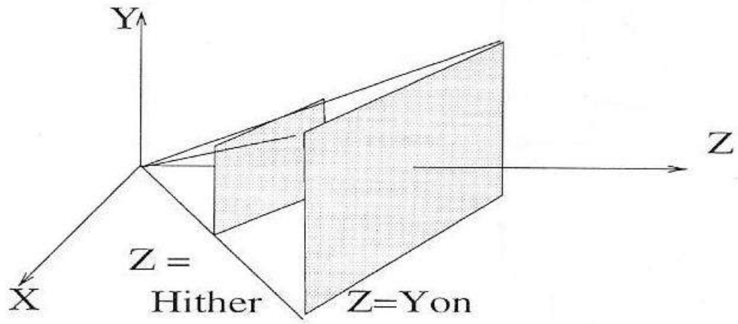
Perspective Projection

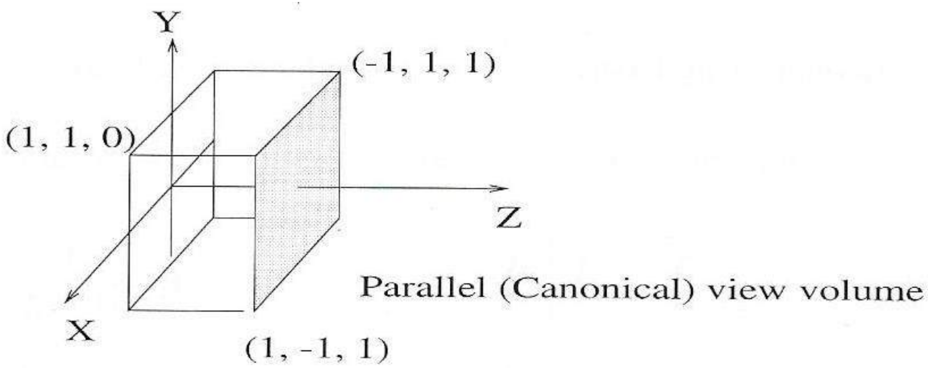


$$x \leftarrow \frac{x}{z}d; \quad y \leftarrow \frac{y}{z}d$$

Perspective PM (square viewport) = $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & \frac{1}{d} & 0 \end{bmatrix}$

Perspective Projection





Aspect Ratio (A_r) = $\frac{W}{H}$

Half Angle of View = θ

Θ is defined wrt to x-axis

$$\text{Normalized PPM} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & A_r & 0 & 0 \\ 0 & 0 & A\tan(\theta) & B\tan(\theta) \\ 0 & 0 & \tan(\theta) & 0 \end{bmatrix}$$

Perspective Projection

Normalized PPM = $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & A_r & 0 & 0 \\ 0 & 0 & Atan(\theta) & Btan(\theta) \\ 0 & 0 & \tan(\theta) & 0 \end{bmatrix}$

A = $\frac{F}{F-N}$

B = - $\frac{N*F}{F-N}$

Apply Perspective Division

How to handle -ve values of w? What does it mean?

As examples,

- Lower-left-near vertex of view volume (in eye space) with coordinates: (-N*tan(θ), -N*tan(θ)/A_r, N) will map to (-1,-1,0) after pers div
- Upper-right-far vertex of view volume with coordinates: (F*tan(θ), F*tan(θ)/A_r, F) will map to (1,1,1) after pers div

Window-to-Viewport Mapping

Change from normalized volume (xyz) to screen coordinates (XY)
xyz: normalized point after perspective division
XY: screen coordinates
v_l,v_b: lower-left corner of viewport
v_r,v_t: upper-right corner of viewport

$$\text{WTV Matrix} = T((v_l+v_r)/2,(v_b+v_t)/2)*S((v_r-v_l)/2,(v_t-v_b)/2)*T(0,0)$$

$$X = x\frac{v_r - v_l}{2} + \frac{v_r + v_l}{2}$$

$$Y = y\frac{v_t - v_b}{2} + \frac{v_t + v_b}{2}$$

In general (window=x_{min},y_{min},x_{max},y_{max}; viewport=u_{min},v_{min},u_{max},v_{max})

$$\text{WTV Matrix} = T(u_{min},v_{min}) \cdot S\left(\frac{u_{max} - u_{min}}{x_{max} - x_{min}}, \frac{v_{max} - v_{min}}{y_{max} - y_{min}}\right) \cdot T(-x_{min},-y_{min})$$

Rendering Pipeline