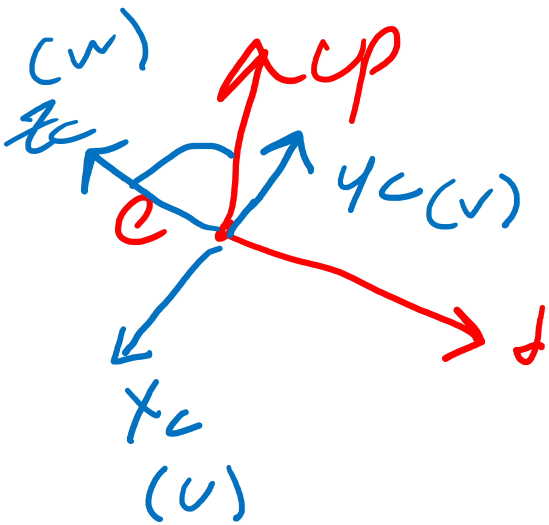
CMSC427 Transformations II: Viewing (second video)

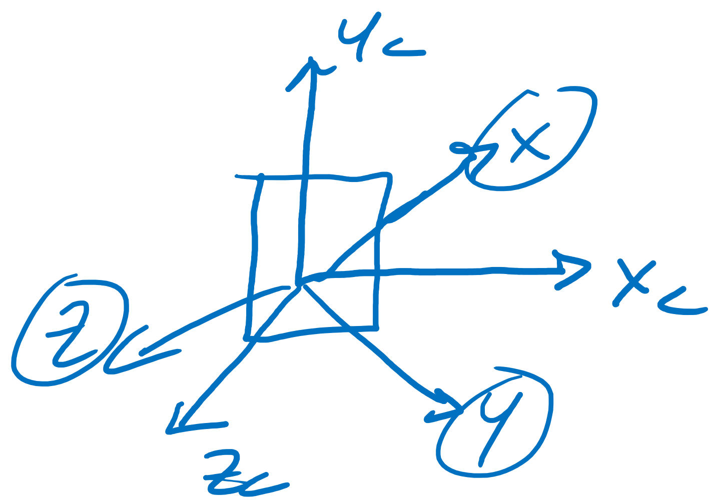
Credit: some slides from Dr. Zwicker

Camera matrix

- z-axis $$\mathbf{z}_c = \frac{\mathbf{e} - \mathbf{d}}{\|\mathbf{e} - \mathbf{d}\|}$$
- x-axis $$\mathbf{x}_c = \frac{\mathbf{up} \times \mathbf{z}_c}{\|\mathbf{up} \times \mathbf{z}_c\|}$$
- y-axis $$\mathbf{y}_c = \mathbf{z_c} \times \mathbf{x}_c$$

Q? Matrix for the rotation?





Rotation matrices

$$\begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} r_{11} \\ r_{21} \\ r_{31} \end{bmatrix}$$

$$\begin{bmatrix} u & v & w \end{bmatrix}$$

$$\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} = \begin{bmatrix} r_{12} \\ r_{22} \\ r_{32} \end{bmatrix}$$

$$\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} r_{13} \\ r_{23} \\ r_{33} \end{bmatrix}$$

$x \rightarrow u$

$y \rightarrow v$

$w \rightarrow z$

Rotation matrices

$p = ai + bj + ck$ $\qquad J =$

Rotation matrices

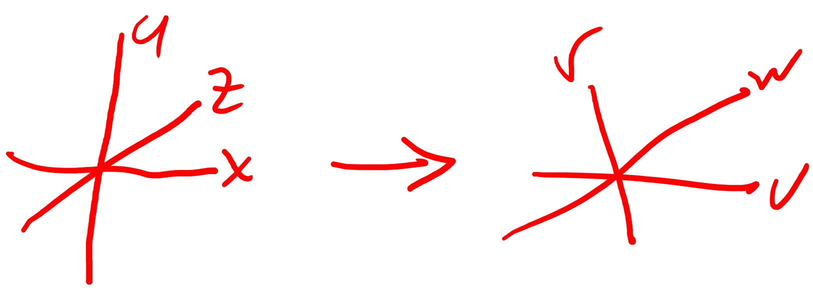
$$q = a\vec{x} + b\vec{y} + c\vec{z}$$

$$Rq = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} u^T & v^T & w^T \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix}$$

$$= R(a\vec{x} + b\vec{y} + c\vec{z})$$

$$= aR\vec{x} + bR\vec{y} + cR\vec{z}$$

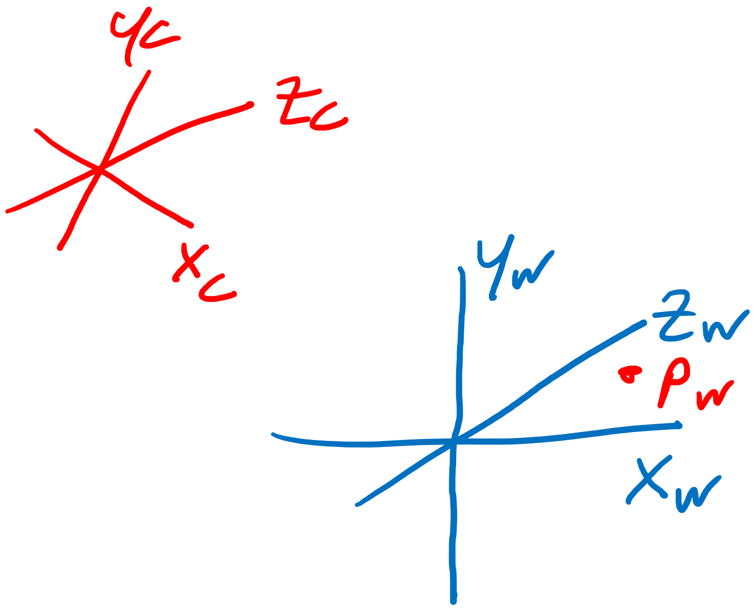
$$= a(u^T \cdot \vec{x}^T) + b(v^T \cdot \vec{y}^T) + c(w^T \cdot \vec{z}^T)$$



$$\Rightarrow R = \begin{bmatrix} u^T & v^T & w^T \end{bmatrix}$$

Camera matrix

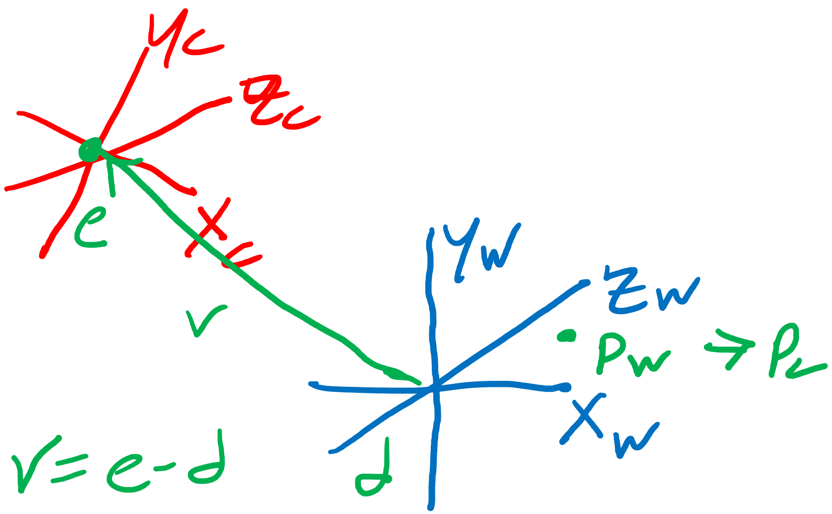
- Camera to world transformation



$P_c = M_c \, l$

Camera matrix

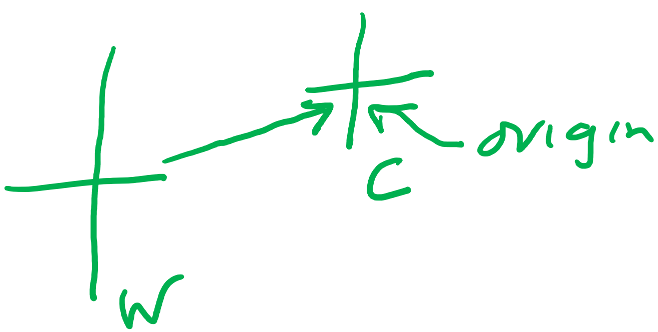
- Camera to world transformation



$$P_c = C\,P_w$$

$$C = M_T \times M_R$$

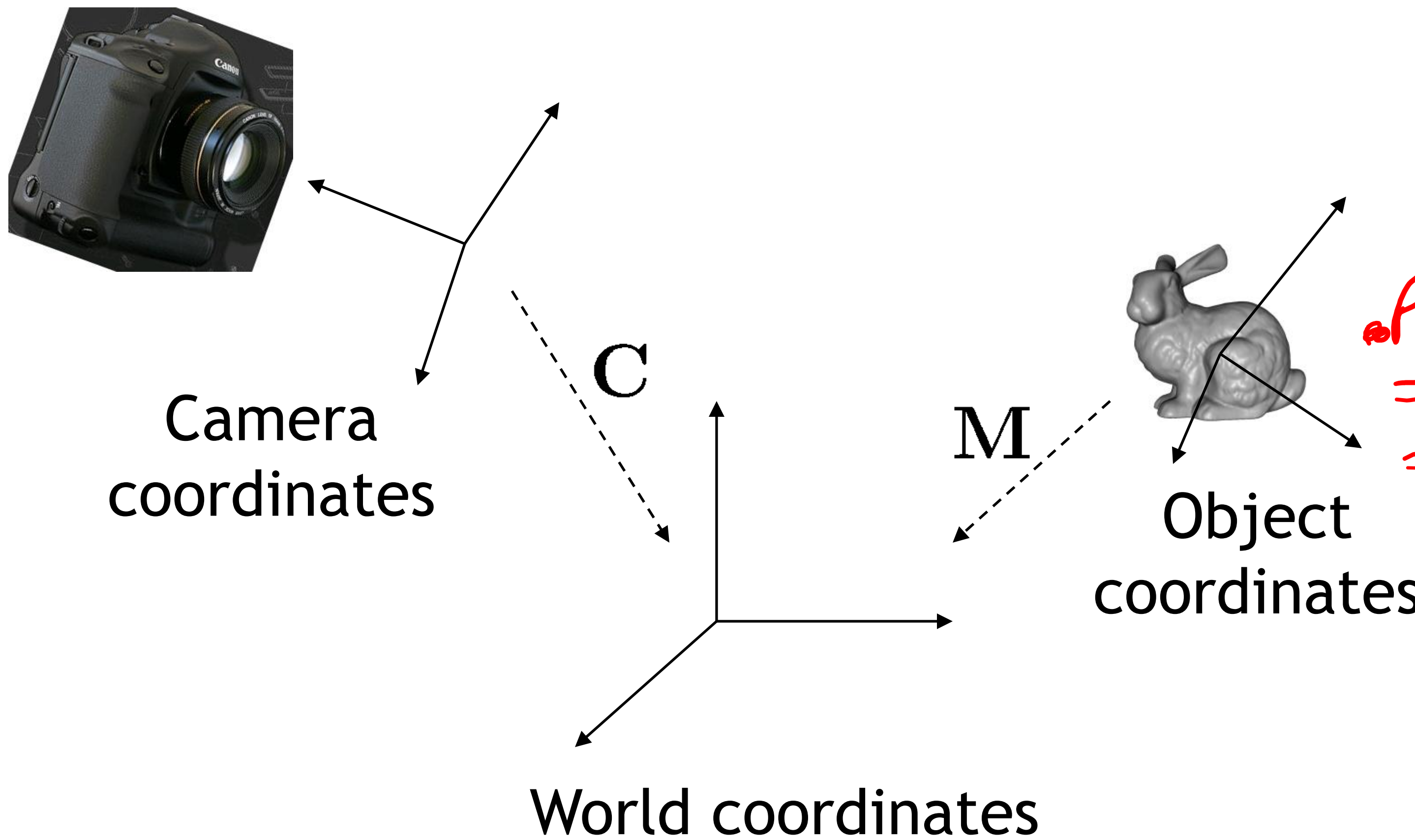
$$M_R = \begin{bmatrix} x_c^T & y_c^T & z_c^T \end{bmatrix}$$



$$M_T = T_{-M_R v}$$

$$C = \begin{bmatrix} x_c^T & y_c^T & z_c^T & -M_R v \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Object, world, camera coords.

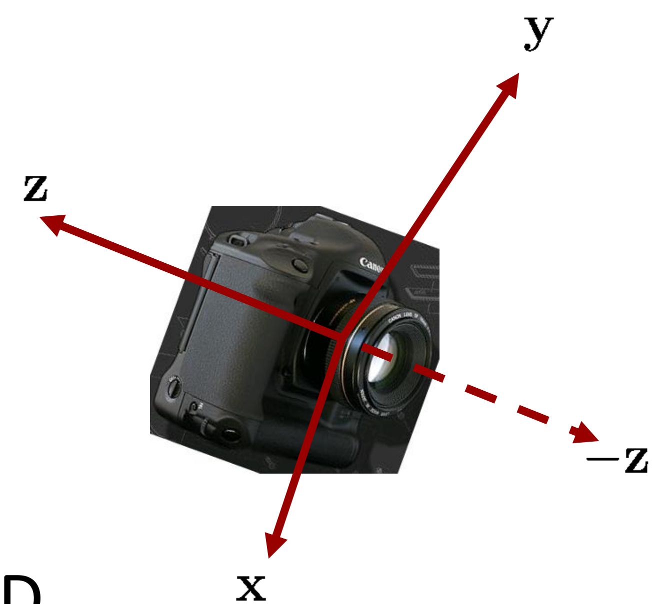


$P_o \Rightarrow P_w \Rightarrow P_c$

$P_w = M P_o \qquad P_c = C P_w \qquad P_c = C M P_o$

Objects in camera coordinates

- We have things lined up the way we like them on screen
  - x to the right
  - y up
  - -z going into the screen
  - Objects to look at are in front of us, i.e. have negative z values
- But objects are still in 3D
- Next: how to project them into 2D



Camera coordinates