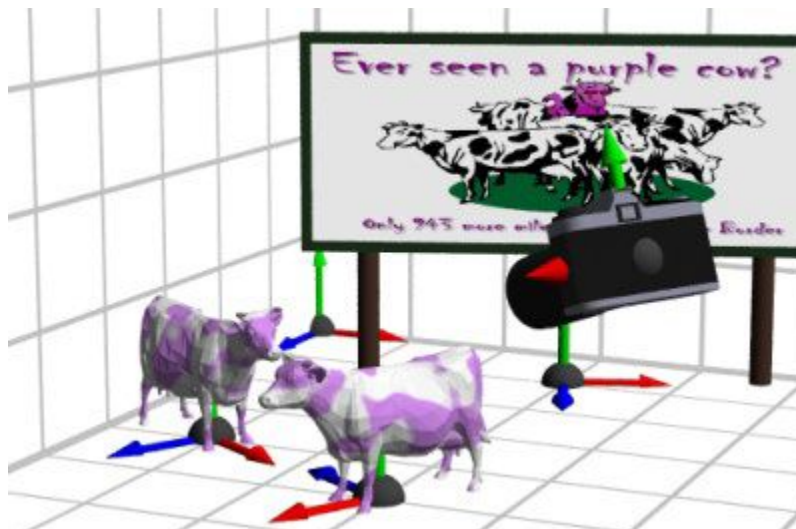


# Camera and Viewing Transforms

Raghavendra G S

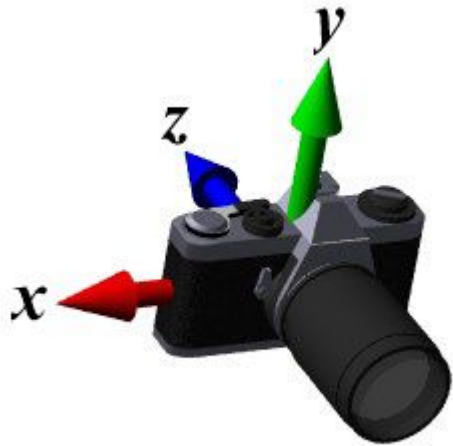
All the world's a stage...



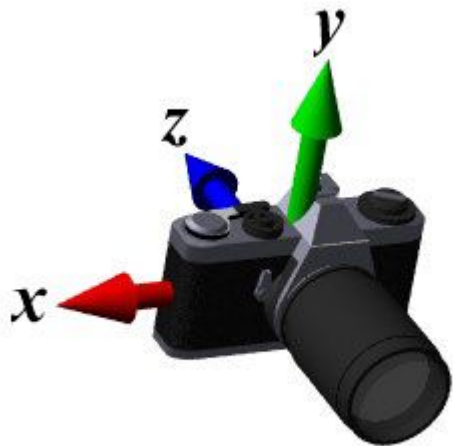
All the world's a stage...



All the world's a stage...



All the world's a stage...



# All the world's a stage...

First calculate the look-at vector and normalize

$$\vec{l} = \mathbf{p} - \mathbf{e} \quad \hat{l} = \frac{\vec{l}}{|\vec{l}|}$$

Compute right vector and normalize

$$\vec{r} = \vec{l} \times \vec{u}_a \quad \hat{r} = \frac{\vec{r}}{|\vec{r}|}$$

Finally, compute up vector by similar procedure.

$$\hat{u} = \hat{r} \times \hat{l}$$

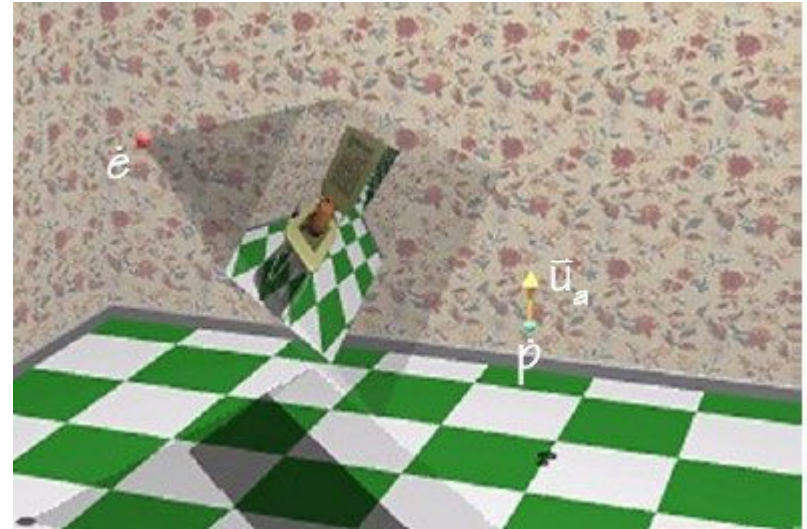




# All the world's a stage...

Also handle translation

$$\begin{bmatrix} \hat{r}_x & \hat{r}_y & \hat{r}_z & 0 \\ \hat{u}_x & \hat{u}_y & \hat{u}_z & 0 \\ -\hat{l}_x & -\hat{l}_y & -\hat{l}_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -e_x \\ 0 & 1 & 0 & -e_y \\ 0 & 0 & 1 & -e_z \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \hat{r} & -\hat{r} \cdot \vec{e} \\ \hat{u} & -\hat{u} \cdot \vec{e} \\ -\hat{l} & \hat{l} \cdot \vec{e} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



# Projection transformation

Orthographic projection



Perspective projection

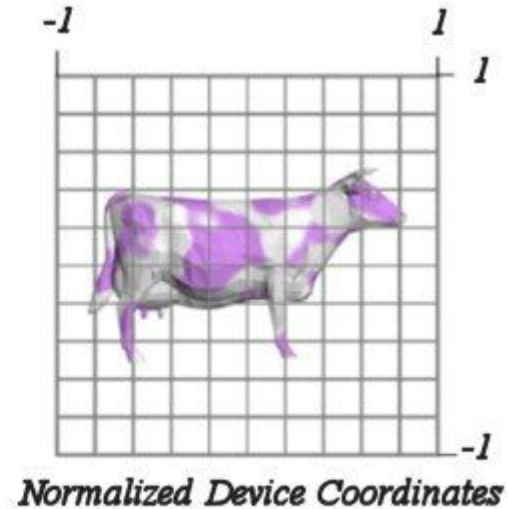
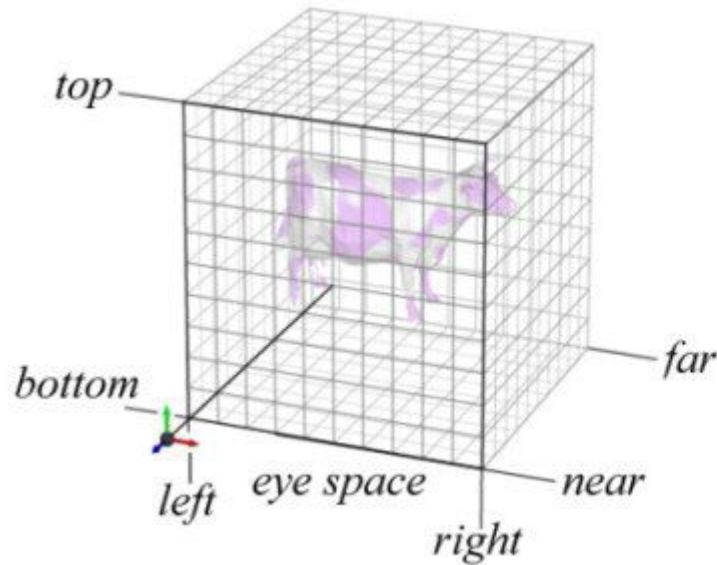




Orthographics projection is simple

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

# Normalized device coordinates



## Normalized device coordinates

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \frac{2}{r-l} & 0 & 0 & \frac{-(r+l)}{r-l} \\ 0 & \frac{2}{t-b} & 0 & \frac{-(t+b)}{t-b} \\ 0 & 0 & \frac{2}{f-n} & \frac{-(f+n)}{f-n} \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

# Projection transformation

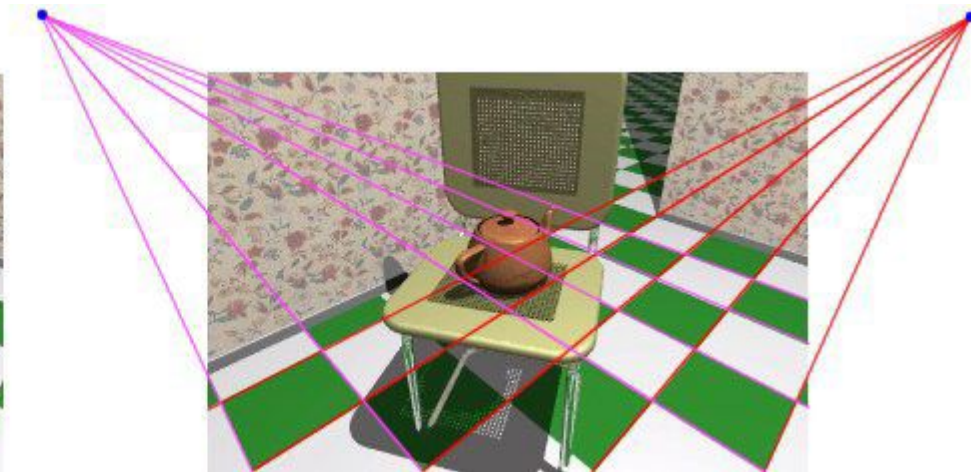
Orthographic projection



Perspective projection



# Perspective projection







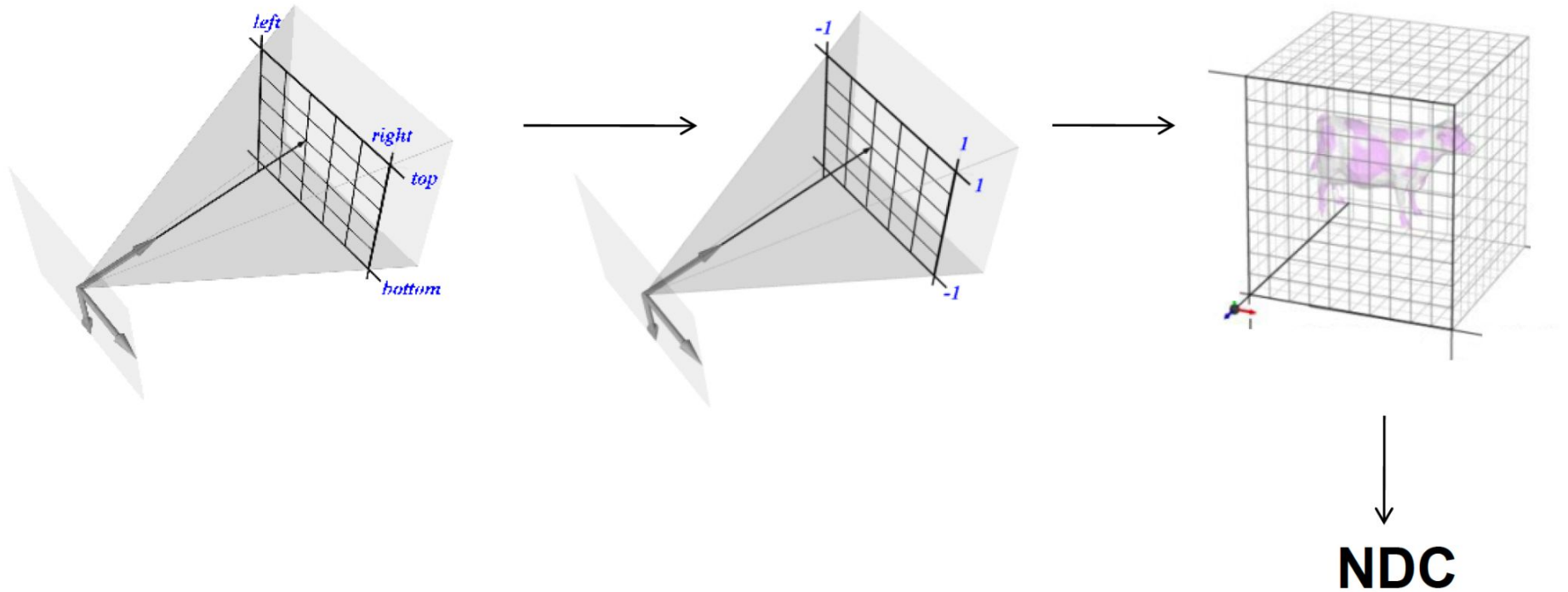
## Perspective projection

$$\begin{bmatrix} wx' \\ wy' \\ wz' \\ w \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

# Perspective projection

$$\begin{bmatrix} wx' \\ wy' \\ wz' \\ w \end{bmatrix} = \begin{bmatrix} \frac{2 \cdot \text{near}}{\text{right} - \text{left}} & 0 & \frac{-(\text{right} + \text{left})}{\text{right} - \text{left}} & 0 \\ 0 & \frac{2 \cdot \text{near}}{\text{top} - \text{bottom}} & \frac{-(\text{top} + \text{bottom})}{\text{top} - \text{bottom}} & 0 \\ 0 & 0 & \frac{\text{far} + \text{near}}{\text{far} - \text{near}} & \frac{-2 \cdot \text{far} \cdot \text{near}}{\text{far} - \text{near}} \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

# Perspective projection



# Perspective projection

Demo

<https://jdeokkim.github.io/projects/mvp-demo/>

Change the parameters in the Model, view and projection matrices to see how the final rendering changes