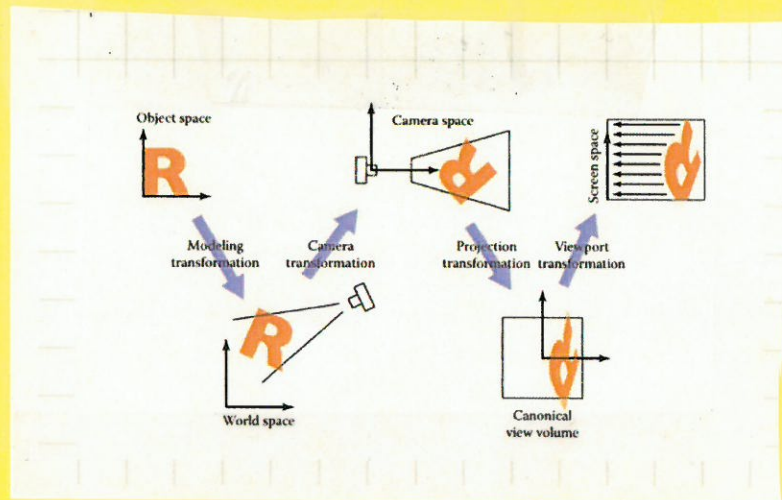


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Assure:- ~~geometry is in canonical view~~  
(all objects that I want to show  
are in  $(x, y, z) \in [-1, 1]^3$ )

- Camera uses orthographic proj

- look in -z direction, ~~to~~



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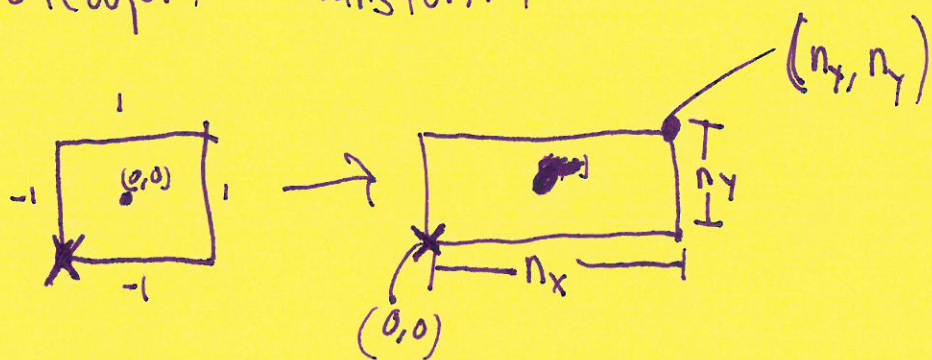
~~Assume: direction is in conventional way  
(all objects that I want to show  
are in (x,y,z) [1,1,1])~~

- Camera has orthographic lens

- looks in -z direction



# Viewport transform

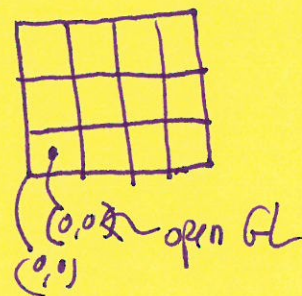


- $x = -1 \rightarrow$  left side of screen  $(0)$
- $x = 1 \rightarrow$  right side of screen  $(n_x) \leftarrow x\text{-width}$
- $y = 1 \rightarrow$  top of the screen  $(n_y) \leftarrow y\text{-width}$
- $y = -1 \rightarrow$  bottom of the screen  $(0)$

$$\begin{bmatrix} X_{\text{screen}} \\ Y_{\text{screen}} \\ 1 \end{bmatrix} = \begin{bmatrix} \cancel{n_x} & 0 & \frac{n_x-1}{2} \\ 0 & \cancel{n_y} & \frac{n_y-1}{2} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X_{\text{canonical}} \\ Y_{\text{canonical}} \\ 1 \end{bmatrix}$$

In 3D

$$M_{vp} = \begin{bmatrix} \frac{n_x}{2} & 0 & 0 & \frac{n_x-1}{2} \\ 0 & \frac{n_y}{2} & 0 & \frac{n_y-1}{2} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$





Viewport transform



- (0) norm to left edge  $\leftarrow 1 - x$
- right  $\rightarrow x \rightarrow (0)$  norm to right edge  $\leftarrow 1 = x$
- bottom  $\rightarrow y \rightarrow (0)$  norm to top of screen  $\leftarrow 1 = y$
- (0) norm to bottom of screen  $\leftarrow 1 = y$

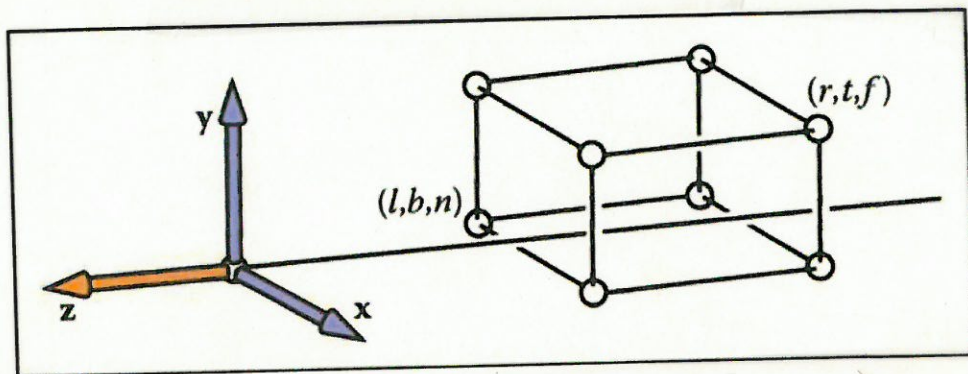
$$\begin{bmatrix} \text{norm } x \\ \text{norm } y \\ 1 \end{bmatrix} = \begin{bmatrix} 1-x \\ y \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} 1-x \\ y \\ z \\ 1 \end{bmatrix}$$





# Orthographic Proj



$x=l$  (left plane)  
 $x=r$  (right plane)  
 $y=b$  (bottom plane)  
 $y=t$  (top plane)  
 $z=n$  (near plane)  
 $z=f$  (far plane)

$$\begin{aligned}
 l &\leq x \leq r \\
 \Leftrightarrow 0 &\leq x-l \leq r-l \\
 0 &\leq \frac{x-l}{r-l} \leq 1 \\
 0 &\leq 2\frac{x-l}{r-l} \leq 2 \\
 -1 &\leq 2\frac{x-l}{r-l} - 1 \leq 1 \\
 -1 &\leq 2\frac{x-l}{r-l} - \frac{r-l}{r-l} \leq 1 \\
 -1 &\leq \frac{2x-2l-r+l}{r-l} \leq 1 \\
 -1 &\leq \frac{2x-l-r}{r-l} \leq 1 \\
 -1 &\leq \frac{2}{r-l}x - \frac{r+l}{r-l} \leq 1
 \end{aligned}$$

Repeat derivation for  $y$  &  $z$





$$x \geq 0$$

$$1 - x \geq 0 \Leftrightarrow$$

$$x \leq 1$$

$$x \geq 0$$

$$1 - x \geq 0$$

$$x \leq 1$$

$$x \leq 1$$

$$x \leq 1$$

$$x \leq 1$$

(left place)

(right place)

(bottom place)

(top place)

(near place)

(far place)

$$x = 0$$

$$x = 1$$

$$x = 0$$

$$x = 1$$

$$x = 0$$

$$x = 1$$

Report deviation for x



$$M_{\text{orth}} = \begin{bmatrix} \frac{2}{r-l} & 0 & 0 & -\frac{r+l}{r-l} \\ 0 & \frac{2}{t-b} & 0 & -\frac{t+b}{t-b} \\ 0 & 0 & \frac{2}{n-f} & -\frac{n+f}{n-f} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

w/ open GL  $n \leq -z \leq f$

$$M_{\text{orth}}^{\text{GL}} = \begin{bmatrix} \times & \times & \times & \times \\ \times & \times & \times & \times \\ \times & \times & -\frac{2}{n+f} & -\frac{n+f}{n+f} \\ \times & \times & \times & \times \end{bmatrix}$$

result

$$\begin{bmatrix} x_{\text{pixel}} \\ y_{\text{pixel}} \\ z_{\text{canonical}} \\ 1 \end{bmatrix} = M_{\text{vp}} M_{\text{orth}} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$



$$\begin{bmatrix} \frac{2+7}{2-7} & 1 & 0 & 0 & \frac{8}{5} \\ \frac{2+7}{2-7} & 1 & 0 & 0 & 0 \\ \frac{2+7}{2-7} & 1 & 0 & 0 & 0 \\ \frac{2+7}{2-7} & 1 & 0 & 0 & 0 \\ \frac{2+7}{2-7} & 1 & 0 & 0 & 0 \\ \frac{2+7}{2-7} & 1 & 0 & 0 & 0 \end{bmatrix} = \text{H20} \text{ M}$$

$$7 \geq 5 - 24 \quad \text{H20} \text{ M}$$

$$\begin{bmatrix} \times & \times & \times & \times \\ \times & \times & \times & \times \\ \frac{4+7}{7+7} & \frac{5}{7+7} & \times & \times \\ \times & \times & \times & \times \end{bmatrix} = \text{H20} \text{ M}$$

$$\begin{bmatrix} \times \\ \times \\ \times \\ \times \end{bmatrix} \text{H20} \text{ M} = \begin{bmatrix} \text{H20} \text{ M} \\ \text{H20} \text{ M} \\ \text{H20} \text{ M} \\ \text{H20} \text{ M} \end{bmatrix}$$