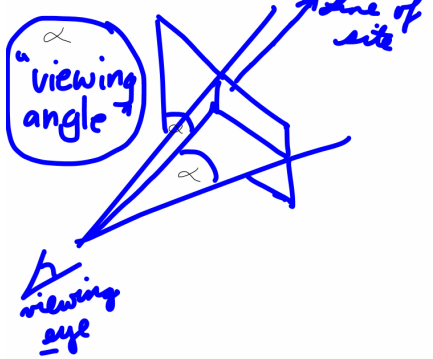
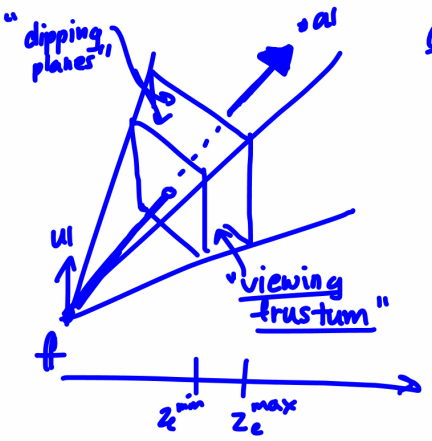
Camera Viewing Model "Pinhole Camera"

illustrations...





Input parameters

ff from point
al at point
up up vector
z_e^{min}, z_e^{max} : "depth values defining front" & back clipping planes

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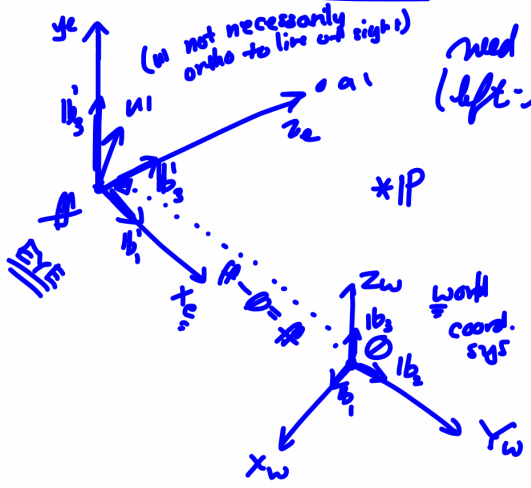
Coordinate System involved:



need 3 basis vectors of (left-handed) eye coord. system:

$$b_3' = \frac{al - ff}{\|al - ff\|} \quad \leftarrow \text{length of } (al - ff)$$

$$b_1' = \frac{b_2' \times up}{\|b_2' \times up\|} \quad \leftarrow \text{cross product}$$

$$b_2' = b_1' \times b_3'$$

(I) World to Eye transformation

2 transformations map world sys to eye sys.:

$$M_1 = \left(\begin{array}{ccc|c} [\,b_1'\,] & & & 0 \\ [\,b_2'\,] & & & 0 \\ [\,b_3'\,] & & & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right) \quad ; \quad M_2 = \left(\begin{array}{ccc|c} 1 & 0 & 0 & f_x \\ 0 & 1 & 0 & f_y \\ 0 & 0 & 1 & f_z \\ \hline 0 & 0 & 0 & 1 \end{array}\right)$$

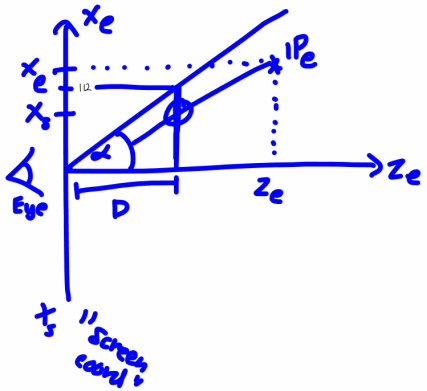
⇒ Apply "inverses" of these two transforms in REVERSE order to get

$$P_e = \left(\begin{array}{ccc|c} [\,b_1'\,] & & & 0 \\ [\,b_2'\,] & & & 0 \\ [\,b_3'\,] & & & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right) \left(\begin{array}{ccc|c} 1 & 0 & 0 & -f_x \\ 0 & 1 & 0 & -f_y \\ 0 & 0 & 1 & -f_z \\ \hline 0 & 0 & 0 & 1 \end{array}\right) P_w$$

P_e: point in Eye coords. ; P_w: point in WORLD coords.

(II) Eye_To_Screen / Eye_To_NDC

← normalized device coordinates



needed: x_s (y_s)

$\tan\alpha = \frac{1}{2D} \rightsquigarrow D = \frac{1}{2\tan\alpha}$

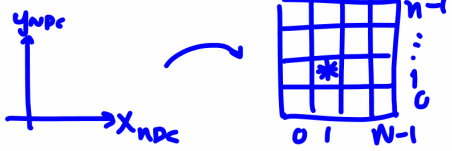
similar triangles:

$\frac{x_s}{D} = \frac{x_e}{z_e} \rightarrow x_s = D - \frac{x_e}{z_e}$

$$x_s = \frac{1}{2\tan\alpha} \cdot \frac{x_e}{z_e}$$

$$y_s = \frac{1}{2\tan\alpha} \cdot \frac{y_e}{z_e}$$

(III) NDC_To_Pix

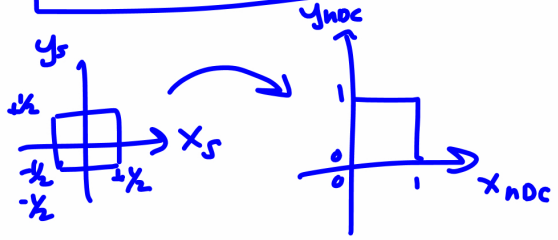


N × N pixels

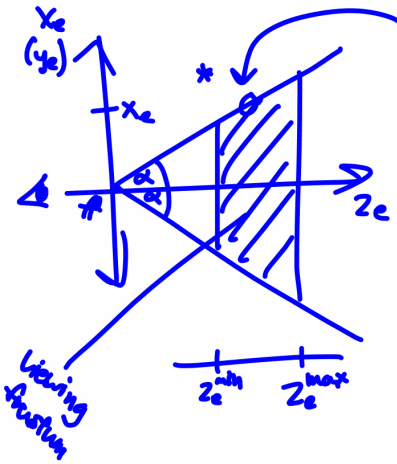
$$\begin{pmatrix} I \\ J \end{pmatrix} = \begin{pmatrix} \text{round}\left((N-1)\, x_{NDC}\right) \\ \text{round}\left((N-1)\, y_{NDC}\right) \end{pmatrix}$$

mapping to NDCs

$$\begin{pmatrix} x_{NDC} \\ y_{NDC} \end{pmatrix} = \begin{pmatrix} 1/2 \\ 1/2 \end{pmatrix} + \begin{pmatrix} x_s \\ y_s \end{pmatrix} = \begin{pmatrix} 1/2 \\ 1/2 \end{pmatrix} + \frac{1}{2\tan\alpha} \begin{pmatrix} x_e/z_e \\ y_e/z_e \end{pmatrix}$$



clipping the "3D world" against viewing frustum:



point on boundary:

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