Orthographic viewing pipeline

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Plan

- Orthographic viewing pipeline

Review: 3D Observer setup

- Where do we assume the observer is looking at the viewing volume from? What do we call this point?
  - (0.5, 0.5, 1), the **View Reference Point (VRP)**.
- What point is the observer looking at?
  - (0.5, 0.5, 0).
- What are our observer coordinate axes called?
  - x ($\vec{U}$), y ($\overrightarrow{VUP}$), z ($\overrightarrow{VPN}$)
- Which one can we figure out first? How do we determine the rest?
  - $\overrightarrow{VPN}$. Assume reasonable $\overrightarrow{VUP}$. Cross product to find $\vec{U}$ (and update $\overrightarrow{VUP}$).

View Transformation Matrix (VTM)

- Recall the 2D chain of transformation matrices...for 3D let's merge them into a single matrix: **View Transformation Matrix (VTM) V**.
  - What will the dimensions of the combined matrix be for 3D?
- We will ultimately left-multiply the data D with V to get to screen coordinates.
- For consistency with right-hand coord system, note $\vec{U} = -\vec{X}, \overrightarrow{VPN} = -\vec{Z}$.
- Let's step through the workflow is a specific data example: visualizing a normalized 3D cloud of dots in the shape of an F.

Step 1) Identity matrix

- $V = I_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

Step 2) Translate VRP to view volume origin.

$$V = T(-VRP_x, -VRP_y, -VRP_z)V = \begin{bmatrix} 1 & 0 & 0 & -VRP_x \\ 0 & 1 & 0 & -VRP_y \\ 0 & 0 & 1 & -VRP_z \\ 0 & 0 & 0 & 1 \end{bmatrix} V$$

Step 3) Normalize observer coordinate axes

$$\vec{u} = \frac{\vec{u}}{||\vec{u}||_2}$$

$$\overrightarrow{VUP} = \frac{\overrightarrow{VUP}}{||\overrightarrow{VUP}||_2}$$

$$\overrightarrow{VPN} = \frac{\overrightarrow{VPN}}{||\overrightarrow{VPN}||_2}$$

where $||v||_2$ means $\sqrt{v_x^2 + v_y^2 + v_z^2}$.

Step 4) Align view volume and observer coordinate axes

$$V = \begin{bmatrix} u_x & u_y & u_z & 0 \\ VUP_x & VUP_y & VUP_z & 0 \\ VPN_x & VPN_y & VPN_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} V$$

Step 5) Scale to normalize view volume

$$V = S(\frac{1}{E_x}, \frac{1}{E_y}, \frac{1}{E_z})V$$

where $E = (E_x, E_y, E_z)$ is the view volume extent.

Step 6) Scale to screen coordinates, invert x, y axes

$$V = S(-s_x, -s_y, 1)V$$

Step 7) Translate by 1/2 screen size

$$V = T(\frac{s_x}{2}, \frac{s_y}{2}, 0)V$$