Orthographic viewing pipeline

Oliver W. Layton

CS251: Data analysis and visualization

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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 (\(\vec{VP}\)), z (\(\vec{VN}\))

• Which one can we figure out first? How do we determine the rest?
  • \(\vec{VN}\). Assume reasonable \(\vec{VP}\). Cross product to find \(\vec{U}\) (and update \(\vec{VP}\)).
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 $\mathbf{U} = -\mathbf{X}$, $\mathbf{V} \mathbf{P} \mathbf{N} = -\mathbf{Z}$.
  
  - Let's step through the workflow in 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

\[ \tilde{u} = \frac{\vec{u}}{\|\vec{u}\|_2} \]

\[ \vec{VUP} = \frac{\vec{VUP}}{\|\vec{VUP}\|_2} \]

\[ \vec{VPN} = \frac{\vec{VPN}}{\|\vec{VPN}\|_2} \]

where \( \|v\|_2 \) means \( \sqrt{v_x^2 + v_y^2 + v_z^2} \).
Step 4) Align view volume and observer coordinate axes

\[ V = \begin{bmatrix}
u_x & u_y & u_z & 0 \\
VUP_x & VUP_y & VUP_z & 0 \\
VPN_x & VPN_y & VPN_z & 0 \\
0 & 0 & 0 & 1
\end{bmatrix} \]
Step 5) Scale to normalize view volume

\[ V = S \left( \frac{1}{E_x}, \frac{1}{E_y}, \frac{1}{E_z} \right) V \]

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

\[ V = T\left(\frac{s_x}{2}, \frac{s_y}{2}, 0\right)V \]