Viewing in 3D

Overview

- 3D Viewing Pipeline/Coordinate Systems
- Camera Specification and Transform
- View Volume

3D Viewing/Rendering Pipeline

Synthetic Camera Model

- Pin-hole camera model (all objects in perfect focus)
- A convenient, flexible approach to specifying viewing parameters.
- Allows operations such as fly-by, swivel, zoom and head-tilt through 3D environments.
- All specification in a viewing (camera or eye) coordinate system.

Camera Specification (simplified)

In World Coordinates

- View Point (viewer position or center of projection with view direction $\vec{N}$)
- View coordinate system defined with respect to view point.

In View Coordinates

- View plane onto which objects are projected to form a 2D image.
- View frustum (volume) which defines the field of view.
Alternative Specification

- **Window**, using field of view angles \((\theta_u, \theta_v)\) and \(d\), the distance to the projection plane.
The Viewing Transformation

\[ M_{wv} \text{ maps} \]

\[
(0, 0, 0) \implies (r_x, r_y, r_z)
\]
\[
(X, Y, Z) \implies (U, V, N)
\]

Hence

\[
\vec{U}^T = \vec{M}_{x}^T = \text{left column of } \vec{M}
\]
\[
\vec{V}^T = \vec{M}_{y}^T = \text{middle column of } \vec{M}
\]
\[
\vec{N}^T = \vec{M}_{z}^T = \text{right column of } \vec{M}
\]
The Viewing Transformation

\[ M = \begin{bmatrix} \vec{U}^T & \vec{V}^T & \vec{N}^T \end{bmatrix} = \begin{bmatrix} u_x & v_x & n_x \\ u_y & v_y & n_y \\ u_z & v_z & n_z \end{bmatrix} \]

\( M \) is the rotation matrix that transforms \((\vec{X}, \vec{Y}, \vec{Z})\) to \((\vec{U}, \vec{V}, \vec{N})\).

Determining View Parameters

- Specify view point and view direction \( \vec{N}' \) in world coordinates (e.g., point camera at origin or center of scene)
- Normalize \( \vec{N} \) to unit length
  \[ \vec{N} = \frac{\vec{N}'}{|\vec{N}'|} \]
- Specify “\( \vec{U}' \vec{P} \)” vector. Normalize to unit length
  \[ \vec{V}' = \frac{\vec{U}' \vec{P}}{|\vec{U}' \vec{P}|} \]
- Calculate \( \vec{U} \) and \( \vec{V} \)
  \[ \vec{U} = \vec{N} \times \vec{V}', \vec{V} = \vec{U} \times \vec{N} \]

View Volume

- The volume of 3D space that is projected and displayed.
- Volume defined by a 2D window on the projection plane and front and back clipping planes (hither/yon, near/far).
- View volume is specified in camera coordinates.
- View volume is a truncated frustum.