Drawing in 3D: Visibility

CSCI 4229/5229
Computer Graphics
Fall 2020

Differences from 2D

- The third dimension (doh!)
- Depth perception
- Hidden lines and surfaces
- Realism
  - Lighting
  - Shading
  - Texture

What is Visible?

- We see only the OUTSIDE of objects
  - Approximated by flat planes
- We cannot see the BACK side of objects
  - About half the planes are invisible
- We cannot see obscured objects
  - Interference zones
  - Hidden Line/Hidden Surface Algorithms

Single Convex Object

- Only surfaces with +Z normal are visible
  - How do we tell front from back on the same surface
- Order of drawing surfaces are not important

Multiple Convex Objects

- Order objects from far to near
- Rely on *painter's algorithm* to *paint over* obscured part of objects
  - Device must support erasing
- Does not work for concave objects
- Does not work when objects intersect

Projection Z for Simple Rotation

glRotatef(ph , 1,0,0);
glRotatef(th , 0,1,0);

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\phi & -\sin\phi \\ 0 & \sin\phi & \cos\phi \end{pmatrix} \begin{pmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{pmatrix}$$

$$= \begin{pmatrix} \cos\theta & 0 & \sin\theta \\ \sin\phi\sin\theta & \cos\phi & -\cos\theta\sin\phi \\ -\sin\theta\cos\phi & \sin\phi & \cos\theta\cos\phi \end{pmatrix}$$

Z-Buffering

- Store depth (z) on a pixel by pixel basis
- Draw a new pixel only if it is nearer than existing z value for that pixel
  - Must initialize z-buffer before drawing
- Requires hardware support
  - 8/16/24/32 bits
  - “z-fighting” when dz too large
  - floating point Z buffer new in OpenGL 3.0

Z-buffering + Face Culling

- Z-buffering ensures correct rendering
- Face Culling eliminates entire backward facing polygons (possibly lots of pixels)
  - Performance gain (on average 2x)
  - Requires more care in constructing objects
- Hint: Use Z-buffering except in rare instances

OpenGL Notes

- Enable Z-buffer
  - glutInitDisplayMode(GLUT_DEPTH);
  - glEnable(GL_DEPTH_TEST);
    - Typically on for whole scene
- Enable face culling
  - glEnable(GL_FACE_CULL);
  - glFrontFace(dir)
    - GL_CCW (default) or GL_CW
  - glCullFace(face)
    - GL_BACK (default), GL_FRONT or GL_FRONT_AND_BACK