CS 536
Computer Graphics

3D Viewing
Week 8, Lecture 15
David Breen, William Regli and Maxim Peysakhov
Department of Computer Science
Drexel University

Overview

- 3D Viewing
- 3D Projective Geometry
- Mapping 3D worlds to 2D screens
- Introduction and discussion of homework #4

Lecture Credits: Most pictures are from Foley/VanDam; Additional and extensive thanks also goes to those credited on individual slides

Recall the 2D Problem

- Objects exist in a 2D WCS
- Objects clipped/transformed to viewport
- Viewport transformed and drawn on 2D screen

From 3D Virtual World to 2D Screen

- Not unlike The Allegory of the Cave (Plato’s "Republic", Book VII)
- Viewers see a 2D shadow of 3D world
- How do we create this shadow?
- How do we make it as realistic as possible?

History of Linear Perspective

- Renaissance artists
  - Alberi (1435)
  - Della Francesca (1470)
  - Da Vinci (1490)
  - Pâlerin (1505)
  - Dürer (1525)

The 3D Problem: Using a Synthetic Camera

- Think of 3D viewing as taking a photo:
  - Select Projection
  - Specify viewing parameters
  - Clip objects in 3D
  - Project the results onto the display and draw

Dürer: Measurement Instruction with Compass and Straight Edge

The 3D Problem: (Slightly) Alternate Approach

- Think of 3D viewing as taking a photo:
  - Select Projection
  - Specify viewing parameters
  - Perform trivial accept/reject test in 3D
  - Project the results onto the image plane
  - Clip lines to world window
  - Transform to viewport and draw

Creating a 3D View: Parameterizing the Camera

Basic Ideas:
- Camera has
  - location
  - lens (focal length)
  - projection type
- World has
  - lights
  - colors
  - objects (visible and hidden surfaces)

Planar Geometric Projections

- Projections onto Planes
  - Consider the line AB
- Perspective Projection
  - a single viewing location
  - similar to a photograph
- Parallel Projection
  - viewing location at ∞
  - good for capturing shape and dimensions

Perspective Projections

- Idea: lines not parallel to projection plane converge to a vanishing point (VP)
- Lines extending to axis VPs are parallel to either x, y or z axes
- Projections characterized by # of axes cut by the projection plane

Perspective Projections: Example

- One-point perspective
- z axis vanishing point
- Projection plane cuts only the z axis

Perspective Projections: Example (cont.)

- Parameters:
  - VRP(WC) (16, 0.54)
  - VPN(WC) (1.0, 1)
  - VUP(WC) (0, 1.0)
  - PRP(VRC) (0.25, 20√2)
  - window(VRC) (-20.20, -5.35)
  - projection perspective
Perspective Projections:
Example (cont.)

• Showing the object relative to the view plane, w/ overhead view

Perspective Projections:
Example (rotating VUP)

• Same parameters as before
• VUP rotated away from y by 10°

Perspective Projections:
Example (centering)

• Parameters:
  – VRP(WC) (0,0,54)
  – VPN(WC) (0,0,1)
  – VUP(WC) (0,1,0)
  – PRP(VRC) (8,6,30)
  – window(VRC) (-1,7,-1,17)
  – projection perspective

Perspective Projections:
Example

• Two-point perspective, cutting x and z
• Used commonly in CAD
• Three-point projections are not much different

Parallel Projections

• Two types, depending on projection direction vector and projection plane normal
• Orthographic Projections
  – both vectors are the same
  – front-, top-, plan-, and side-elevation projections
• Oblique Projections
  – vectors are different
**Parallel Projections: Example**

- Parameters:
  - VRP(WC) \((0,0,0)\)
  - VPN(WC) \((0,0,1)\)
  - VUP(WC) \((0,1,0)\)
  - PRP(VRC) \((8,8,100)\)
  - window(VRC) \((-1.17,-1.17)\)
  - projection parallel

---

**Axonometric Orthographic Projections**

- Projections to planes not normal to principle coordinate axes, i.e. showing several faces
- The *Isometric Projection*
  - very common
  - projection plane at equal angles to each of the coordinate axes
  - 8 of them, one in each octant

---

**Oblique Projections**

- Projection direction and Projection plane normal differ
- Preserves certain angles and distances
- Good for use in illustration and measurement

---

**Oblique Projections**

- Cavalier - all lines (including receding lines) are made to their true length
- Cabinet - receding lines are shortened by one-half their true length to approximate perspective foreshortening
Oblique Projections are Good for Illustrations

Projection Relationships

- As the distance to the projection point moves toward infinity, the two projection families unify
  - Projection plane
  - Direction to center of projection
  - Distance to CoP