CS4620/5620: Lecture 6

Perspective

Announcements

• HW 1 out
  – Due in two weeks (Mon 9/17)
  – Due right before class
  – Turn it in online AND in class (preferably)
Transforming normal vectors

- Transforming surface normals
  - differences of points (and therefore tangents) transform OK
  - normals do not --> use inverse transpose matrix

\[
\begin{align*}
  \mathbf{t} \cdot \mathbf{n} &= \mathbf{t}^T \mathbf{n} = 0 \\
  \text{want: } M \mathbf{t} \cdot X \mathbf{n} &= \mathbf{t}^T M^T X \mathbf{n} = 0 \\
  \text{so set } X &= (M^T)^{-1} \\
  \text{then: } M \mathbf{t} \cdot X \mathbf{n} &= \mathbf{t}^T M^T (M^T)^{-1} \mathbf{n} = \mathbf{t}^T \mathbf{n} = 0
\end{align*}
\]

History of projection

- Ancient times: Greeks wrote about laws of perspective
- Renaissance: perspective is adopted by artists

Duccio c. 1308
History of projection

• Later Renaissance: perspective formalized precisely

http://smarthistory.khanacademy.org/Brunelleschi.html
Plane projection in drawing:
like ray tracing

Durer, 1525

Plane projection in drawing:
hardware pipeline rendering

Basis Of Perspective — Lines Of Sight Through A Picture Plane

The concept of the picture plane may be better understood by looking through a window or other transparent plane from a fixed viewpoint. Your lines of sight, the multitude of straight lines leading from your eye to the subject, will all intersect this plane. Therefore, if you were to reach out with a loose pencil and draw the image of the subject in this plane you would be “transferring” the infinite number of points of intersection of sight rays and plane. The result would be that you would have “transferred” a real three-dimensional object to a two-dimensional plane.
Plane projection in photography

• This is another model for what we are doing
  – applies more directly in realistic rendering

Ray generation vs. projection

• Viewing by projection
  – start with 3D point
  – compute image point that it projects to
  – do this using transforms

• Viewing in ray tracing
  – start with image point
  – compute 3D point that projects to that point using ray
  – do this using geometry

• Inverse processes
Classical projections

- Emphasis on cube-like objects
  – traditional in mechanical and architectural drawing

Planar Geometric Projections

Parallel

Orthographic

Multiview Orthographic

Axonometric

Perspective

Oblique

One-point

Two-point

Three-point

Axonometric

[after Carlbom & Paciorek 78]
Parallel projection

- Viewing rays are parallel rather than diverging
  - like a perspective camera that's far away

Multiview orthographic

Figure 2.1. Multiview orthographic projection: plan, elevations, and section of a building.

[Carlbom & Paciorek 78]
Multiview orthographic

- projection plane parallel to a coordinate plane
- projection direction perpendicular to projection plane

Off-axis parallel

**axonometric**: projection plane perpendicular to projection direction but not parallel to coordinate planes

**oblique**: projection plane parallel to a coordinate plane but not perpendicular to projection direction.
“Orthographic” projection

- In graphics usually we lump axonometric with orthographic
  - projection plane perpendicular to projection direction
  - image height determines size of objects in image

Perspective

**one-point:** projection plane parallel to a coordinate plane (to two coordinate axes)

**two-point:** projection plane parallel to one coordinate axis

**three-point:** projection plane not parallel to a coordinate axis
**Perspective projection (normal)**

- Perspective is projection by lines through a point; “normal” = plane perpendicular to view direction
  - magnification determined by:
    - image height
    - object depth
    - image plane distance
  - f.o.v. $\alpha = 2 \arctan(h/(2d))$
  - $y' = d \frac{y}{z}$
  - “normal” case corresponds to common types of cameras

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**View volume**

**orthographic vs. perspective**
Field of view (or f.o.v.)

- The angle between the rays corresponding to opposite edges of a perspective image
  - easy to compute only for “normal” perspective
  - have to decide to measure vert., horiz., or diag.
- In cameras, determined by focal length
  - confusing because of many image sizes
  - for 35mm format (36mm by 24mm image)
    - 18mm = 67° v.f.o.v. — super-wide angle
    - 28mm = 46° v.f.o.v. — wide angle
    - 50mm = 27° v.f.o.v. — “normal”
    - 100mm = 14° v.f.o.v. — narrow angle (“telephoto”)

Choice of field of view

- In photography, wide angle lenses are specialty tools
  - “hard to work with”
  - easy to create weird-looking perspective effects
- In graphics, you can type in whatever f.o.v. you want
  - and people often type in big numbers!
Perspective distortions

- Lengths

Specifying perspective projections

- Many ways to do this
  - common: from, at, up, v.f.o.v. (but not for shifted)

- One way (used in ray tracer):
  - viewpoint, view direction, up
    - establishes location and orientation of viewer
    - view direction is the direction of the center ray
  - image width, image height, projection distance
    - establishes size and location of image rectangle