Viewing

Viewing

- map 3d world points to 2d image plane positions
  - two stages

- viewing transform
  - map world coordinates to camera coordinates
  - change of coordinate system
- projection
  - map camera coordinates to image plane coordinates
  - orthographic or perspective

Viewing Transform

- any affine transform

- useful to define one for our viewer model
  - defined by origin, forward, up

- computed by
  - orthonormalilze frame from the vectors
  - construct a matrix for a change of coord. syst.
  - seen I previous lecture

Projection

- in general, function that transforms points from *m*-space to *n*-space where *m*>*n*

- in graphics, maps 3d points to 2d image coordinates

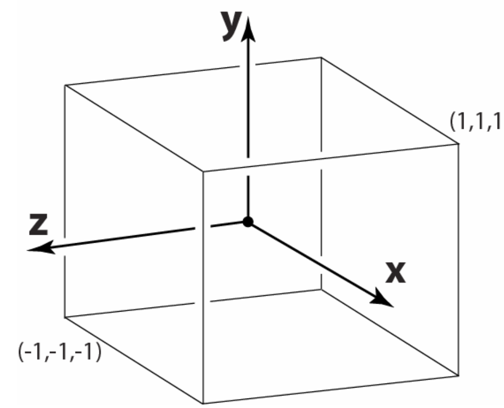
Canonical View Volume

- the result of a projection
  - everything out of it will not be rendered

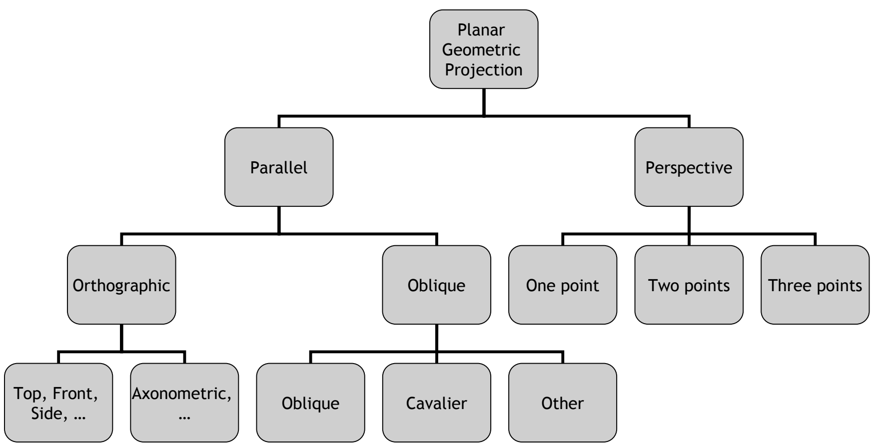
- (x,y) are image plane coordinates in [-1,1]x[-1,1]
- keep around the z normalized in [-1,1]
  - define a near and far distance
    - everything on the *near plane* has z=1
    - everything on the *far plane* has z=-1
    - inverted z!
  - will become useful later on

Canonical View Volume

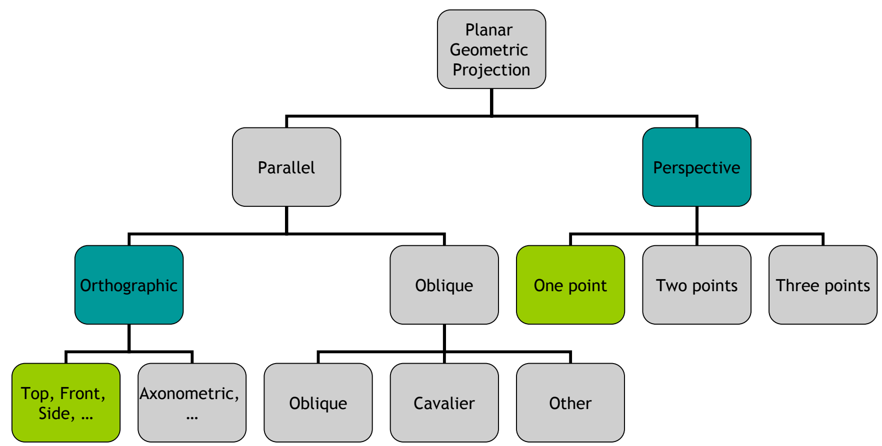
- why introducing near/far clipping planes?
  - mostly to reduce z range, motivated later



Taxonomy of projections

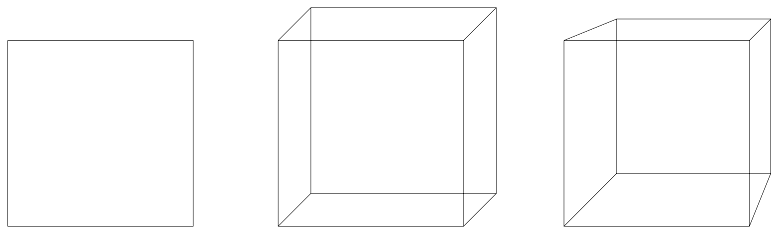


Taxonomy of projections



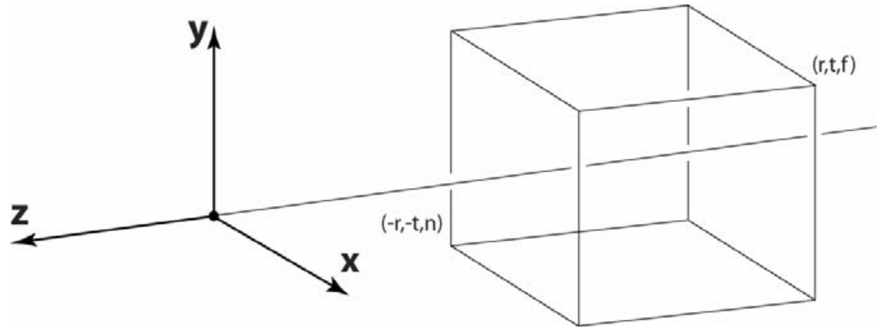
Taxonomy of projections

Orthographic Oblique Perspective



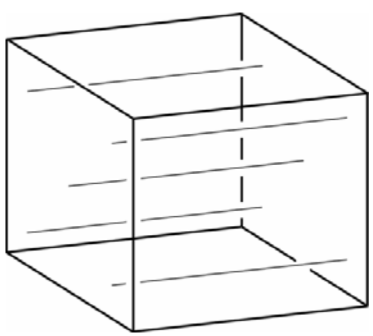
Orthographic Projection

- box view volume



Orthographic Projection

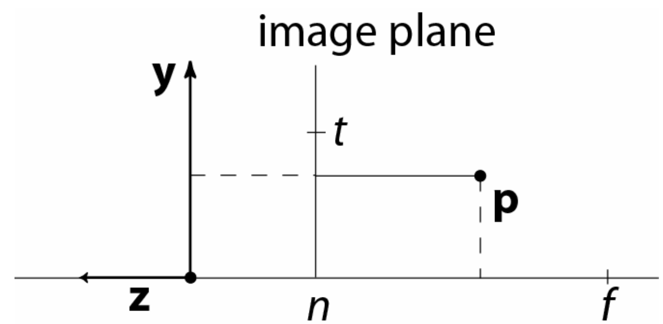
- viewing rays are parallel



Orthographic Projection

- centered around z axis

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} x/r \\ y/t \\ (2z-n-f)/(n-f) \end{bmatrix}$$



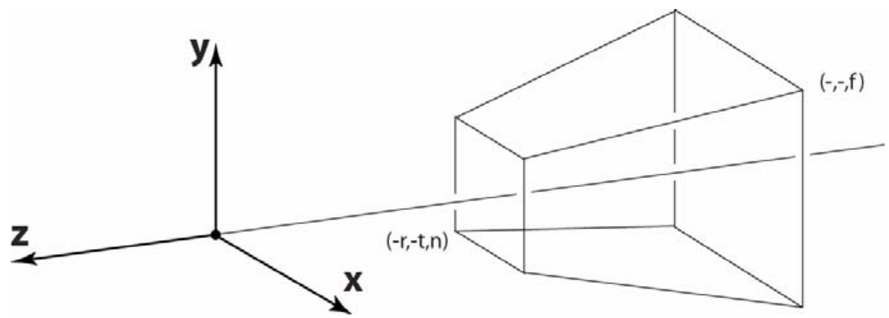
Orthographic Projection

- write in matrix form

$$\begin{bmatrix} 1/r & 0 & 0 & 0 \\ 0 & 1/t & 0 & 0 \\ 0 & 0 & 2/(n-f) & -(n+f)/(n-f) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

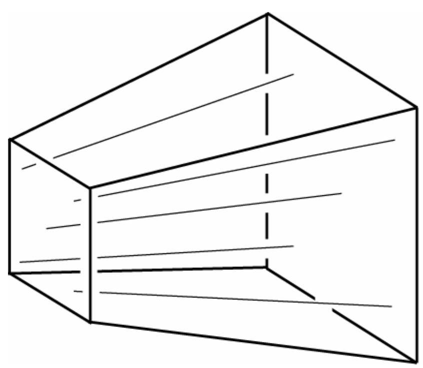
Perspective Projection

- truncated pyramid view volume



Perspective Projection

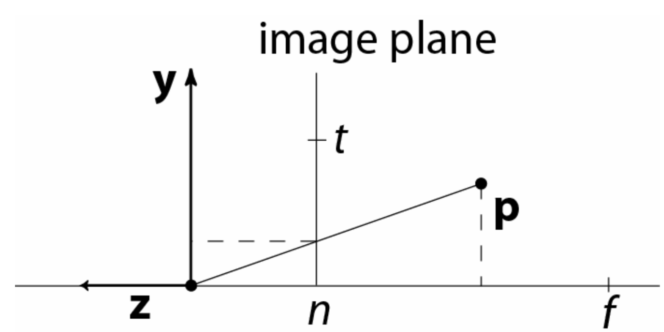
- viewing rays converge to a point



Perspective Projection

- centered around z axis

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} (nx)/(rz) \\ (ny)/(tz) \\ \ldots \end{bmatrix}$$



Perspective Projection

- write it in matrix form
  - use homogeneous coordinates, since w≠1!

$$\begin{bmatrix} n/r & 0 & 0 & 0 \\ 0 & n/t & 0 & 0 \\ 0 & 0 & (f+n)/(n-f) & -2fn/(n-f) \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

Projection Properties

- orthographic projection is affine
- perspective projection is not
  - *does not map origin to origin*
  - maps lines to lines
  - *parallel lines do not remain parallel*
  - *length ratios are not preserved*
  - closed under composition

More on projections

- the given matrices are simplified cases
- should be able to define more general cases
  - non-centered windows
  - non-square windows
- can find derivation in the Shirley's book
  - but it is a simple extension of these

- note that systems have different conventions
  - pay attention at their definition
  - sometimes names are the same

General Orthographic Projection

$$\begin{bmatrix} \frac{2}{r-l} & 0 & 0 & \frac{l+r}{l-r} \\ 0 & \frac{2}{t-b} & 0 & \frac{b+t}{b-t} \\ 0 & 0 & \frac{2}{n-f} & \frac{n+f}{n-f} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

General Perspective Projection

$$\begin{bmatrix} \frac{2n}{r-l} & 0 & \frac{l+r}{l-r} & 0 \\ 0 & \frac{2n}{t-b} & \frac{b+t}{b-t} & 0 \\ 0 & 0 & \frac{f+n}{n-f} & \frac{2fn}{f-n} \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

