Faculty of German Engineering and Industrial Management Education - FDIBA

Introduction to Computer Graphics

Projections

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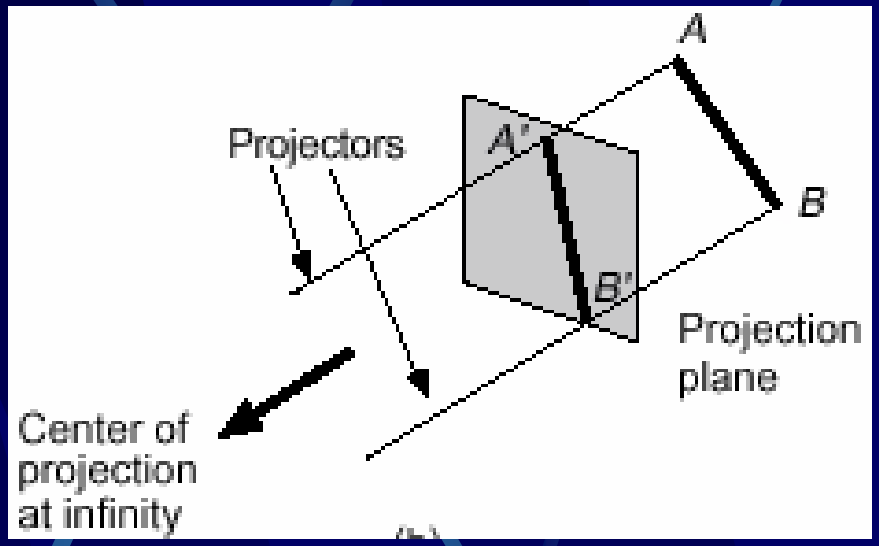
Why do we use projections

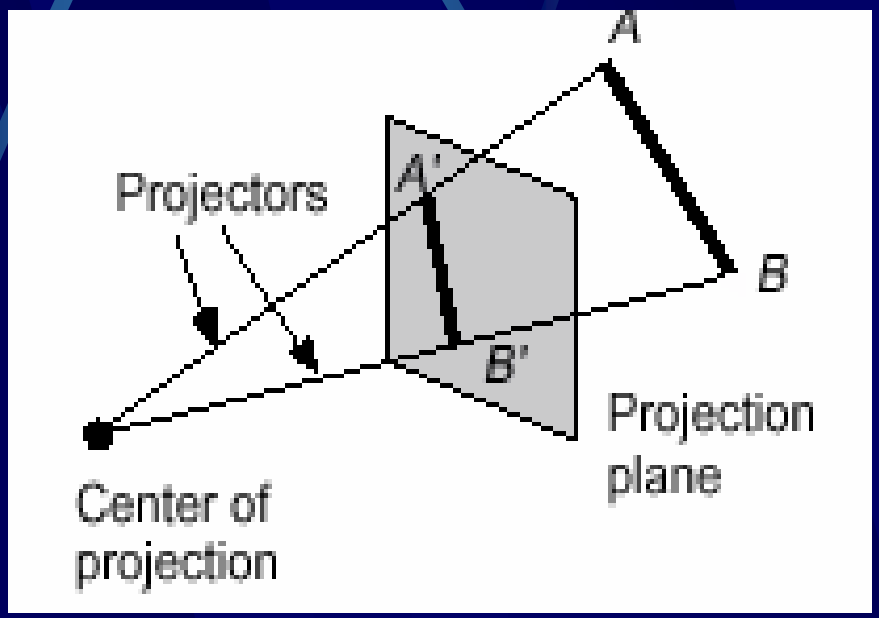
- **Transform from 3D space into 2D**
  - **Projection plane**
  - **Projectors (projection lines)**
- **Types:**
  - parallel: determined by the **direction** of projection
  - perspective: determined by the **center** of projection

Projections

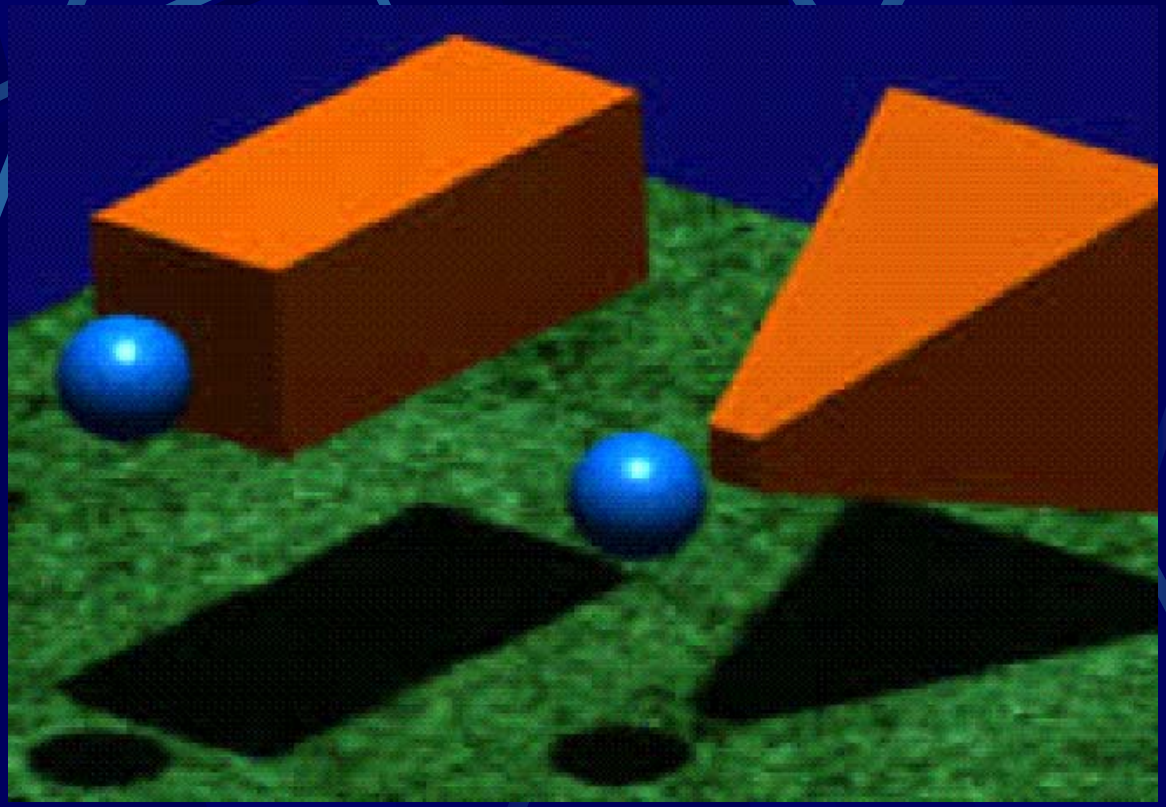
Parallel



Perspective

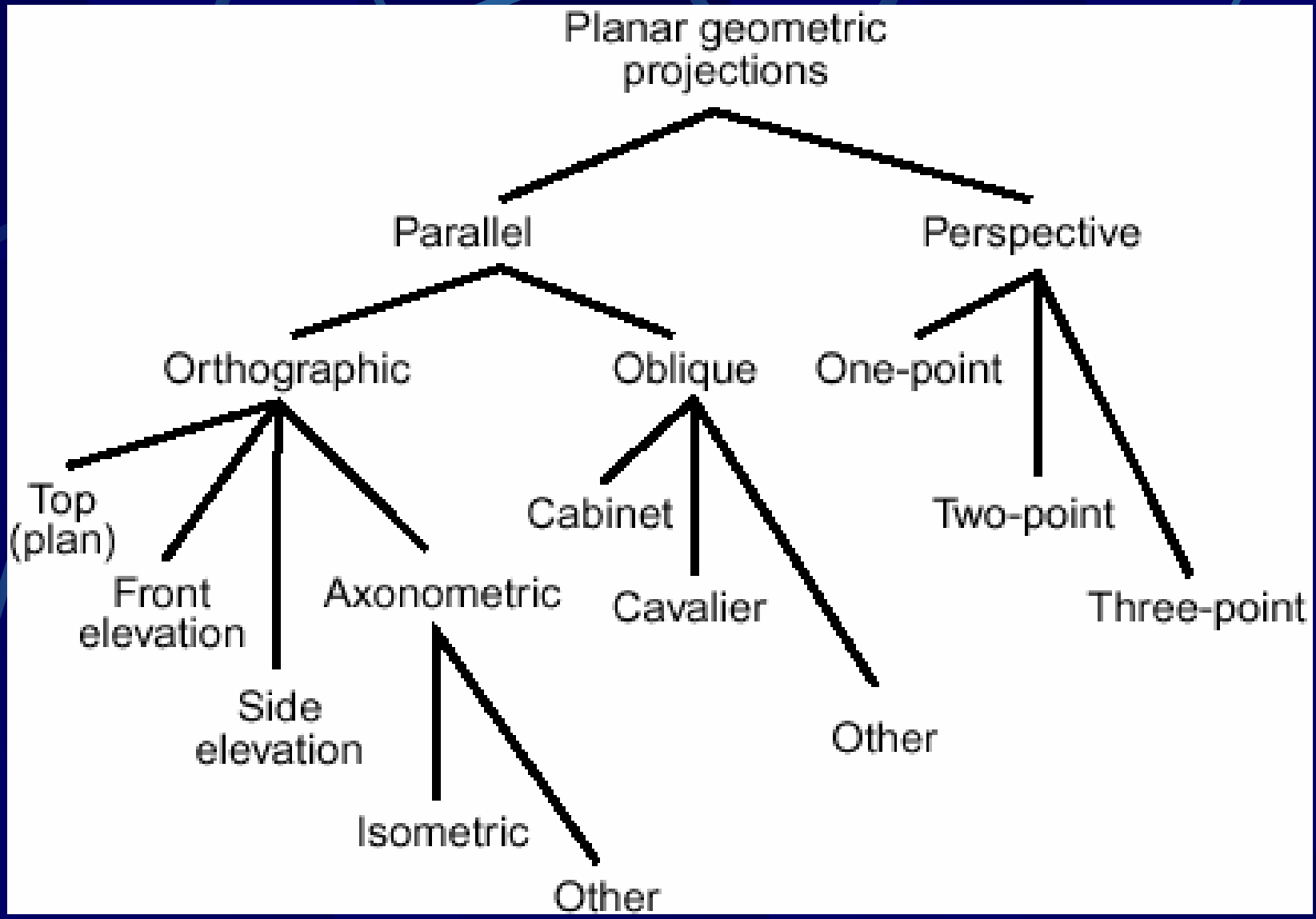


Projections



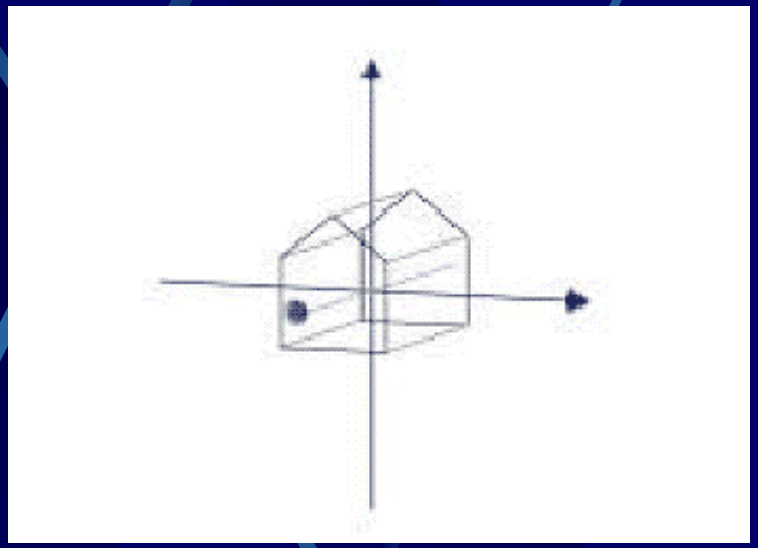
Parallel **Perspective**

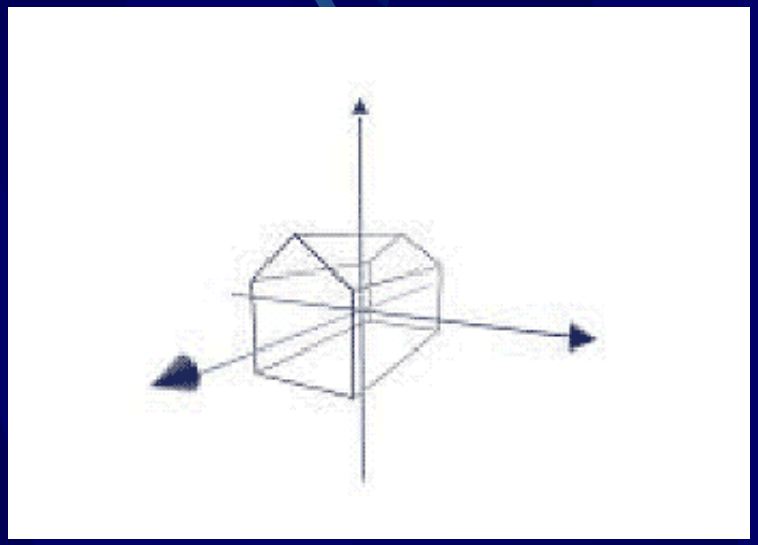
Types of Projections



Types of Projections

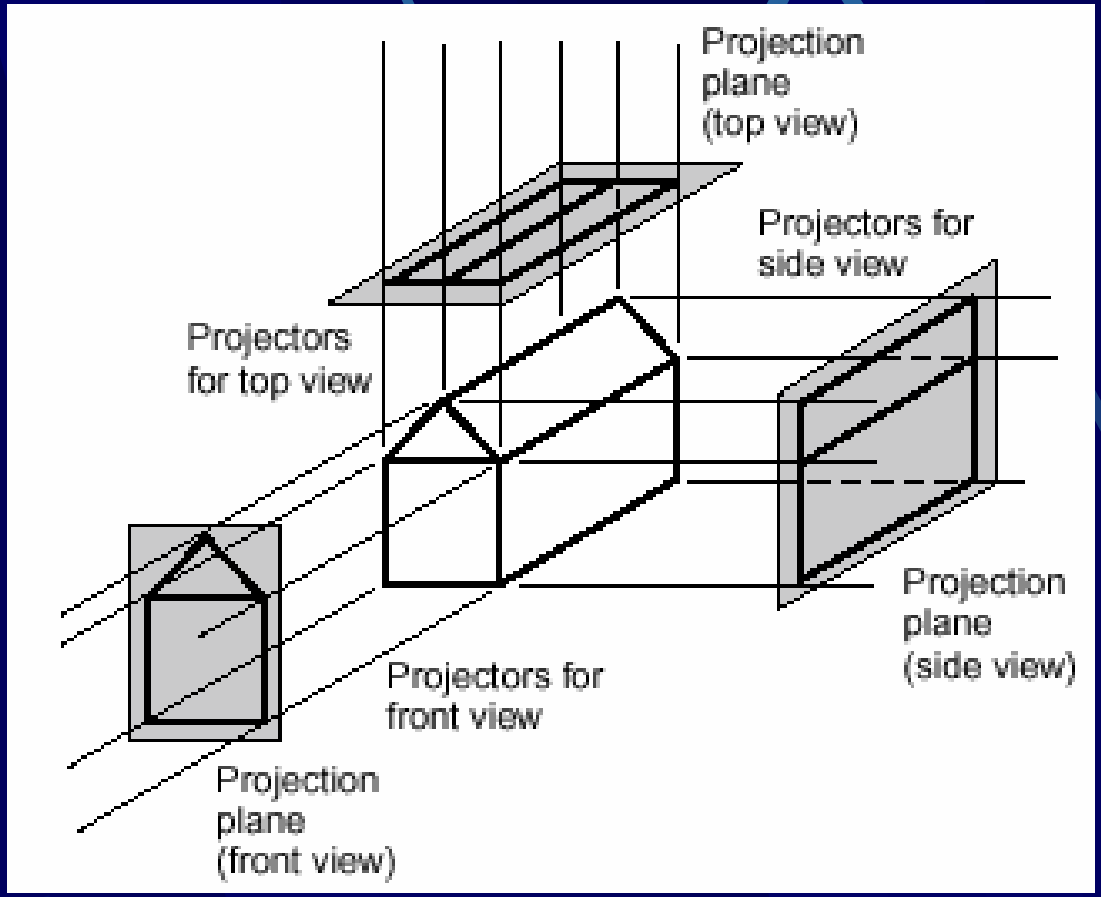
- **Parallel** projections used for engineering and architecture because they can be used for measurements
- **Perspective** imitates our eyes or a camera and looks more natural





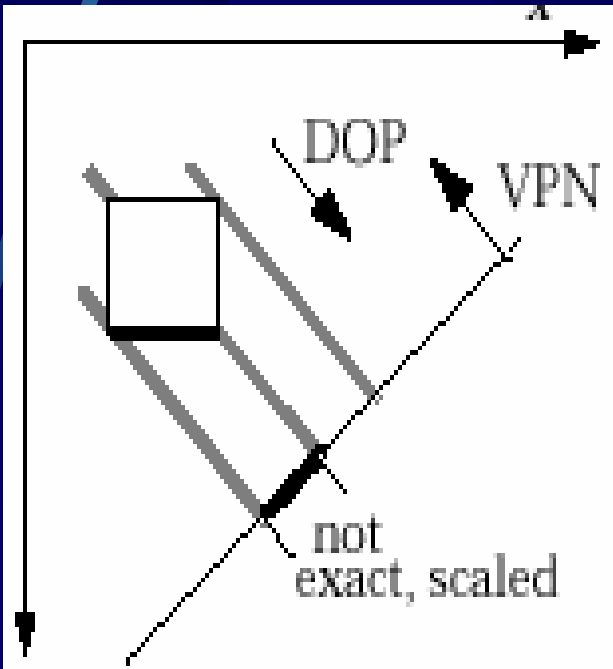
Multi-view Orthographic

- Usually need multiple views to get a three-dimensional feeling for object



Axonometric Projection

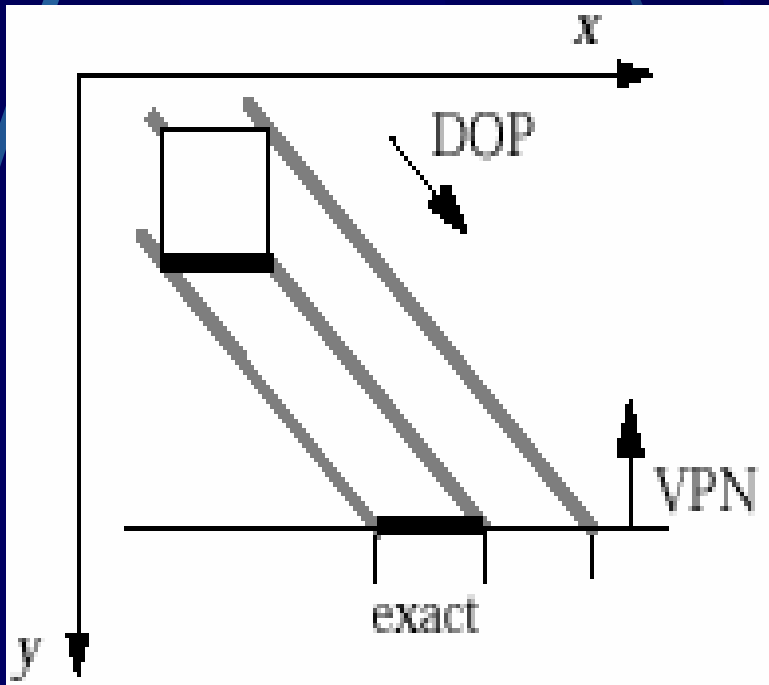
Assume object face of interest lies in principal plane, i.e., parallel to *xy*, *yz* or *zx* planes.
(DOP = **Direction of Projection**, VPN = **View Plane Normal**)



- VPN ∥ a principle coordinate axis
- DOP ∥ VPN
- adjacent faces, none exact, uniformly foreshortened(as a function of angle between face normal and DOP)

Oblique Projection

Assume object face of interest lies in principal plane, i.e., parallel to *xy*, *yz* or *zx* planes.
(DOP = **Direction of Projection**, VPN = **View Plane Normal**)



3) Oblique

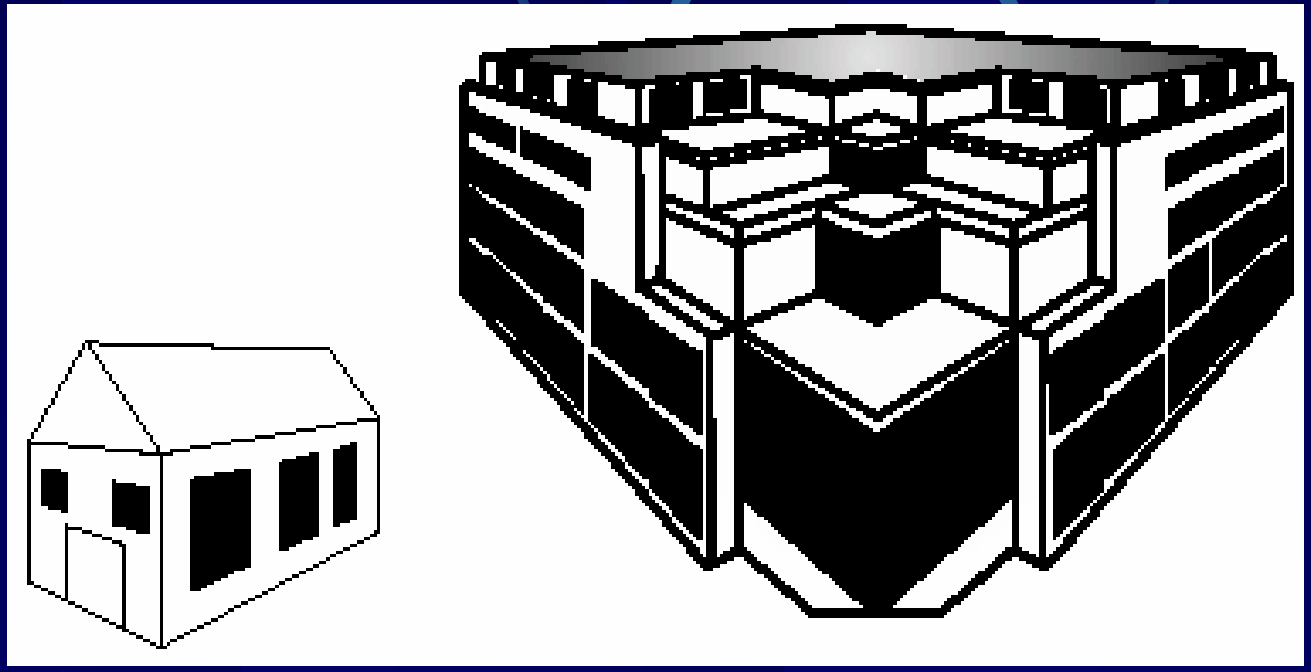
- VPN ∥ a principle coordinate axis
- DOP ∦ VPN
- adjacent faces, one exact, others uniformly foreshortened

Perspective Projection

- **Used for**:
  - – advertising
  - – presentation drawings for architecture, industrial design, engineering
  - – fine art
- **Pros**:
  - – gives a realistic view and feeling for three dimensional form of object
- **Cons**:
  - – does not preserve shape of object or scale (except where object intersects projection plane)

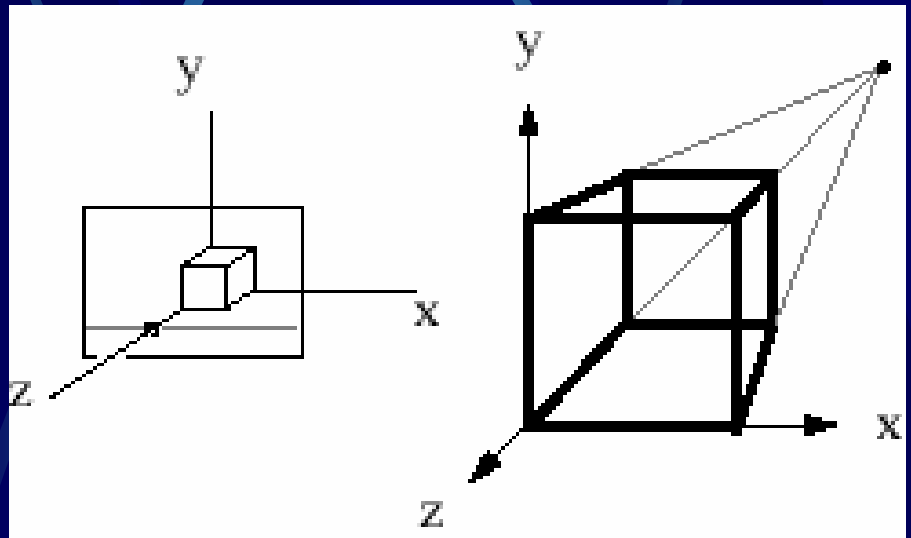
Perspective Projection

- Different from a parallel projection because:
  - parallel lines not parallel to the projection plane converge
  - size of the object is diminished with distance
  - foreshortening is not uniform.



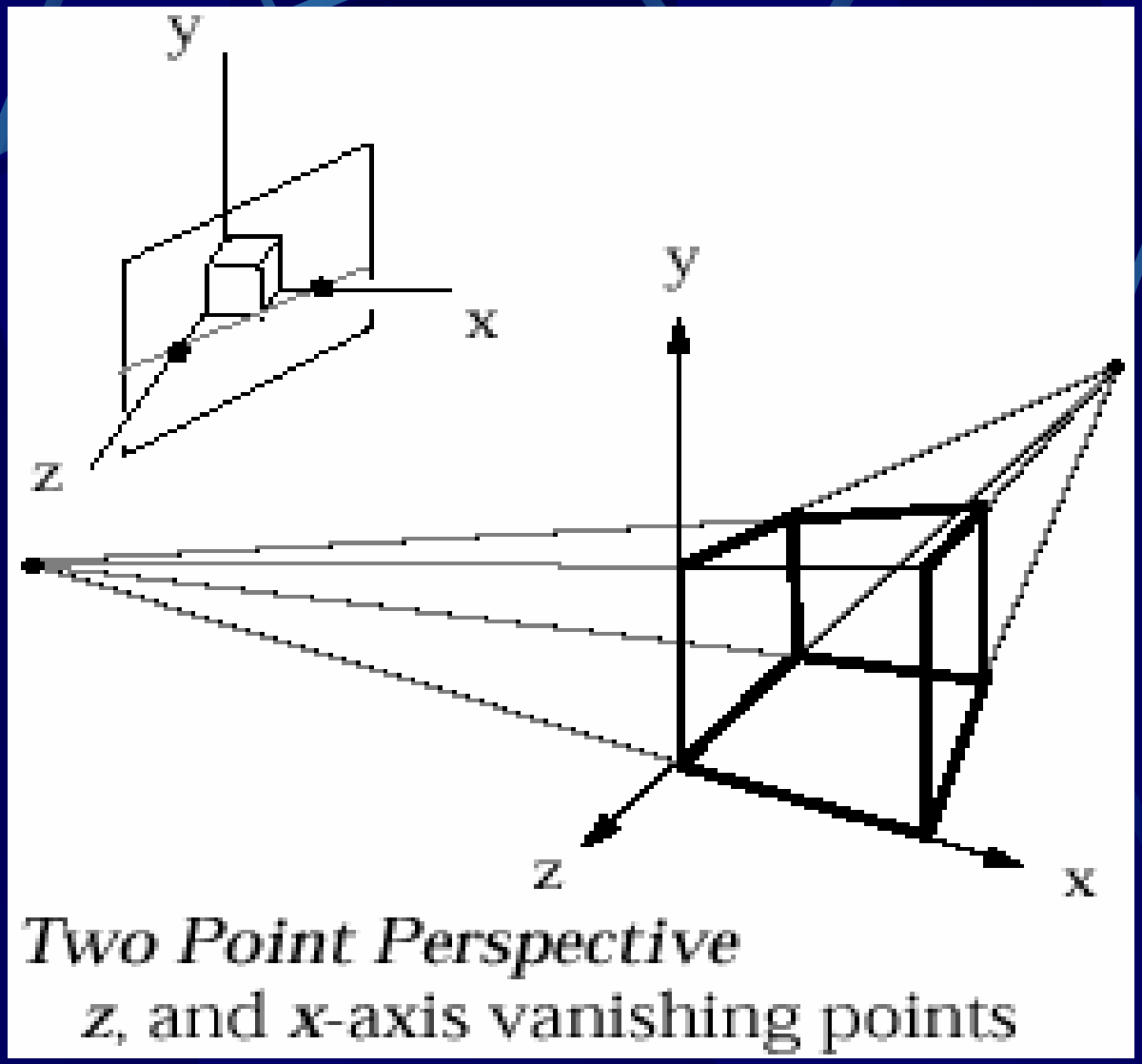
Vanishing Points

- For right-angled forms whose face normals are perpendicular to the *x*, *y*, *z* coordinate axes:
- **the number of vanishing points** = number of principal coordinate axes intersected by projection plane



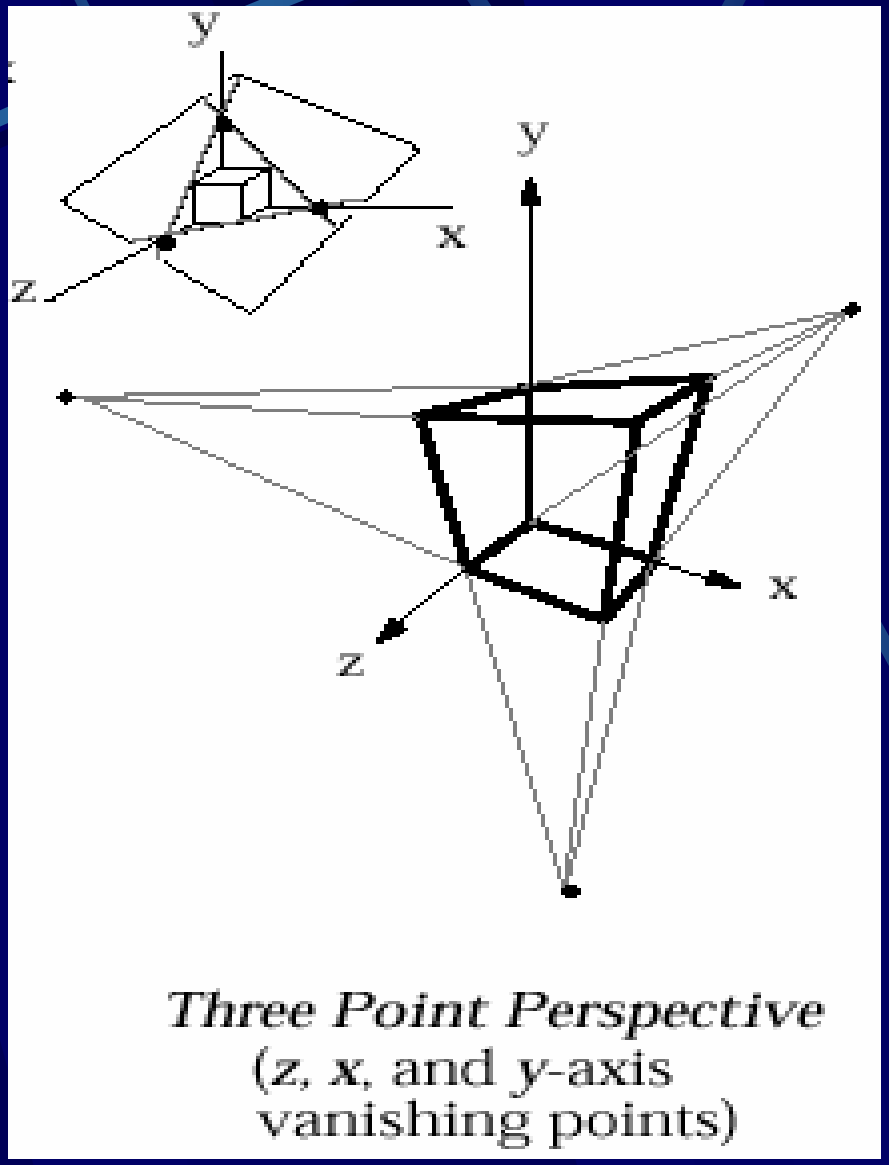
One Point Perspective
(*z*-axis vanishing point)

Vanishing Points



Two Point Perspective
z, and *x*-axis vanishing points

Vanishing Points



Three Point Perspective
(*z*, *x*, and *y*-axis
vanishing points)

Vanishing Points Examples

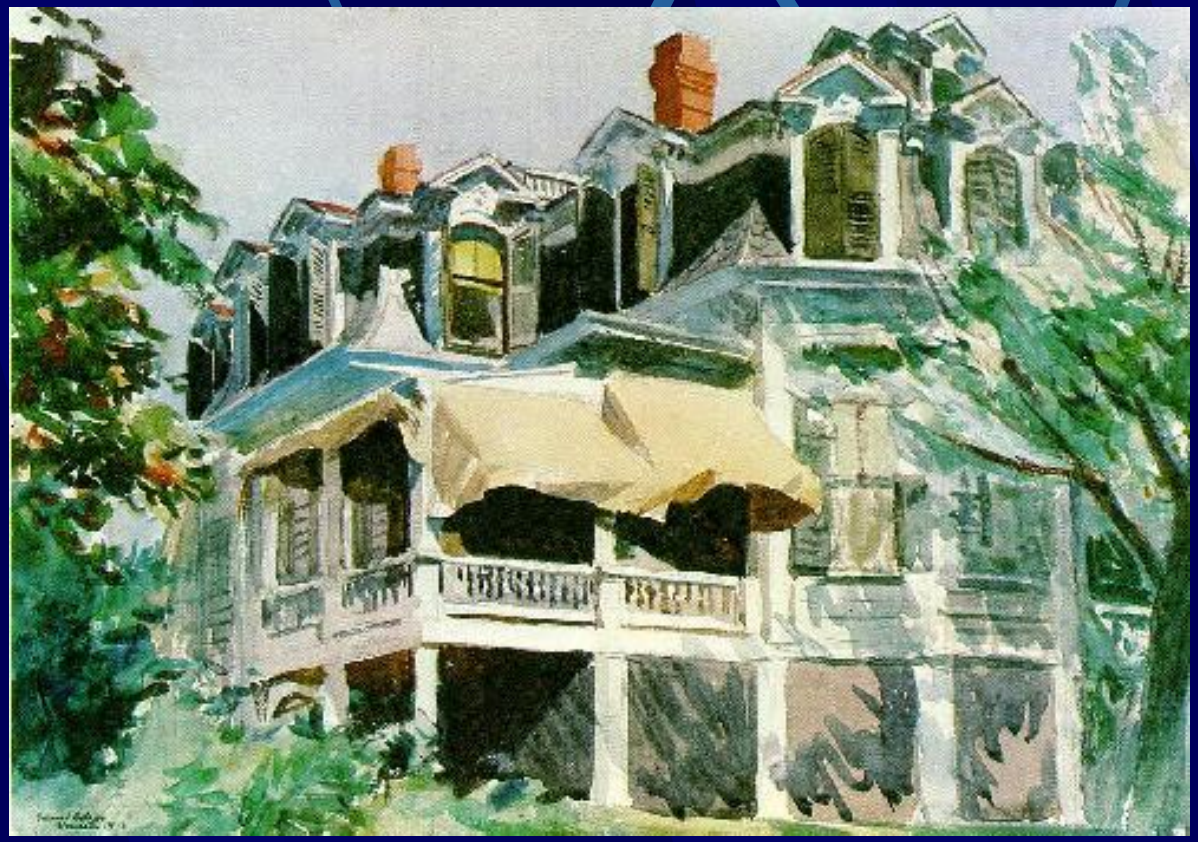
- Here is the first ever painting (*Trinity with the Virgin, St. John and Donors*) done in perspective by Masaccio, in 1427. The image on the right shows that it is indeed a one-point perspective drawing

Vanishing Points Examples

- A painting (*The Piazza of St. Mark, Venice*) done by Canaletto in 1735-45 in one-point perspective

Vanishing Points Examples

- Painting in two point perspective by Edward Hopper
- *The Mansard Roof* 1923 (240 Kb); Watercolor on paper, 13 3/4 x 19 inches; The Brooklyn Museum, New York



Vanishing Points Examples

- Here is a painting (*City Night*, 1926) by Georgia O'Keefe, that is approximately in three-point perspective.

Mathematics of Projection

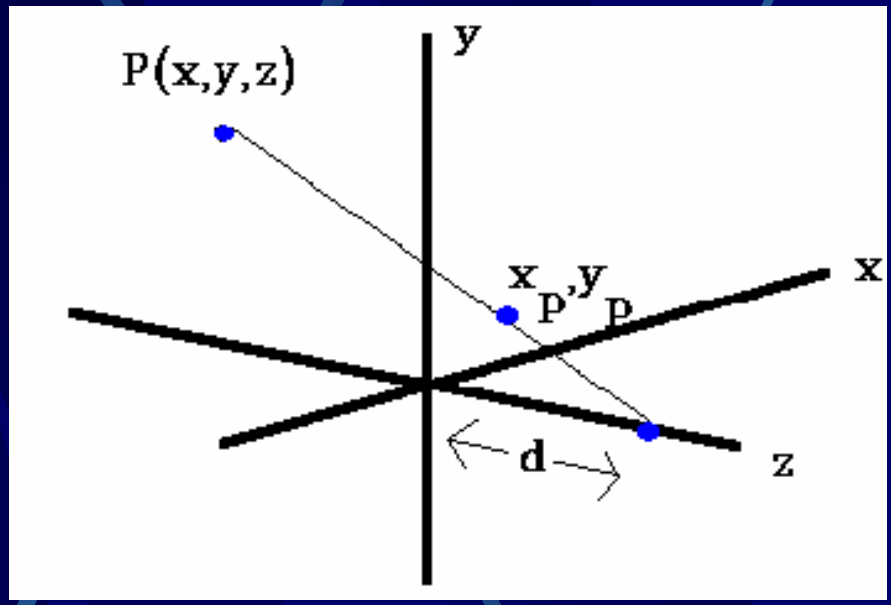
- Assumptions:
- Project plane -> xOy
- Parallel:
  - Viewing direction || axis Z
- Perspective:
  - Observer (Look point) -> at the positive axis Z, at Distance D

Mathematics of Projection

- **Parallel**
- $x' = x$
- $y' = y$
- $z' = 0$

Mathematics of Projection

- **Perspective**
- x’ = D/(D-z)*x
- y’ = D/(D-z)* y
- z’ = 0



- To preserve the depth information:
- z’ = D/(D-z)*z
- For hidden lines and surfaces removal algorithms