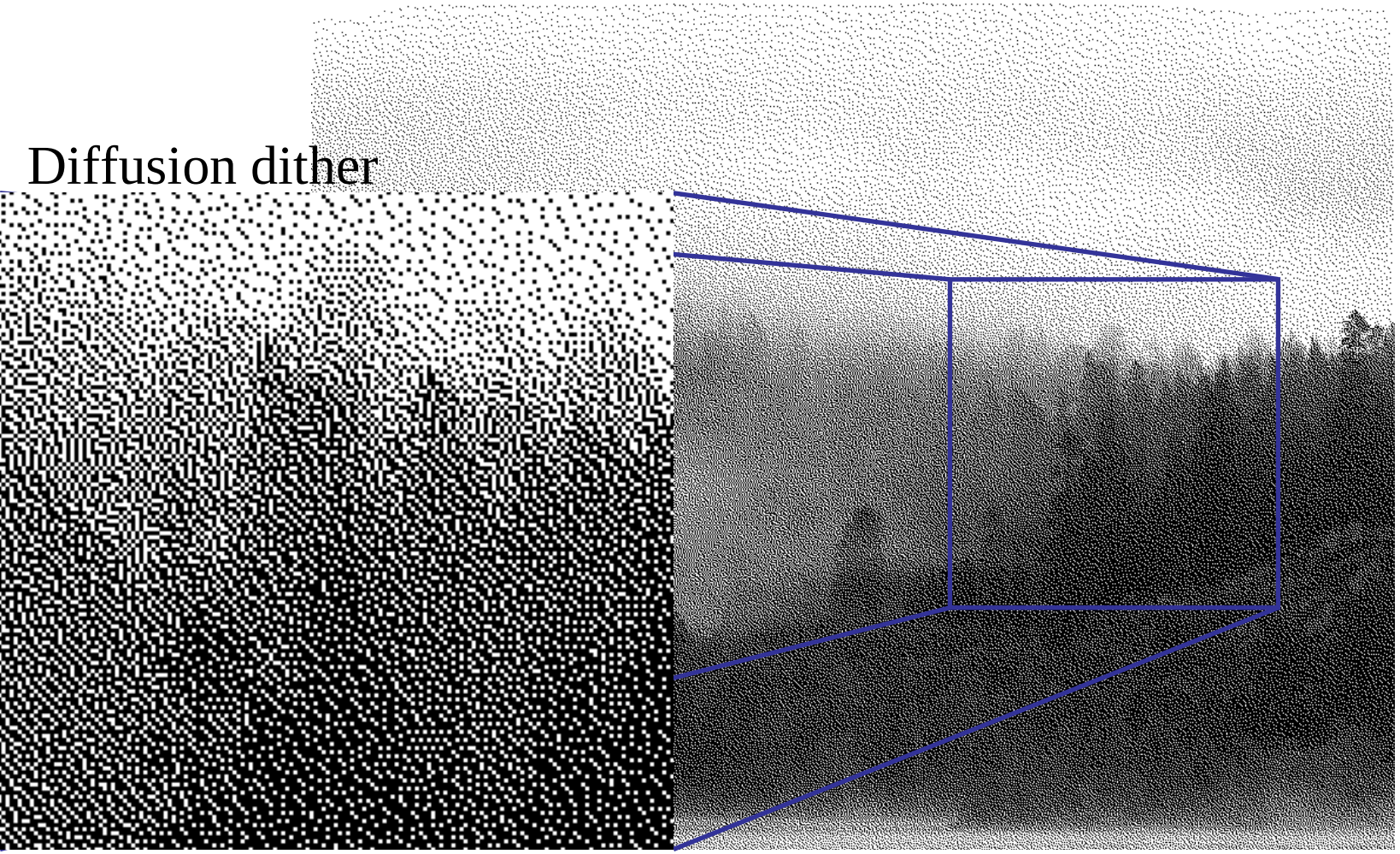
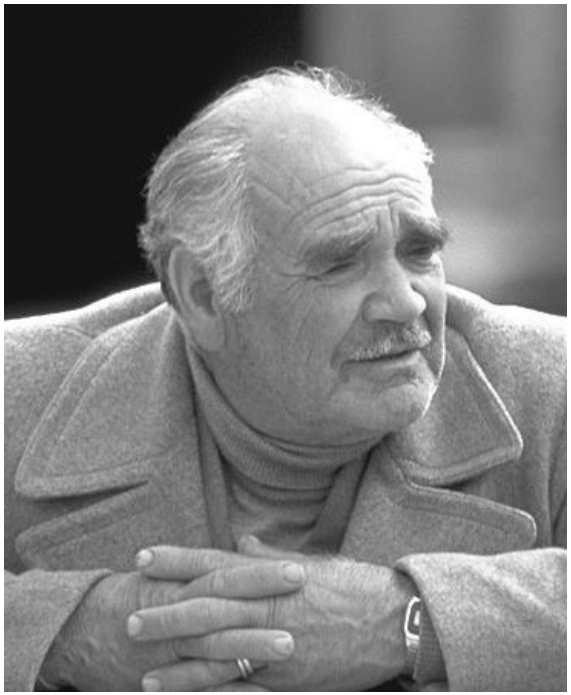
Quiz

- Why is dithering necessary?



Quiz

- Why is dithering necessary?
  - To reproduce gray levels on binary displays



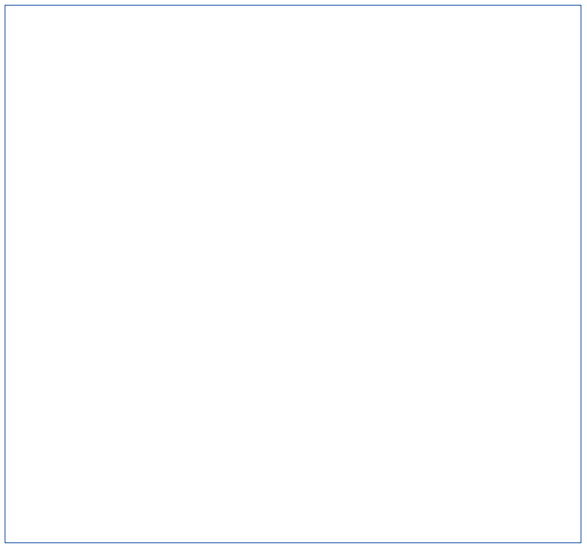
Laser printed image
WITH dithering

Laser printed image
WITHOUT dithering

Quiz

- Is a pixel with value 255 twice as bright as another pixel with value 128?

n=128

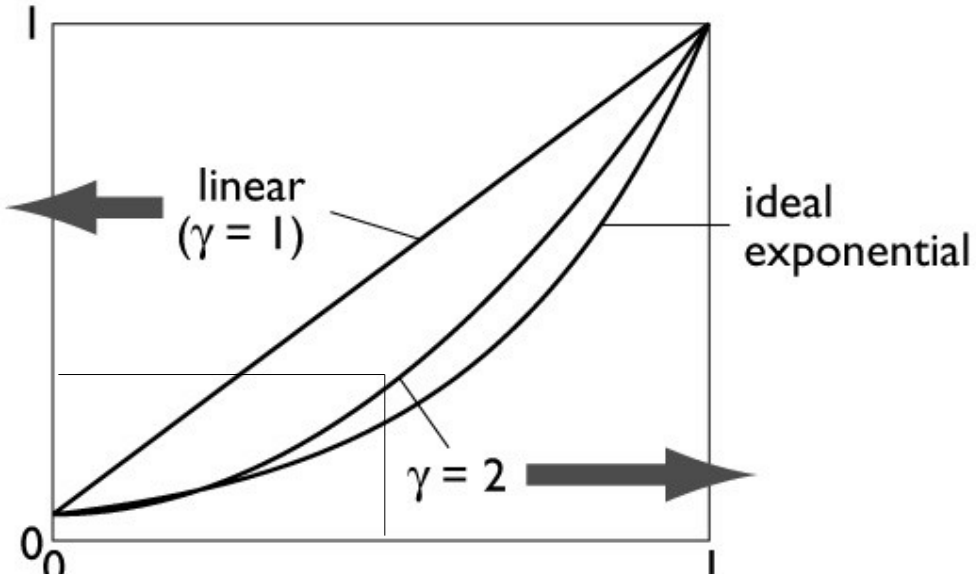


n=255

Quiz

- Is a pixel with value 255 twice as bright as another pixel with value 128?
  - No, 128 is darker than half the brightness of 255 because of the Gamma function
  - Displays are calibrated to use the standard gamma=2.2

$$I(n) = (n/N)^{\gamma}$$



How many levels are necessary for a smooth gradation W/O visible steps?

How many levels are necessary for a smooth gradation W/O visible steps?

- It depends on the dynamic range of a display

- Ideal case : exponential quantization

2% steps are most efficient because we cannot notice a change less than 2%:

$$0 \mapsto I_{\min}; 1 \mapsto 1.02 I_{\min}; 2 \mapsto (1.02)^2 I_{\min}; \ldots$$

120 steps are needed for 10:1 dynamic range because

$$(1.02)^{120} = 10.76$$

240 steps are needed for 100:1 dynamic range

High precision (e.g. 72bpp) is necessary for an HDR image

Perspective

Lecture 3

[Richard Zakia]

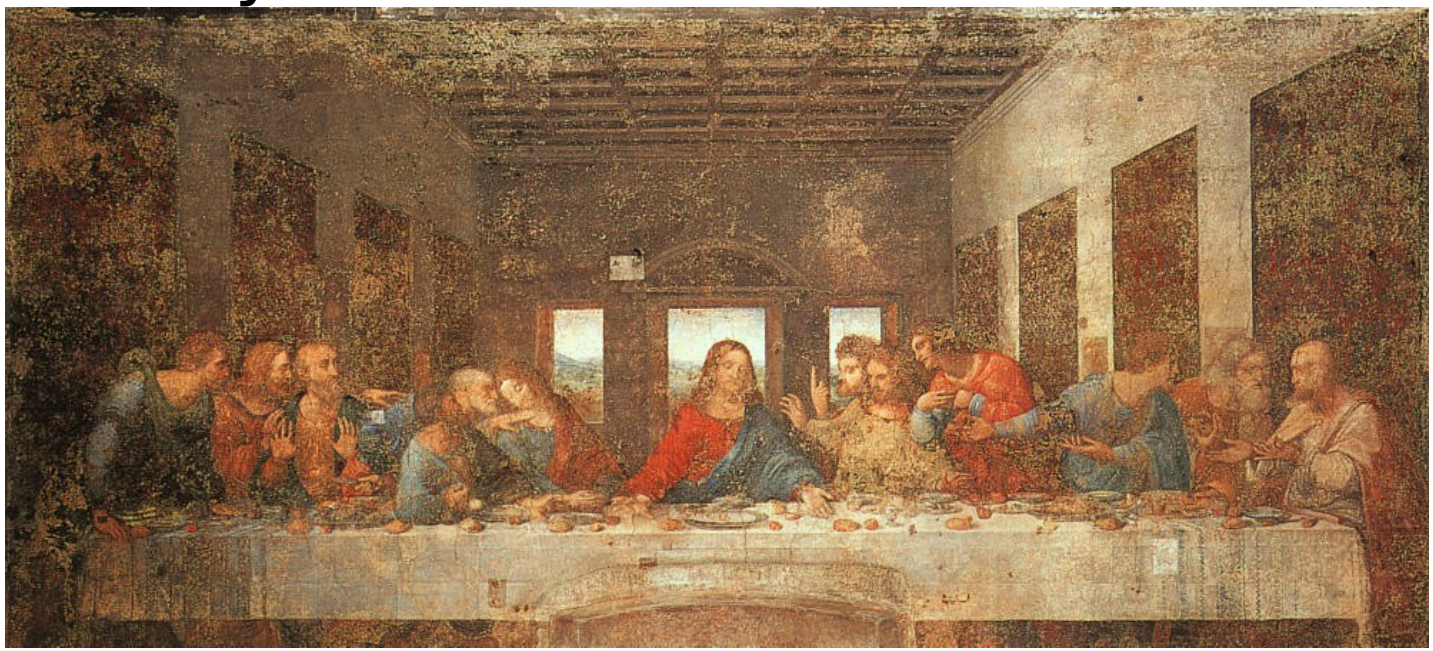
History of projection

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

Duccio c. 1308

History of projection

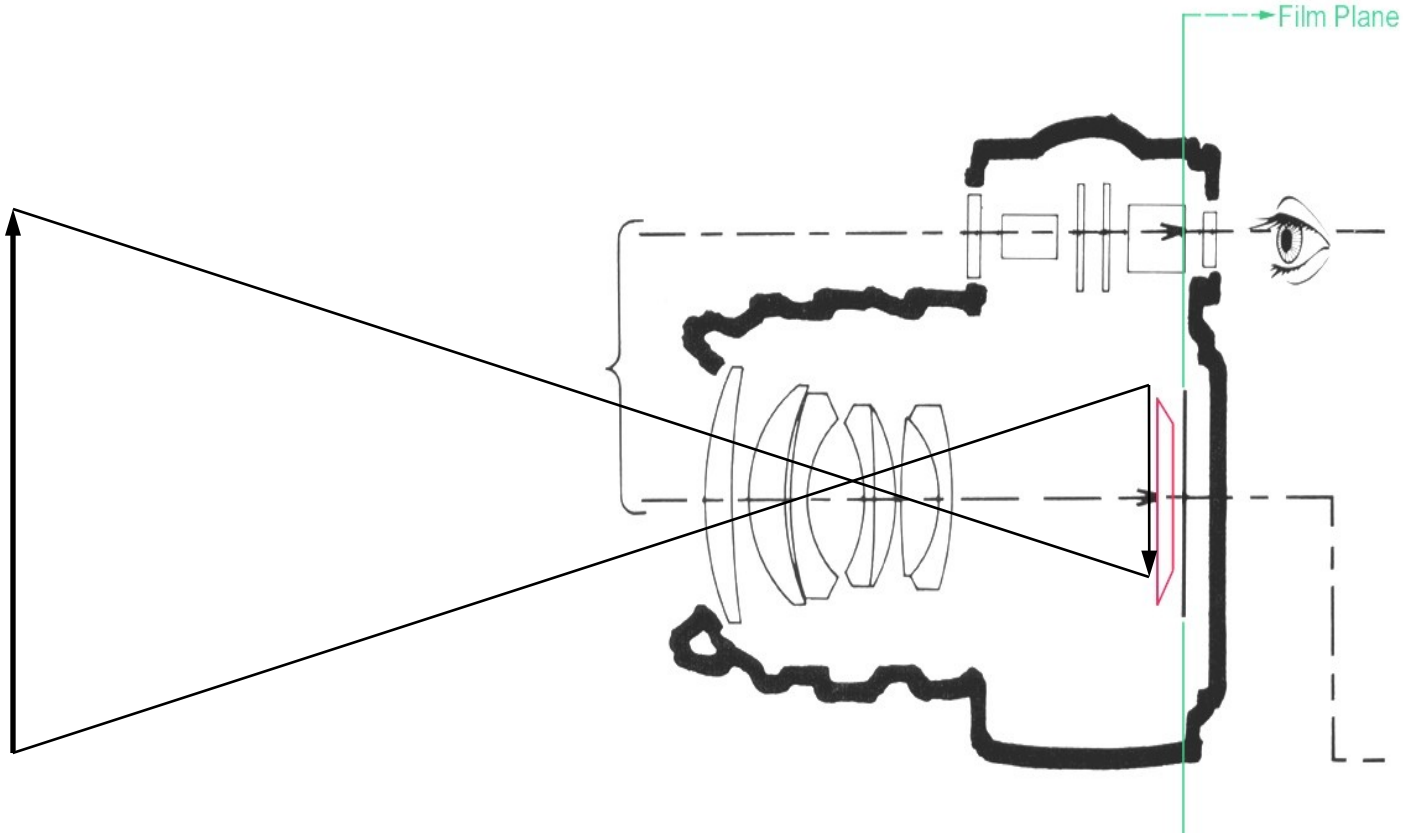
- Later Renaissance: perspective formalized precisely



da Vinci c. 1498

Plane projection in photography

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



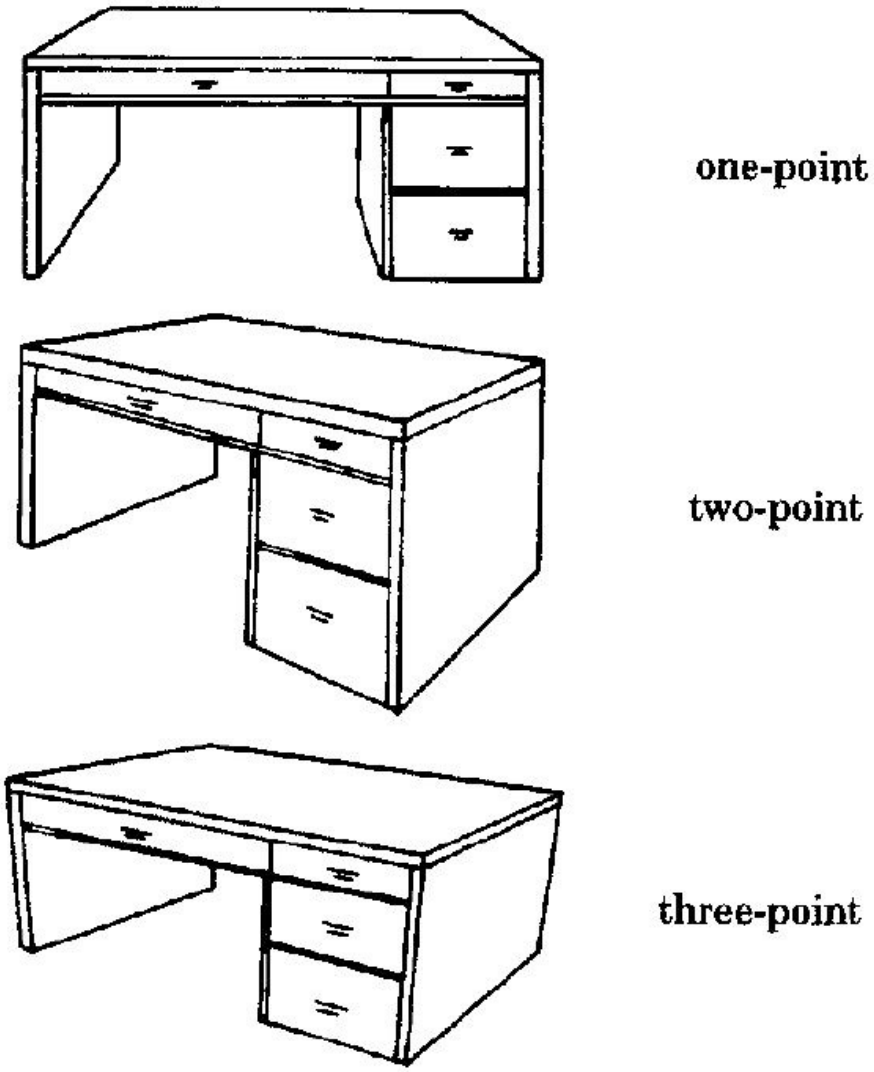
[Source unknown]

Perspective

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

two-point: projection plane parallel to one coordinate axis

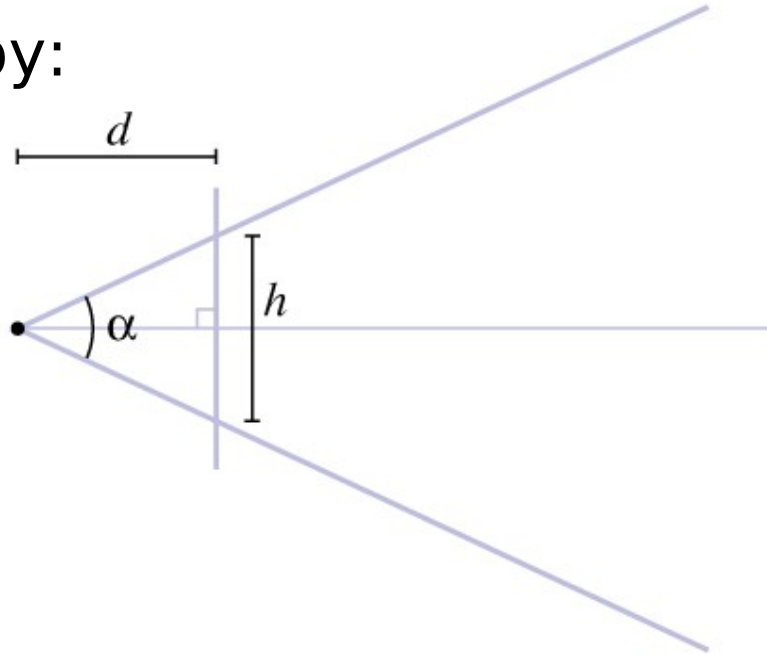
three-point: projection plane not parallel to a coordinate axis



[Carlbom & Paciorek 78]

Perspective projection (normal)

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



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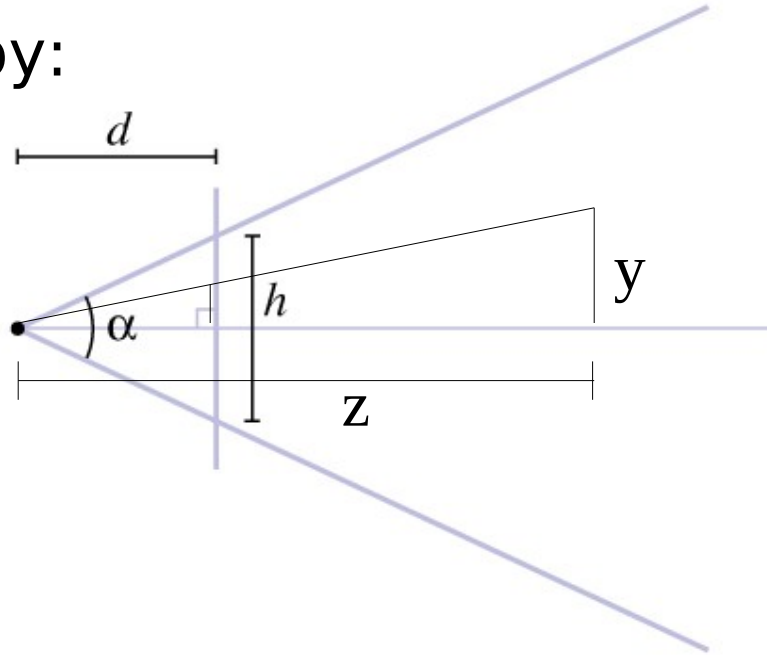
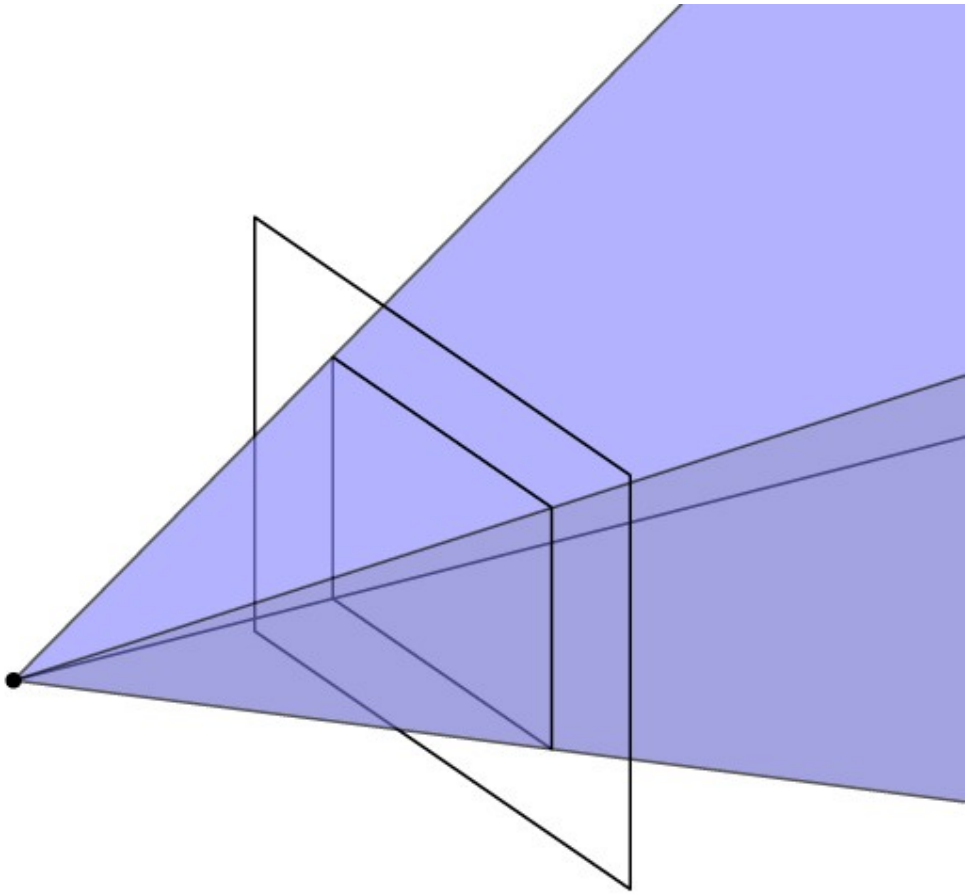


View volume: perspective



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”)

Field of view

- Determines “strength” of perspective effects

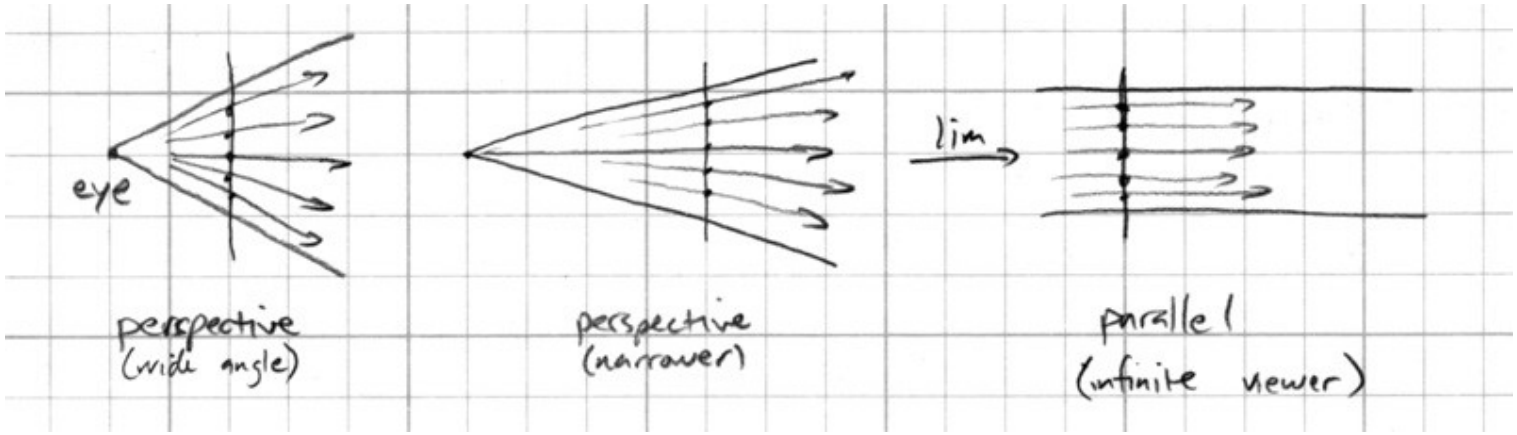
close viewpoint
wide angle
prominent foreshortening

far viewpoint
narrow angle
little foreshortening

[Ansel Adams]

Parallel projection

- Viewing rays are parallel rather than diverging



Multiview orthographic

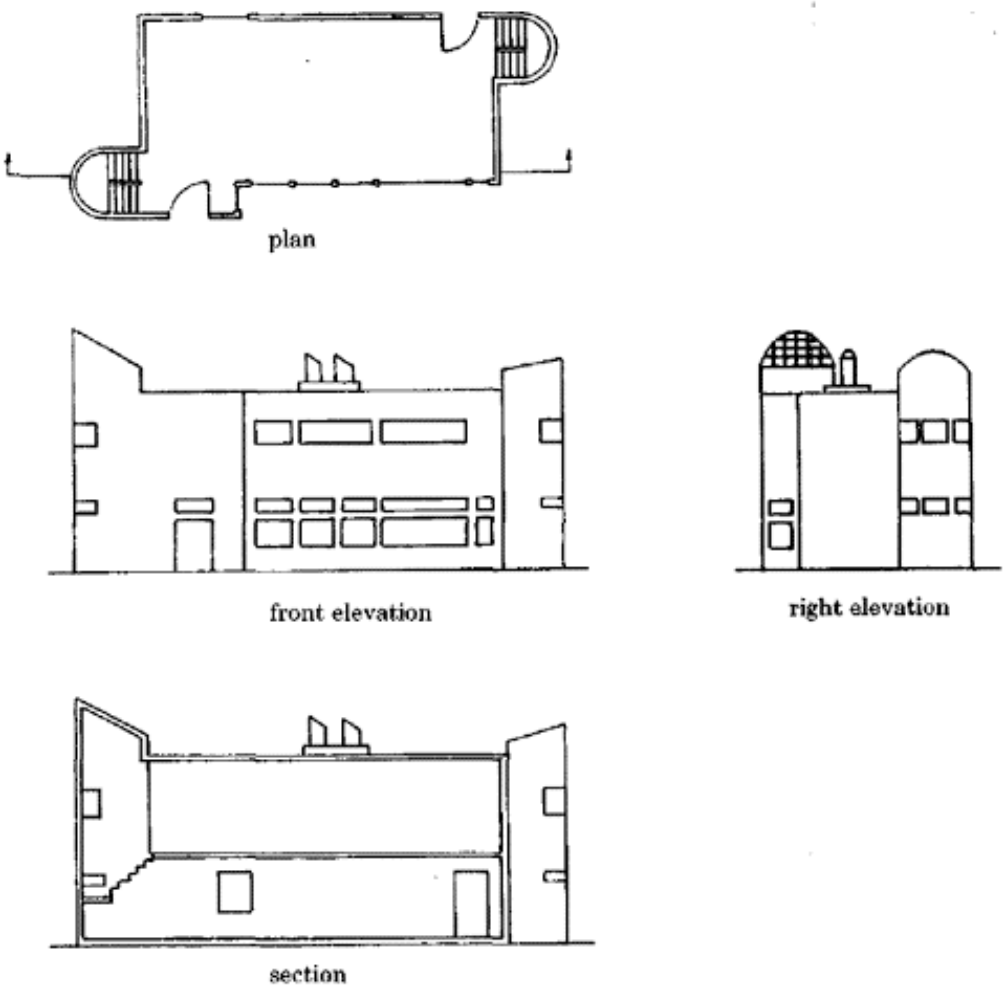
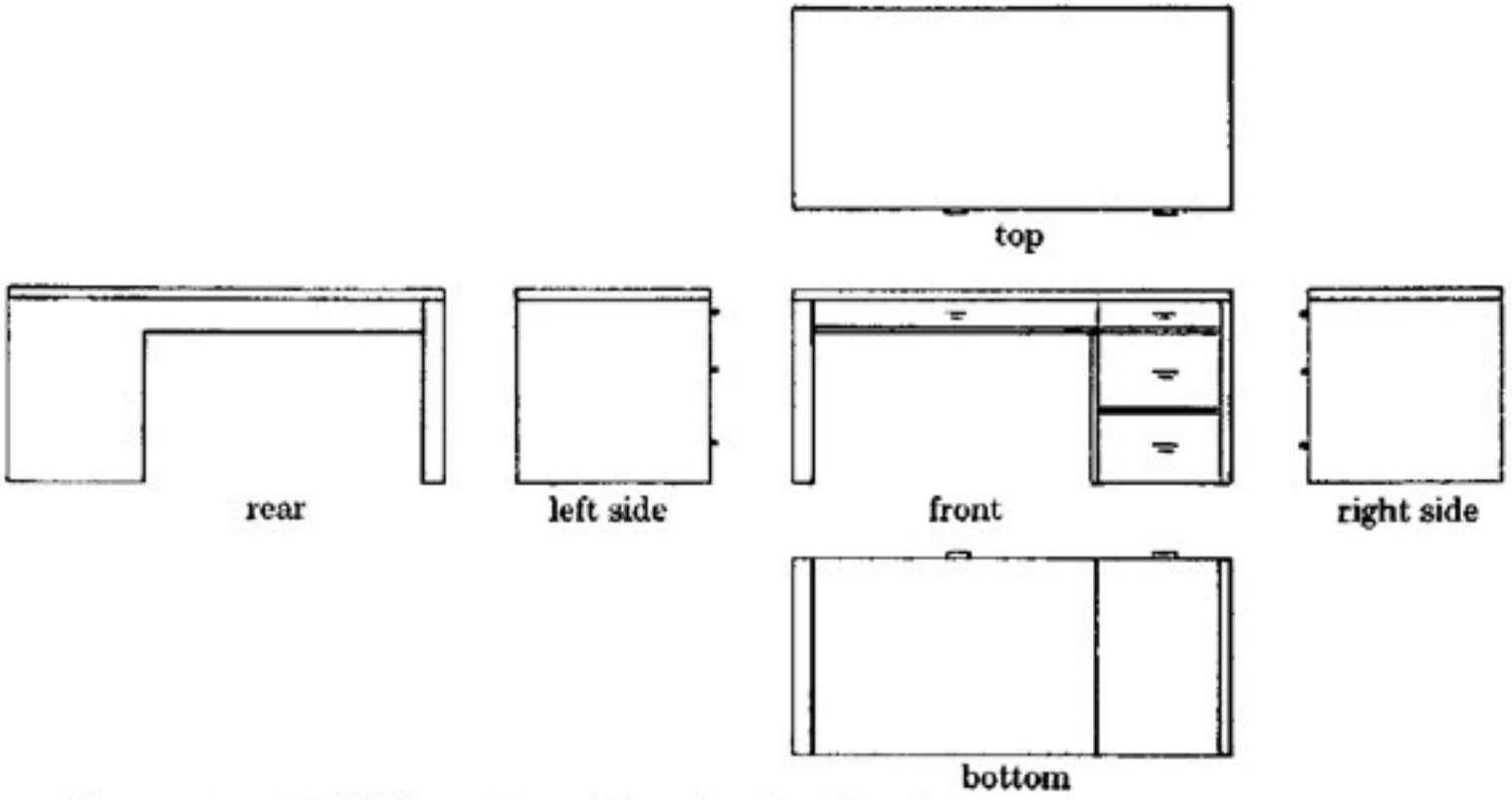


FIGURE 2-1. Multiview orthographic projection: plan, elevations, and section of a building.

[Carlbom & Paciorek 78]

Multiview orthographic

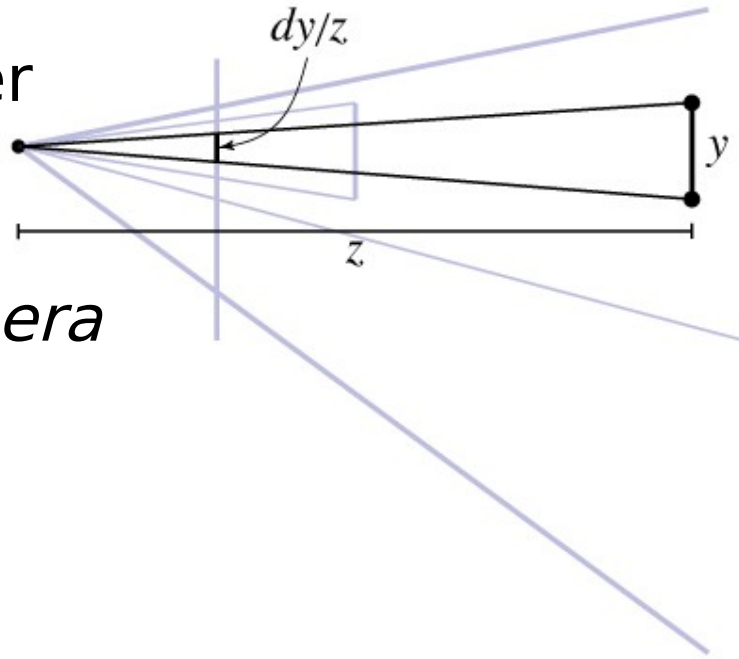


[Carlbom & Paciorek 78]

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

Shifted perspective projection

- Perspective but with projection plane not perpendicular to view direction
  - additional parameter: projection plane normal
  - exactly equivalent to cropping out an off-center rectangle from a larger "normal" perspective
  - corresponds to *view camera* in photography



Why shifted perspective?

- Control convergence of parallel lines
- Standard example: architecture
  - buildings are taller than you, so you look up
  - top of building is farther away, so it looks smaller
- Solution: make projection plane parallel to facade
  - top of building is the same distance *from the projection plane*
- Same perspective effects can be achieved using post-processing
  - (though not the focus effects)
  - choice of *which* rays vs. arrangement of rays in image

[Philip Greenspun]

camera tilted up: converging vertical lines

[Philip Greenspun]

lens shifted up: parallel vertical lines

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
  - image plane normal
    - can be different from view direction to get shifted perspective