Projection Taxonomy

COMP 557

Paul Kry

Review

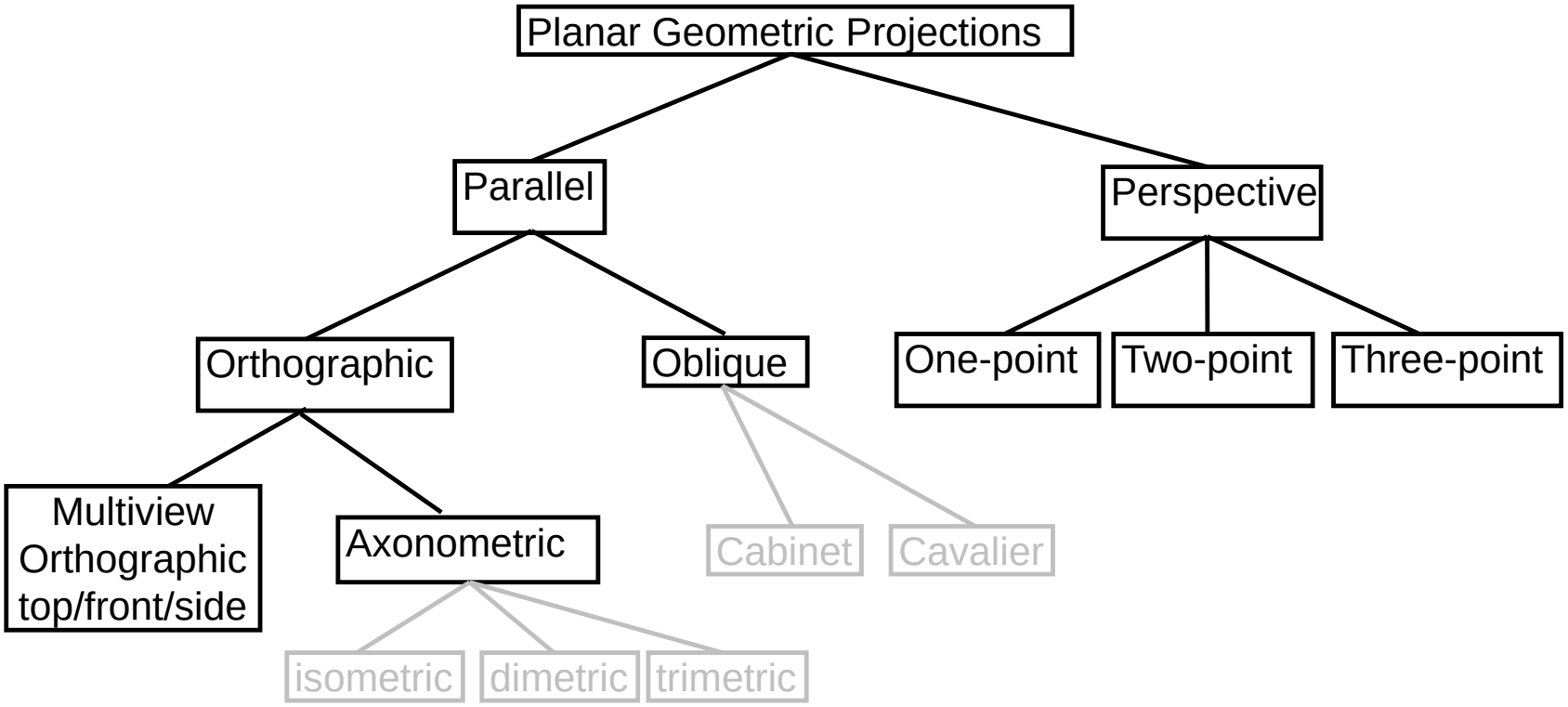
- What goes where on projection?
- gluPerspective and glFrustum
- Frustum applications
  - Tiled rendering, anaglyphs, depth of field, shifted perspective
- History of projection
- Depth Cues

Recall: Ray Generation vs. Projection

- Viewing in ray tracing
  - start with image point
  - compute ray that projects to that point
  - do this using geometry
- Viewing by projection
  - start with 3D point
  - compute image point that it projects to
  - do this using transforms
- Both provide planar projection

Taxonomy of Classical Projections

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

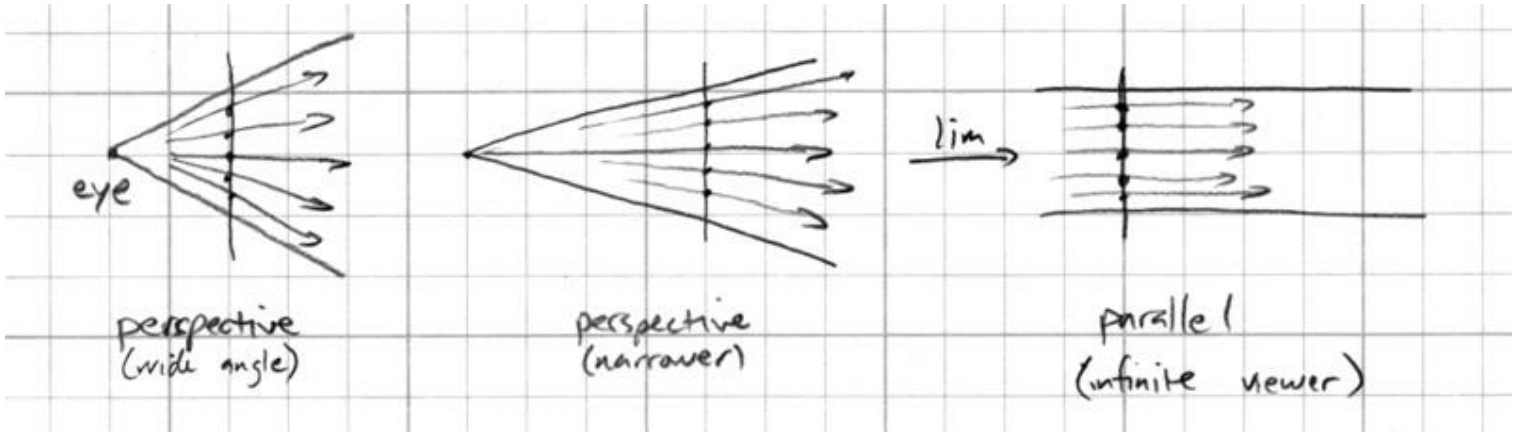


[after Carlbom & Paciorek 78]

Based on slides by Steve Marschner

Parallel Projection

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



Based on slides by Steve Marschner

Multiview Orthographic

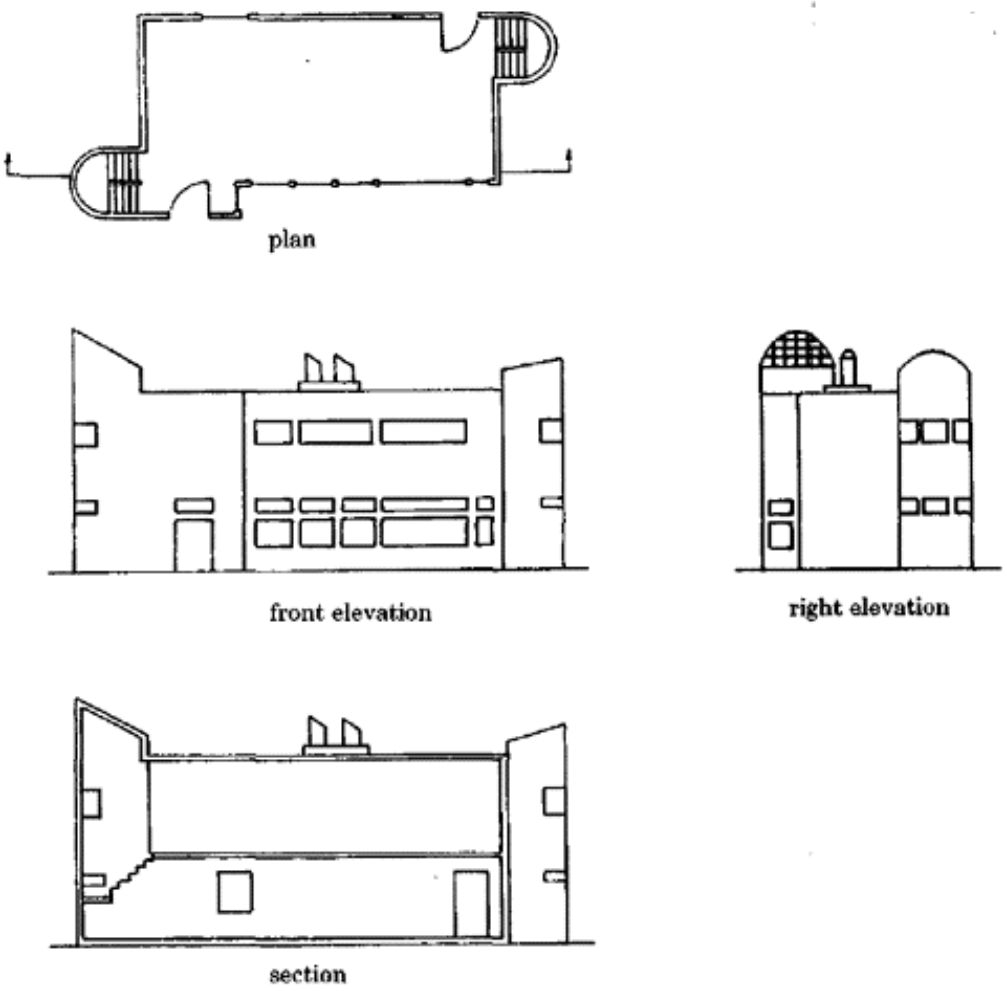


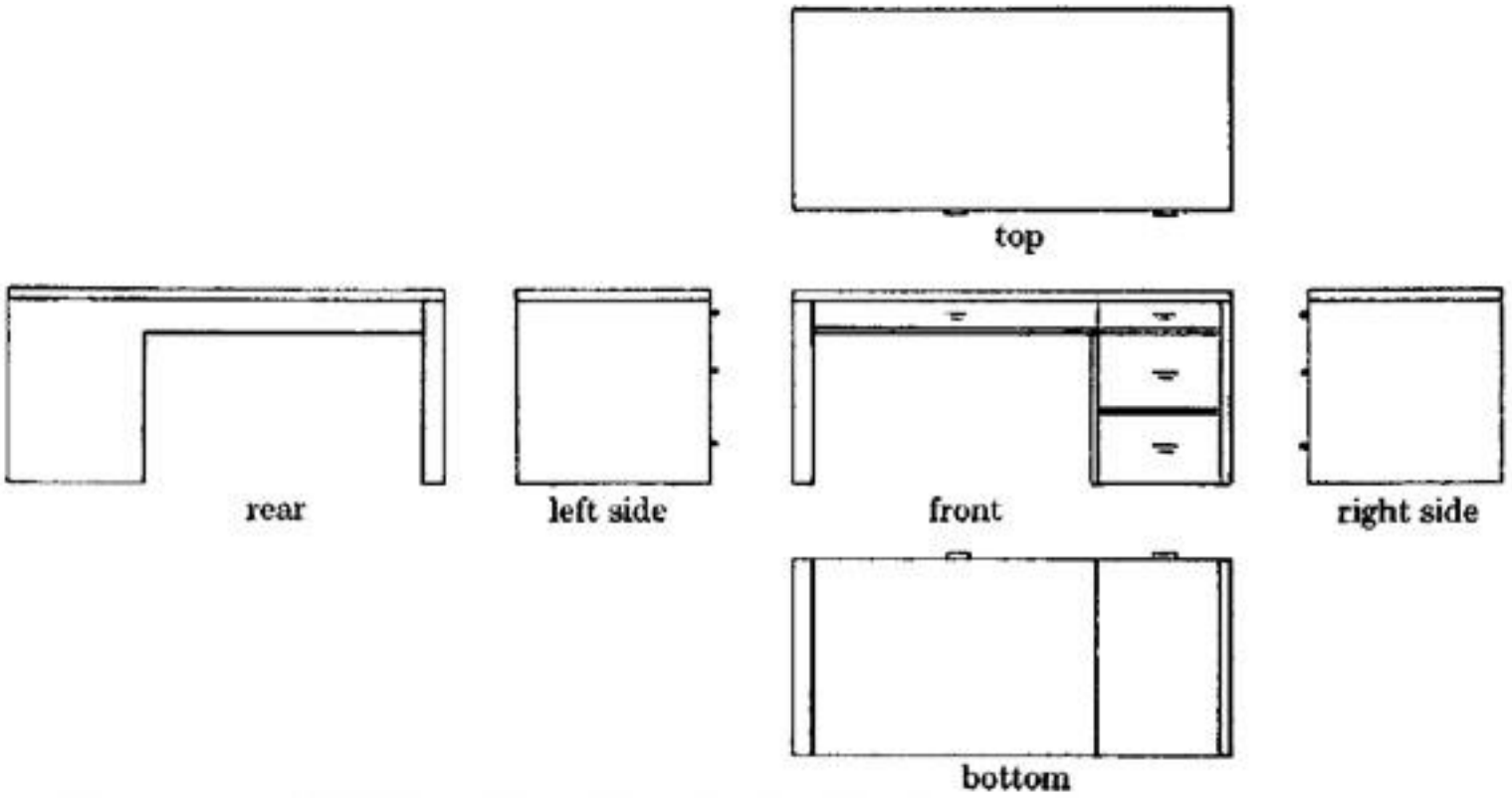
FIGURE 2-1. Multiview orthographic projection: plan, elevations, and section of a building.

[Carlbom & Paciorek 78]

Based on slides by Steve Marschner

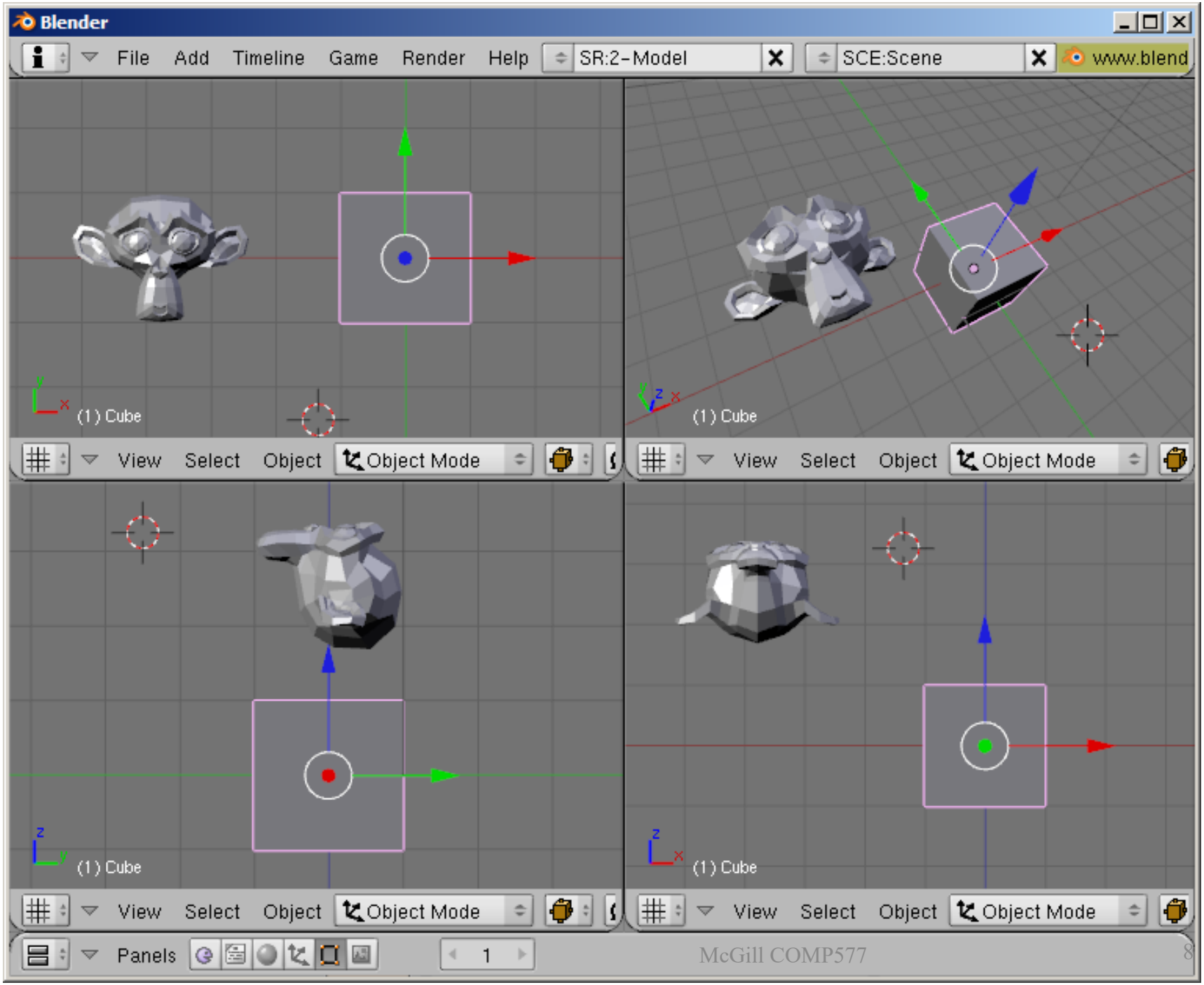
Multiview Orthographic

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



[Carlbom & Paciorek 78]

Based on slides by Steve Marschner


Blender
File
Add
Timeline
Game
Render
Help
SR:2-Model
SCE:Scene
www.blend
(1) Cube
View
Select
Object
Object Mode
(1) Cube
View
Select
Object
Object Mode
(1) Cube
View
Select
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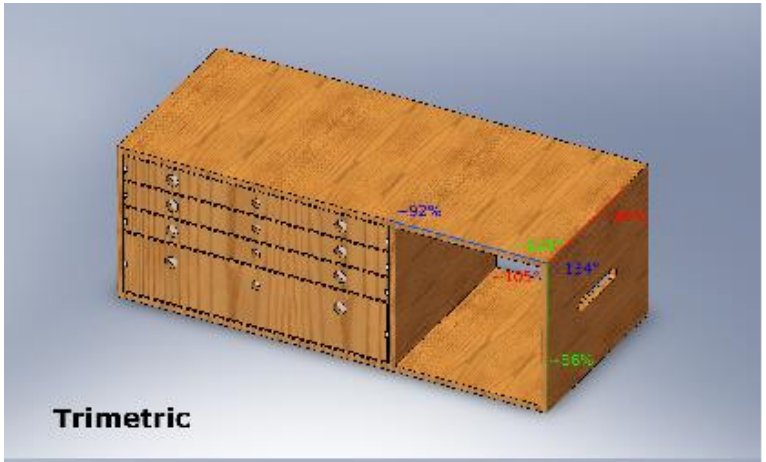
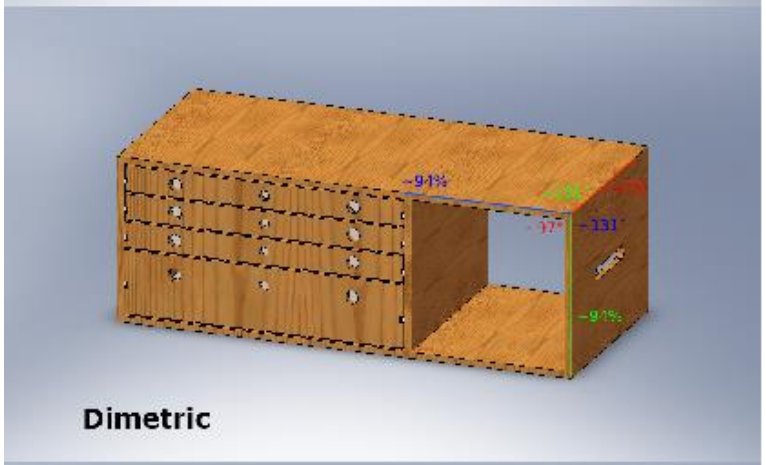
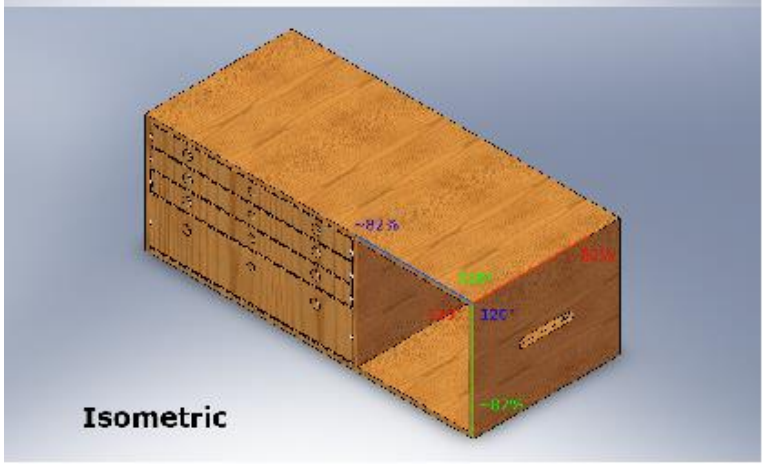
Object Mode
(1) Cube
View
Select
Object
Object Mode
Panels
1

Off-axis parallel

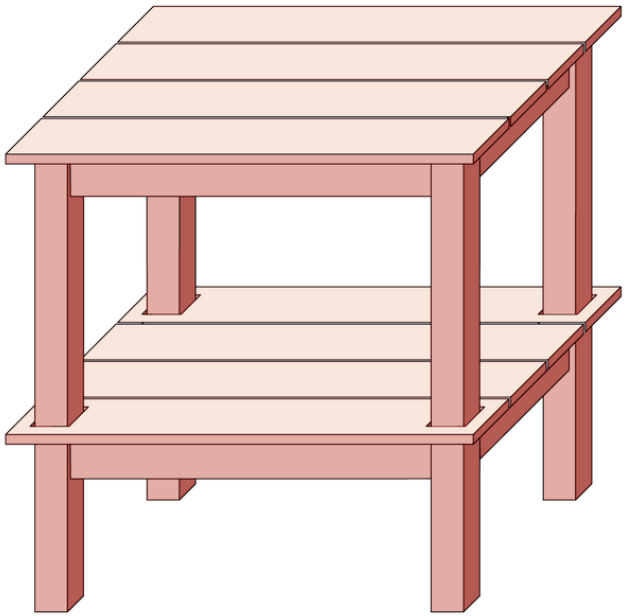




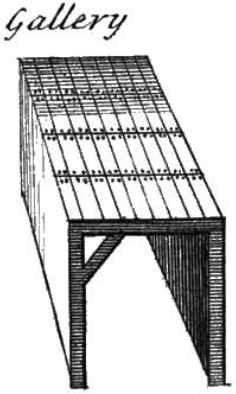


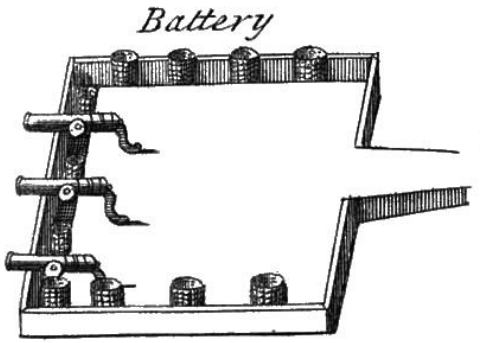
axonometric: projection plane perpendicular to projection direction but not parallel to coordinate planes

Oblique Parallel Projection



Cabinet, ½ length in z



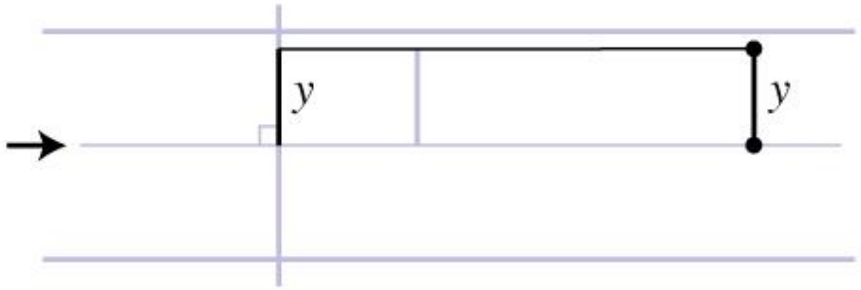


Cavalier... same length in all dimensions

oblique: projection plane parallel to a coordinate plane but not perpendicular to projection direction.

Orthographic Projection

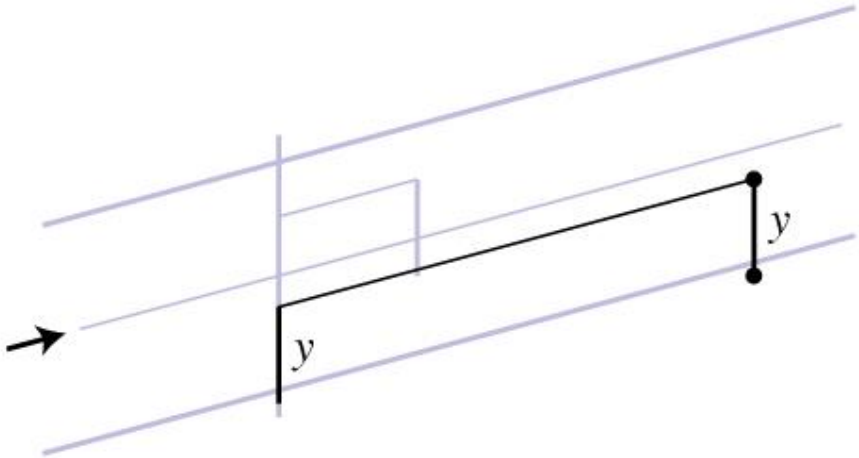
- In graphics, we associate axonometric with orthographic
  - projection plane perpendicular to projection direction
  - image height determines size of objects in image



Based on slides by Steve Marschner

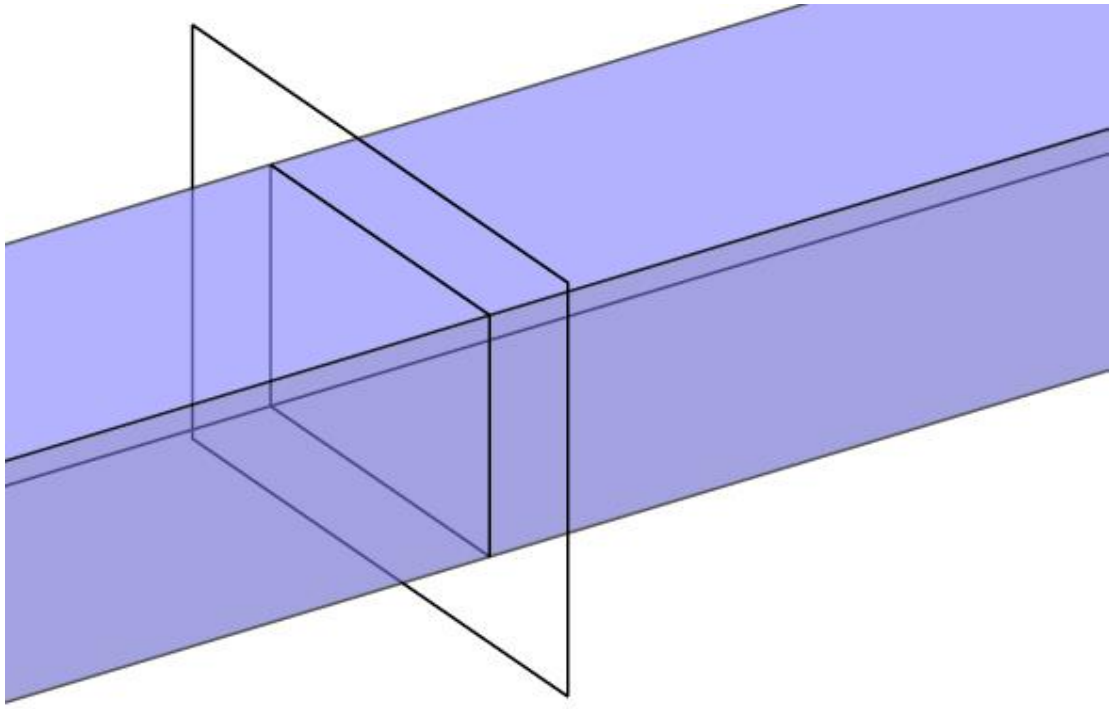
Oblique projection

- View direction no longer coincides with projection plane normal (one more parameter)
  - objects at different distances still same size
  - objects are shifted in the image depending on their depth

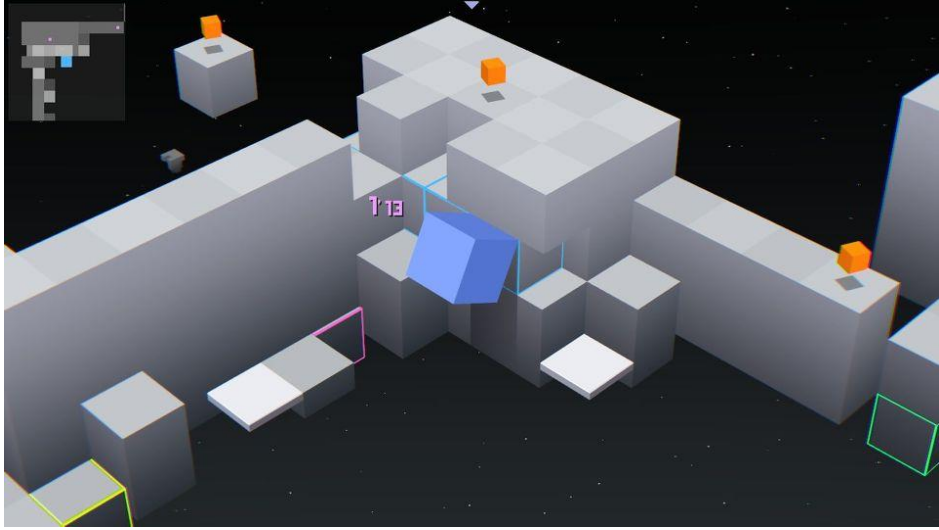


Based on slides by Steve Marschner

Orthographic View Volume



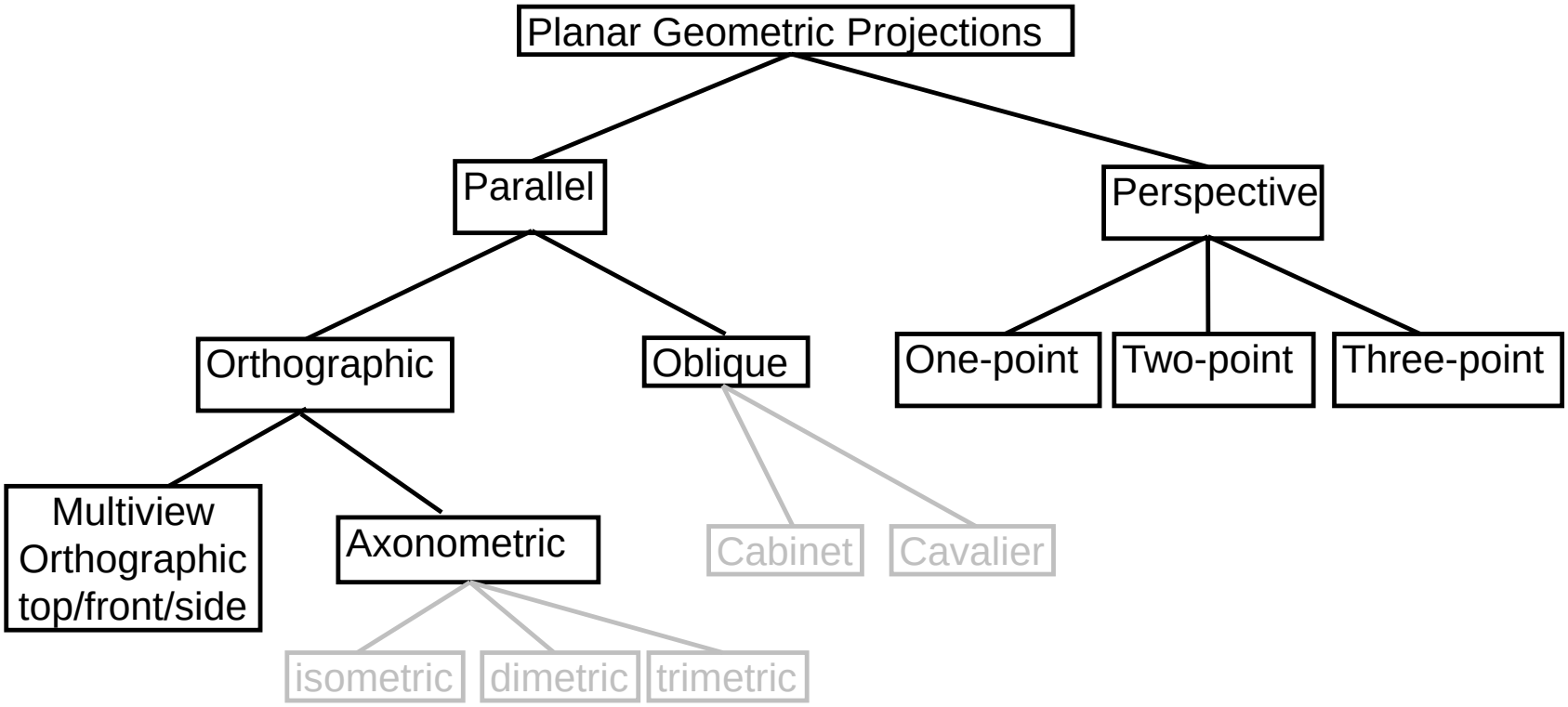
Recall: view volume is specified by left right top and bottom



Parallel projections in video games?

Taxonomy of Classical Projections

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



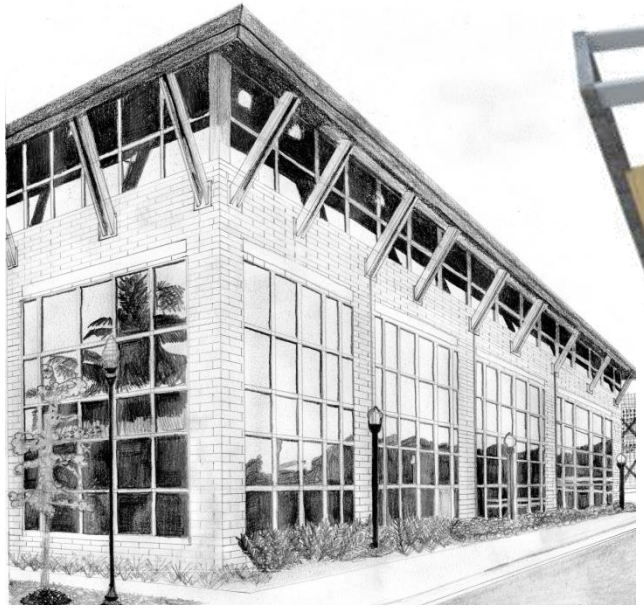
[after Carlbom & Paciorek 78]

Based on slides by Steve Marschner

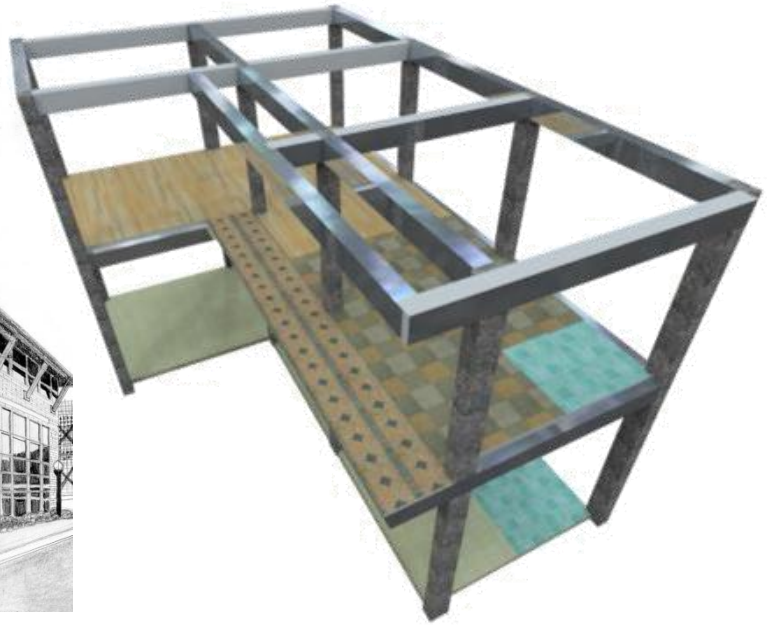
Perspective

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

two-point: projection plane parallel to one coordinate axis

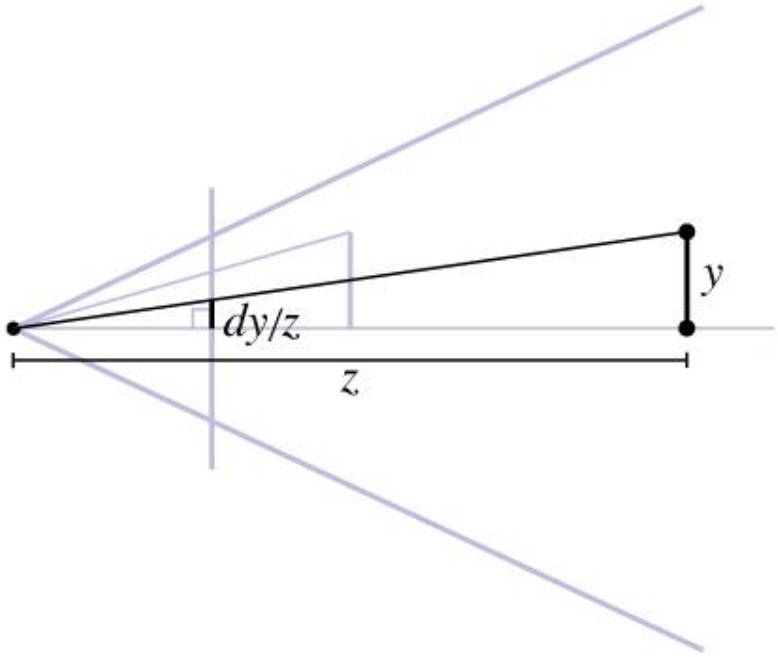


three-point: projection plane not parallel to a coordinate axis



Perspective projection (normal)

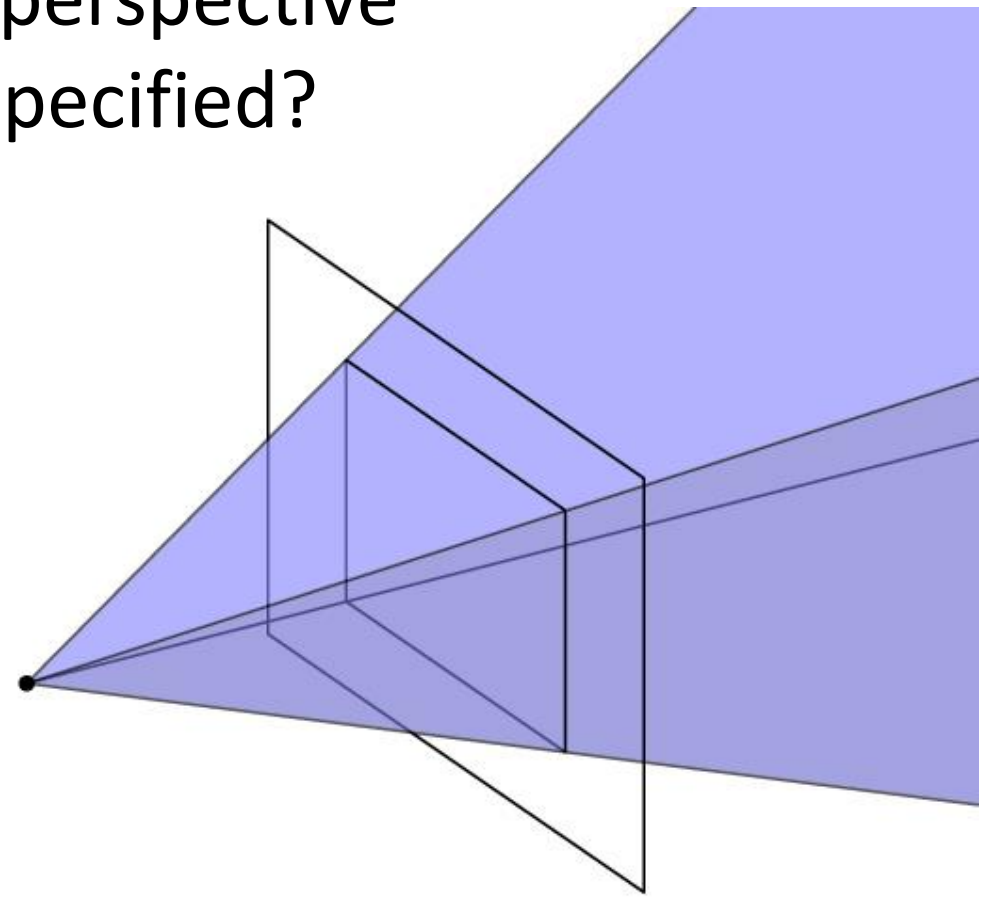
- Perspective is projection by lines through a point; "normal" = plane perpendicular to view direction
  - magnification determined by:
    - image height
    - object depth
    - image plane distance
  - FOV = 2 atan(h / (2d))
  - $y' = d\ y\ /\ z$
  - "normal" case corresponds to common types of cameras



Based on slides by Steve Marschner

View volume: perspective

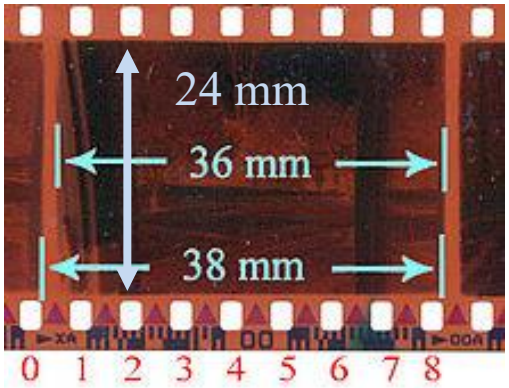
- Recall: how is perspective view volume specified?



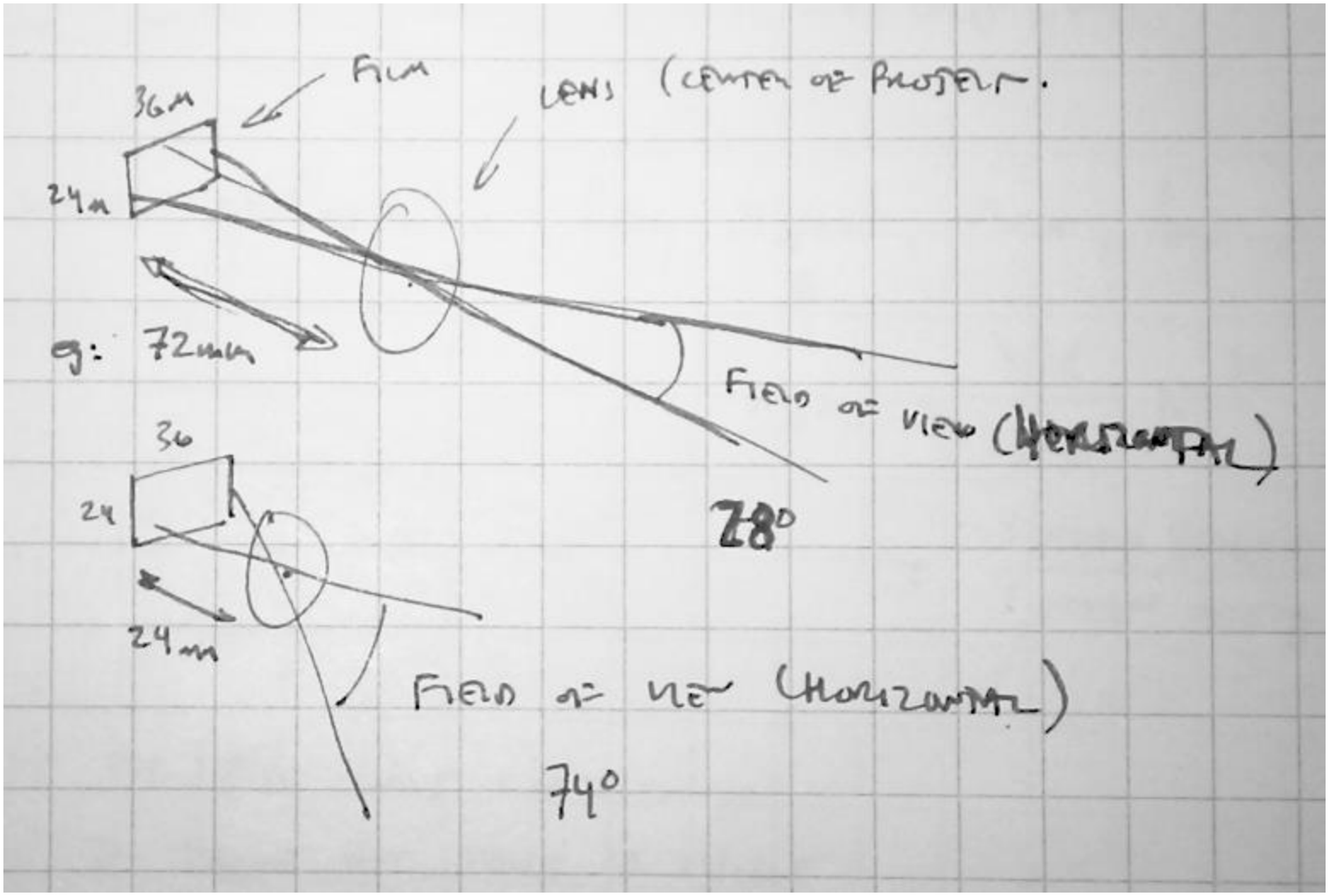
Based on slides by Steve Marschner

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
  - Must decide to measure vertical, horizontal, or diagonal
- In cameras, determined by focal length
  - This is confusing because it depends on film image size
  - For still photography, 35mm format: 36 x 24 mm image



- 18mm = — super-wide angle
- 28mm = — wide angle
- 50mm = — “normal”
- 100mm = — narrow angle (“telephoto”)


FILM
LENS (CENTER OF PROJECTOR.
36m
24m
g: 72mm
FIELD OF VIEW (HORIZONTAL)
78°
36
24
24mm
FIELD OF VIEW (HORIZONTAL)
74°

Field of view

- Determines “strength” of perspective effects

close viewpoint
wide angle
prominent foreshortening

far viewpoint
narrow angle
little foreshortening

[Ansel Adams]

Based on slides by Steve Marschner


18mm

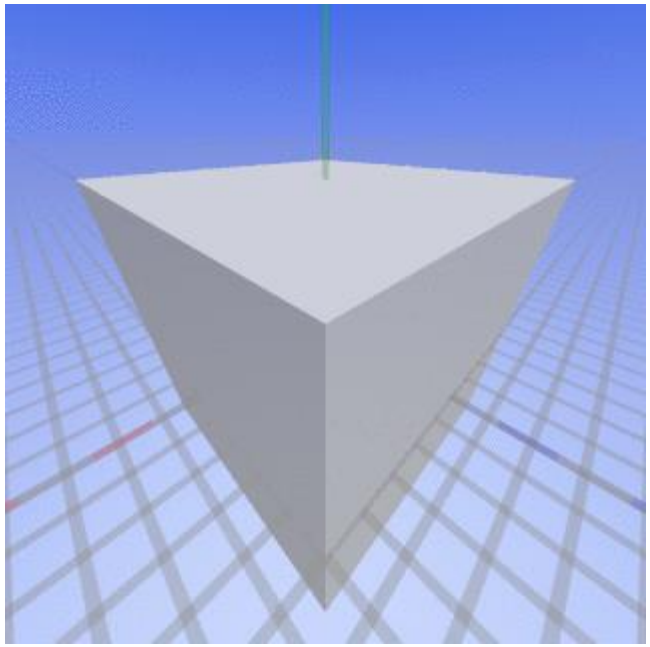
Choice of field of view

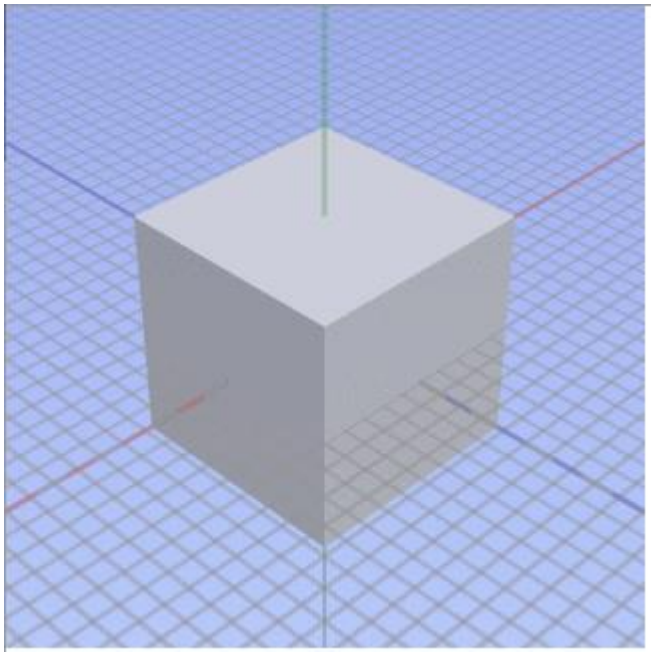
- In photography, wide angle lenses are specialty tools
  - "hard to work with"
  - easy to create weird-looking perspective effects
- In graphics, you can type in whatever f.o.v. you want
  - Don't be one of those people that type in big numbers unless you really mean it!

[Ken Perlin]

Based on slides by Steve Marschner

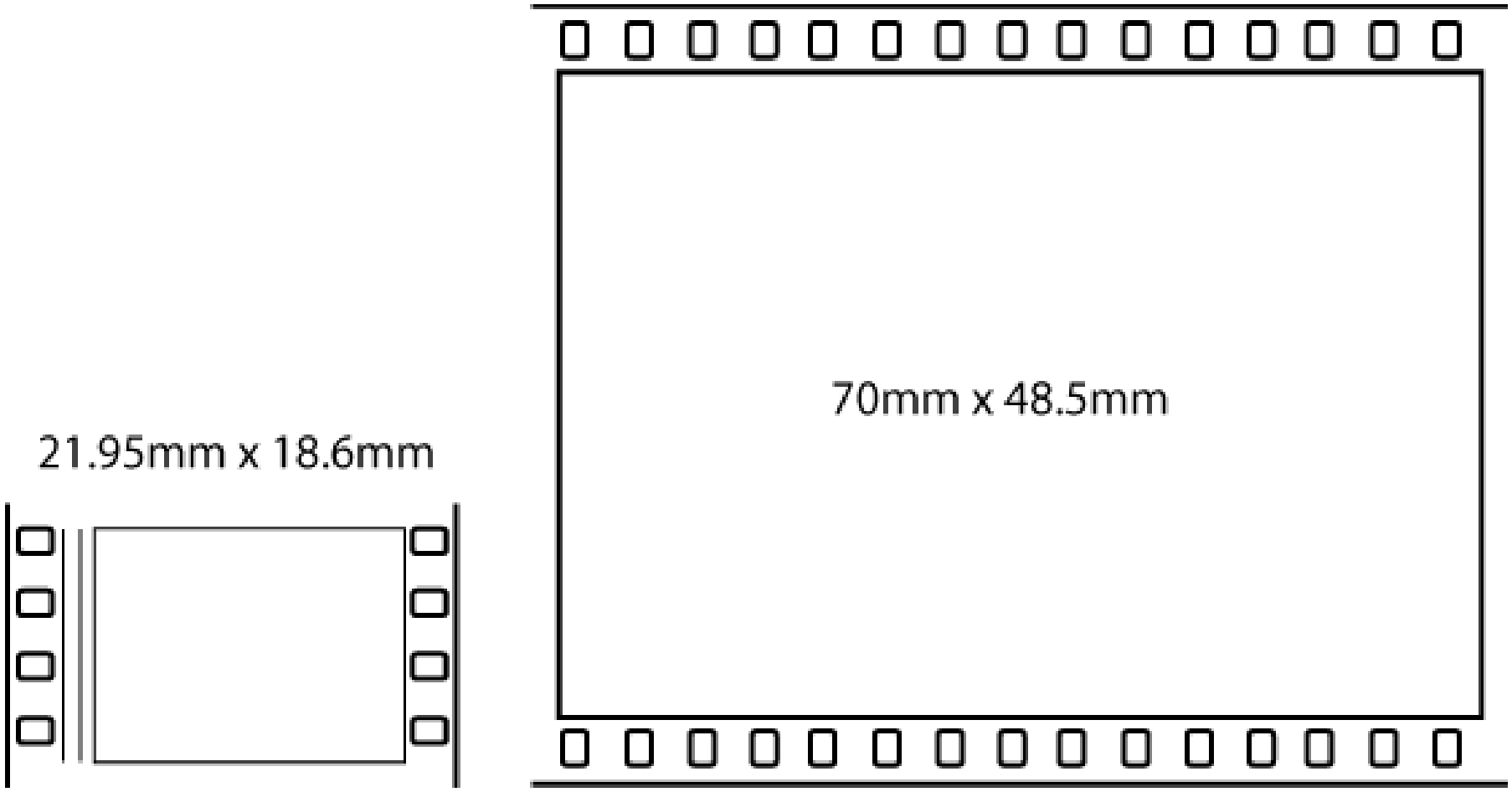
Perspective Distortions





Based on slides by Steve Marschner

Brief aside...



35mm
Academy Format

70mm
IMAX Format

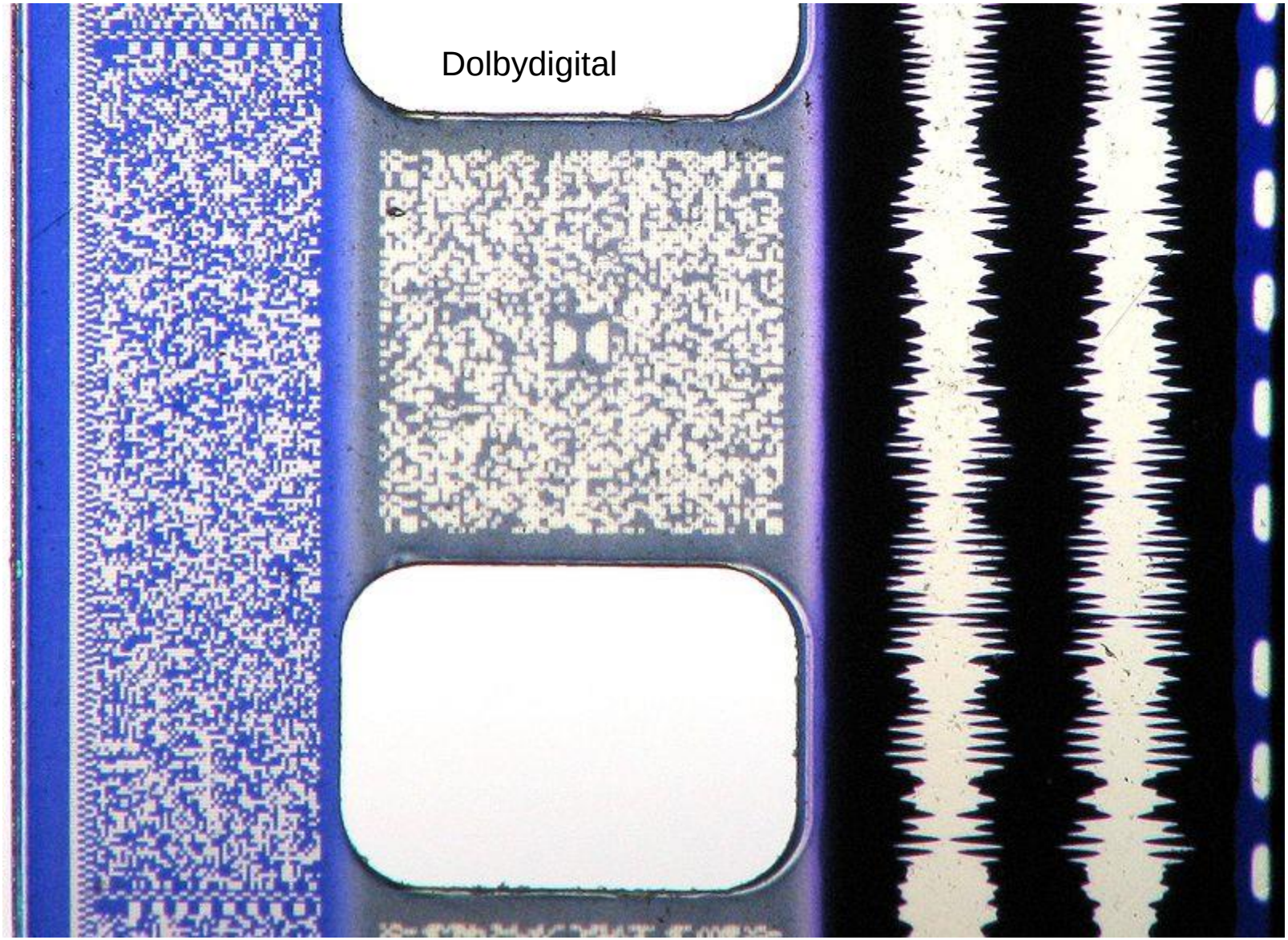
Widescreen
anamorphic
e.g., CinemaScope

SDDS
(sony dynamic digital sound)

Dolbydigital

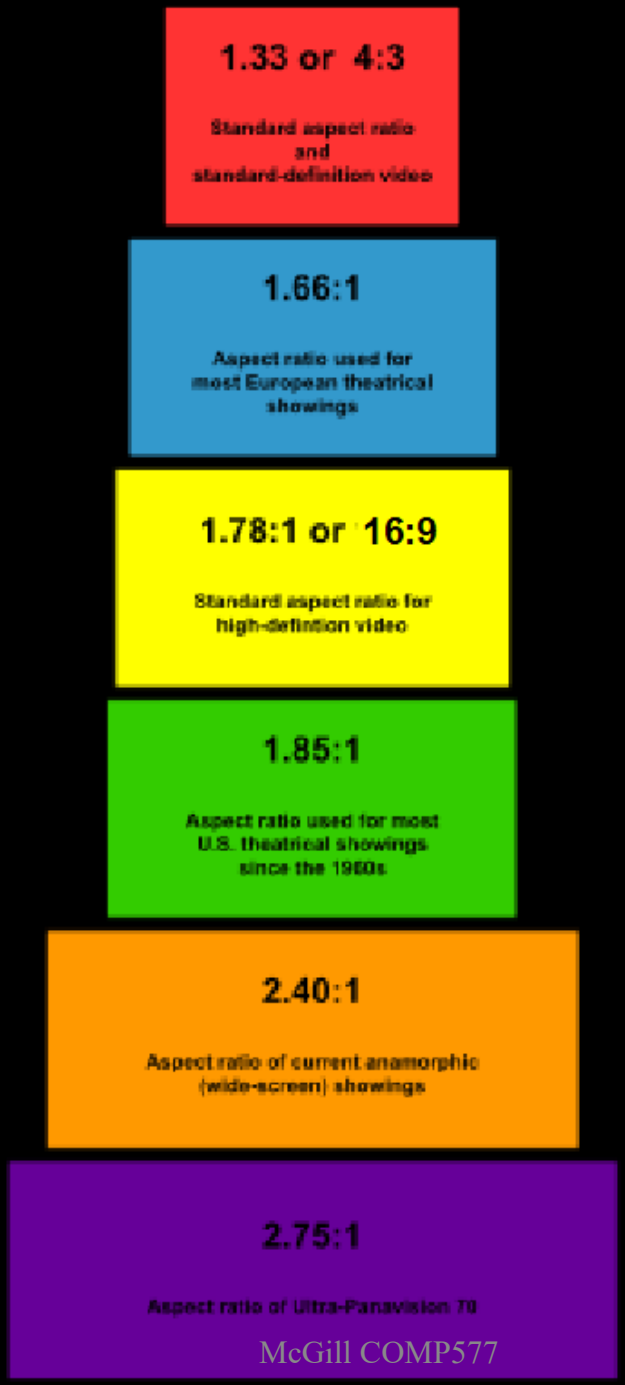
Analog optical

DTS
time code

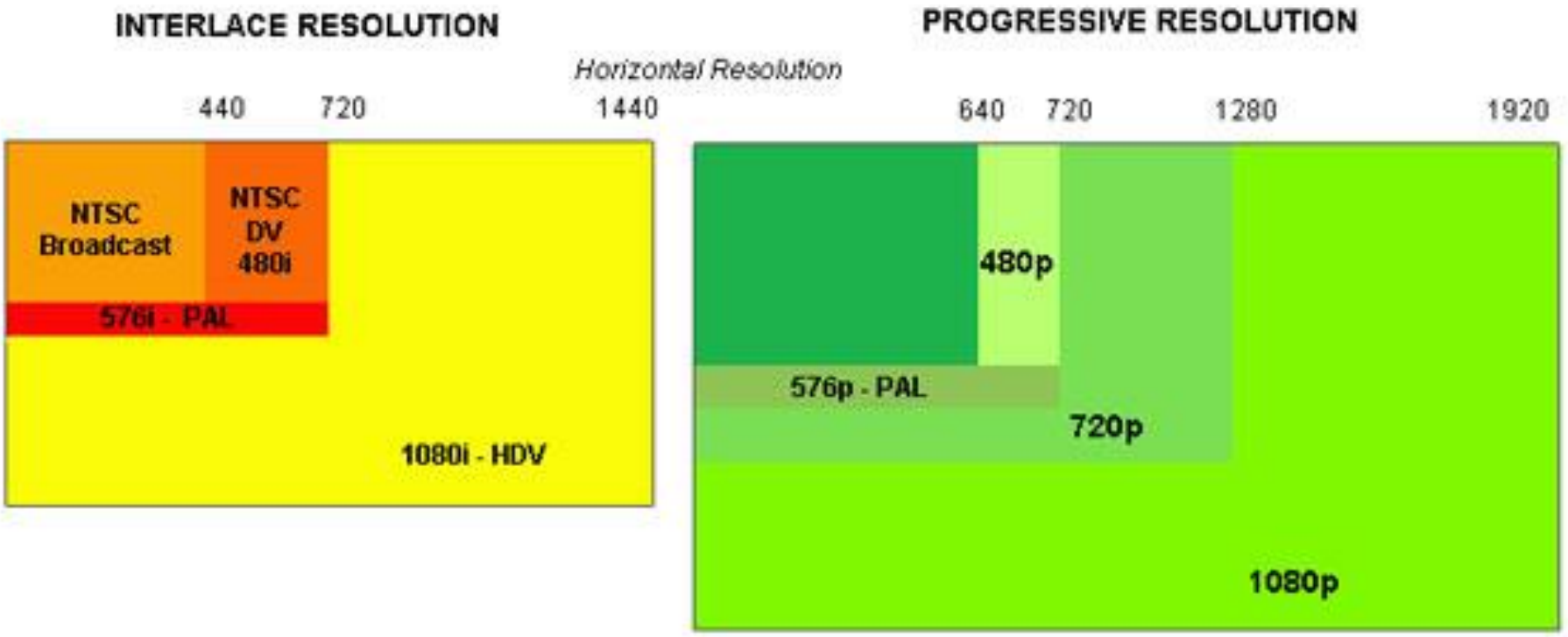


ANAMORPHIC VINTAGE OVAL BOKEH FILTER+ FLARE/STREAK

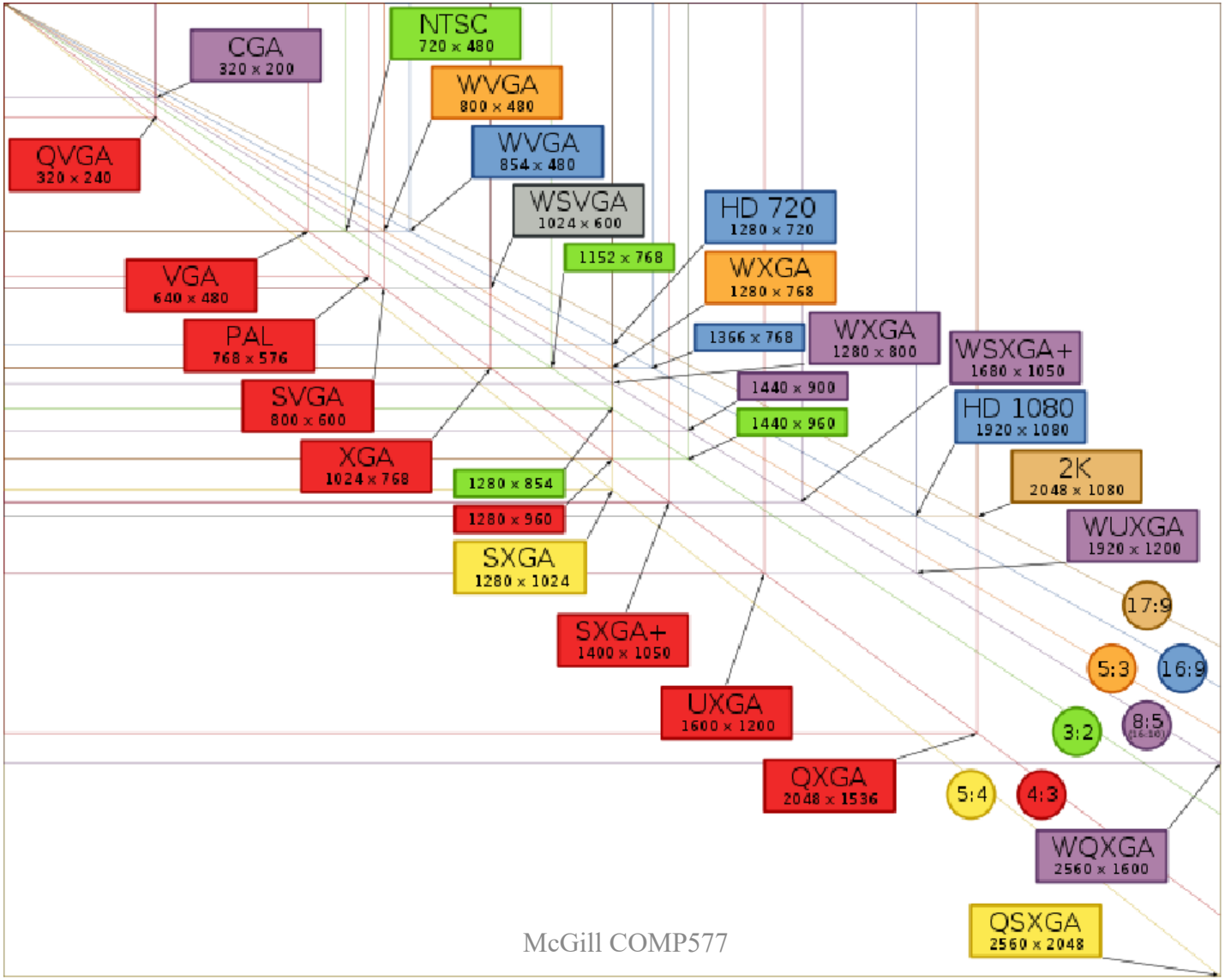
GET A VINTAGE LOOK TO YOUR VIDEOS


1.33 or 4:3
Standard aspect ratio and standard-definition video
1.66:1
Aspect ratio used for most European theatrical showings
1.78:1 or 16:9
Standard aspect ratio for high-definition video
1.85:1
Aspect ratio used for most U.S. theatrical showings since the 1960s
2.40:1
Aspect ratio of current anamorphic (wide-screen) showings
2.75:1
Aspect ratio of Ultra-Panavision 70

Common Resolutions



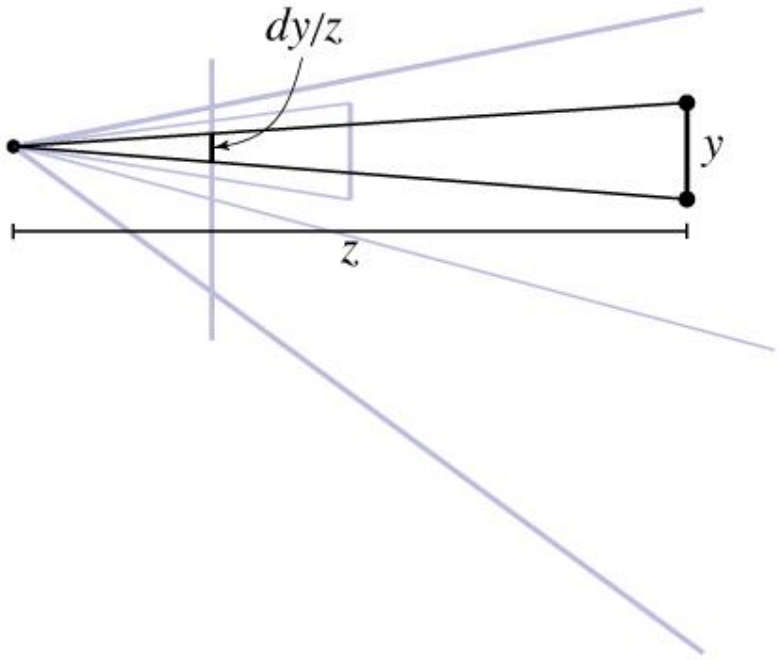
Resolutions and Aspect Ratios Square Pixels?



Back to projections...

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

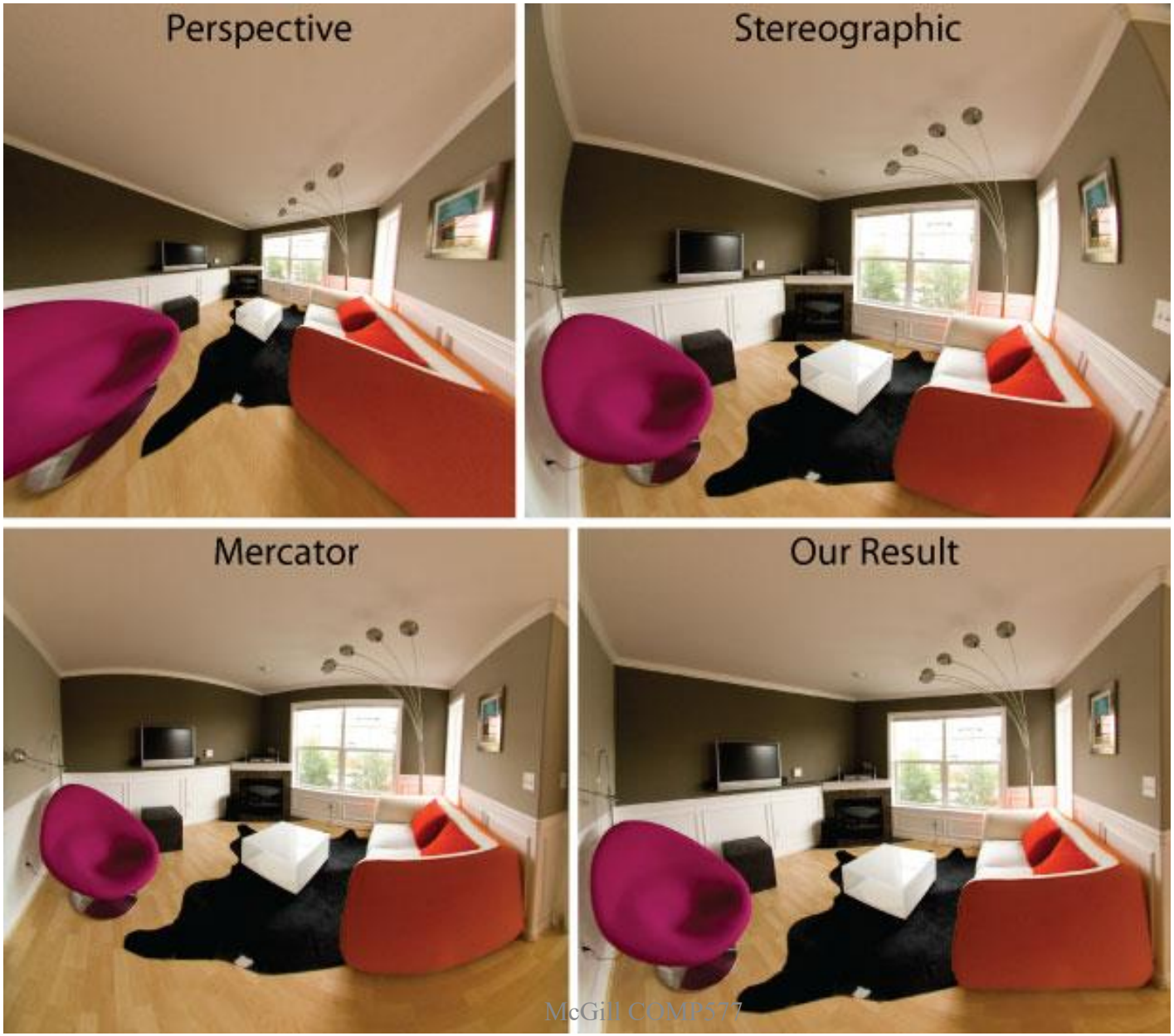
- Many ways to do this
  - common: from, at, up, v.f.o.v. (but not for shifted)
- One way:
  - viewpoint, view direction, up
    - establishes location and orientation of viewer
    - view direction is the direction of the center ray
  - image width, image height, projection distance
    - establishes size and location of image rectangle
  - image plane normal
    - can be different from view direction to get shifted perspective

Non-planar Projections...

Non-planar Projections... (panoramas, environment maps, etc.)

YAMAHA

Optimizing Content-Preserving Projections for Wide-Angle Images
Robert Carroll, Maneesh Agrawala, Aseem Agarwala, SIGGRAPH 2009



Perspective

Mercator

Stereographic

Our Result




RYAN: Render Your Animation Nonlinearly Projected,
P. Coleman & K. Singh
NPAR 04