

CS-C3100 Computer Graphics

Part 2 – Rendering

11.3 Cameras and ray generation



TAAV®
TALLER DE ARQUITECTURA VIRTUAL

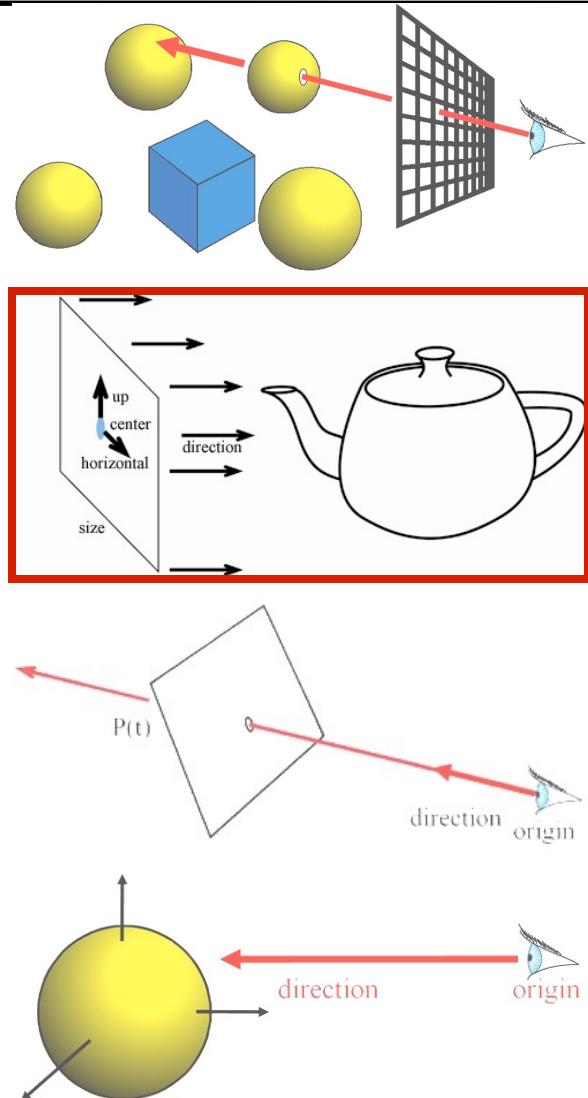
Jaakko Lehtinen
with lots of slides from Frédo Durand

In This Video

- Camera definitions
 - pinhole (perspective), orthographic, ...
 - normalized view coordinates $[-1,1]^2$
- Ray generation from a camera description
 - given (x, y) on screen, what is the corresponding ray?

Ray Casting

- Ray Casting Basics
- Camera and Ray Generation
- Ray-Plane Intersection
- Ray-Sphere Intersection



Cameras

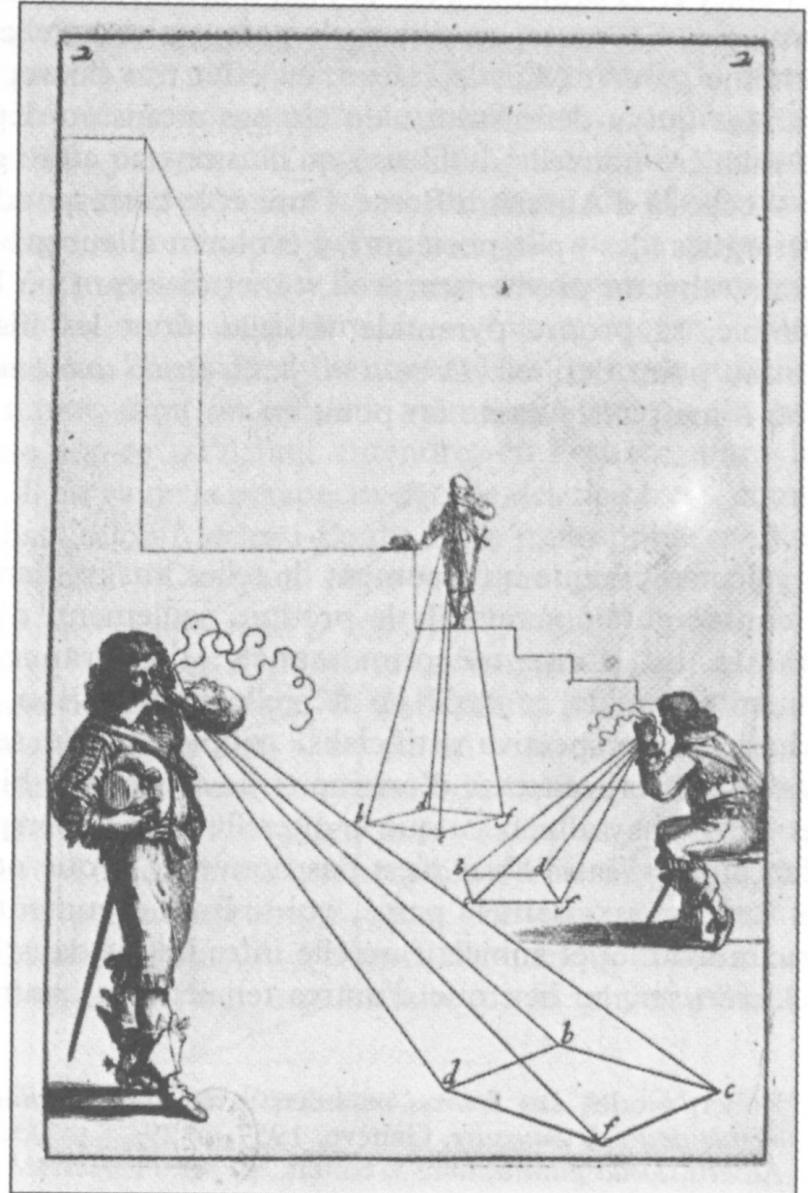
For every pixel

Construct a ray from the eye

For every object in the scene

Find intersection with ray

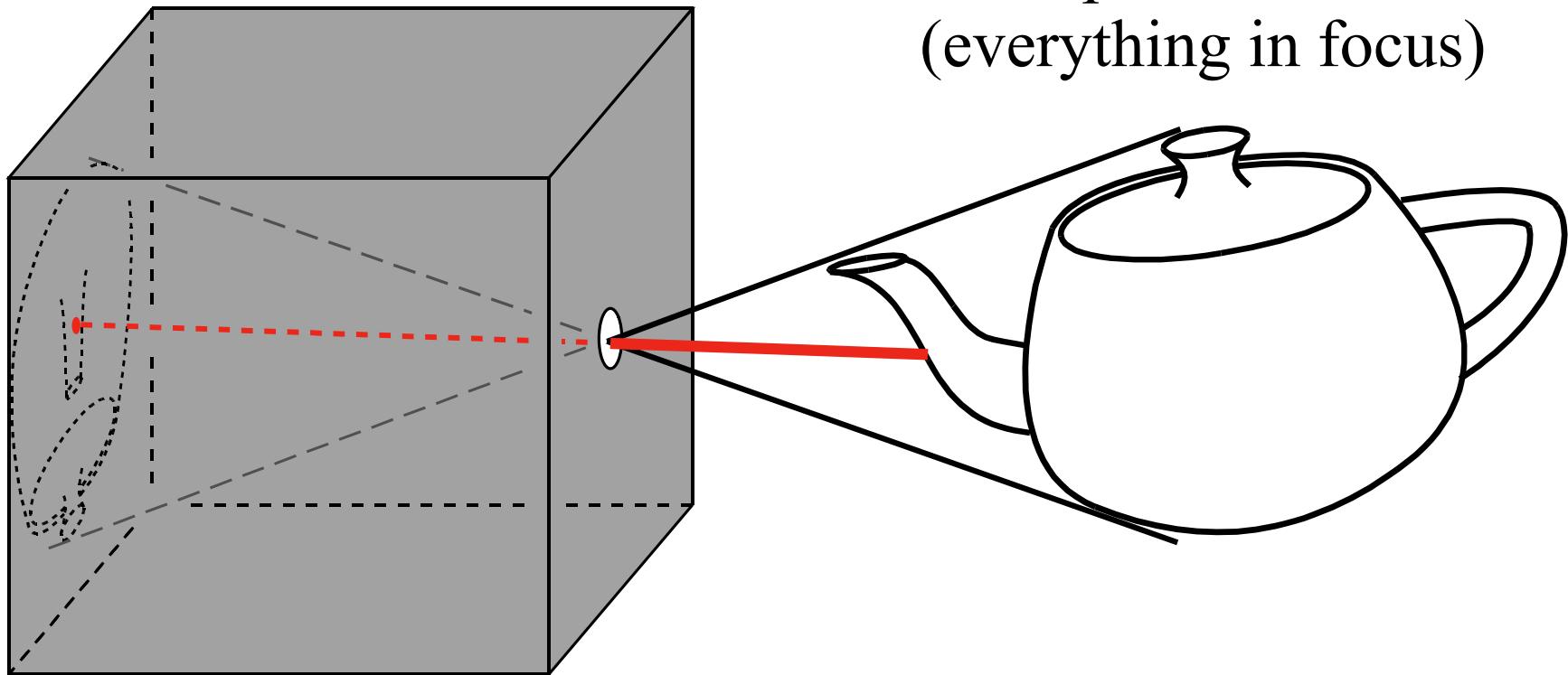
Keep if closest



Abraham Bosse, *Les Perspecteurs*. Gravure extraite de la *Manière*

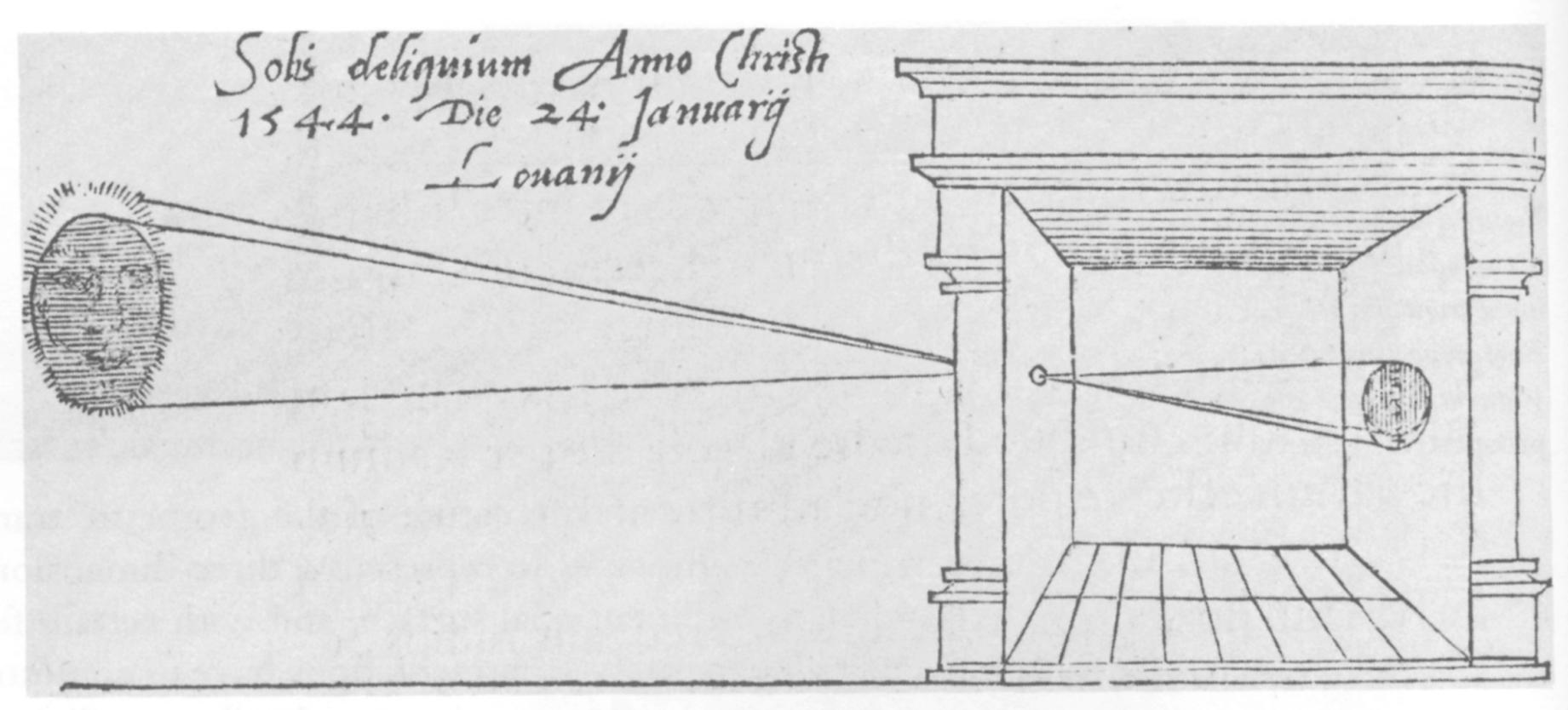
Pinhole Camera

- Box with a tiny hole
 - Inverted image
 - Similar triangles
- Perfect image if hole infinitely small
 - Pure geometric optics
 - No depth of field issue (everything in focus)

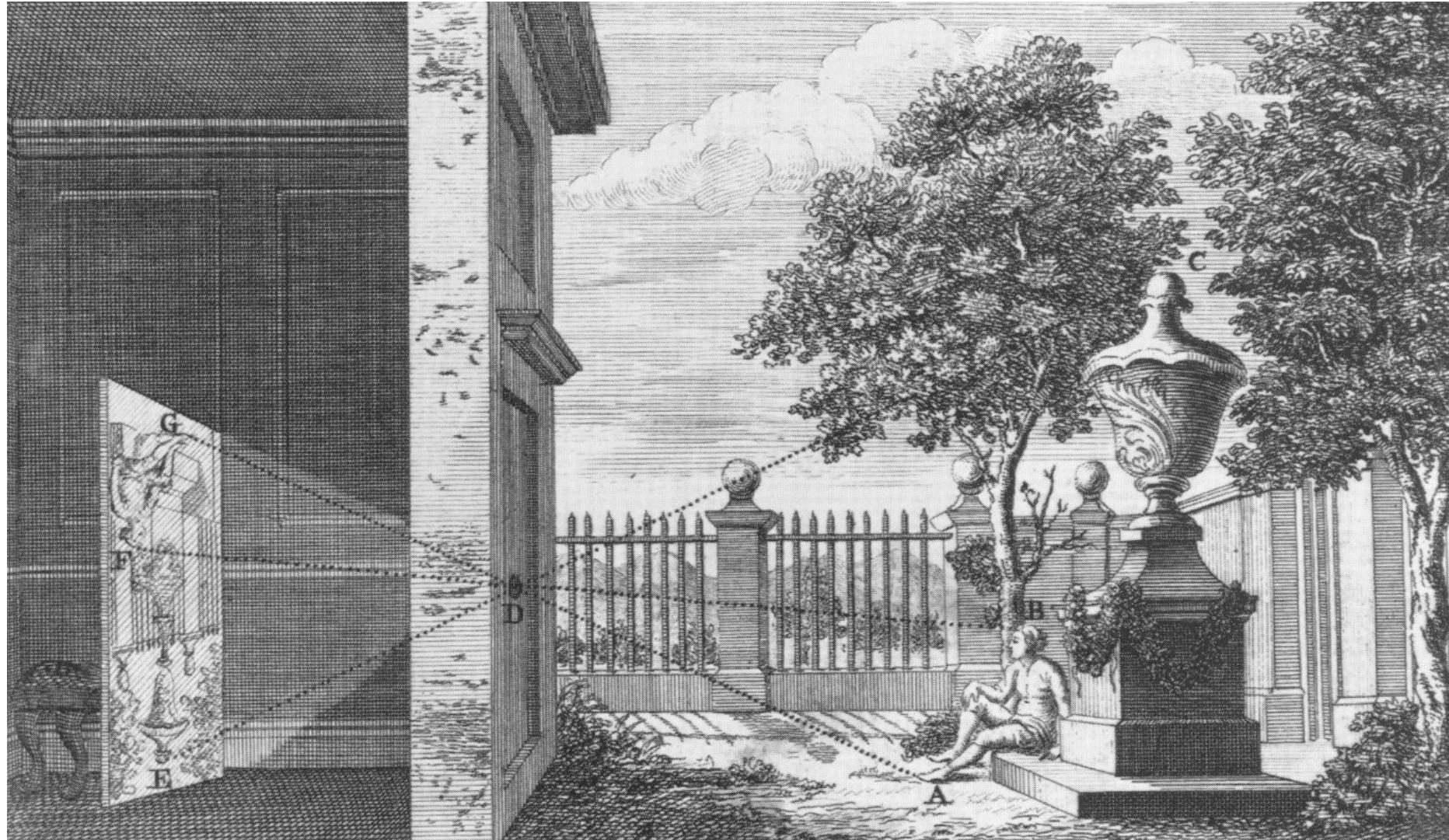


Oldest Illustration

- From Gemma Frisius, 1545



Also Called “Camera Obscura”



Camera Obscura Today

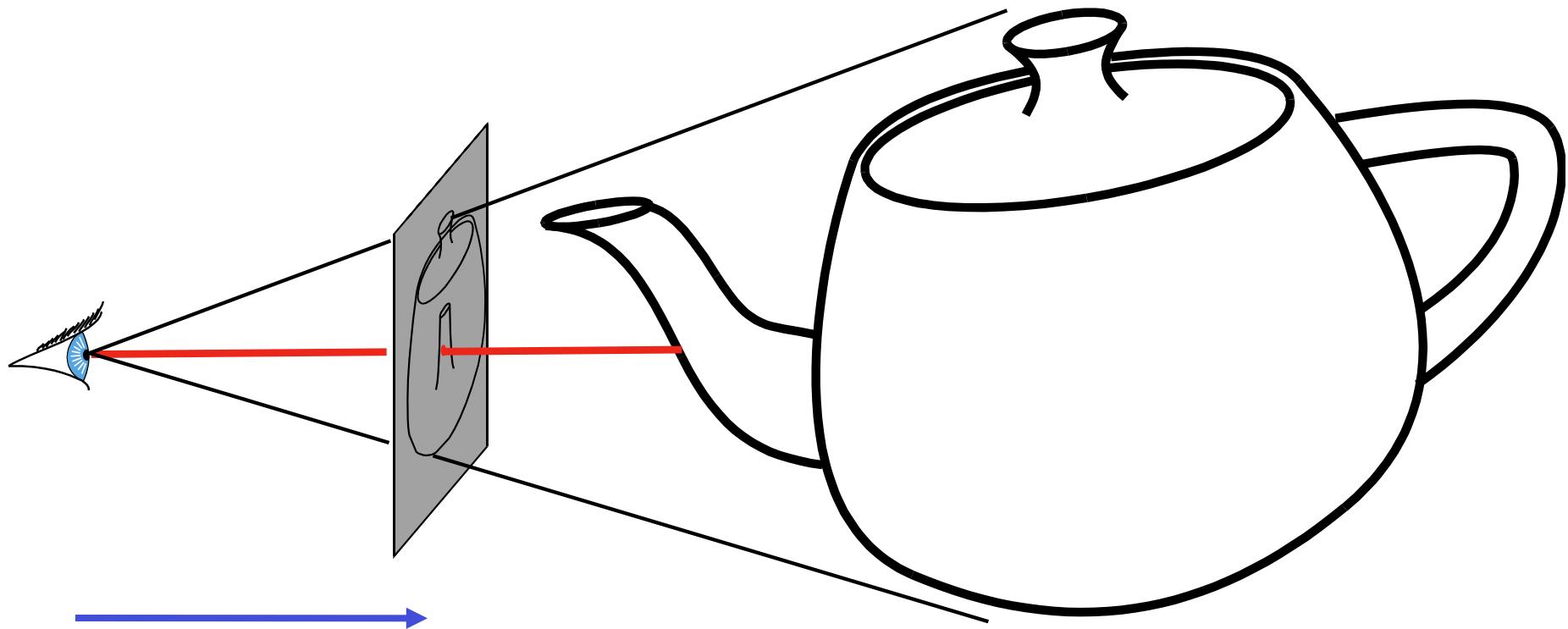


Abelardo Morell
www.abelardomorell.net

You can submit your own
pictures taken this way for a little
extra credit! Include something
graphics-related in the scene ;)

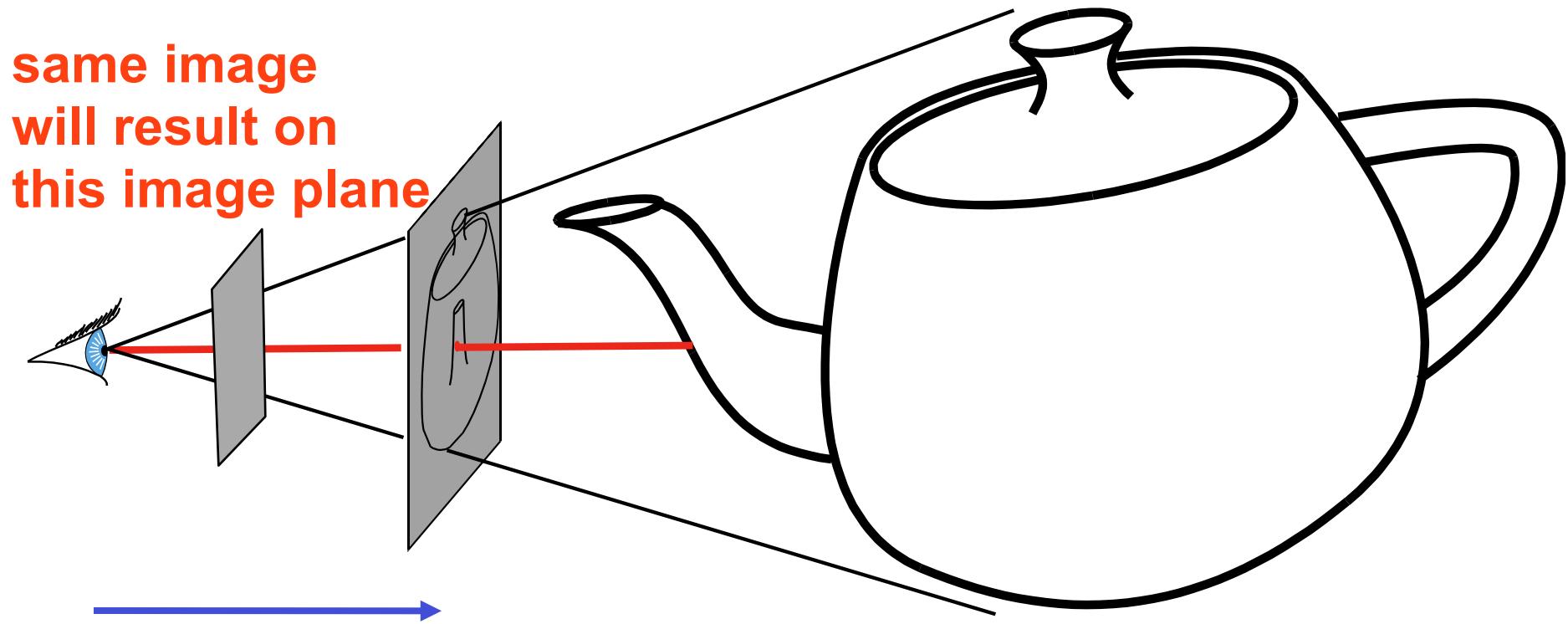
Simplified Pinhole Camera

- Eye-image pyramid (view frustum)
- Note that the distance/size of image are arbitrary

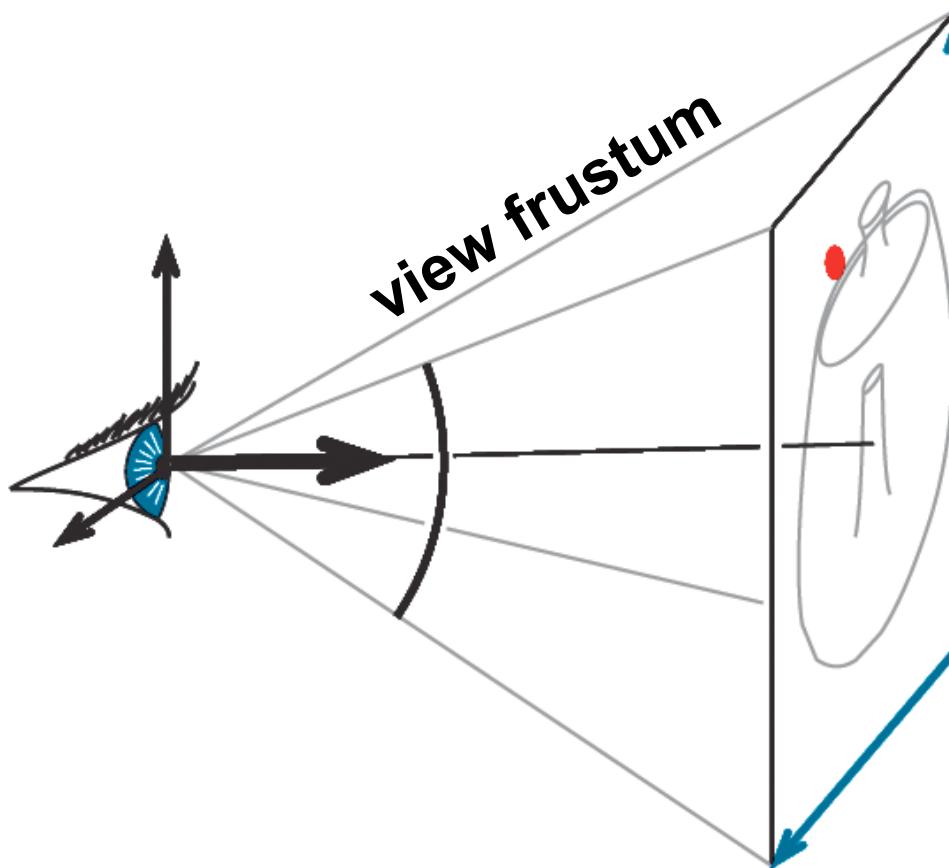


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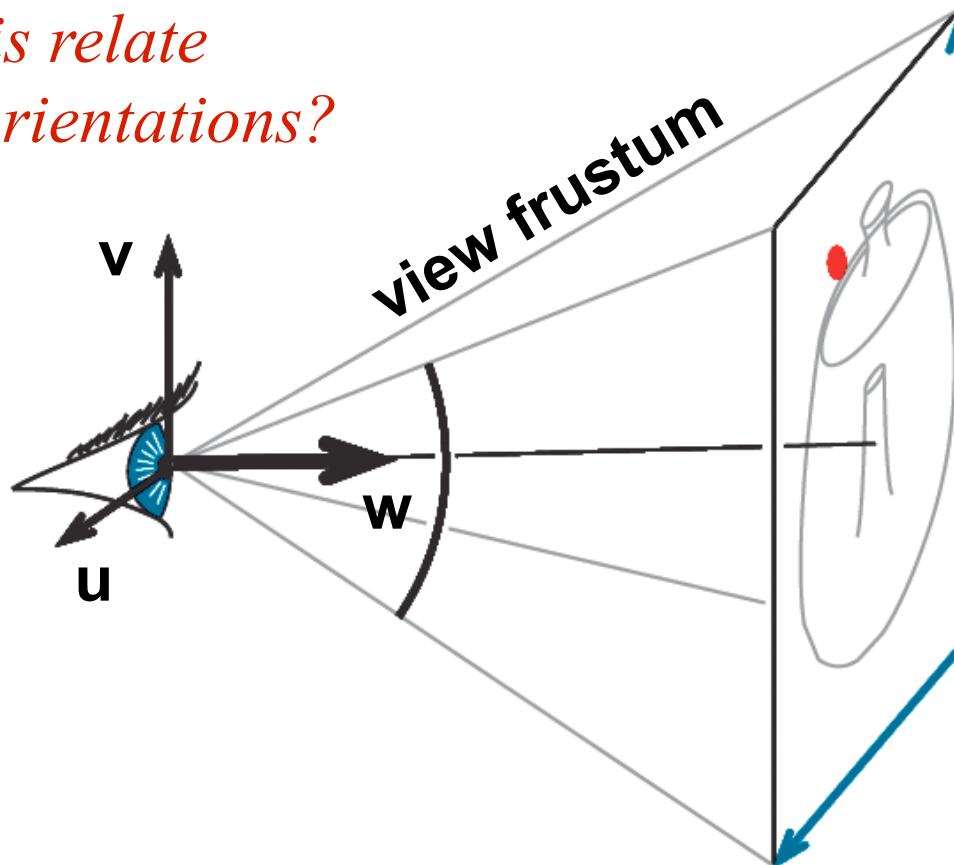
Camera Description?



Camera Description?

- Eye point e (*center*)
- Orthobasis u, v, w (*horizontal, up, direction*)
 - *How does this relate to matrices/orientations?*

Object
coordinates
World
coordinates
**View
coordinates**
Image
coordinates



Camera Description?

- Eye point e (*center*)
- Orthobasis u, v, w (*horizontal, up, direction*)
- Field of view *angle*
- Image rectangle *aspect ratio*

Object
coordinates
World
coordinates
**View
coordinates**
Image
coordinates

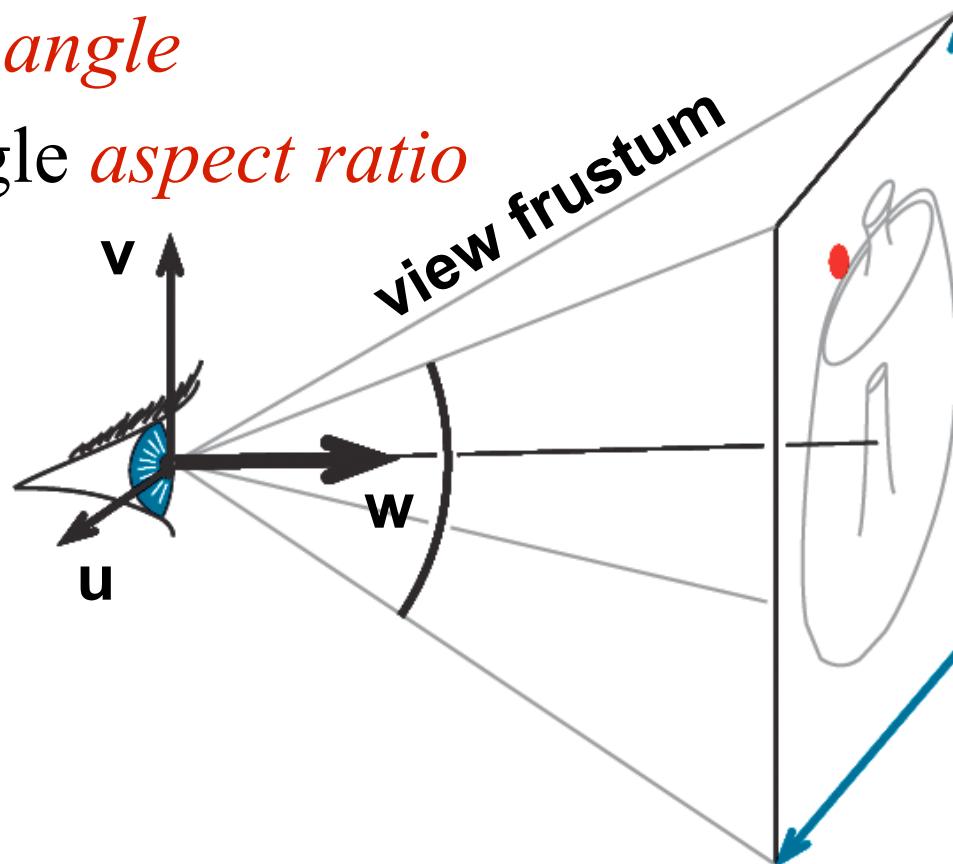
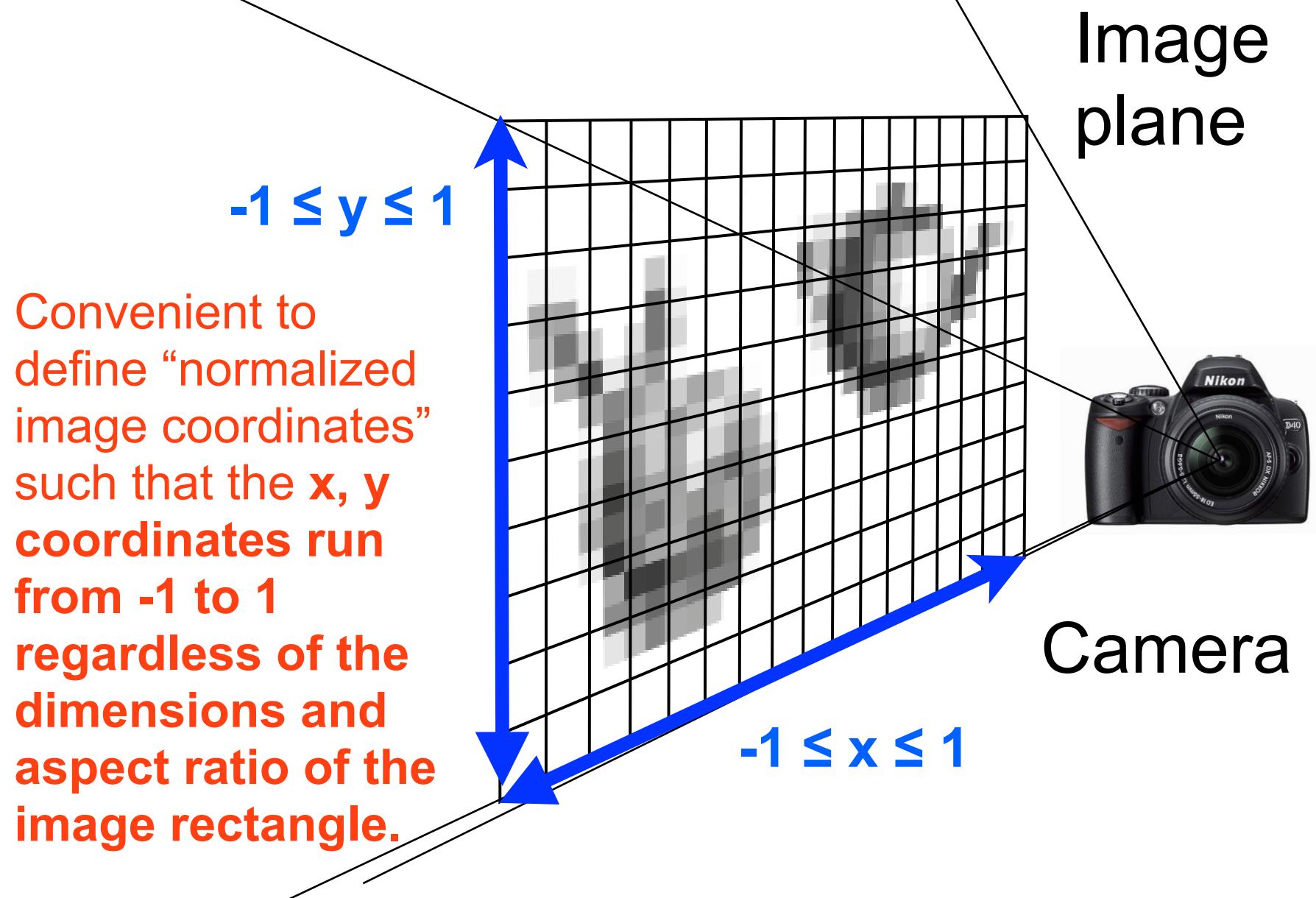
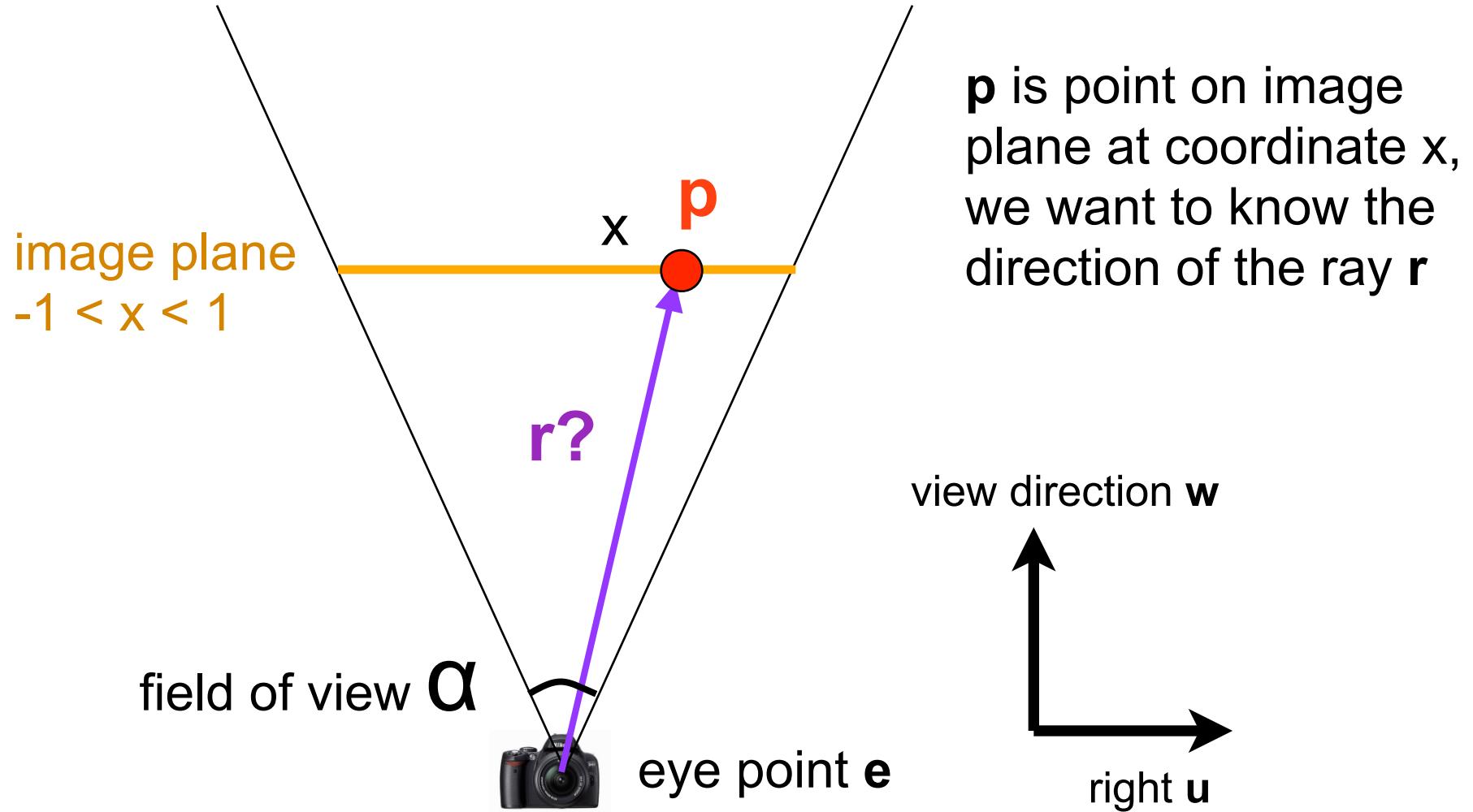


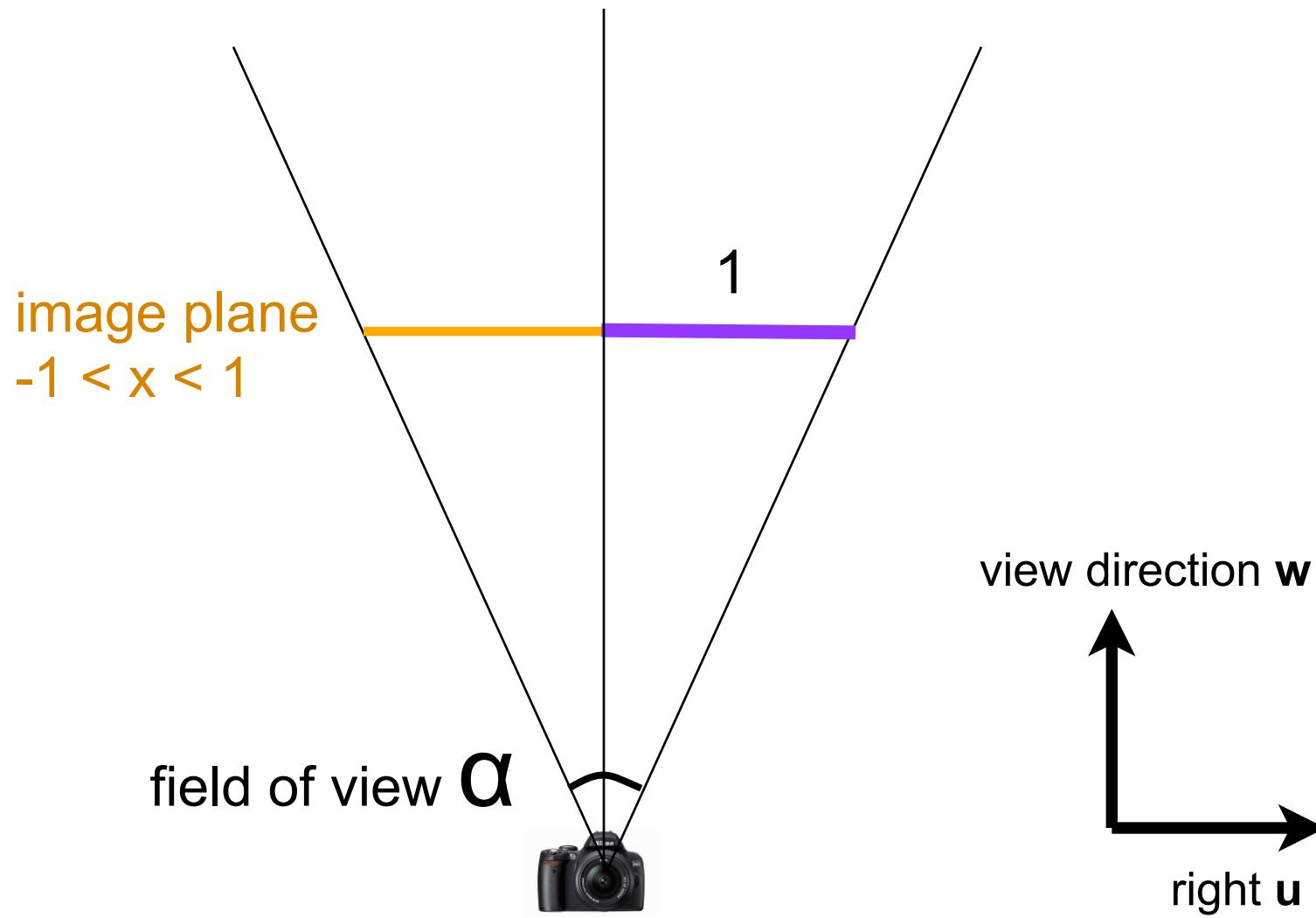
Image Coordinates



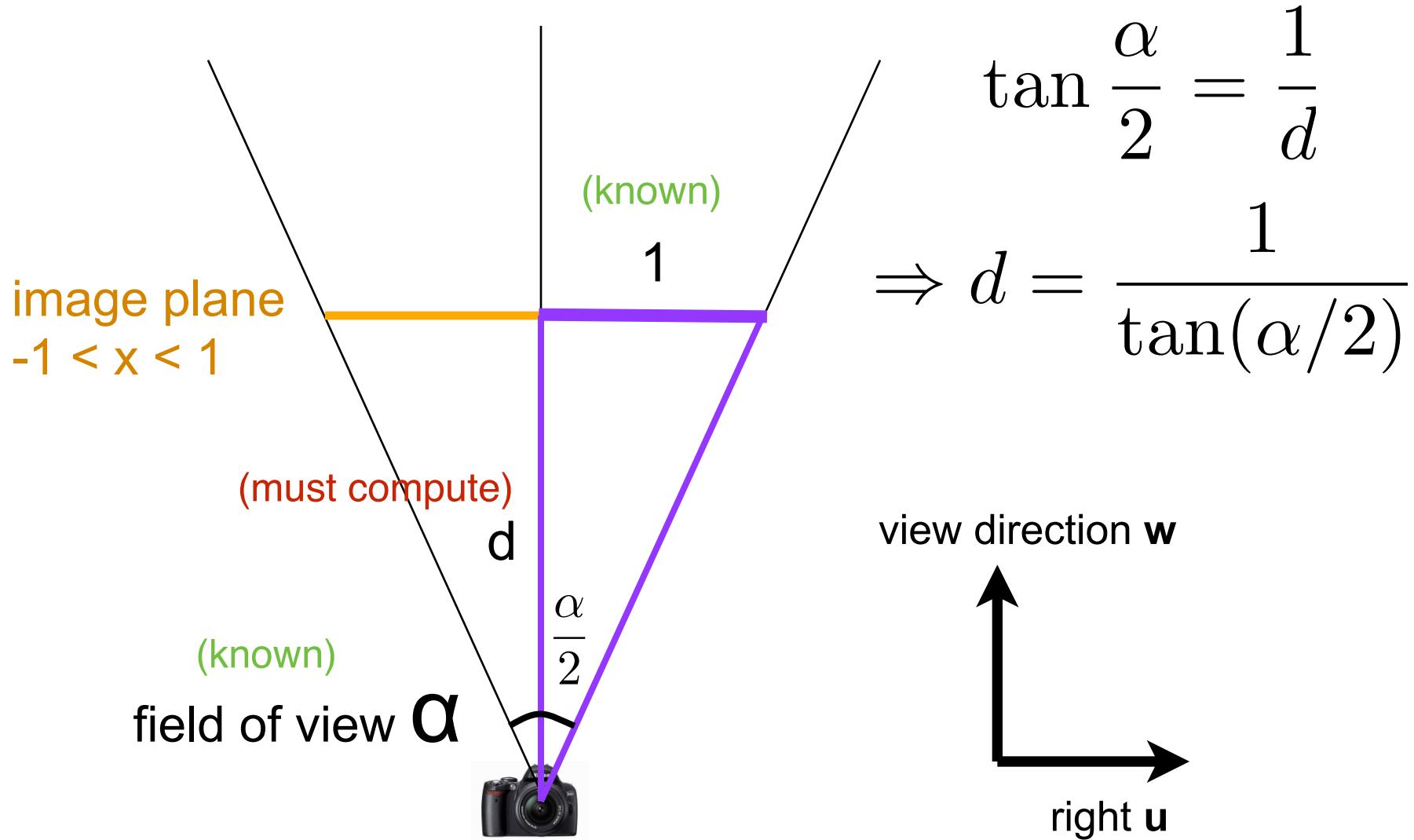
Ray Generation in 2D



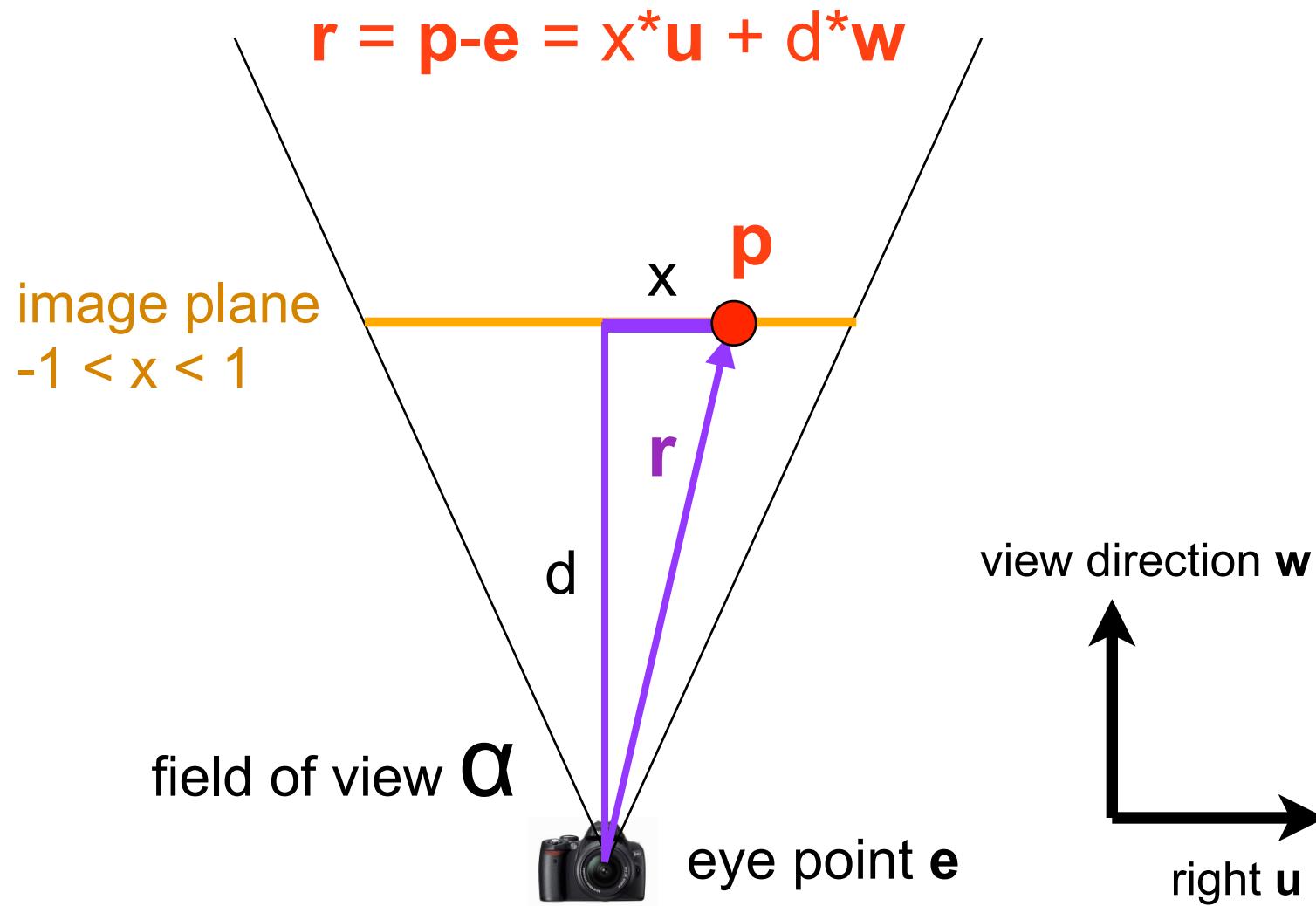
Ray Generation in 2D



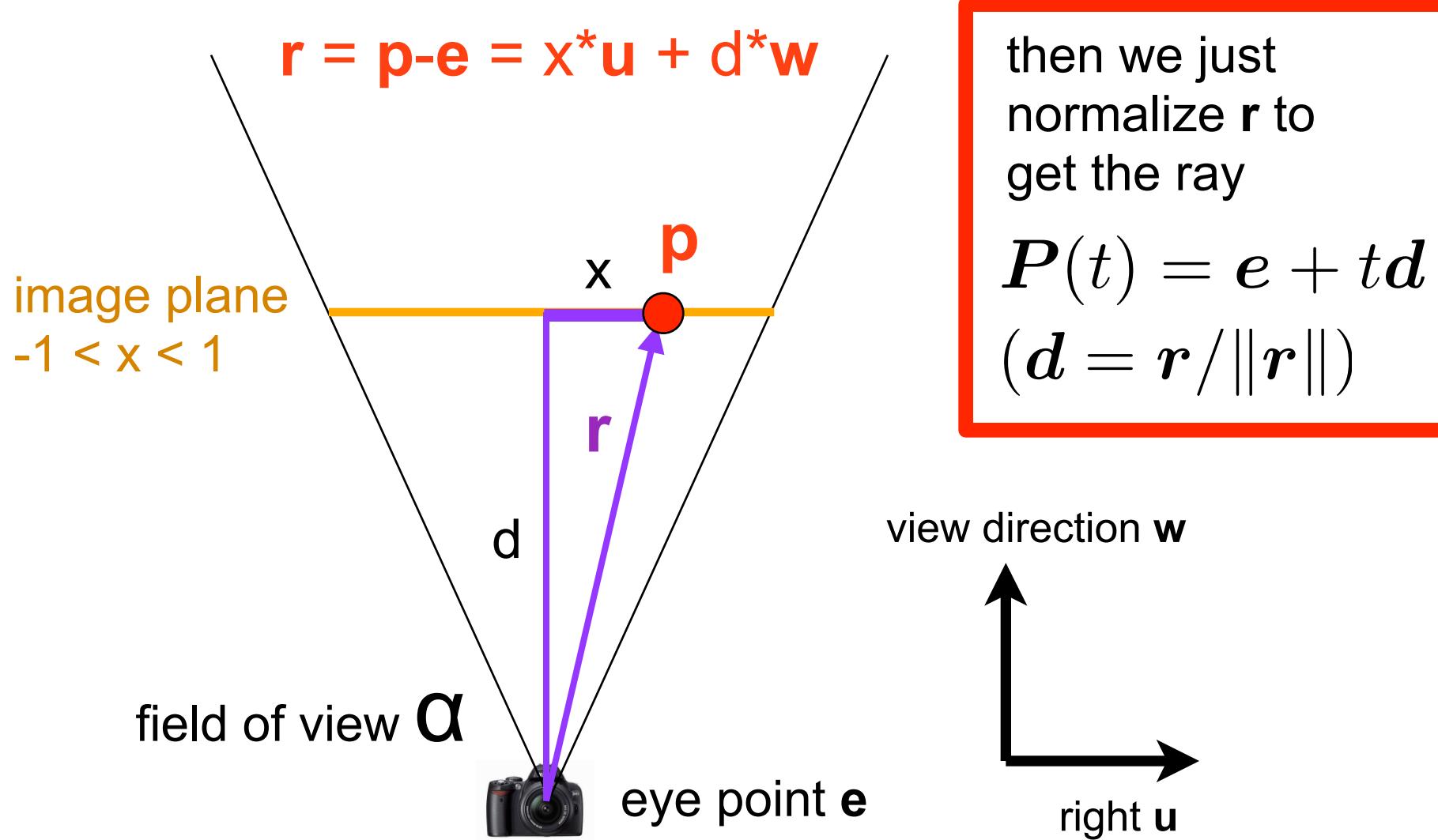
Ray Generation in 2D



Ray Generation in 2D



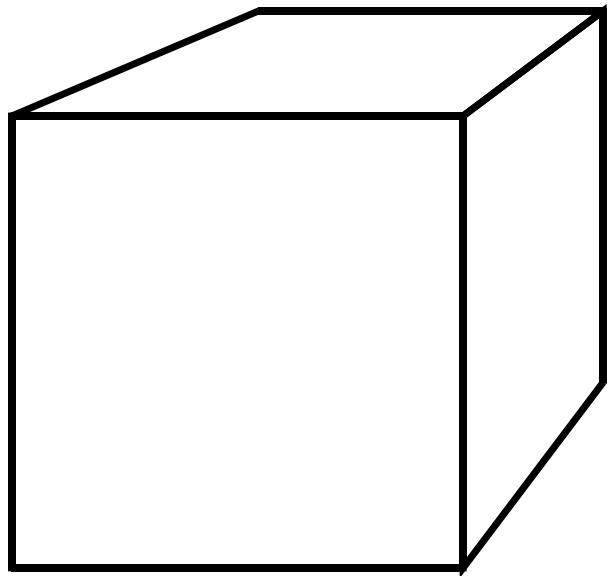
Ray Generation in 2D



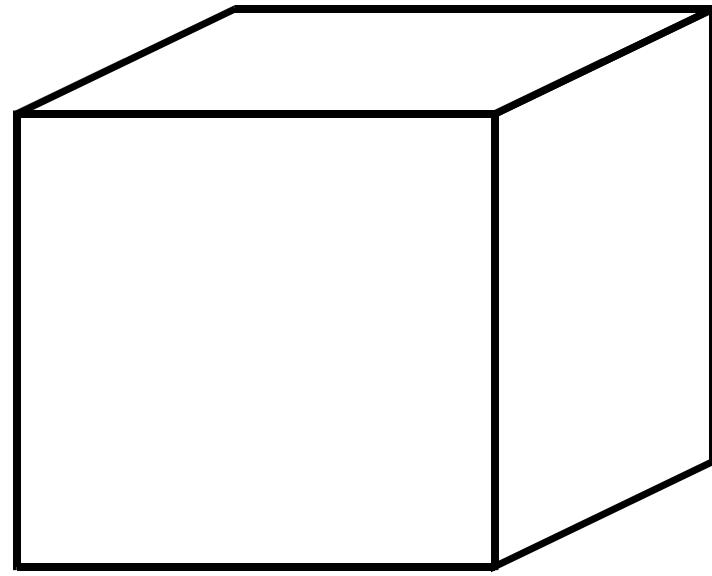
That was 2D, 3D is just as simple

- y coordinate is treated just like x , except accounting for aspect ratio
 - $\mathbf{r} = x^*\mathbf{u} + \text{aspect}^*y^*\mathbf{v} + d^*\mathbf{w}$
 - Again, \mathbf{u} , \mathbf{v} , \mathbf{w} are the basis vectors of the view coordinate system
 - Aspect ratio handles non-square viewports
 - Think of your 16:9 widescreen TV
- The point of the exercise with computing d was to allow us to use the $[-1,1]$ image coordinate system regardless of field of view.

Perspective vs. Orthographic



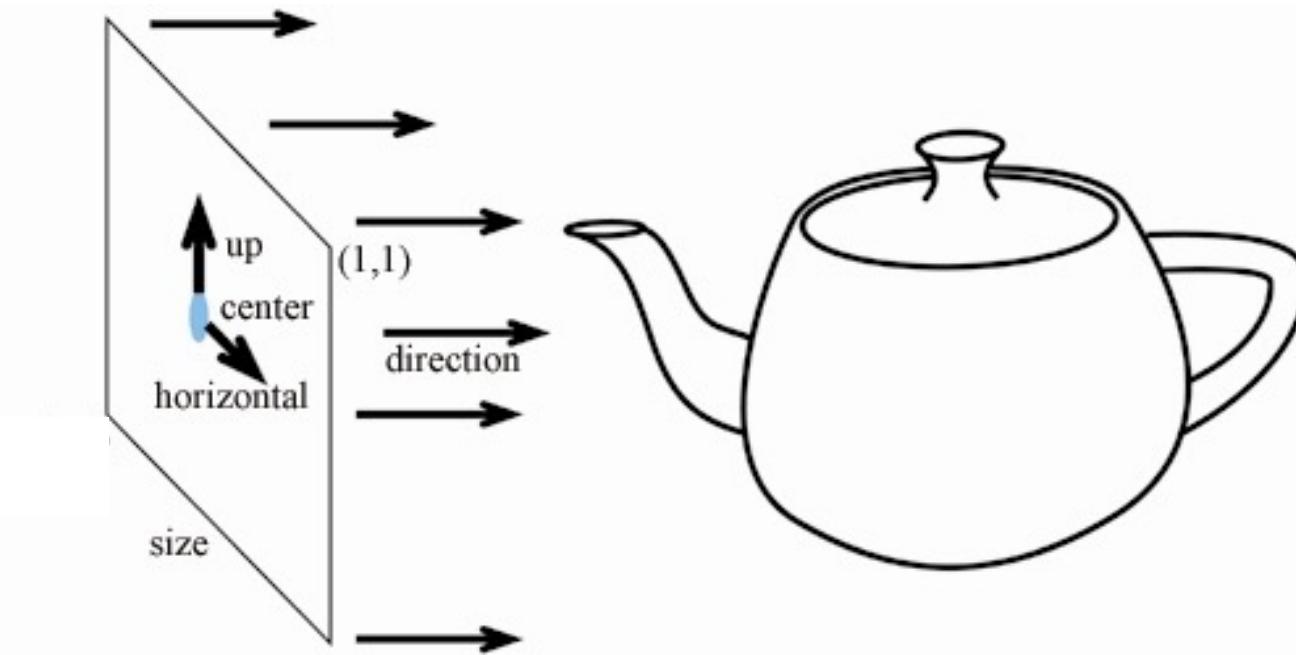
perspective



orthographic

- Parallel projection
- No foreshortening
- No vanishing point

Orthographic Camera



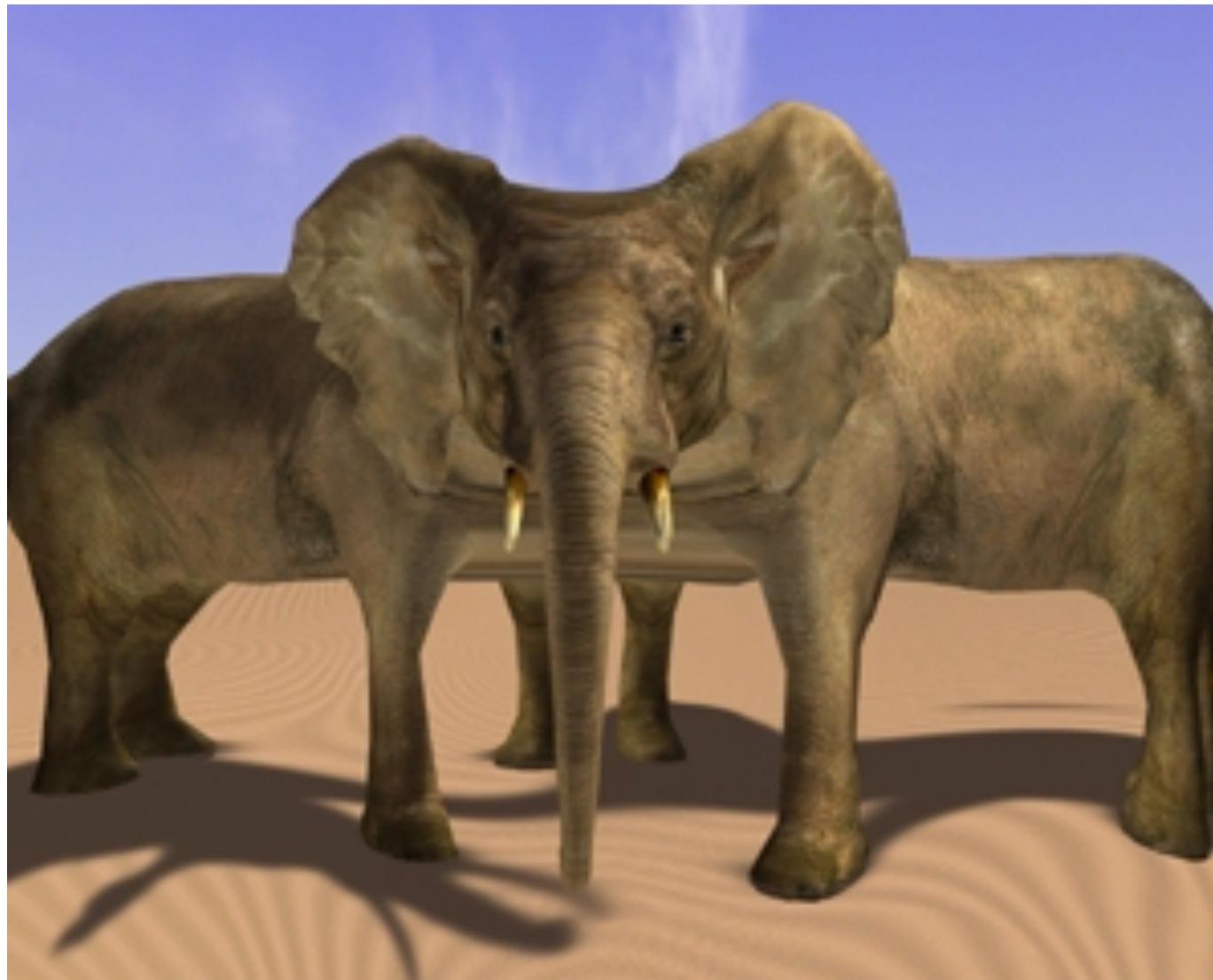
- Ray Generation?
 - Origin = $e + x \cdot \text{size} \cdot \mathbf{u} + y \cdot \text{size} \cdot \mathbf{v}$
 - Direction is constant: \mathbf{w}

Other Weird Cameras

- E.g. fish eye, omnimax, panorama



Further out...



Even Funkier
Multiperspective
Imaging

Time is just another dimension

- “Time displacement” or “slit scan” ([youtube](#))



Time is just another dimension

- “Time displacement” or “slit scan” ([youtube](#))



That's All!

