ISTA 352

Lecture 13

Two eyes are better than one

(After a bit of camera cleanup)

Administrivia

- Homework II due in less than three days

Camera matrix, *M*

Actual pixel coords are (u,v) = (U/W, V/W)

$$\begin{pmatrix} U \\ V \\ W \end{pmatrix} = \begin{pmatrix} \text{Transformation} \\ \text{representing} \\ \text{intrinsic parameters} \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} \text{Transformation} \\ \text{representing} \\ \text{extrinsic parameters} \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \\ 1 \end{pmatrix}$$

Projection. By convention we use **f=1** and put the scale of the W component into the intrinsic parameter matrix.

First part makes it so that we are in standard camera coords where we know how to project.

Intrinsic parameters

- The extrinsic and projection matrices together map the world into a "canonical" image where:
  - unit distance from the pinhole
  - center directly (normal) behind the pinhole
  - image bounds are (-1,-1) to (1,1)
- To map it to the real camera with focal length f, with the origin at the top-left corner, pixels that may not be square, etc, we use one more matrix (the one on left in the previous equation)

Camera parameter summary

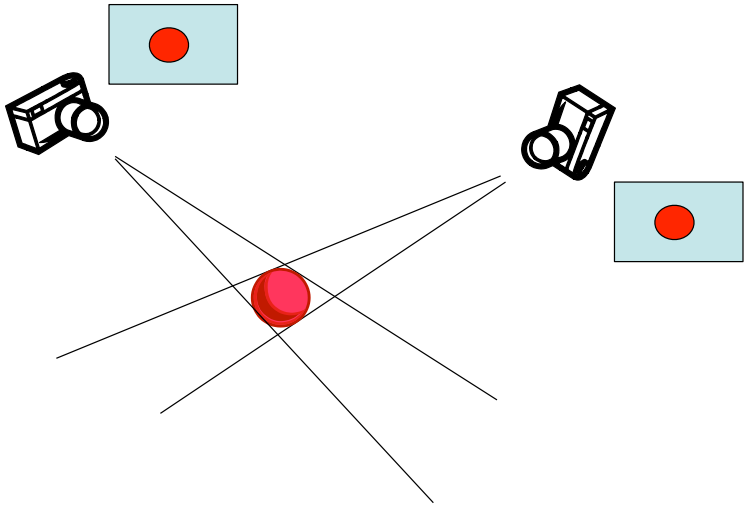
The number of parameters are the number of intrinsic parameters *plus* the number of extrinsic parameters.

Extrinsic parameters:	
location	(3)
orientation	(3)
Intrinsic parameters:	
focal length	(1)
pixel aspect ratio	(1)
principal point	(2)
skew	(1)
	11

Often assume skew is zero

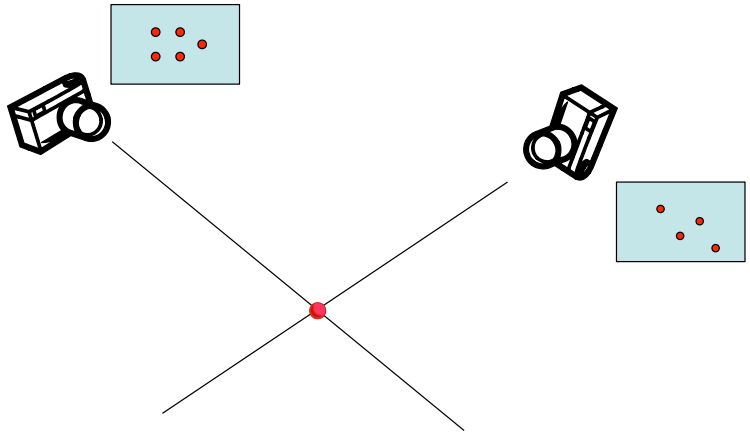
Two Eyes or Cameras (stereo)

- The human vision system (HVS) infers depth in many ways
  - Shading cues
  - Texture consistency
  - Occlusion reasoning
  - Stereo views



Stereo technology

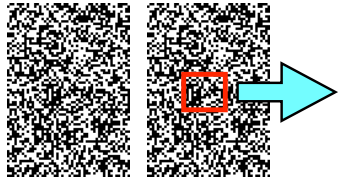
- If you are looking at a 3D scene, the angle to a point is different for each eye
- If we want to recreate this using a flat screen, we can emulate this by recreating the angle for each eye
- But we need to control what each sees
- This is basis for most stereo technologies (including the anaglyphs we just looked at)



We can find the 3D location of a point seen in two images using geometry **but** we need to know that the points **correspond**.

Random dot stereogram

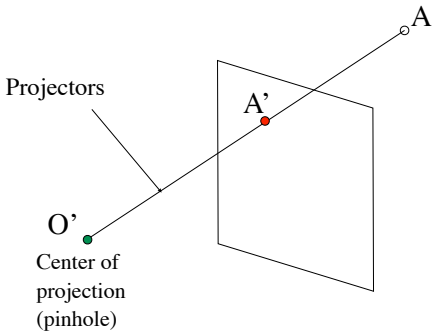
(from WikiPedia)



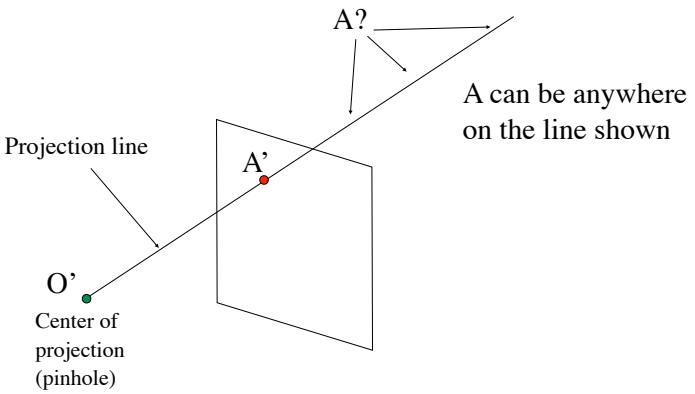
Random dot stereogram

(from WikiPedia)

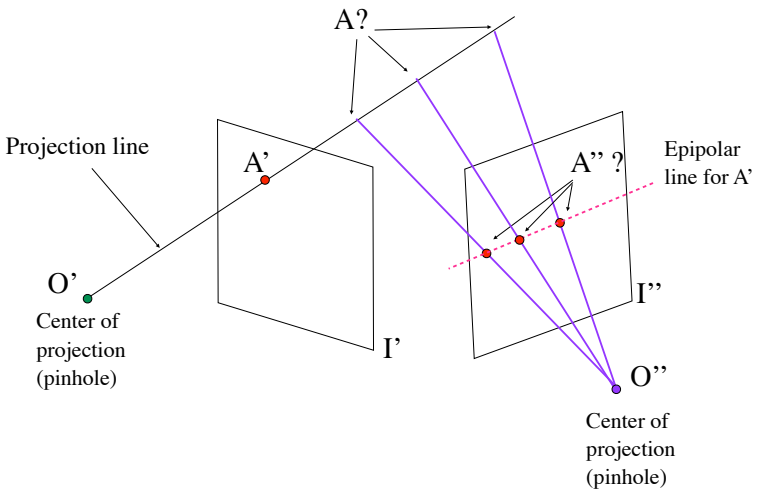
Remember Projection?



Given an image point where is in the world?

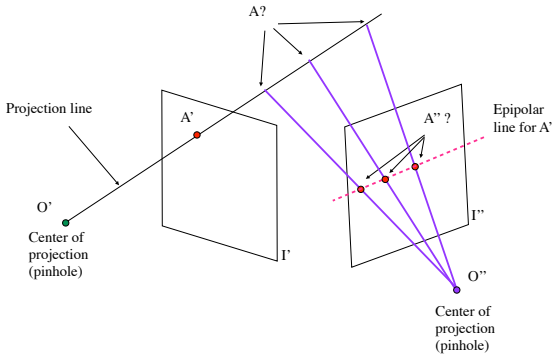


Given an image point where is in the world?



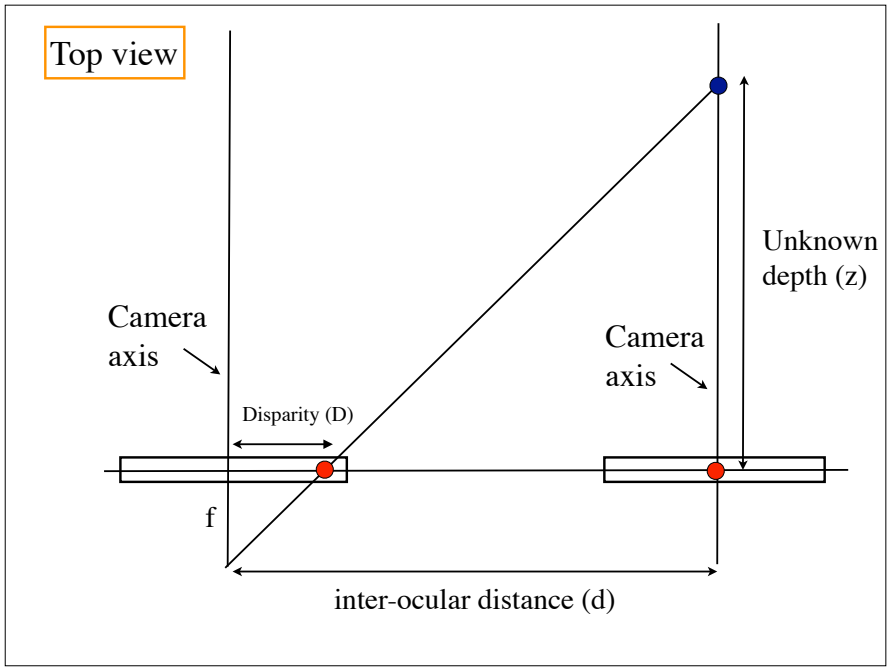
The Epipolar line

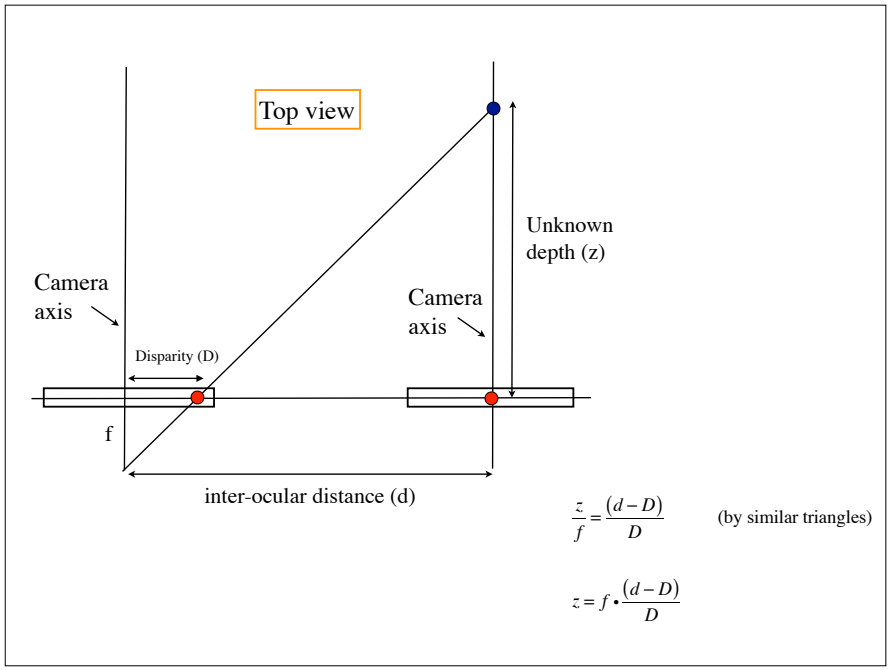
- The point A" (image I") corresponding to A' (image I') is constrained to lie on projection of the line through O' and A' onto I"
  - The line in I" is the epipolar line for A'
  - Understanding this makes finding matches faster and reduces mismatches



Simple stereo example

- Suppose two identical cameras with parallel image planes, with the same X-axis
  - Epipolar lines are now corresponding horizontal lines
- Consider a point that happens to be at the origin of the right camera
- Suppose we have a match in the left camera
  - Is the location of the match constrained?





$$\frac{z}{f} = \frac{(d-D)}{D}$$ (by similar triangles)

$$z = f \cdot \frac{(d-D)}{D}$$