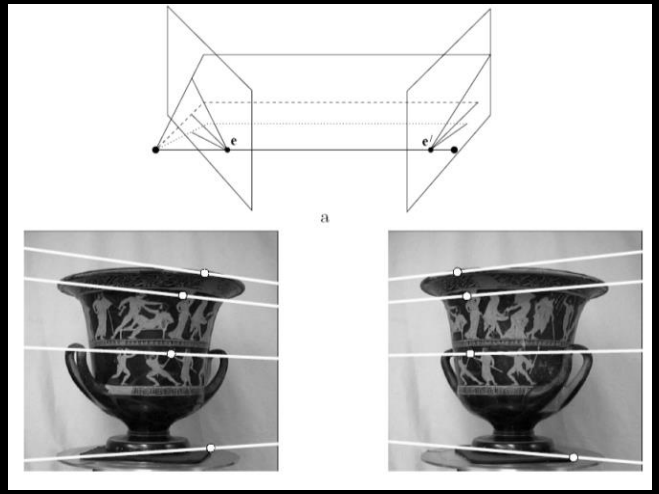
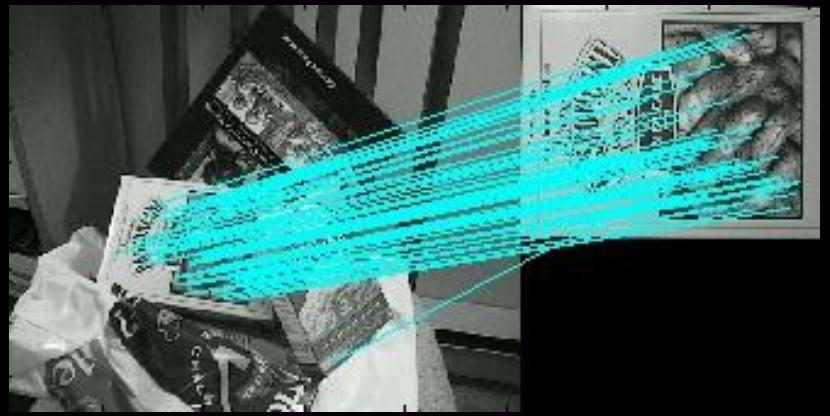
CS4495/6495
Introduction to Computer Vision

3B-L1 *Stereo geometry*

Stereo: A Special case of Multiple views



Hartley and Zisserman



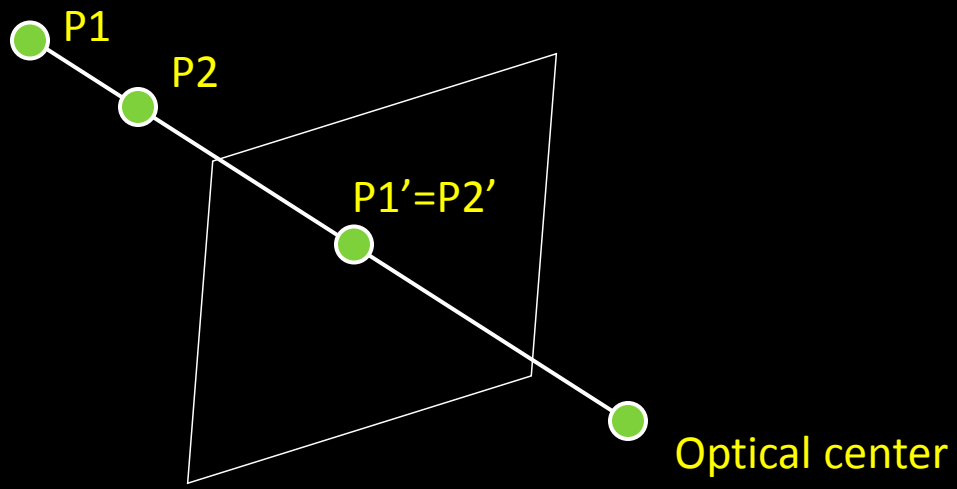
Why multiple views?

- Structure and depth are inherently ambiguous from single views.

Images from S. Lazebnik

Why multiple views?

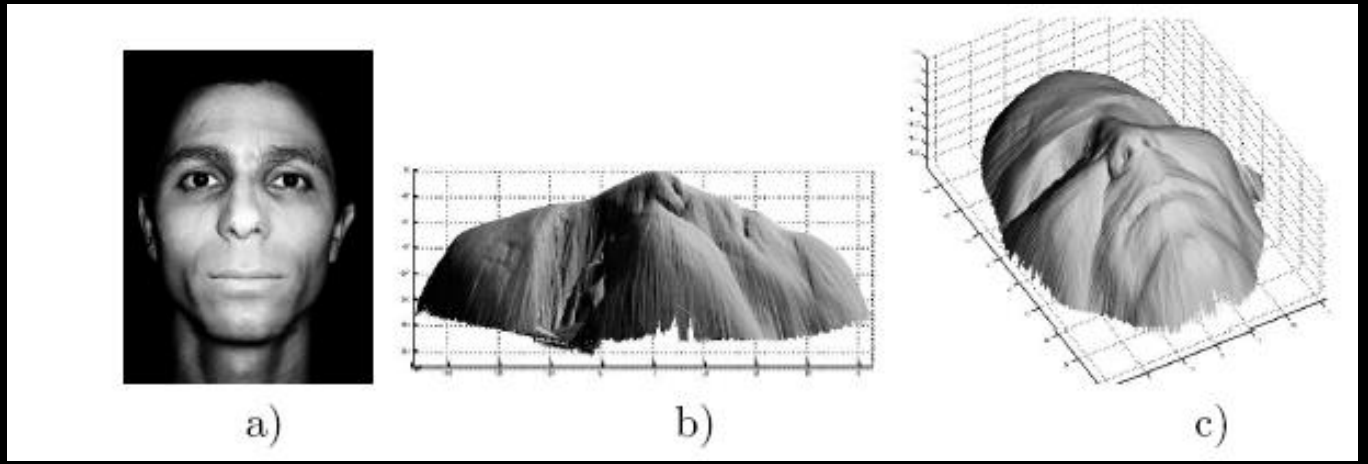
- Structure and depth are inherently ambiguous from single views.



Perspective effects

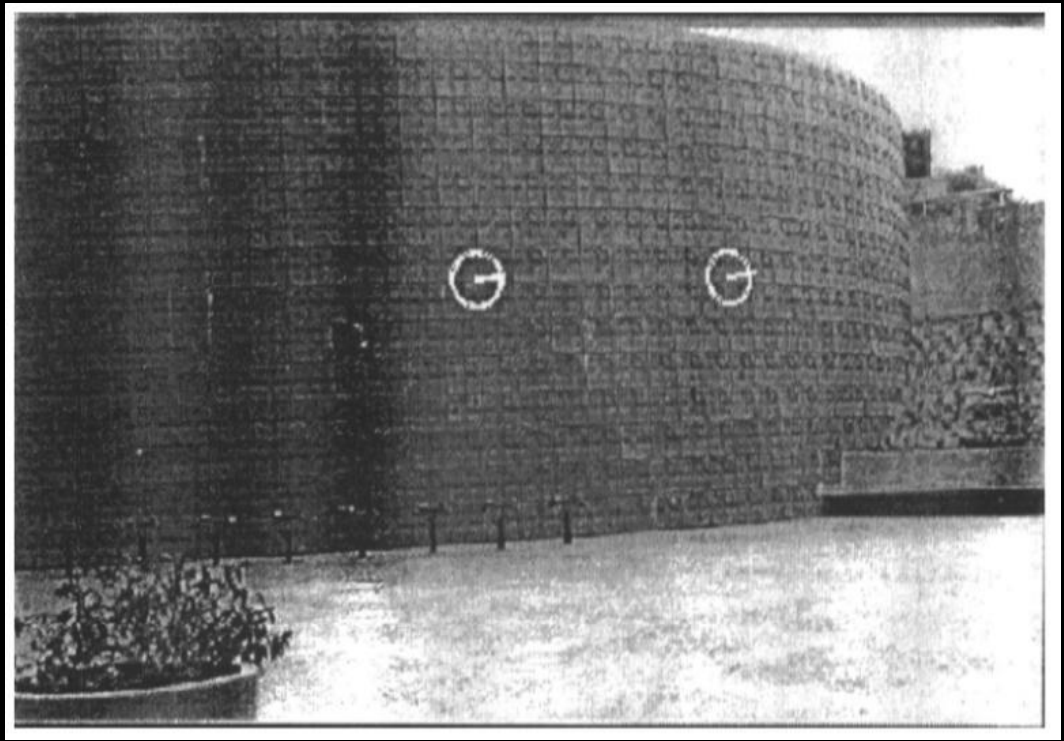
S. Seitz

Shading



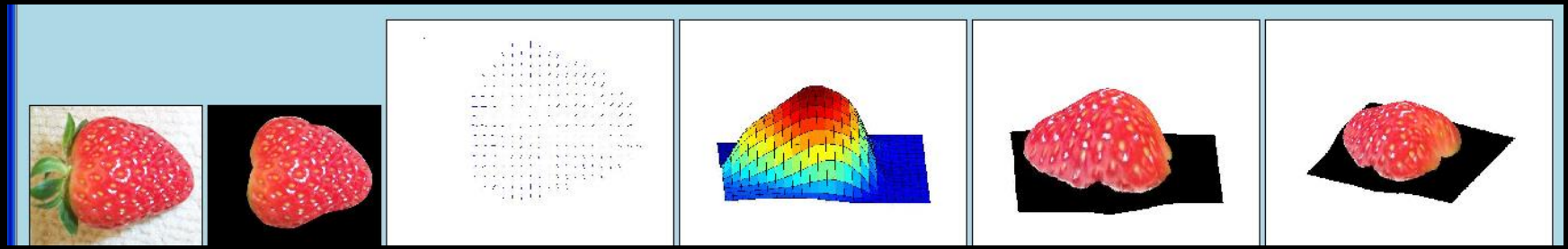
K. Grauman

Texture



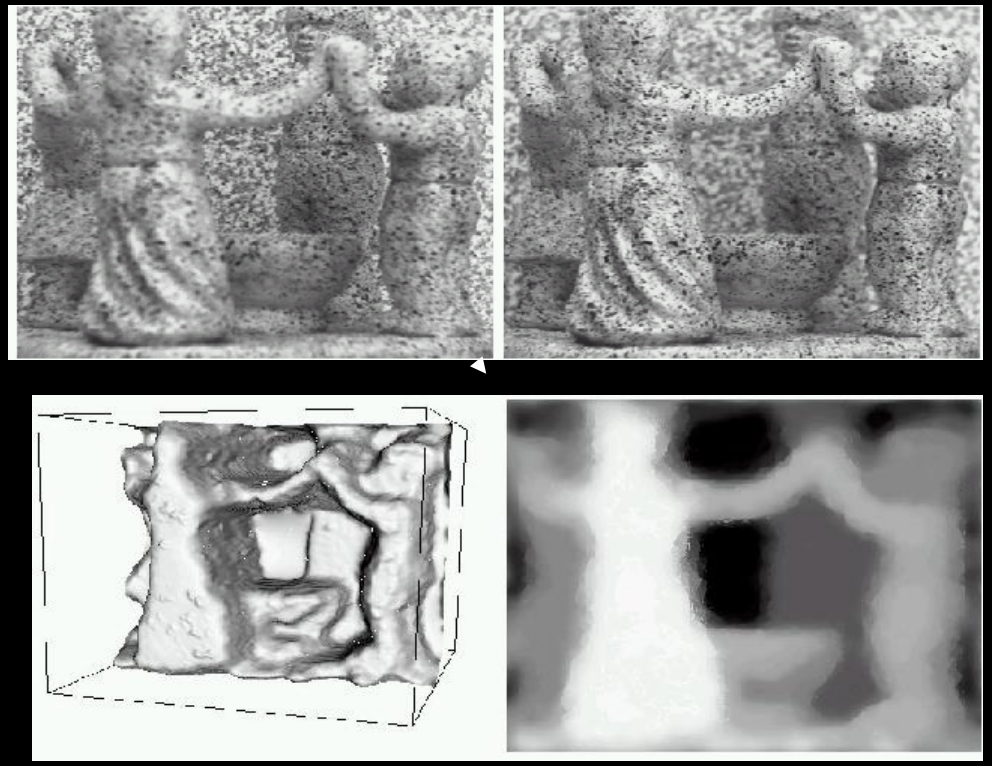
A.M. Loh. The recovery of 3-D structure using visual texture patterns.

Texture



A.M. Loh. The recovery of 3-D structure using visual texture patterns.

Focus/defocus



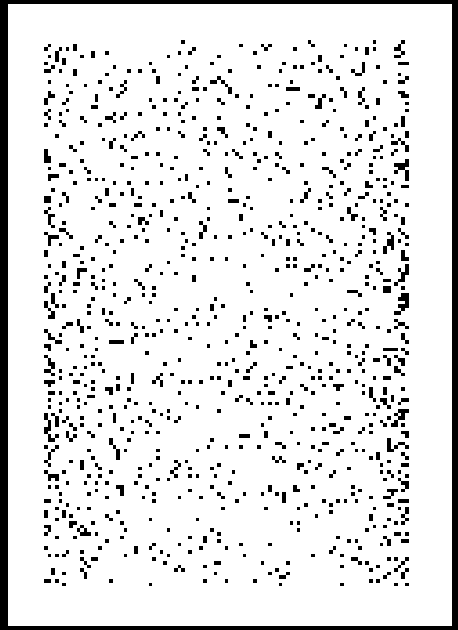
Images from same point of view, different camera parameters

3d shape / depth estimates

Figures from H. Jin and P. Favaro, 2002

Motion

Figures from L. Zhang



Shape cues

Estimating scene shape from one eye

- “Shape from X”: Shading, Texture, Focus, Motion…

- Very popular circa 1980

But we (and lots of creatures) have two eyes!

Stereo:

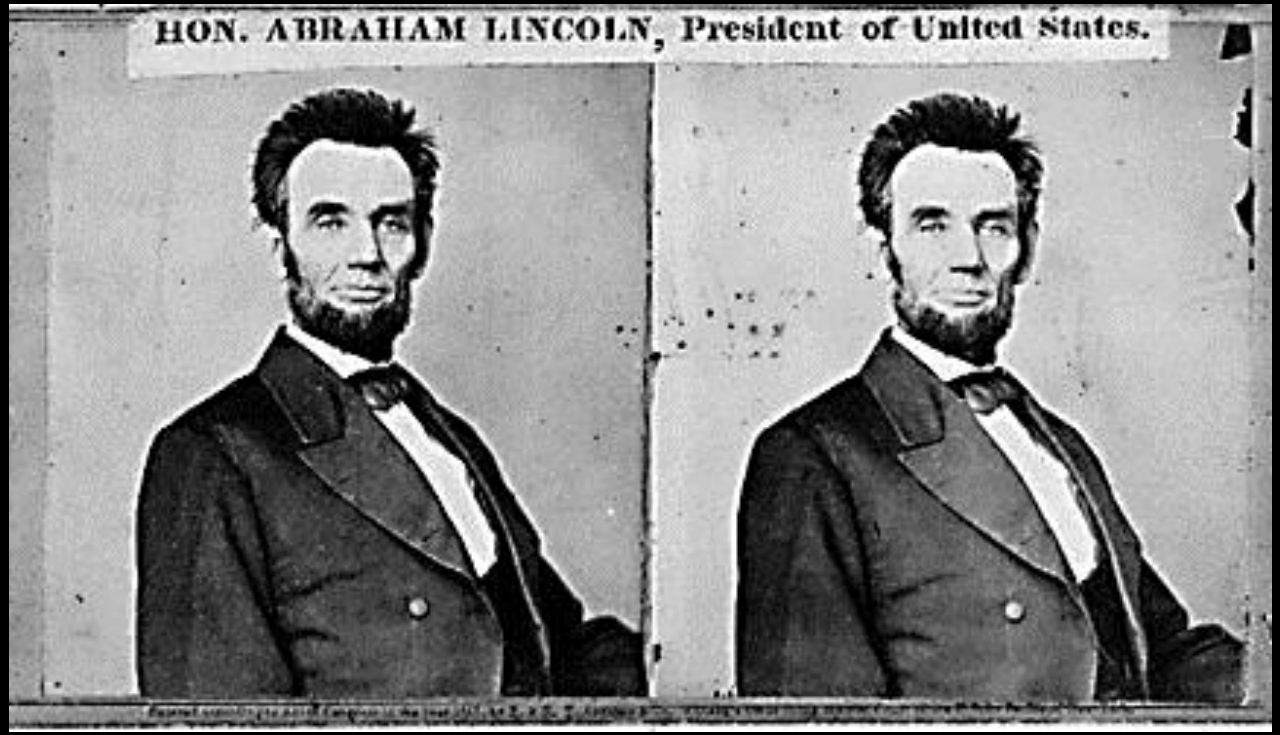
- The image from one eye is a little different than the image form he other eye.
- Think of shape from “motion” between two views
- Infer 3d shape of scene from two (multiple) images from different viewpoints

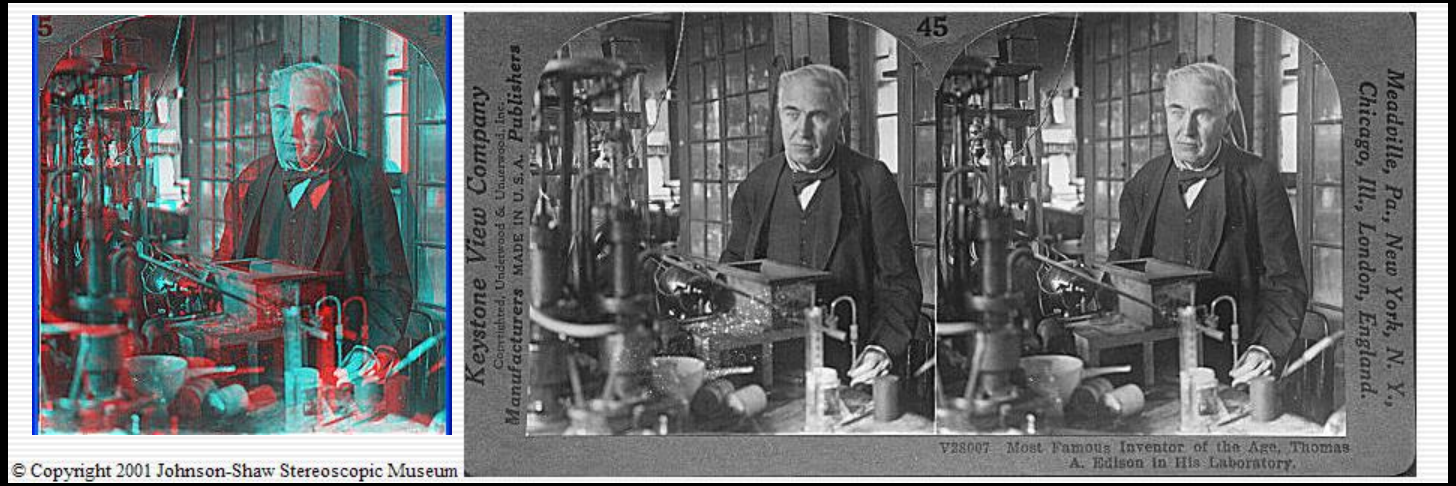
Stereo photography and stereo viewers

Take two pictures of the same subject from two slightly different viewpoints and display so that each eye sees only one of the images.

Invented by Sir Charles Wheatstone
1838

People fascinated by 3D





http://www.johnsonshawmuseum.org

Public Library, Stereoscopic Looking Room, Chicago, by Phillips, 1923

Teesta suspension bridge
Darjeeling, India

Stereo photography and stereo viewers

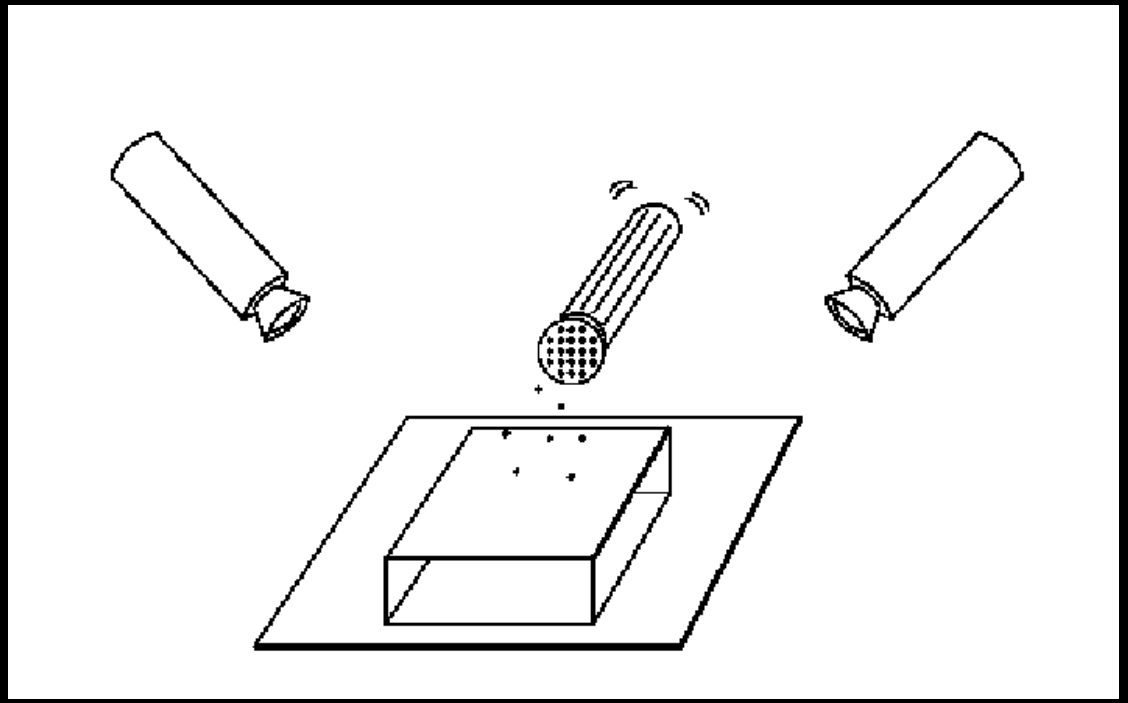
When I grew up…

Stereo photography and stereo viewers

The Basic Idea: Two slightly different images

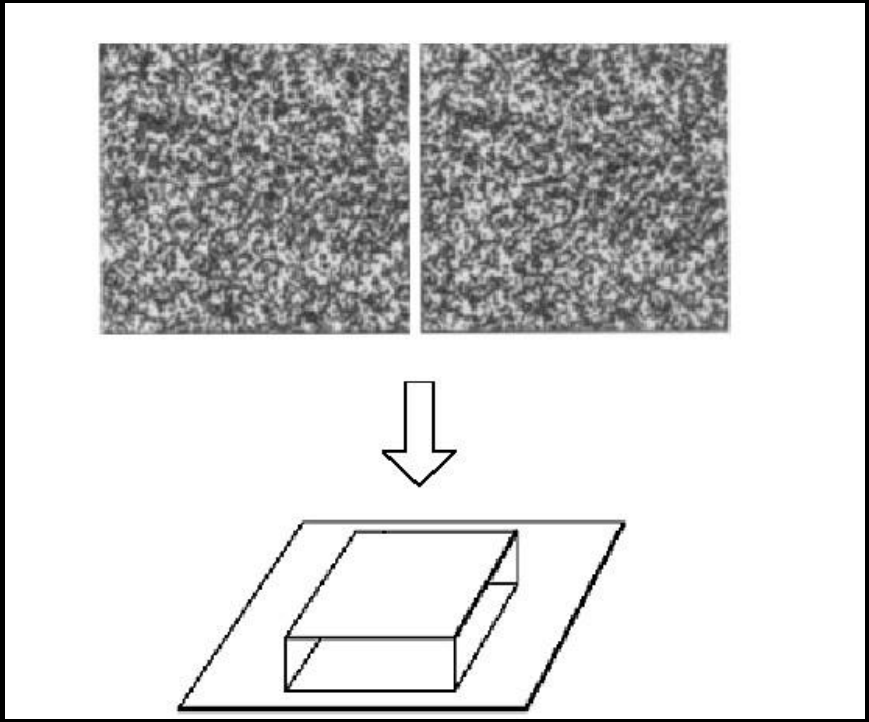
http://www.well.com/~jimg/stereo/stereo_list.html

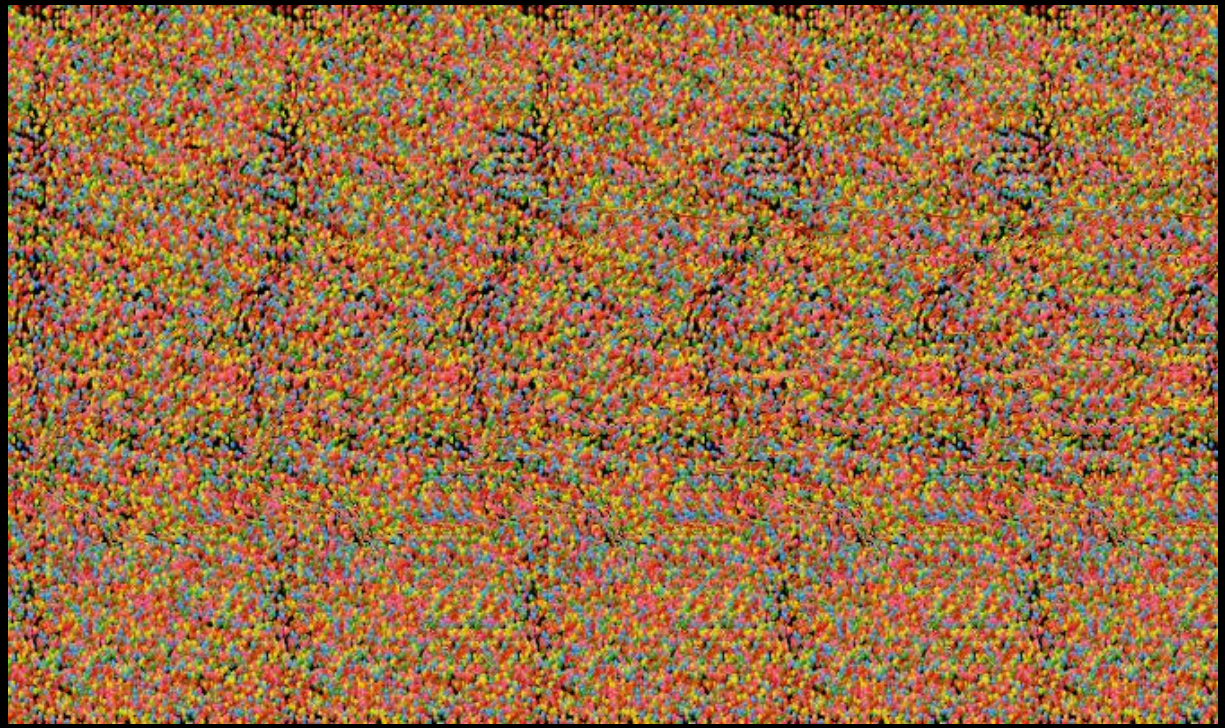
Random dot stereograms



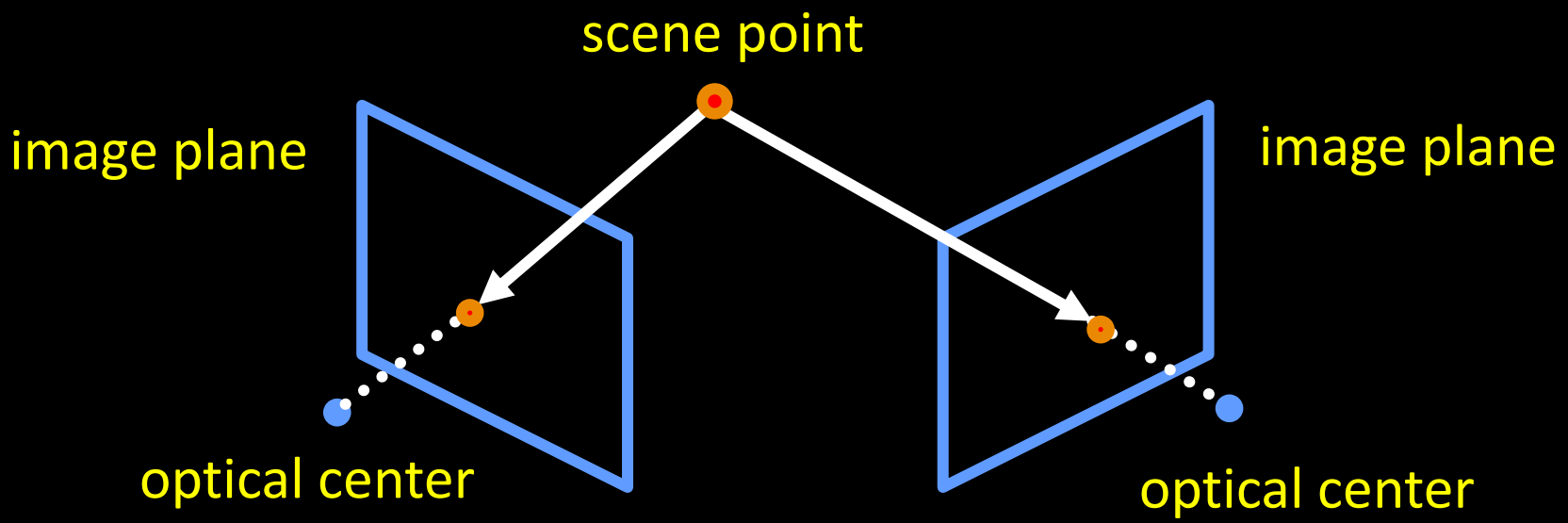
Forsyth & Ponce

Random dot stereograms





Basic stereo geometry

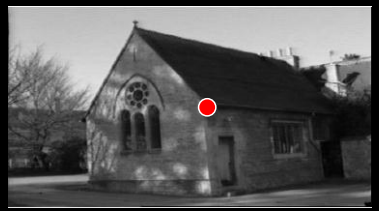


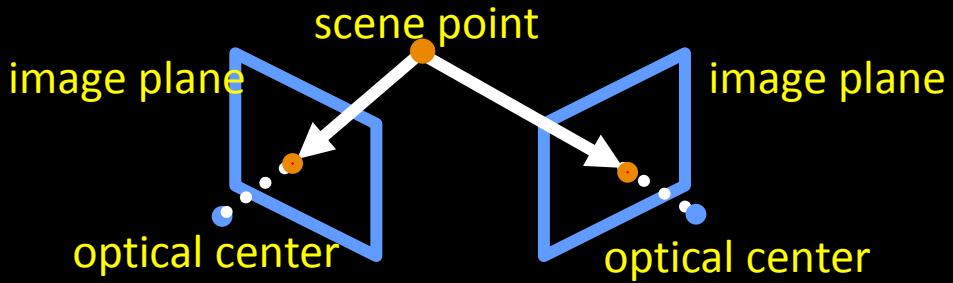
Estimating depth with stereo

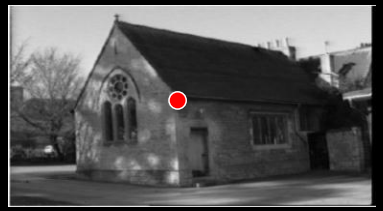
Stereo: shape from “motion” between two views

We’ll need to consider:

- Info on camera pose (“calibration”)
- Image point correspondences





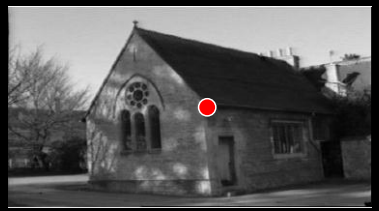


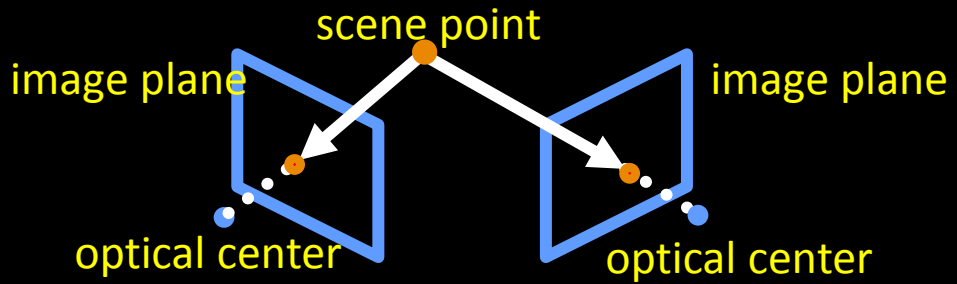
Estimating depth with stereo

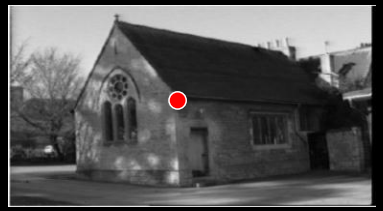
Stereo: shape from “motion” between two views

We’ll need to consider:

- Info on camera pose (“calibration”)
- Image point correspondences

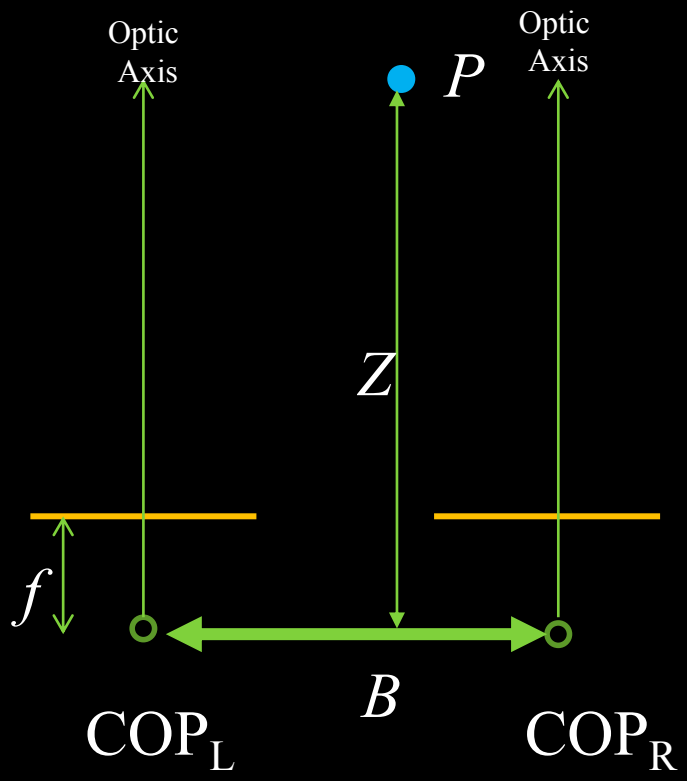






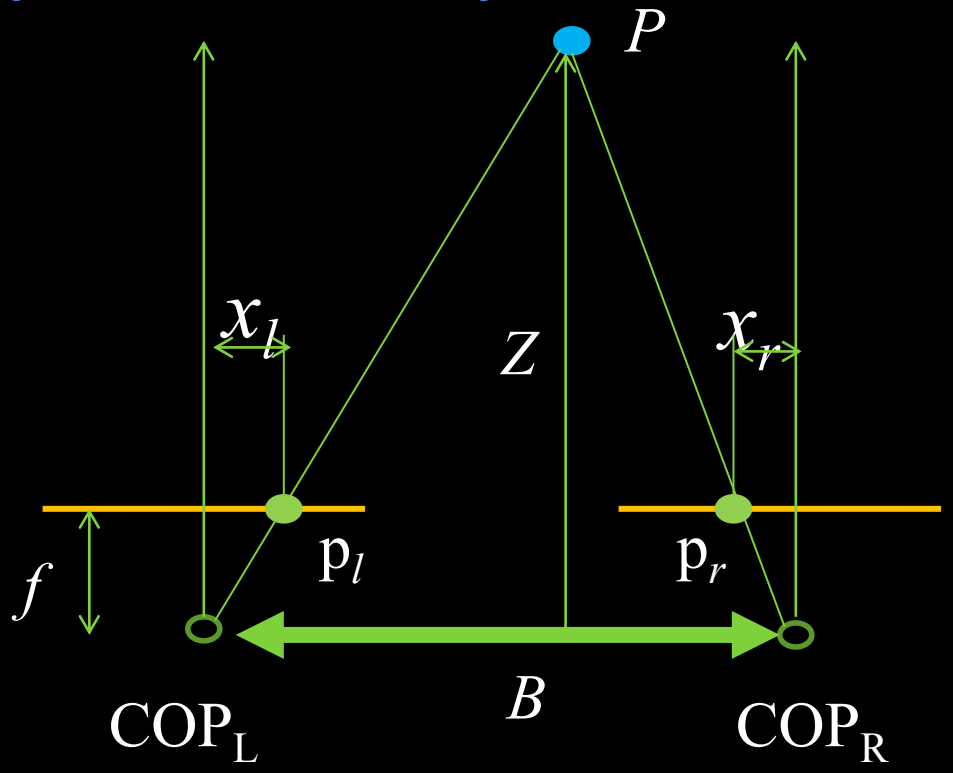
Geometry for a simple stereo system

- First, assuming parallel optical axes, known camera parameters (i.e., calibrated cameras)
- Figure is looking down on the cameras and image planes
- Baseline B, focal length f
- Point P is distance Z in camera coordinate systems



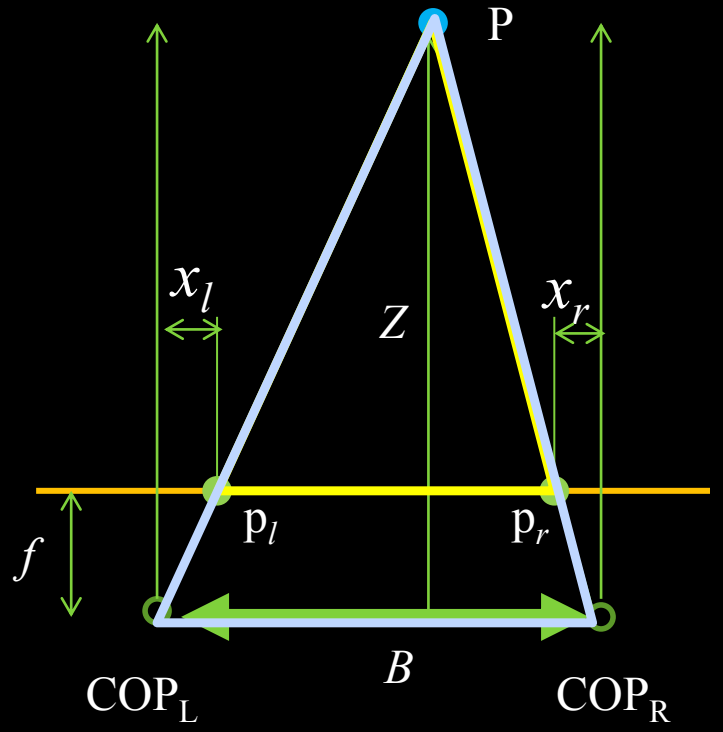
Geometry for a simple stereo system

- Point *P* projects into left and right images.
- Distance is positive in left image, and negative in right



Geometry for a simple stereo system

- What is the expression for Z?
- Similar triangles (p_l, P, p_r) and (C_L,P, C_r):



$$\frac{B - x_l + x_r}{Z - f} = \frac{B}{Z}$$

$$Z = f\frac{B}{x_l - x_r}$$

Disparity

Depth from disparity

image I(x,y)

image I‘(x,y)

Depth from disparity

image I(x,y)

Disparity map D(x,y)

Depth from disparity

$(x',y')=(x+D(x,y), y)$

image $I'(x',y')$