



# Multi-View Geometry (Ch7 New book. Ch 10/11 old book)

Guido Gerig

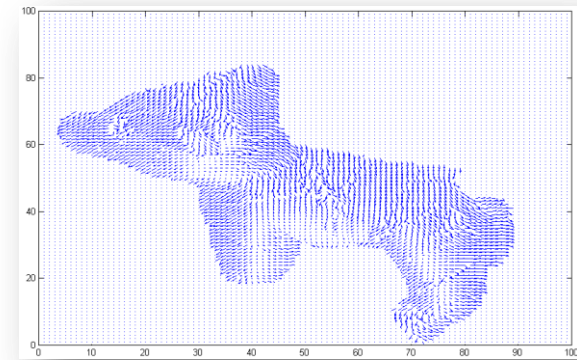
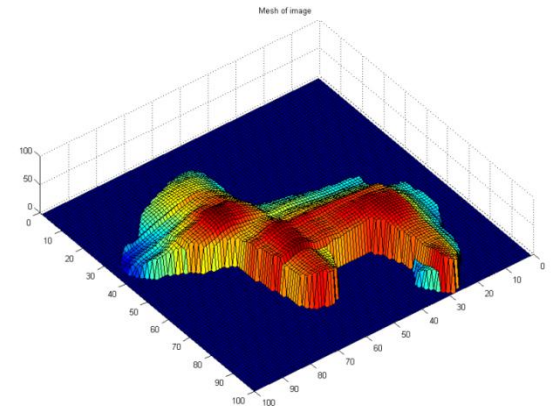
CS 6320 Spring 2013

Credits: M. Shah, UCF CAP5415, lecture 23

<http://www.cs.ucf.edu/courses/cap6411/cap5415/>, Trevor Darrell, Berkeley, C280, Marc Pollefeys

# Visual cues

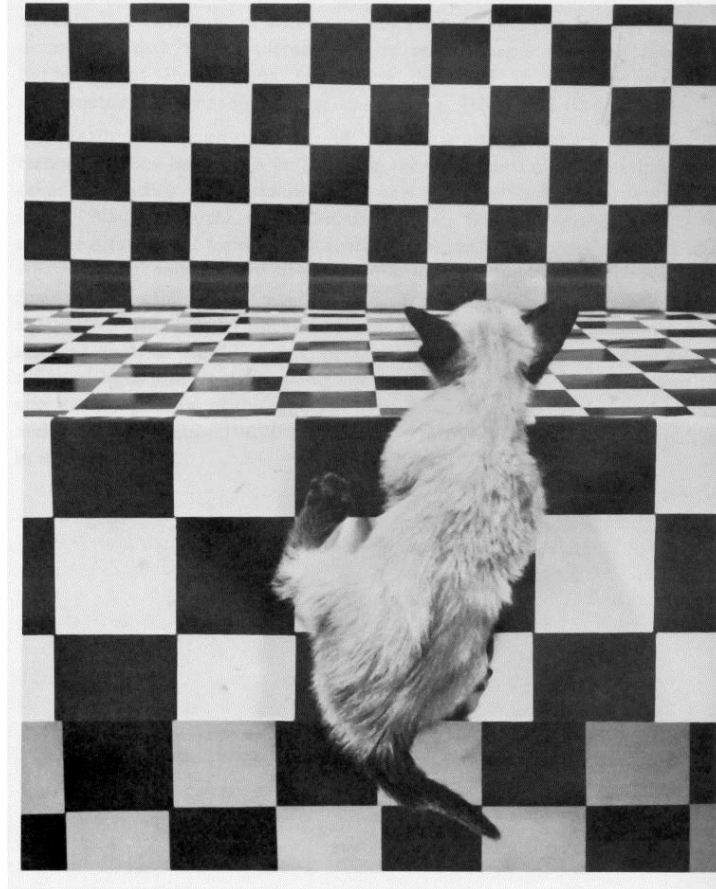
- Shading





# Visual cues

- Shading
- Texture



*The Visual Cliff*, by William Vandivert, 1960



# Visual cues

- Shading
- Texture
- Focus



From *The Art of Photography*, Canon



# Visual cues

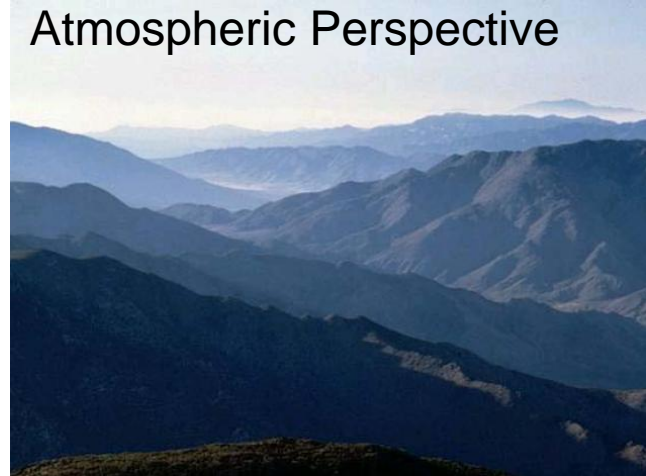
- Shading
- Texture
- Focus
- Motion



# Visual cues

- Shading
- Texture
- Focus
- Motion
- **Shape From X** (X = shading, texture, focus, motion, rotation, ...)

Atmospheric Perspective



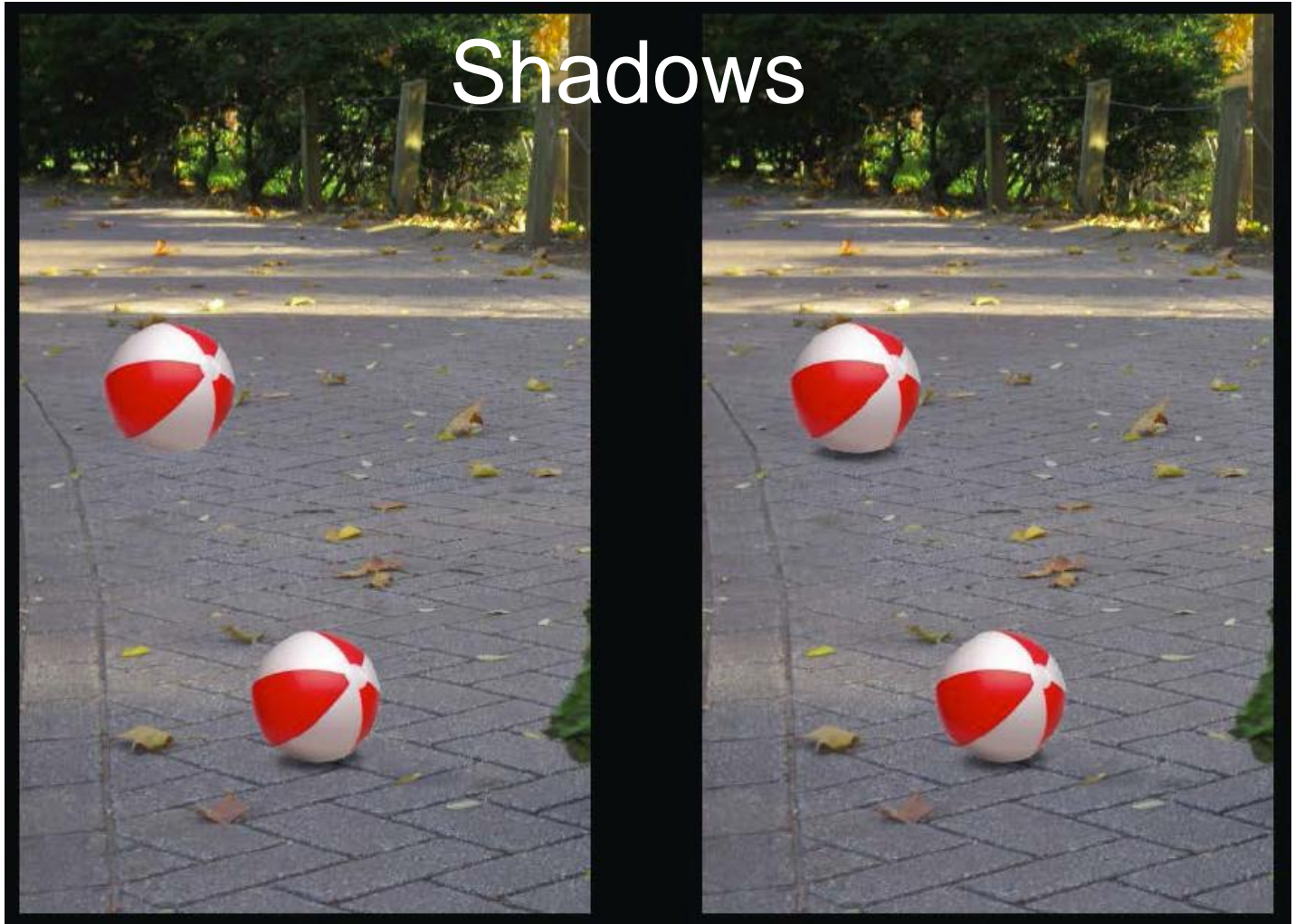
Linear Perspective





# Visual cues

## Shadows



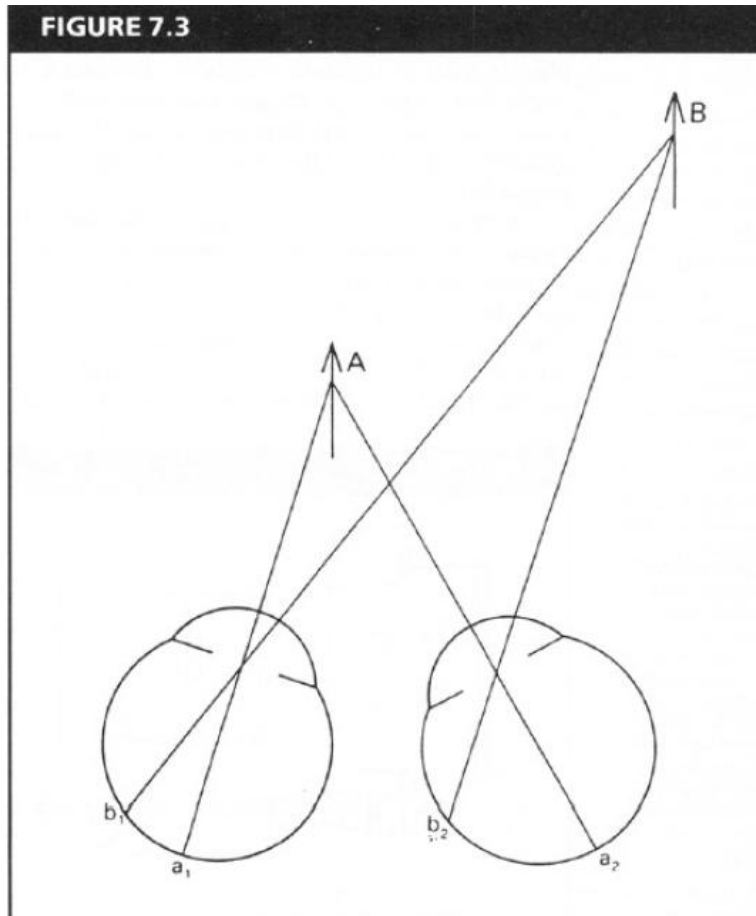


# Visual cues

- Shading
- Texture
- Focus
- Motion
- Shape From X (X = shading, texture, focus, motion, rotation, ...)
- Stereo (disparity, multi-view)



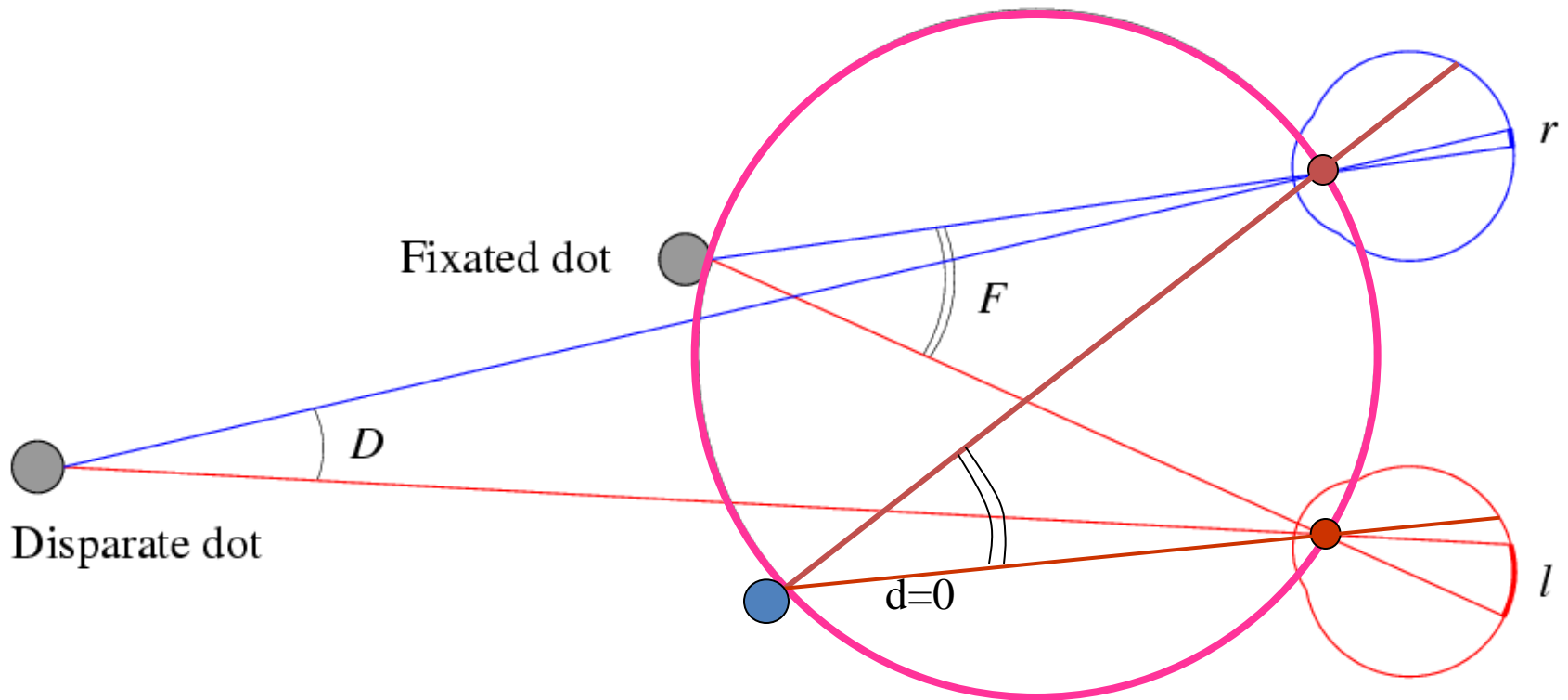
# Human stereopsis: disparity



**Disparity** occurs when eyes fixate on one object; others appear at different visual angles

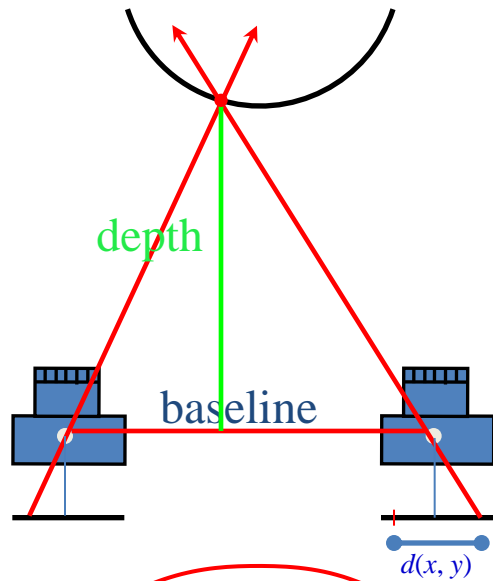
From Bruce and Green, Visual Perception, Physiology, Psychology and Ecology

# Human stereopsis: disparity



Disparity:  $d = r - l = D - F$ .

# Stereo Vision



$$Z(x, y) = \frac{f B}{d(x, y)}$$

$Z(x, y)$  is depth at pixel  $(x, y)$   
 $d(x, y)$  is disparity

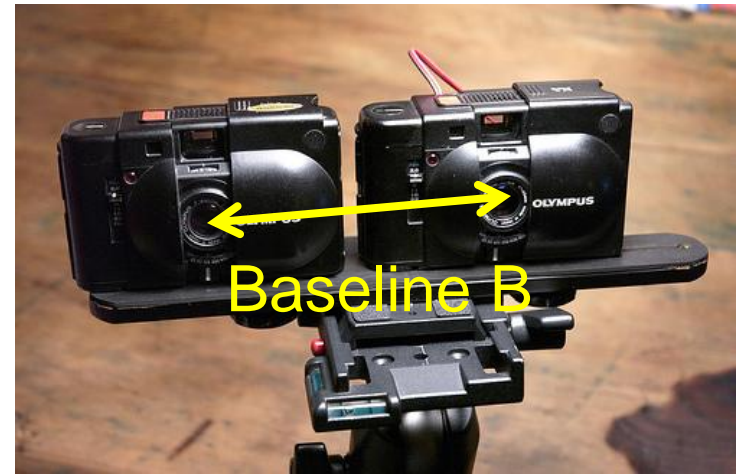
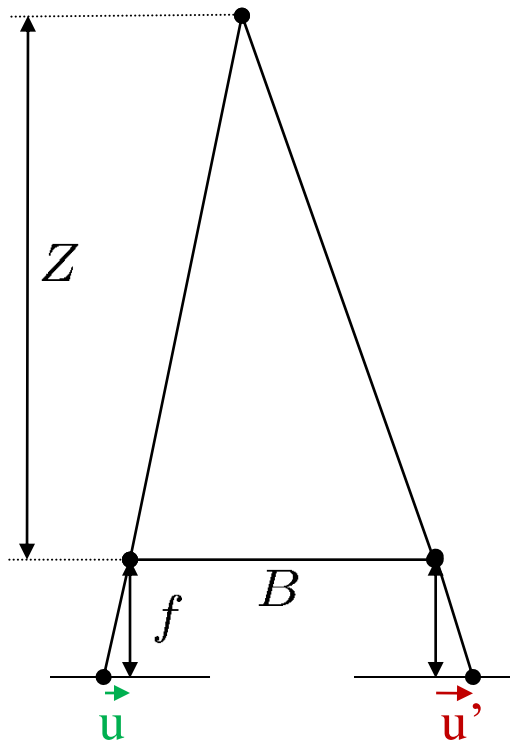
Left

Right



Matching correlation  
windows across scan lines

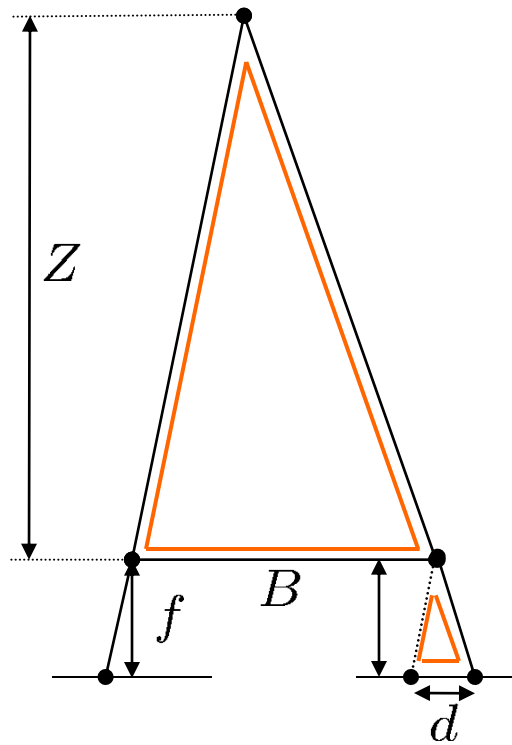
# Standard stereo geometry



*Disparity  $d$ :*

$$d = |u' - u|$$

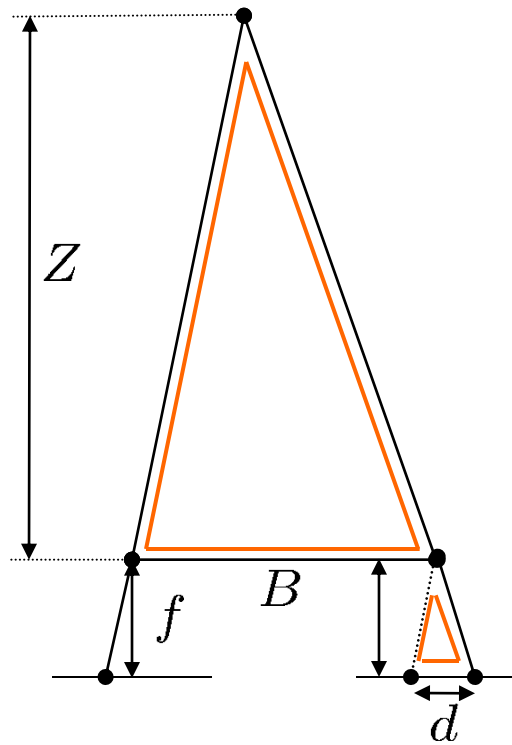
# Standard stereo geometry



$$\frac{B}{Z} = \frac{d}{f}$$

$$d = \frac{Bf}{Z}$$

# Standard stereo geometry

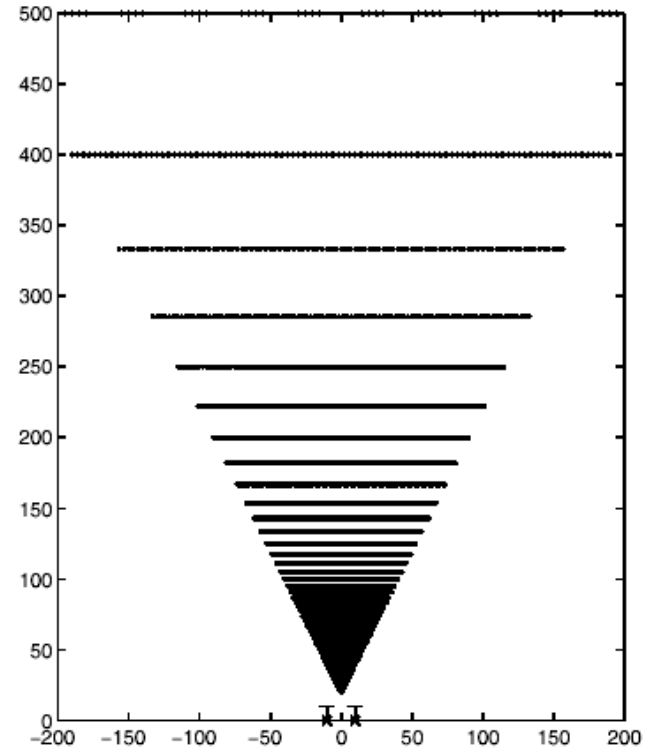


$$\frac{B}{Z} = \frac{d}{f}$$

$$d = \frac{Bf}{Z}$$

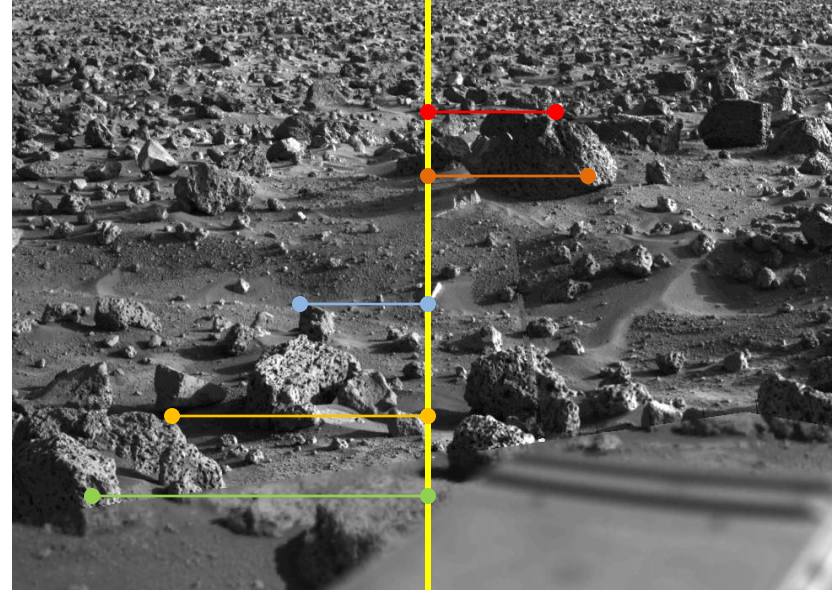
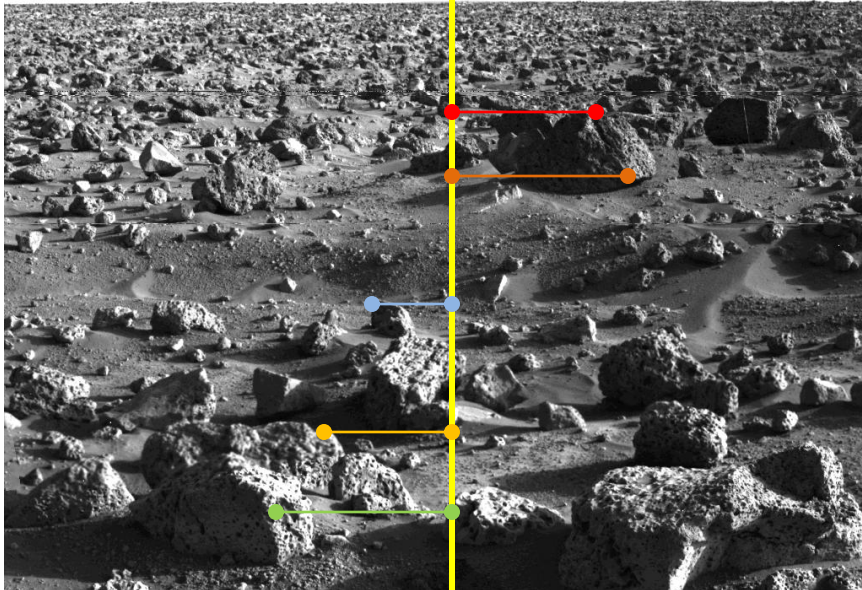
$$\frac{dd}{dZ} = \frac{Bf}{Z^2}$$

$$\Delta Z = \frac{Z^2}{Bf} \Delta d$$



# Stereo Correspondence

- Search over disparity to find correspondences
- Range of disparities to search over can change dramatically within a single image pair.



# Why is disparity important?



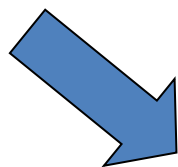
I1



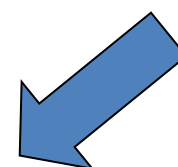
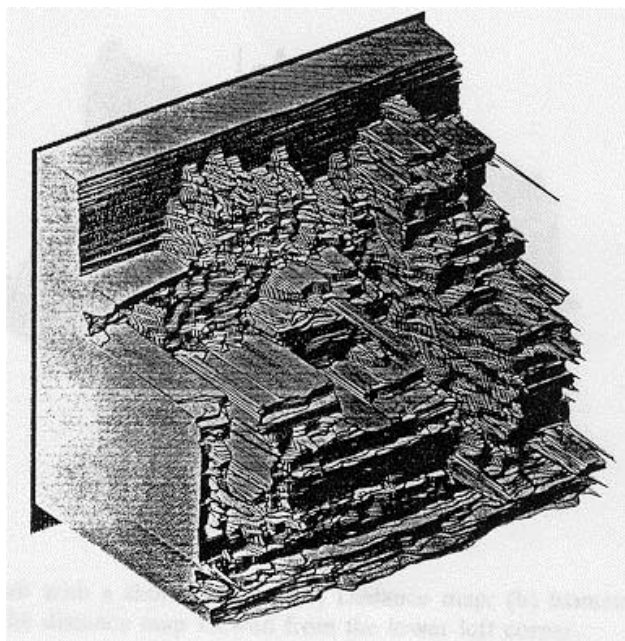
I2



I10



Given dense  
disparity map,  
we can  
calculate a  
depth/distance/  
range map.

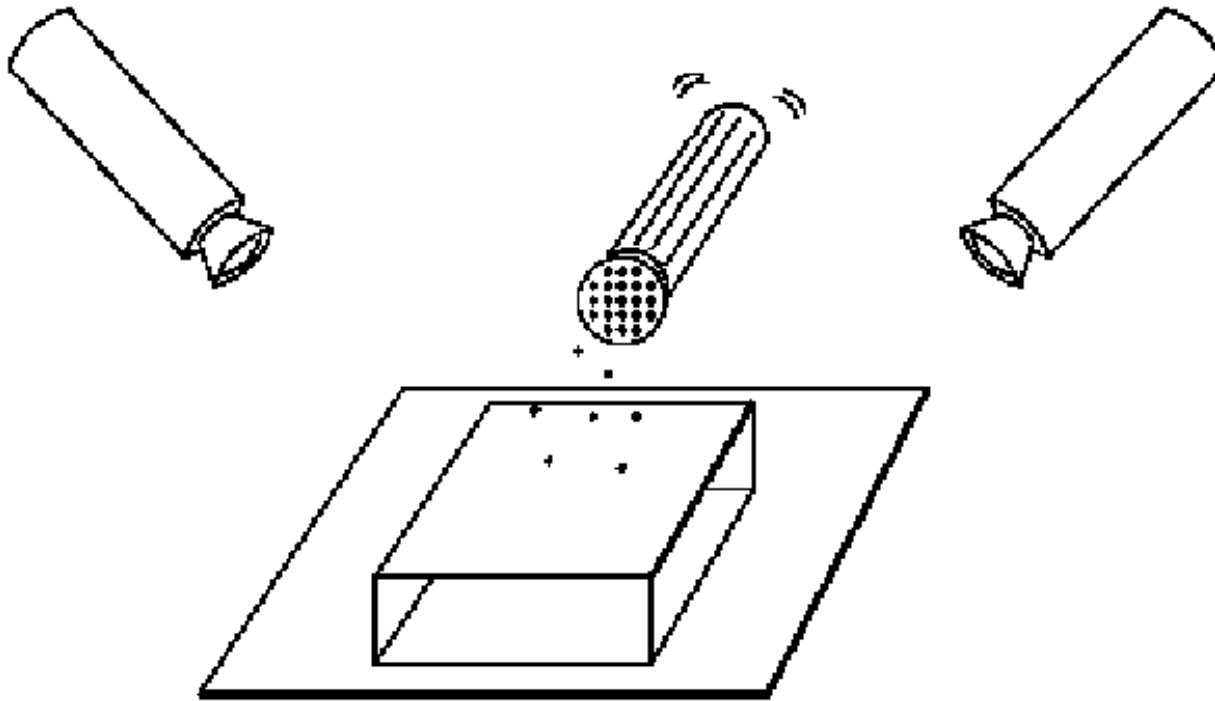




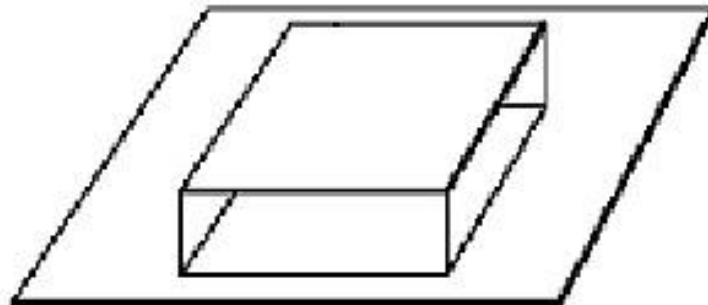
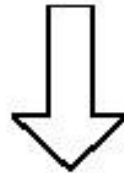
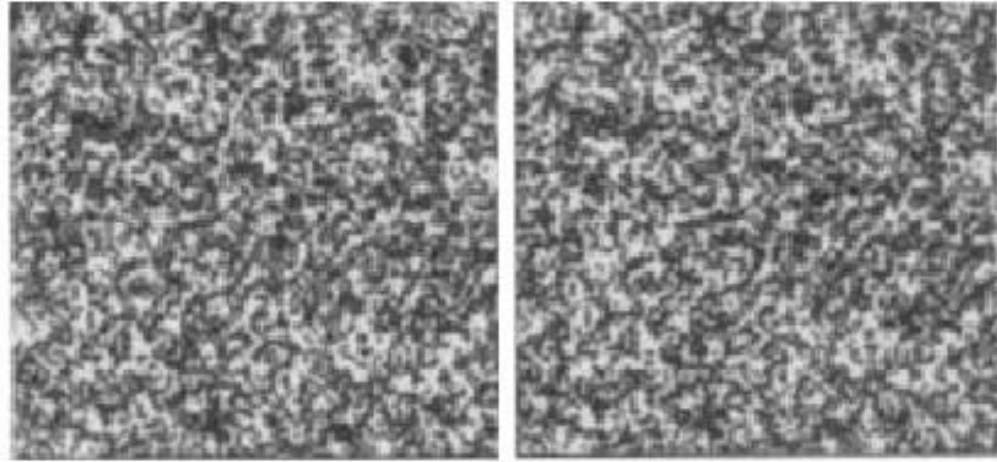
# Random dot stereograms

- Julesz 1960: Do we identify local brightness patterns before fusion (monocular process) or after (binocular)?
- To test: pair of synthetic images obtained by randomly spraying black dots on white objects

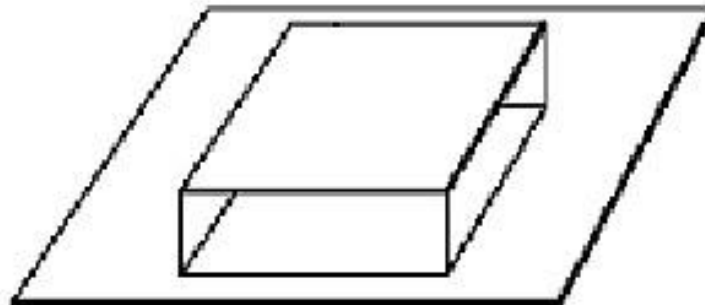
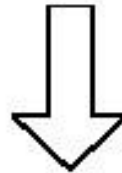
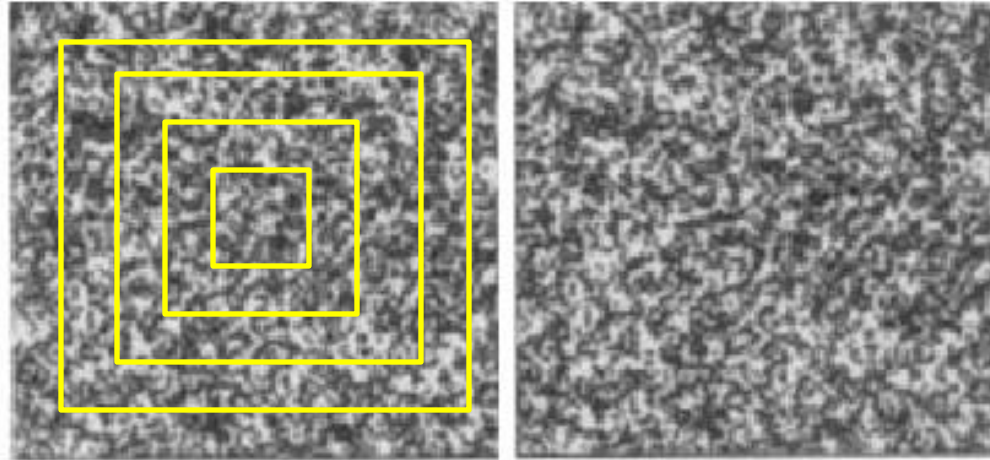
# Random dot stereograms



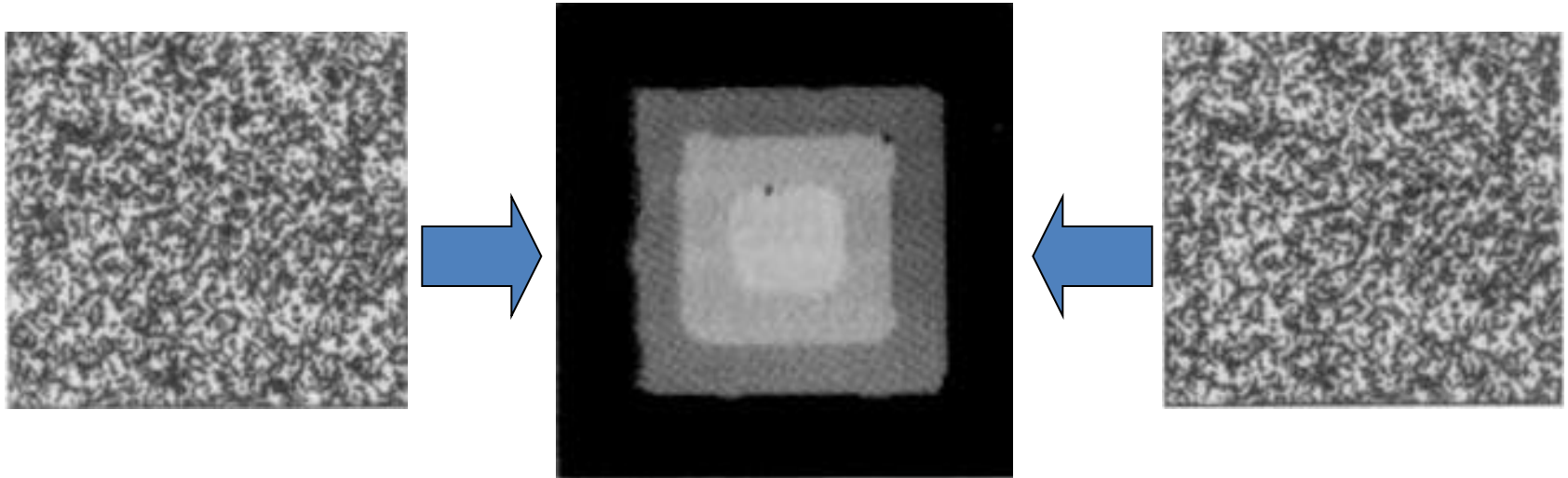
# Random dot stereograms



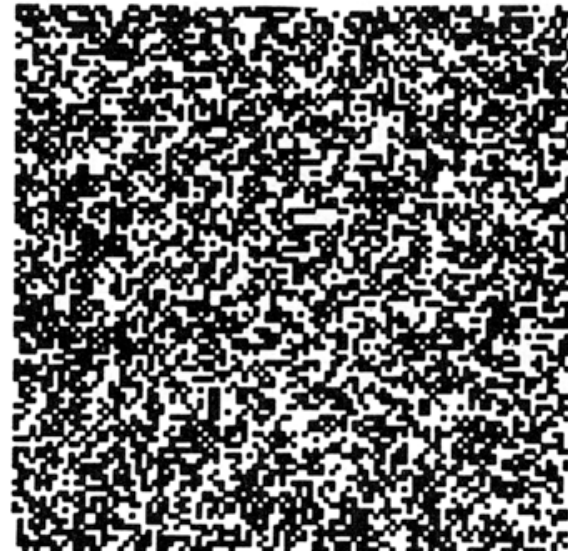
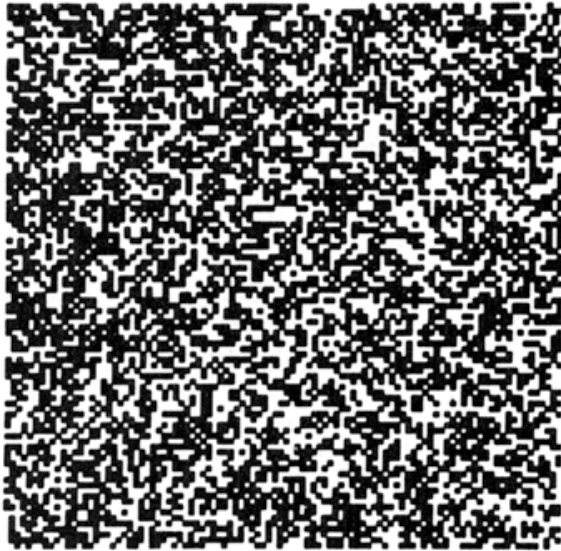
# Random dot stereograms



# A Cooperative Model (Marr and Poggio, 1976)



# Random dot stereograms



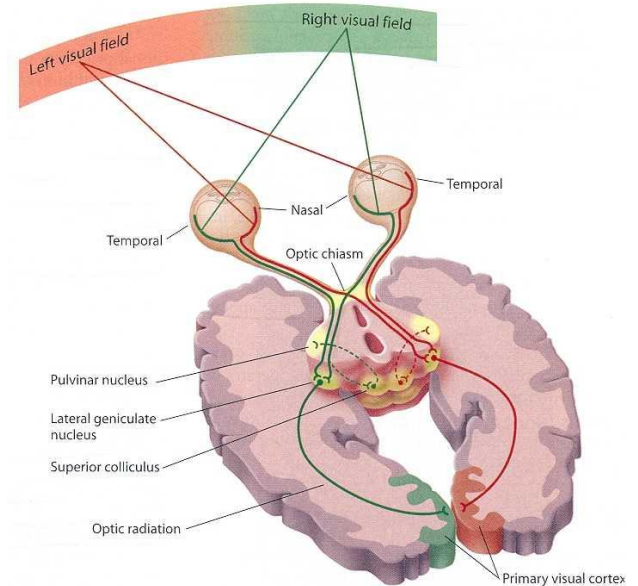
**Figure 5.3.8** A random dot stereogram. These two images are derived from a single array of randomly placed squares by laterally displacing a region of them as described in the text. When they are viewed with crossed disparity (by crossing the eyes) so

that the right eye's view of the left image is combined with the left eye's view of the right image, a square will be perceived to float above the page. (See pages 210–211 for instructions on fusing stereograms.)

# Random dot stereograms

- When viewed monocularly, they appear random; when viewed stereoscopically, see 3d structure.
- Conclusion: human binocular fusion not directly associated with the physical retinas; must involve the central nervous system
- Imaginary\* “*cyclopean retina*” that combines the left and right image stimuli as a single unit

\*This was because it was as though we have a cyclopean eye inside our brains that can see cyclopean stimuli hidden to each of our actual eyes.



[Visual Pathway.jpg](http://Visual Pathway.jpg) [wiki.ucl.ac.uk](http://wiki.ucl.ac.uk)



# Autostereograms

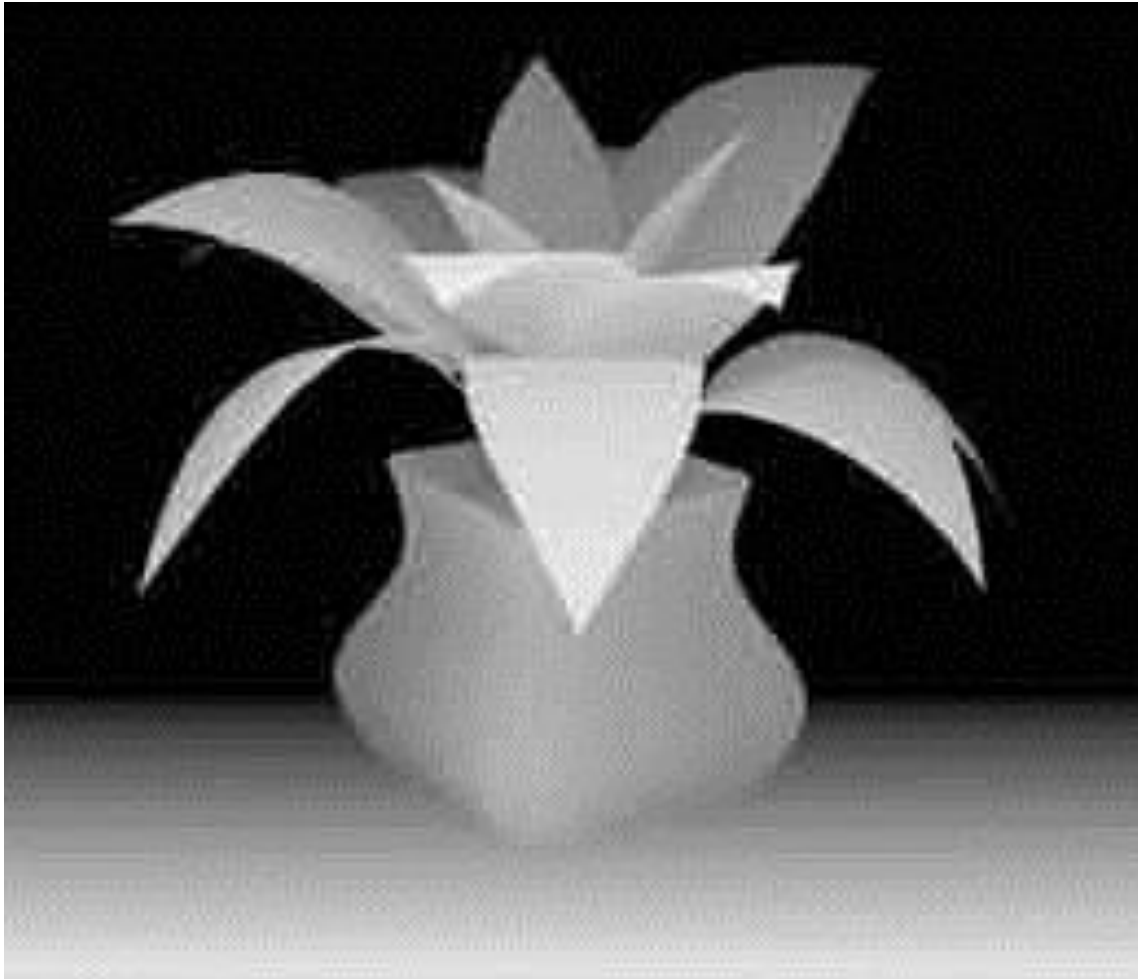


Exploit disparity as depth cue using single image

(Single image random dot stereogram, Single image stereogram)

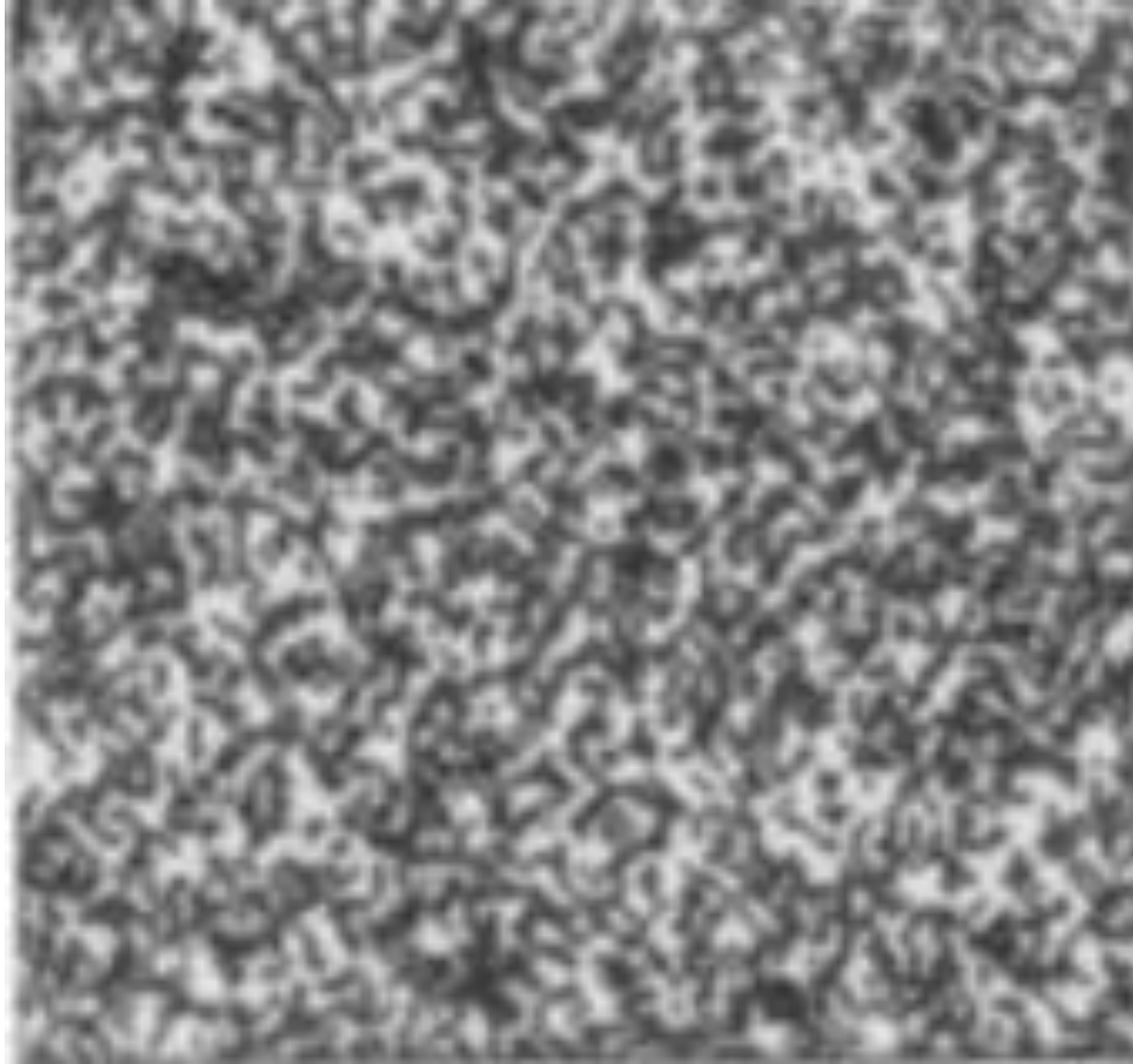


# Autostereograms



# Optical flow

Where do pixels move?



# Optical flow

Where do pixels move?





[http://www.well.com/~jim/stereo/stereo\\_list.html](http://www.well.com/~jim/stereo/stereo_list.html)

# Stereo photography and stereo viewers

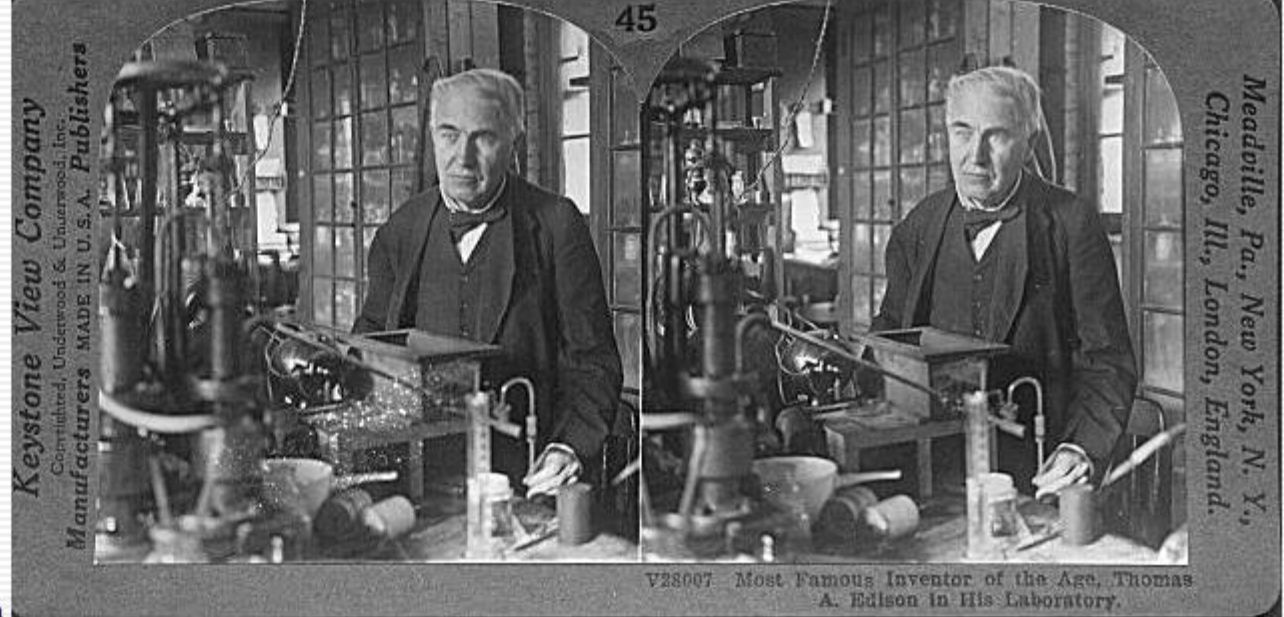
Take two pictures of the same subject from two slightly different viewpoints and display so that each eye sees only one of the images.



Invented by Sir Charles Wheatstone, 1838



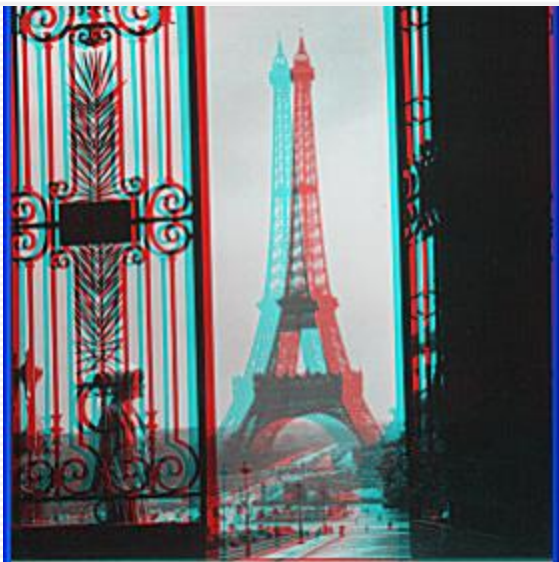
Image courtesy of fisher-price.com



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Grauman



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

