

Stereo Vision I

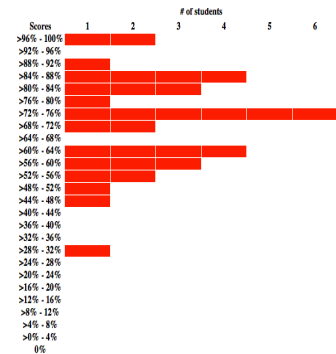
Introduction to Computer Vision
CSE 152
Lecture 13

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Intro Computer Vision

Midterm Stats

Statistics	
Percent of Course:	20.00%
Total Number of Scores:	31
Mean:	70.50
Median:	72.09
High Score:	96.51 (2)
Low Score:	29.07 (1)
Standard Deviation:	15.67



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Shape-from-X (i.e., Reconstruction)

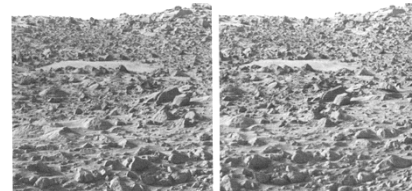
- Methods for estimating 3-D shape from image data. X can be one (or more) of many cues.
 - Stereo** (two or more views, known viewpoints)
 - Motion** (moving camera or object)
 - Shading
 - Changing lighting (**Photometric Stereo**)
 - Texture variation
 - Focus/blur
 - Prior knowledge/context
 - structured light/lasers

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Binocular Stereopsis: Mars

Given two images of a scene where relative locations of cameras are known, estimate depth of all common scene points.

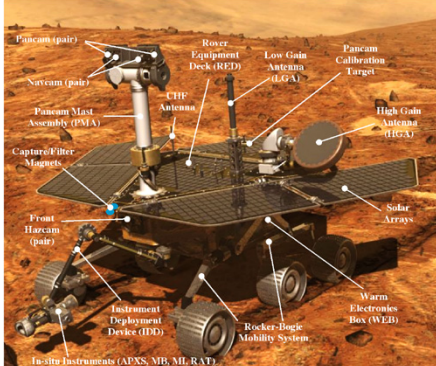


Two images of Mars

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Mars Rovers: Spirit and Opportunity

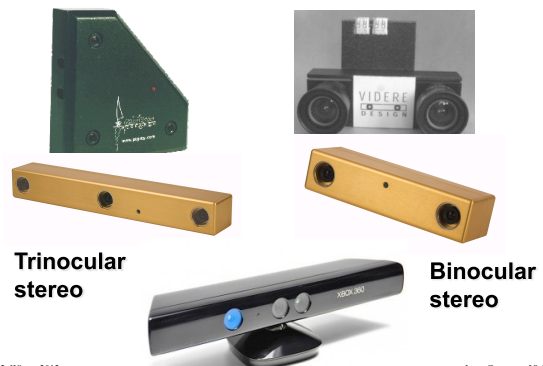


Four pairs of stereo cameras

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Commercial Stereo Heads



Trinocular stereo

Binocular stereo

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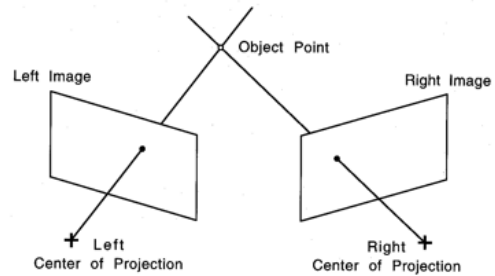
Need for correspondence



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Triangulation



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Stereo Vision Outline

- Offline: Calibrate cameras & determine “epipolar geometry”
- Online
 1. Acquire stereo images
 2. Rectify images to convenient epipolar geometry
 3. Establish correspondence
 4. Estimate depth

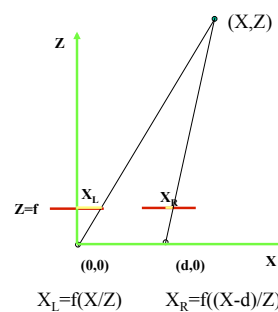
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BINOCULAR STEREO SYSTEM

Estimating Depth

2D world with 1-D image plane



Two measurements: X_L, X_R
Two unknowns: X, Z

Constants:

Baseline: d

Focal length: f

$$X = \frac{d X_L}{(X_L - X_R)}$$

$$Z = \frac{d f}{(X_L - X_R)}$$

Disparity: $(X_L - X_R)$

$$X_L = f(X/Z) \quad X_R = f((X-d)/Z)$$

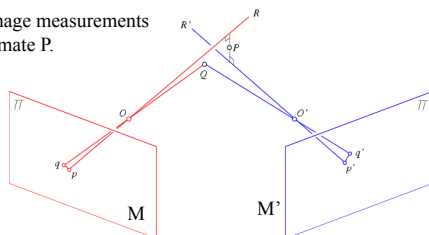
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(Adapted from G> Hager)

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Reconstruction: General 3-D case

Given two image measurements p and p' , estimate P .



- Linear Method: find P such that

$$\begin{cases} p \times M P = 0 \\ p' \times M' P = 0 \end{cases} \iff \begin{pmatrix} p \times \\ p' \times \end{pmatrix} \begin{bmatrix} M \\ M' \end{bmatrix} P = 0$$
 Where M and M' are the two camera matrices

- Non-Linear Method: find Q minimizing $d^2(p, q) + d^2(p', q')$ where $q = MQ$ and $q' = M'Q$

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Two Approaches

1. Feature-Based

- From each image, process “monocular” image to obtain image features or cues (e.g., corners, lines).
- Establish correspondence between the detected features.

2. Area-Based

- Directly compare image regions between the two images and search for correspondences.

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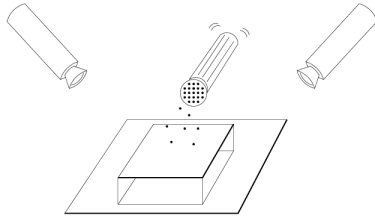
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Human Stereopsis: Binocular Fusion

How are the correspondences established?

Julesz (1971): Is the mechanism for binocular fusion a monocular process or a binocular one??

- There is anecdotal evidence for the latter (camouflage).

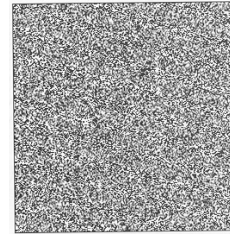


- Random dot stereograms provide an objective answer

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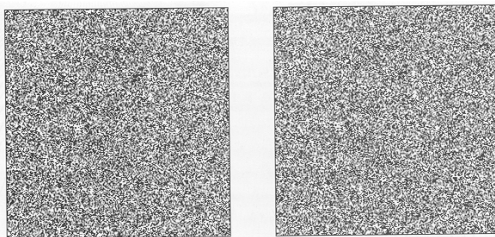
Random Dot Stereograms



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Random Dot Stereograms



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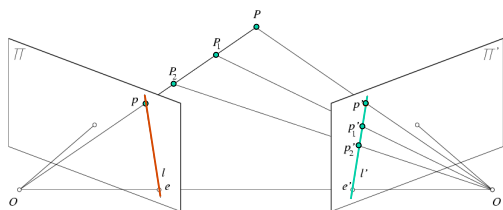
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Need for correspondence



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- Potential matches for p have to lie on the corresponding epipolar line l' .
- Potential matches for p' have to lie on the corresponding epipolar line l .

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