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

Example: Helmholtz Stereo

Depth + Normals + BRDF

Images

Normals + Depth

Rendering using depth, normals, reflectance

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

Mars Rovers: Spirit and Opportunity

Four pairs of stereo cameras
Mars Exploratory Rovers: Spirit and Opportunity

An Application: Mobile Robot Navigation


The INRIA Mobile Robot, 1990.

Commercial Stereo Heads

Need for correspondence

Trinocular stereo Binocular stereo

Triangulation

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
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: $f$

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

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

Disparity: $(X_L - X_R)$

(Adapted from Hager)