What is an Image?

• a record of radiant energy received by a sensor
What is Image Understanding?

 Recovering information about the world, the "scene", from images
Applications of computational vision

• robotics
• manufacturing
• inspection
• agriculture
• mining
• remote sensing
• medicine
• surveillance, monitoring
In particular:

- biometrics - identifying people: static and moving
- document understanding
- communication
- gestures
- assisting humans
- autonomous vehicles
- content-based image retrieval
- model-building
Others:

- online museums
- virtual stores
- electronic malls
- infotainment
- Special effects: http://www.2d3.com/
- image compositing
- electronic games
Image understanding

We distinguish between using general knowledge of the world and specific knowledge of the world:

image analysis uses general facts about image formation and generic assumptions about the world to produce a description of the world in image coordinates

scene analysis produces scene descriptions in 3D coordinates and involves identification of objects --- "those surfaces compose a chair“ and localization of particular objects -- the chair is at (x,y,z) and at orientation (rho,theta,phi)

“that region of the image looks like a bicycle”
Computer vision:

- computational vision
to emphasize the abstract computation problem
without reference to mechanism
includes machine and biological vision
- robot vision - Horn's book
emphasizes the non-human side of things
- robotics - (Brady/Winston)
"the intelligent connection of perception to action"
emphasizes the active aspect of vision, serving as an information gatherer
- cognitive vision
emphasizes the meaning of the scene, the task in which the vision system is engaged
Approaches to vision

- Horn emphasizes optical and physical aspects

- Marr models vision as information processing
  human vision system (inspiration)
  neurobiology - animal to human
  psychophysics –
  
  the scientific study of the relationship between stimuli (specified in physical terms) and the sensations and perceptions evoked by these stimuli.

illusion
Is this image processing?

How does this differ from image processing?

We emphasize the process of image formation: light interacts with objects in the 3D world.

Image processing produces a new image, perhaps indicating image features.

Pattern recognition is its precursor:
- analyze 2d patterns via and statistical and structural patterns includes pattern classification

But image analysis is not image coding or compression or restoration or enhancement.
Is this AI?

Perhaps not --- only general knowledge applies, but how does a human understand an image? with knowledge of the world?

AI first expert reasoning (chess--not now AI!, checkers...) then perception
(1966 MIT summer vision project... Papert
http://dspace.mit.edu/handle/1721.1/6125

Early vision lived in a Blocks world

But it has become clear that much of Intelligence is at the common-sense perceptual level (Rod Brooks)
Topics

Overview

Image formation
  Perspective and orthographic projection
  Cameras: intrinsic and extrinsic geometry

Sampling Theory and the Fourier Transform
  Images, sampling, tesselations, quantization, noise, The adequacy of digital images: bandlimited signals
  Transform domain approaches: the Fourier transform, linear systems theory as an analysis tool
  Linear shift-invariant operations: convolution
  Template matching: global templates, local templates, matched filtering
Topics 2

Edge Detection
Linear filters; Physical causes of edges
Detectors: Marr-Hildreth, Laplacian of Gaussian, detection of maximum of gradient
Filters, gradients, edges, Canny up through non-maximum suppression, hysteresis
Prior information: Bayesian methods, regularization corners and SIFT

Shape from shading and photometric stereo
photometry, shape and images
modeling image formation: geometry, radiometry and the image irradiance equation
BRDF, reflectance function, reflectance map
photometric stereo, inter-reflection
Topics 3

Optical flow and tracking

motion field and optical flow, Horn-Schunck, aperture problem, Lucas-Kanade

Multi-view geometry

epipolar geometry, the fundamental matrix and essential matrix binocular stereo
Techniques, methods, tools

Linear Algebra
Linear systems
Fourier analysis
Calculus in two and three dimensions:
  differential and integral
Discrete Mathematics
Numerical Methods
Analytical Geometry (not necessarily differential)
Probability/Statistics
Computational tools: Matlab (Python?)