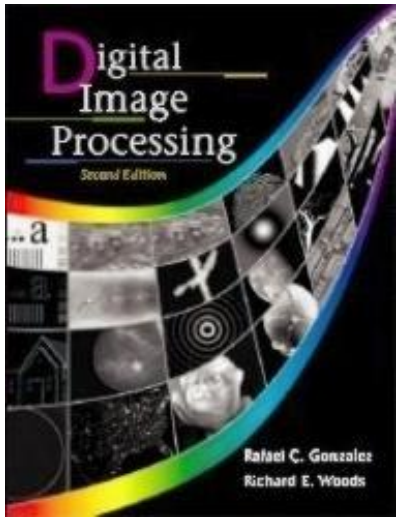
Digital Image Processing

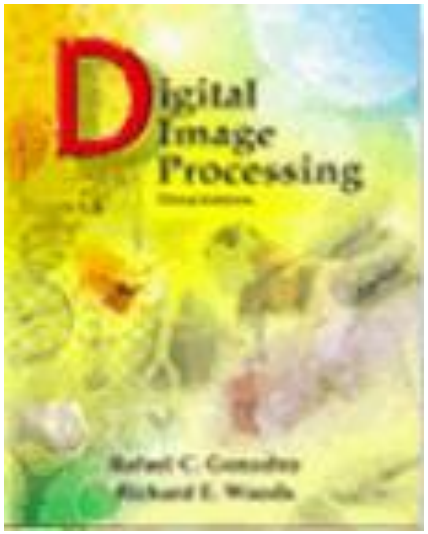
Lecture # 1 (a): Introduction

Course Information

- Books
  - Digital Image Processing, Rafael C. Gonzalez & Richard E. Woods, Addison-Wesley



Second Edition



Third Edition

Image Processing

Image Analysis

Pattern Recognition

Machine Vision

Computer Vision

Image Processing & Machine Vision

- Continuum from Image Processing to Machine Vision:
  - low, mid and high-level processes

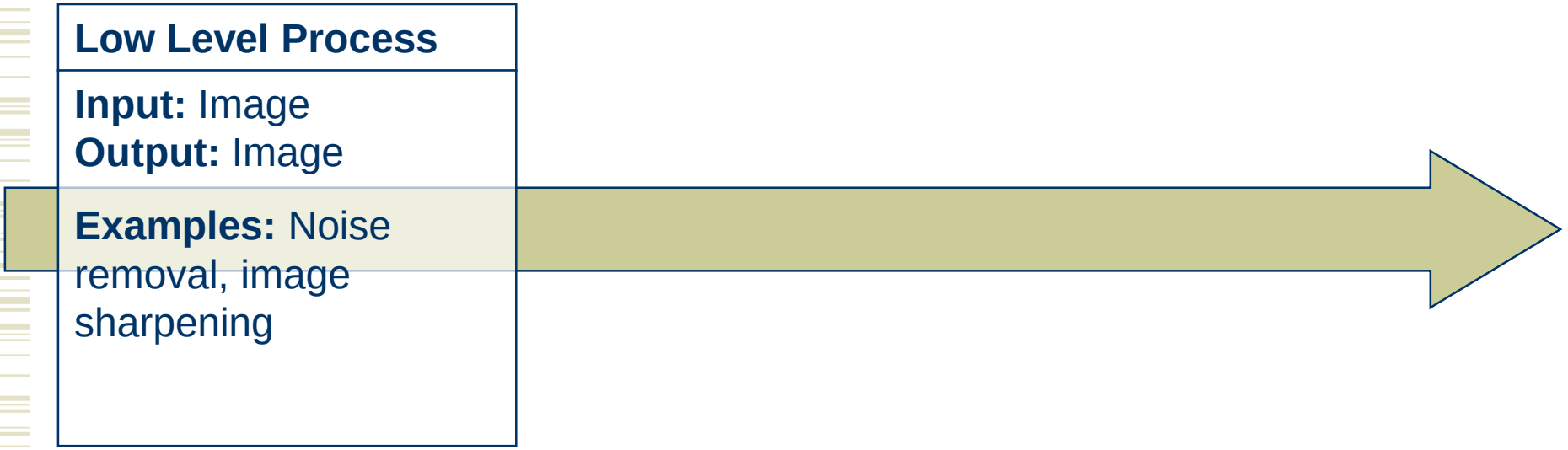
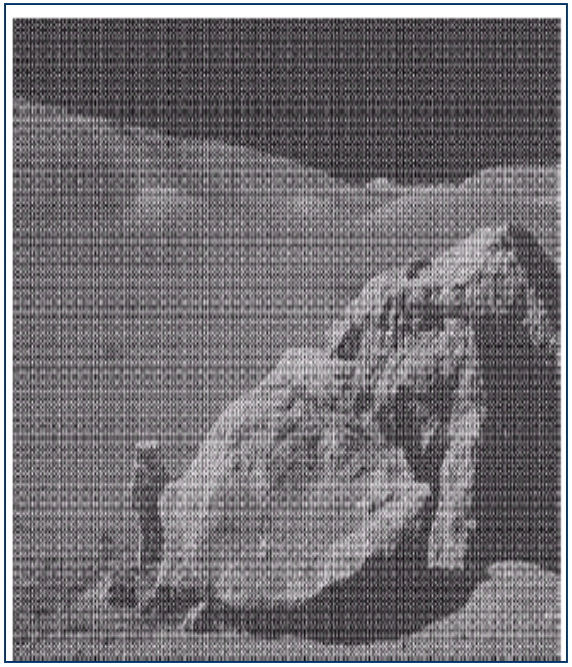


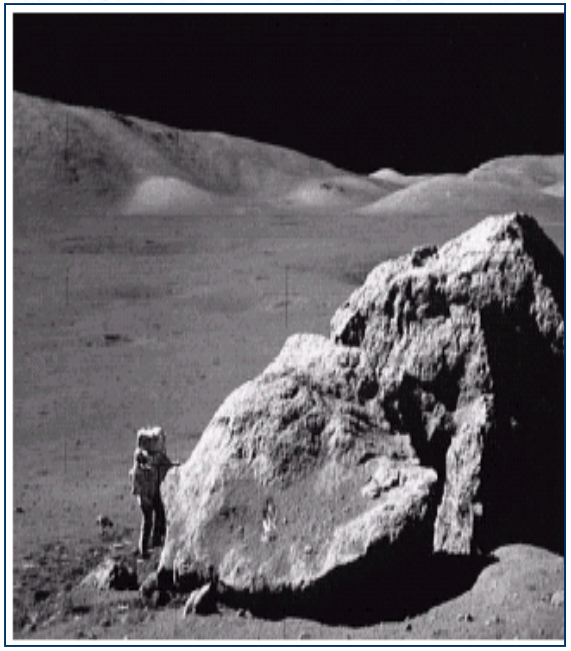
Image Processing

Example: Low Level Processing

Photo restoration



Damaged Image



Restored Image

Image Processing & Machine Vision

- Continuum from Image Processing to Machine Vision:
  - low, mid and high-level processes

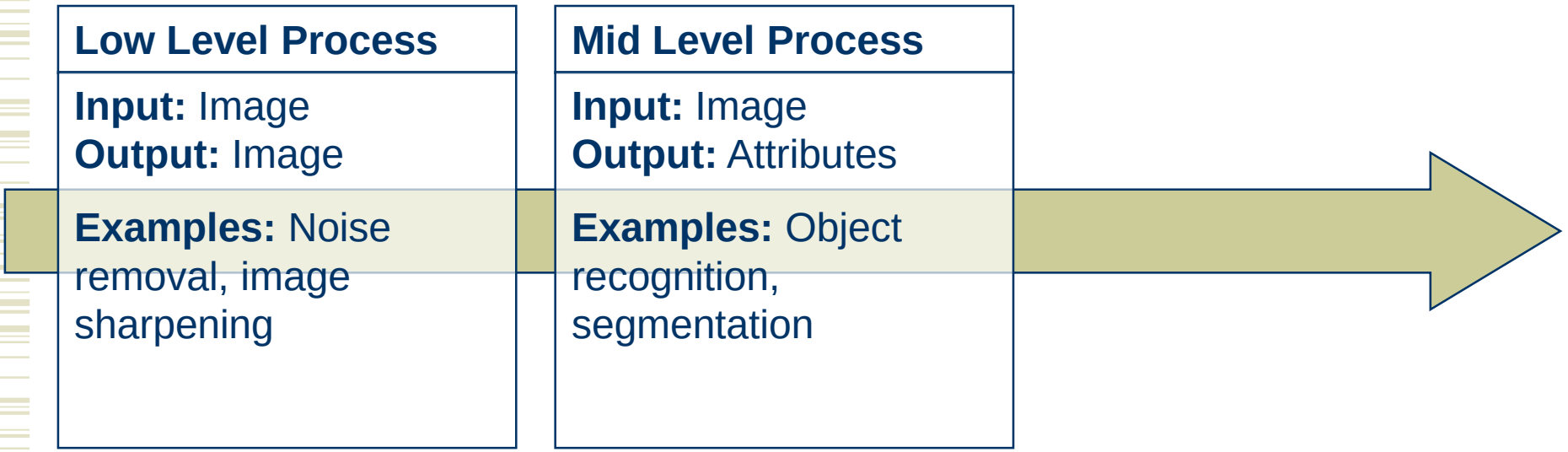
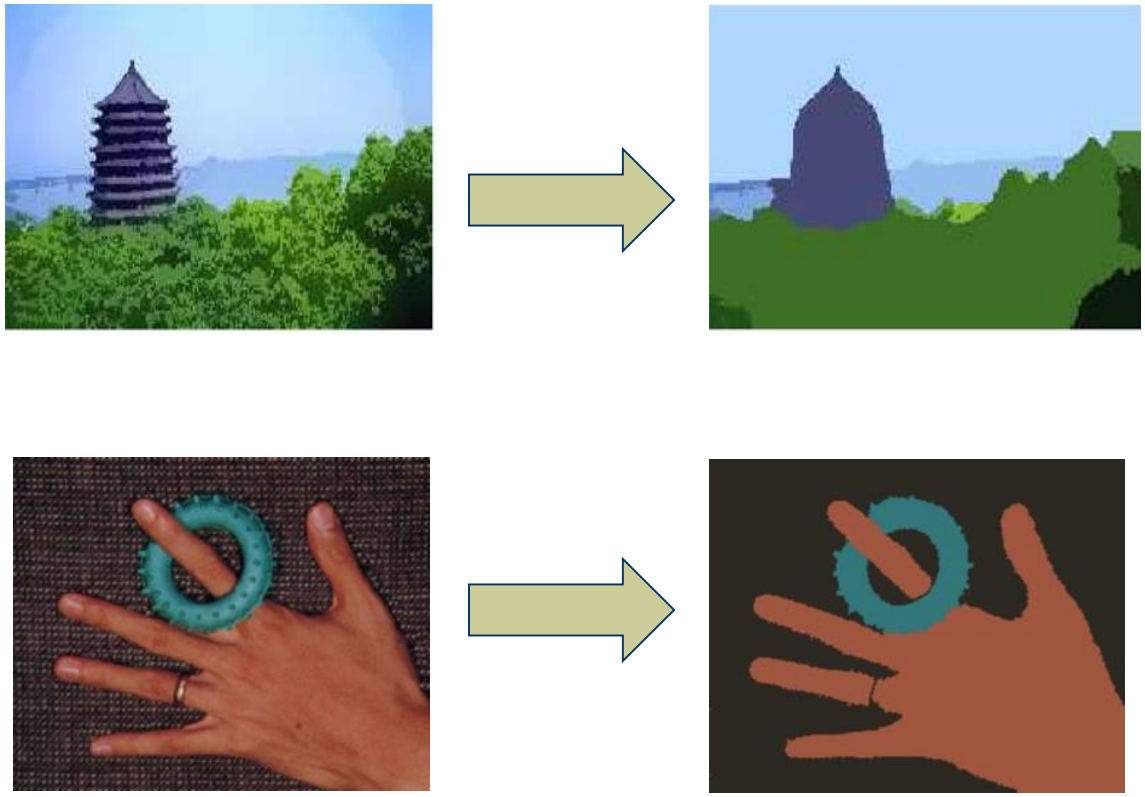


Image Processing

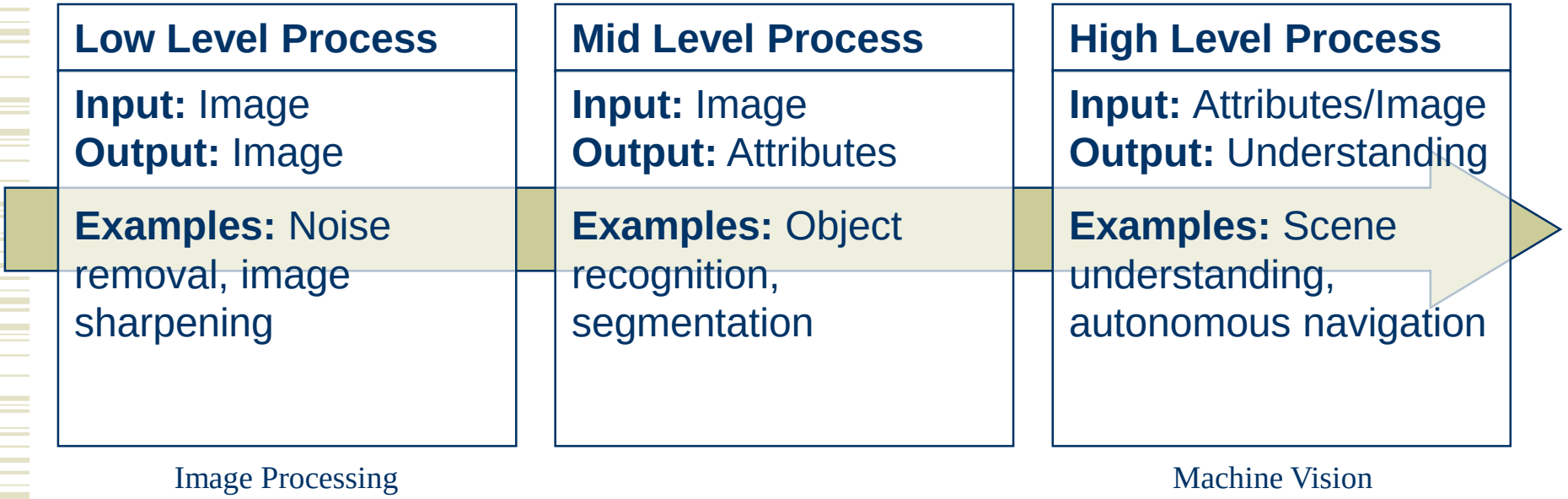
Example: Mid Level Processing



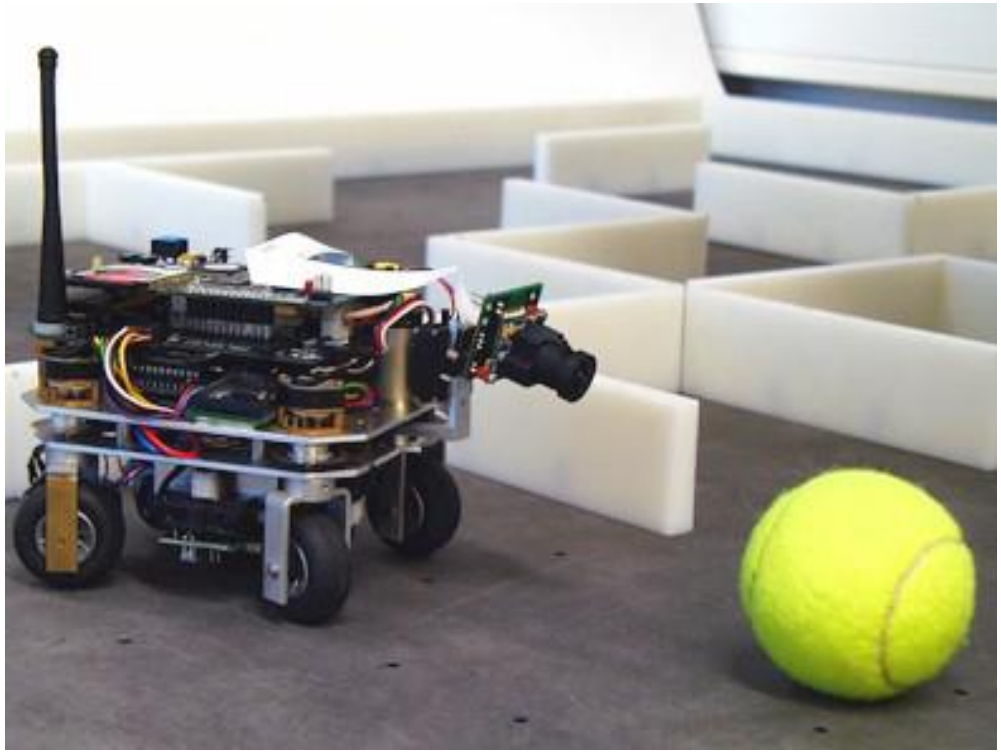
Segmentation of image into regions

Image Processing & Machine Vision

- Continuum from Image Processing to Machine Vision:
  - low, mid and high-level processes



Example: High Level Processing

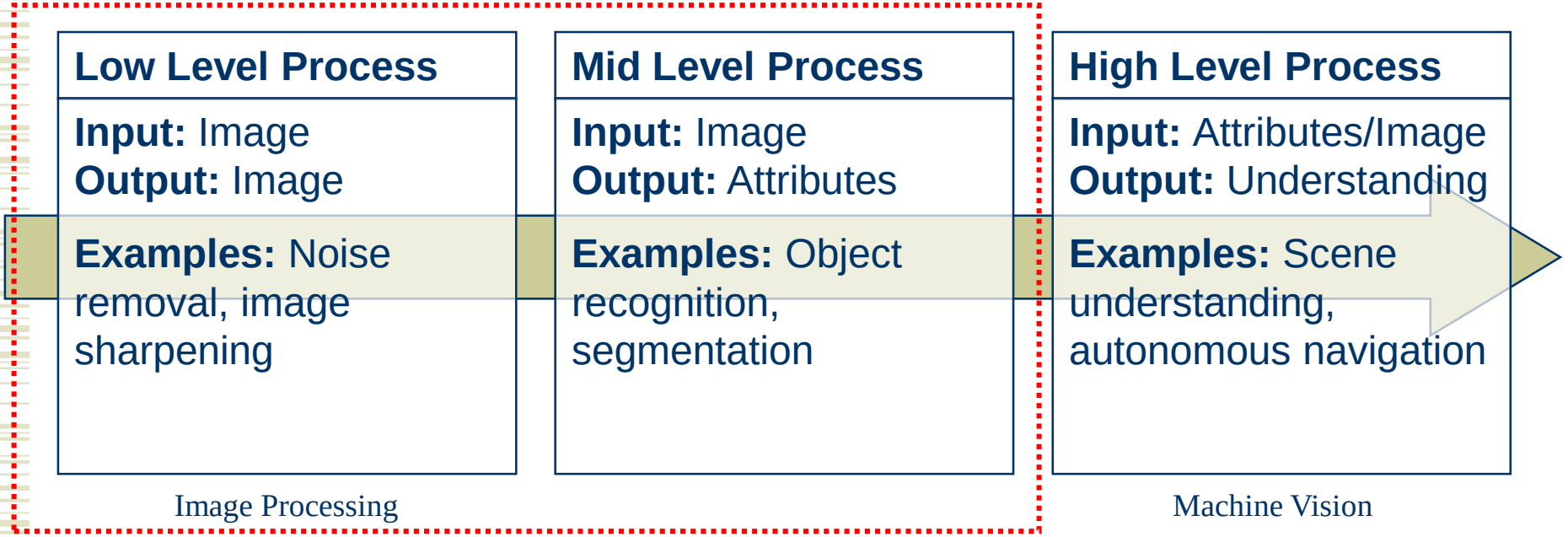


Robot Navigation

Image Processing & Machine Vision

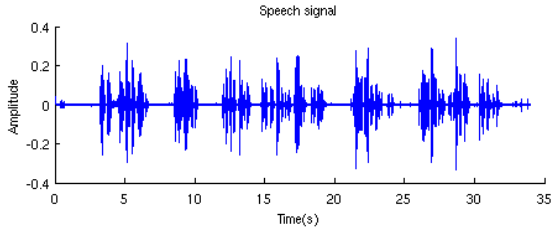
- Continuum from Image Processing to Machine Vision:
  - low, mid and high-level processes

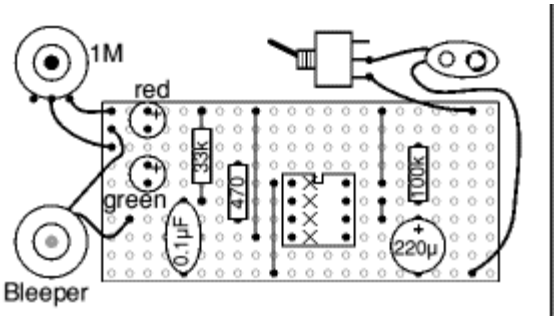
In this course



Pattern Recognition

A pattern is the opposite of a chaos, it is an entity that can be given a name





Recognition

- Identification of a pattern as a member of a category
  - Classification (Supervised: known categories)
  - Clustering (Unsupervised: learning categories)

Supervised Classification

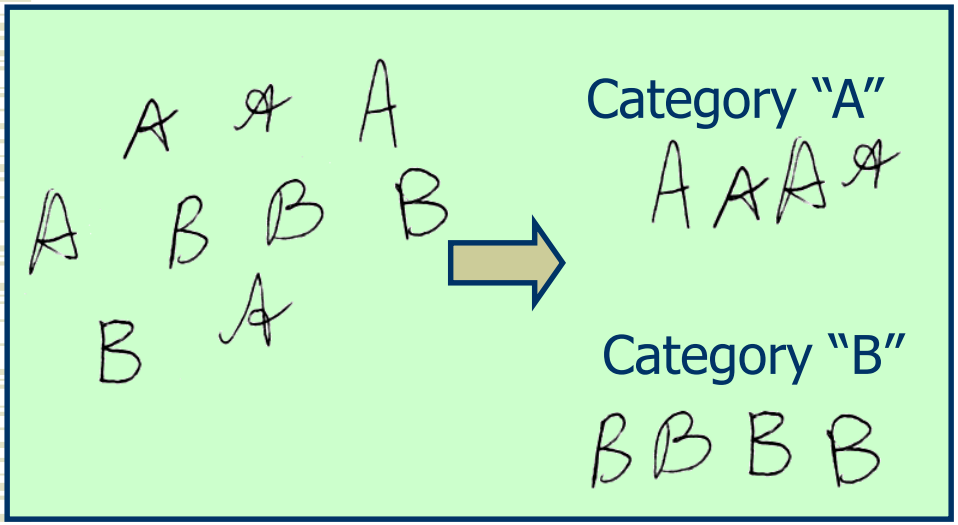
Labeled training Samples

Recognition (Classification)

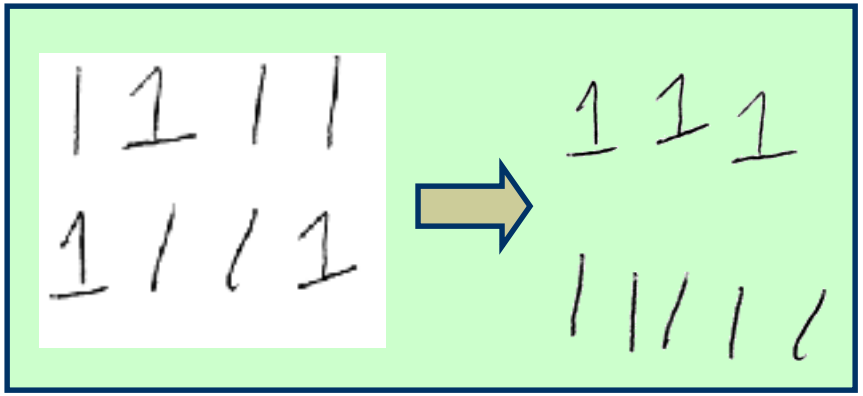
Unsupervised Classification

Un-labeled training Samples

Classification vs. Clustering



Classification



Clustering

Pattern Recognition

Given an input pattern, make a decision about the "category" or "class" of the pattern

Pattern Class

- A collection of similar (not necessarily identical) objects
- Intra-class variability
- Inter-class similarity

Pattern Class

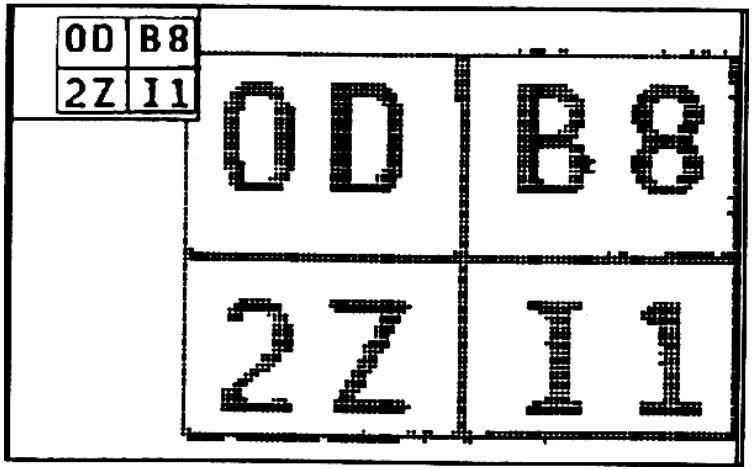
Intra-class variability

The letter "T" in different typefaces

Same face under different expression, pose, illumination

Pattern Class

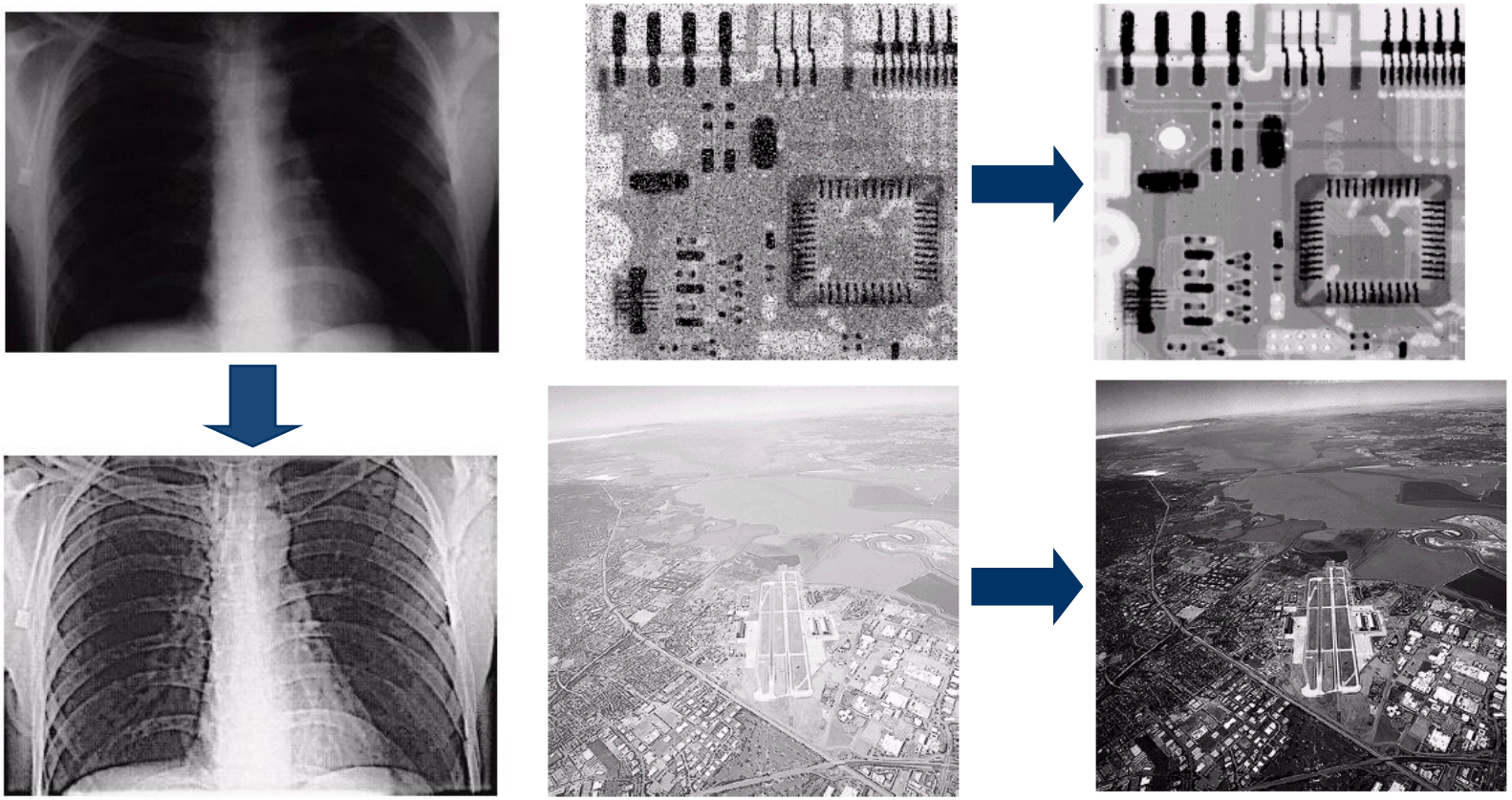
Inter-class similarity



Characters that look similar

Example Applications

Examples: Image Enhancement



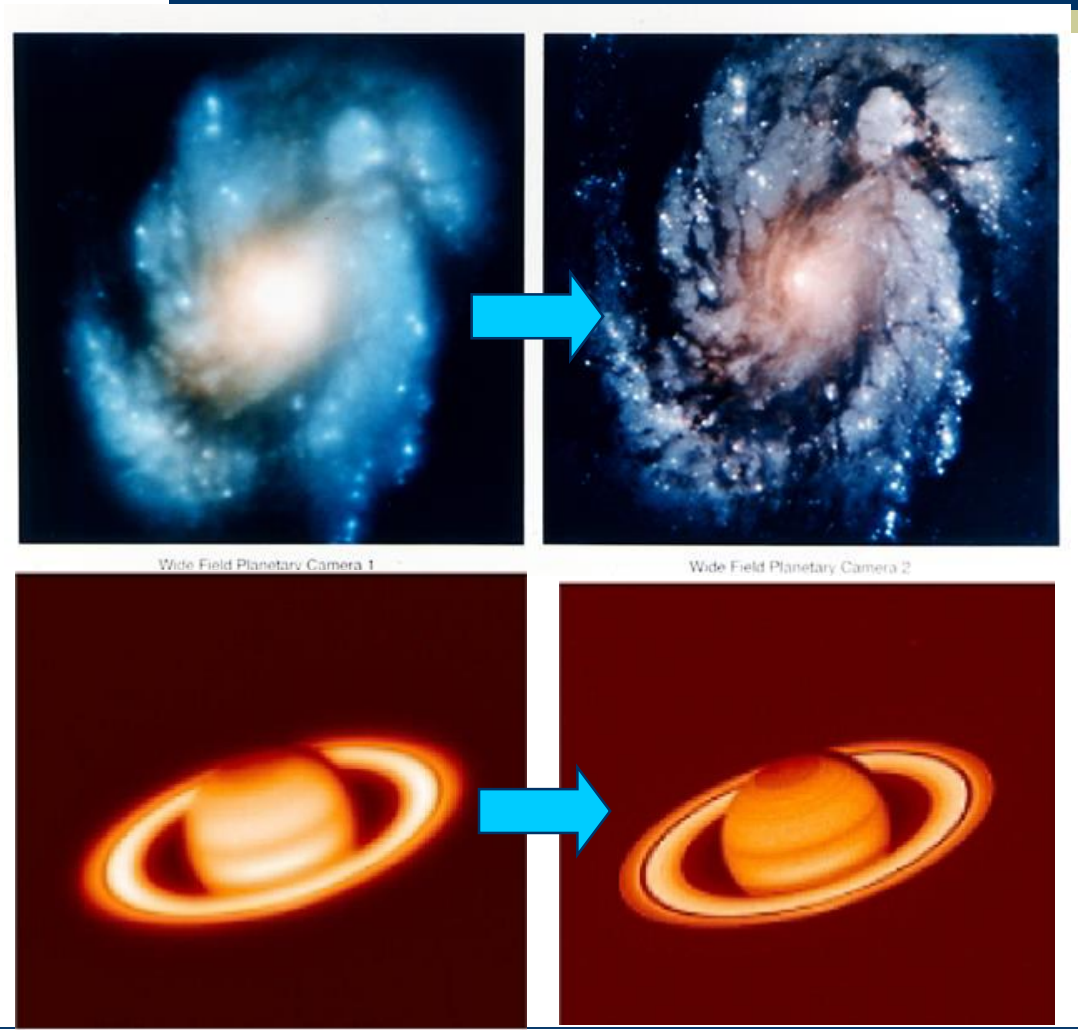
Examples: The Hubble Telescope

- Launched in 1990 the Hubble telescope can take images of very distant objects

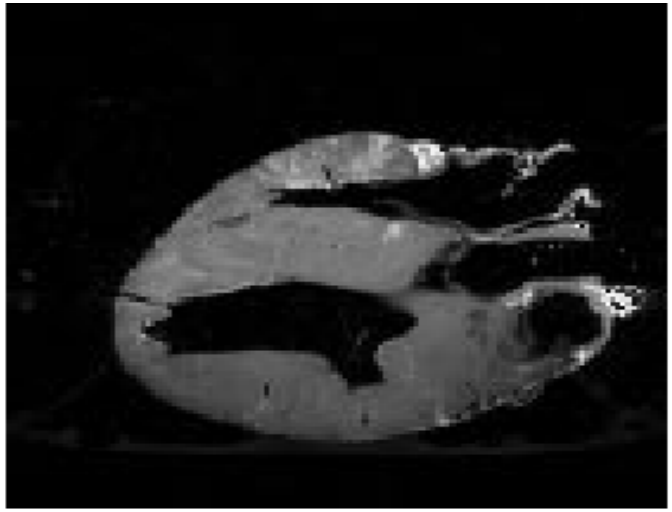
- However, an incorrect mirror made many of Hubble's images useless

- Image processing techniques were used to fix this

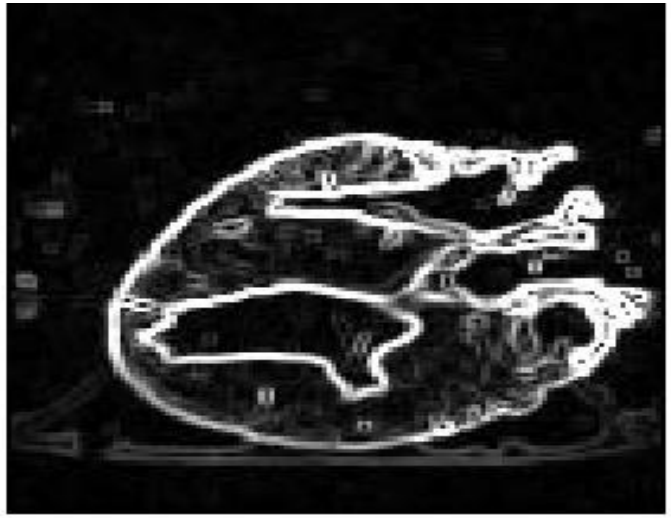
Examples: The Hubble Telescope



Examples: Medicine

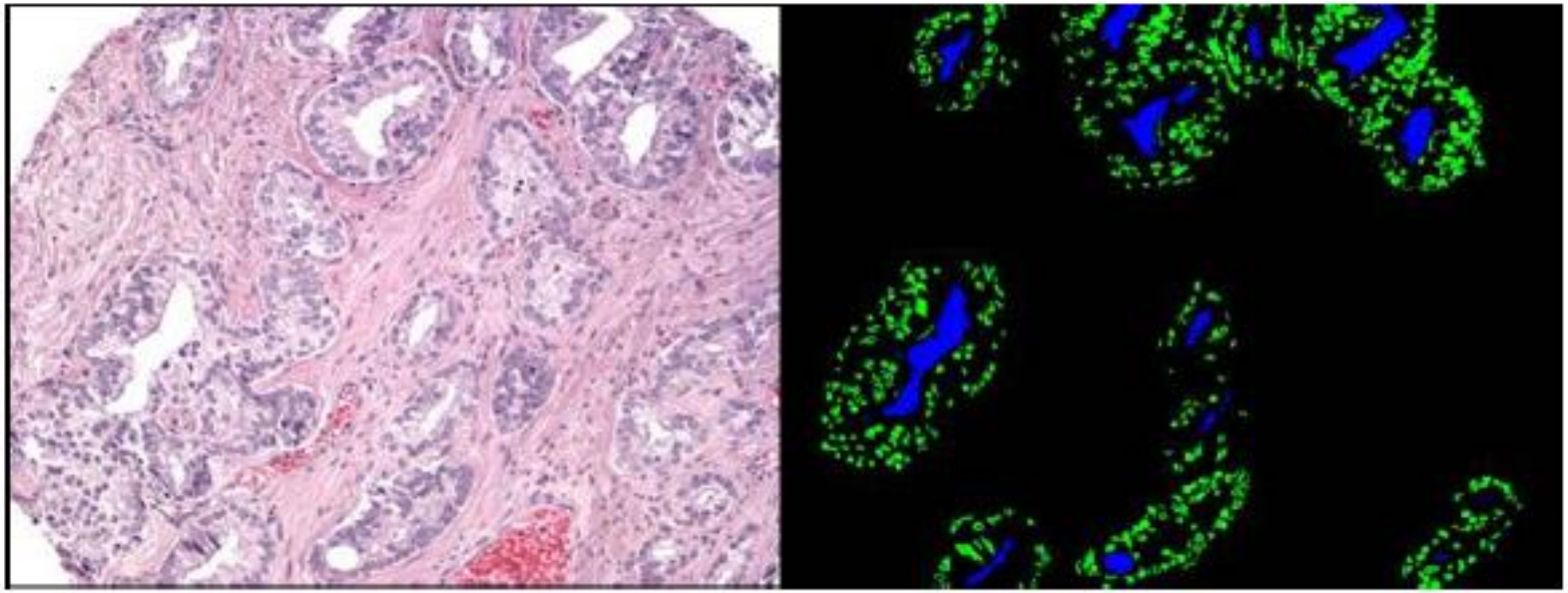


Original Image of a Dog Heart



Separation of tissues

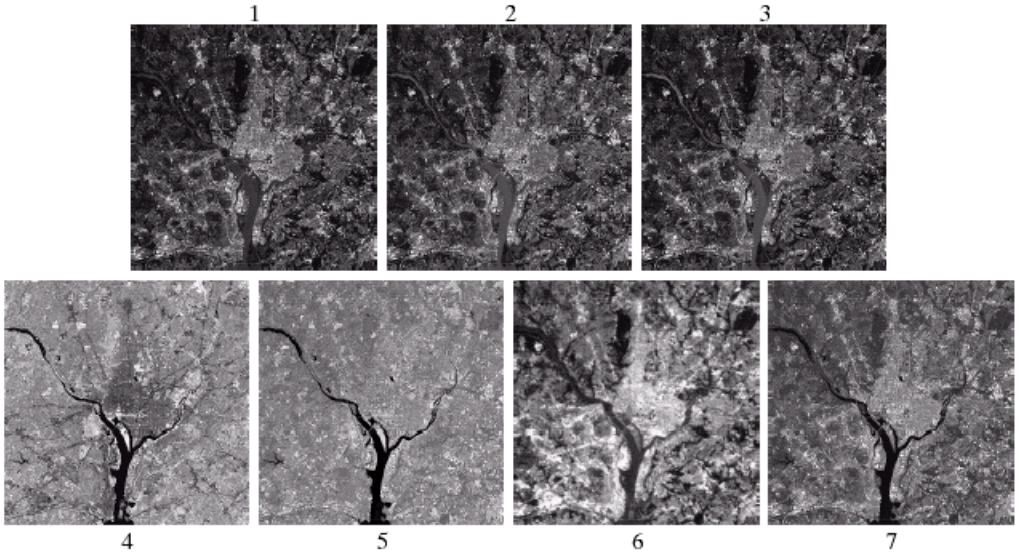
Examples: Medicine

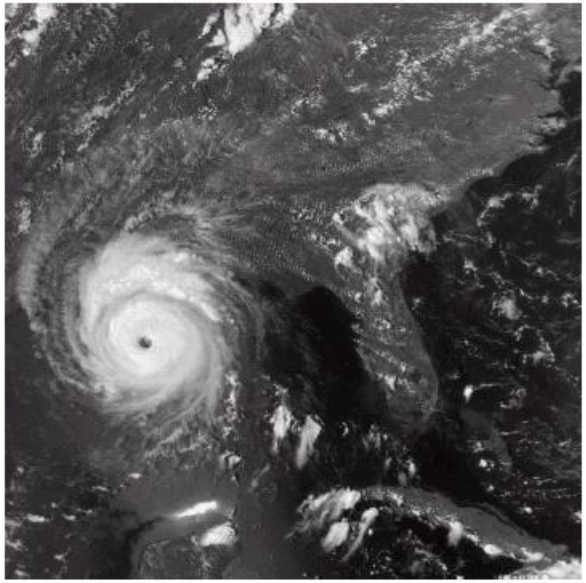


Microscopic tissue data - Cancer Detection

Examples: GIS

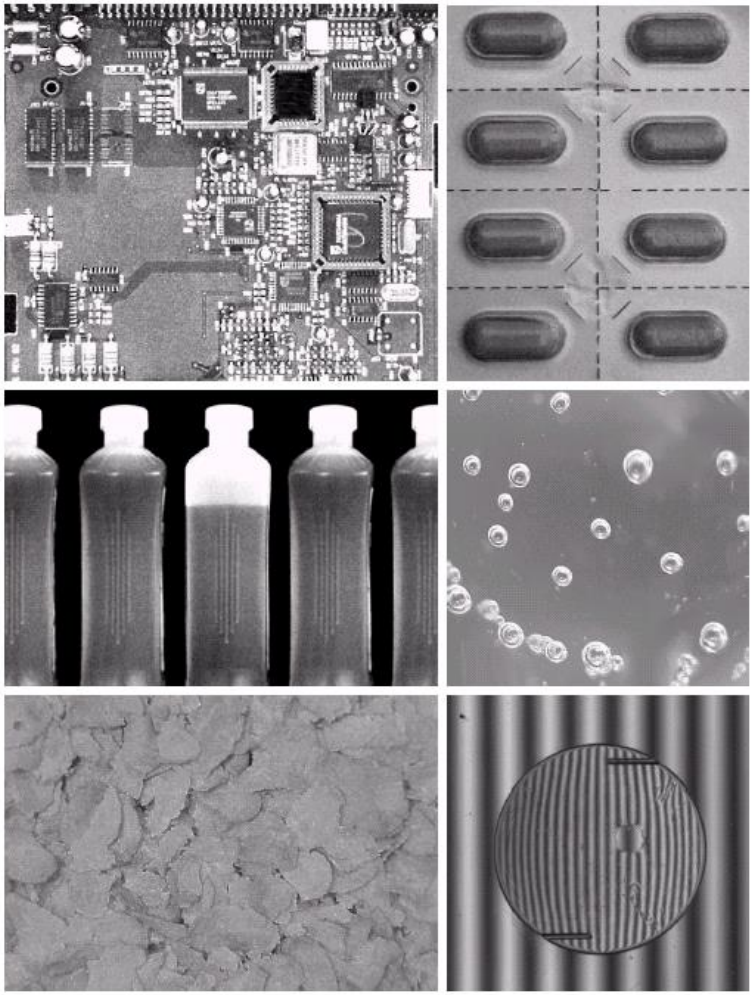
- Geographic Information Systems
  - Manipulation of Satellite Imagery
  - Terrain Classification, Meteorology





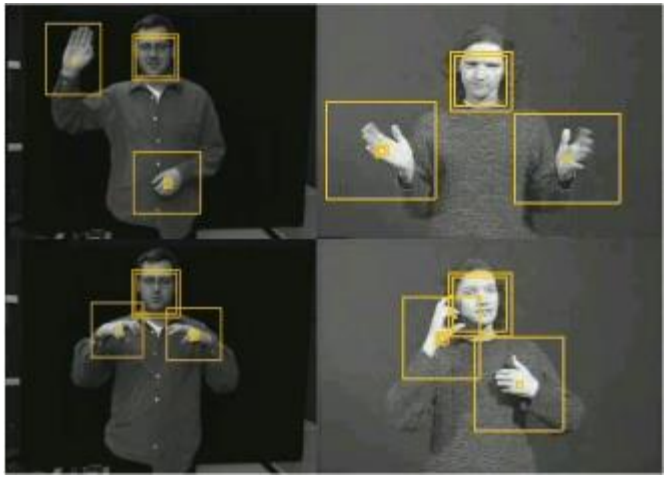
Examples: Industrial Inspection

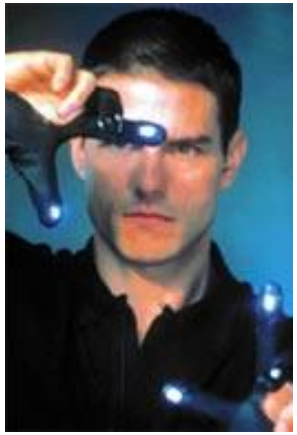
- Human operators are expensive, slow and unreliable
- Make machines do the job instead

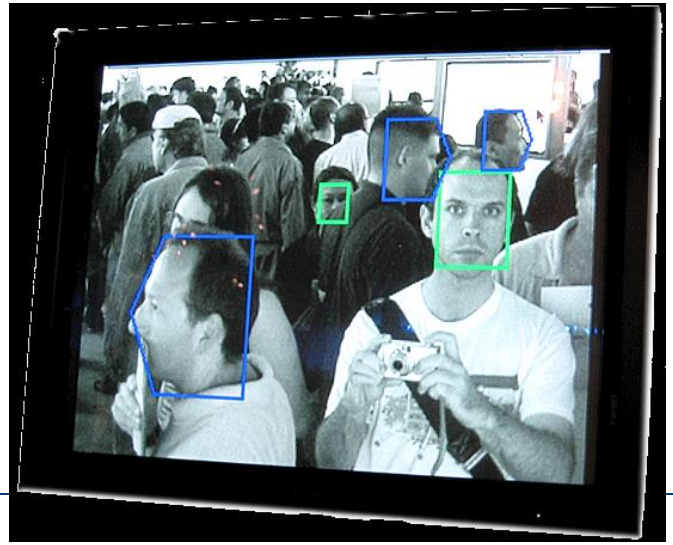


Examples: HCI

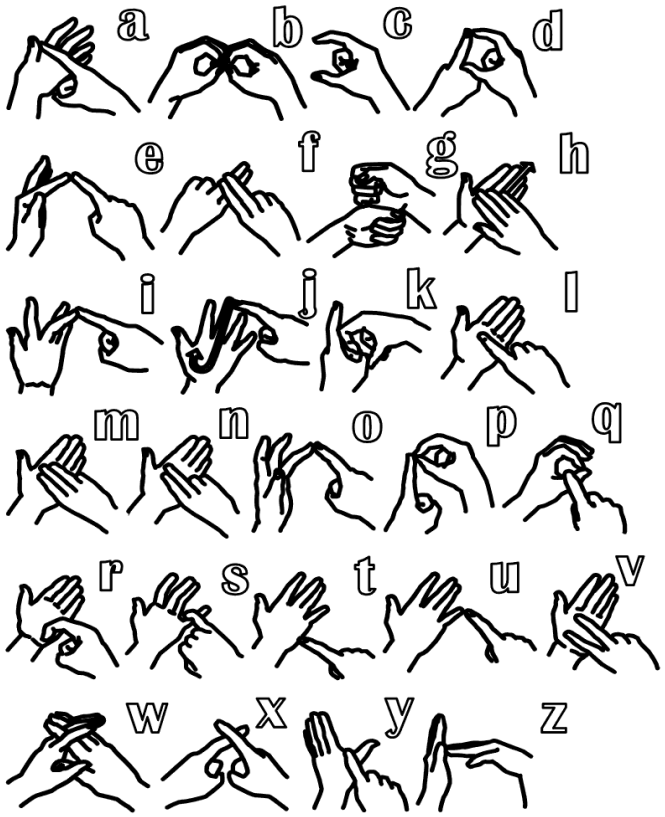
- Try to make human computer interfaces more natural
  - Gesture recognition
  - Facial Expression Recognition
  - Lip reading



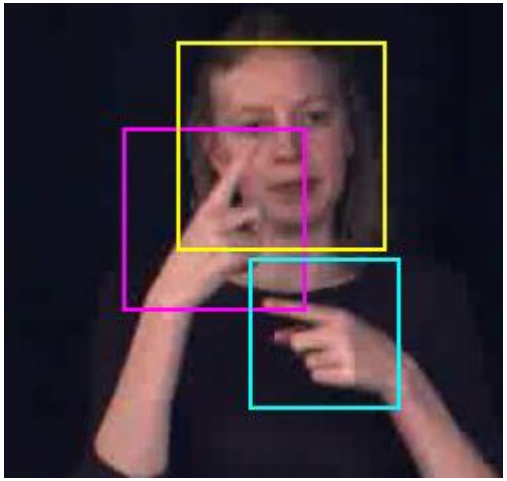




Examples: Sign Language/Gesture Recognition



British Sign Language Alphabet



Examples: Facial Expression Recognition

- Implicit customer feedback

Examples: Facial Expression Recognition

- Implicit customer feedback

Upper Face Action Units

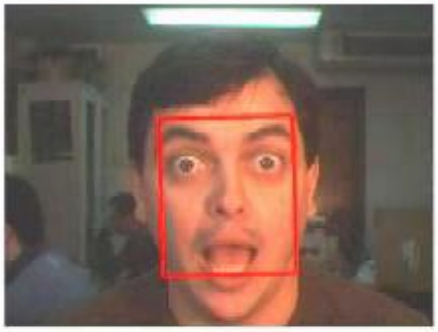
AU4	AU1+4	AU1+2
		
Brows lowered and drawn together	Medial portion of the brows is raised and pulled together	Inner and outer portions of the brows are raised
AU5	**AU6**	**AU7**
		
Upper eyelids are raised	Cheeks are raised and eye opening is narrowed	Lower eyelids are raised

Lower Face Action Units

AU25	AU26	AU27
		
Lips are relaxed and parted	Lips are relaxed and parted; mandible is lowered	Mouth is stretched open and the mandible pulled down
AU12	**AU12+25**	**AU20+25**
		
Lip corners are pulled obliquely	AU12 with mouth opening	Lips are parted and pulled back laterally

Examples: Facial Expression Recognition

- Implicit customer feedback



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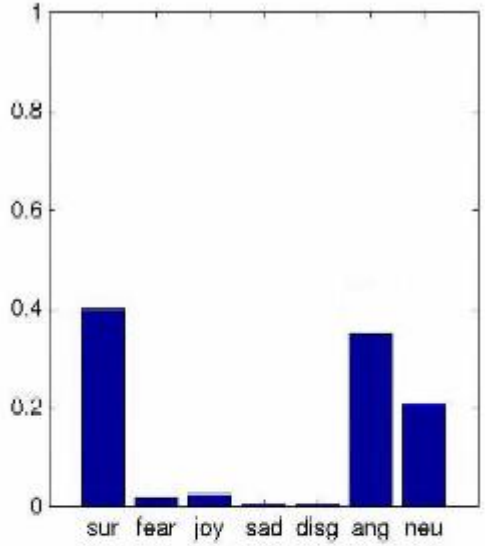
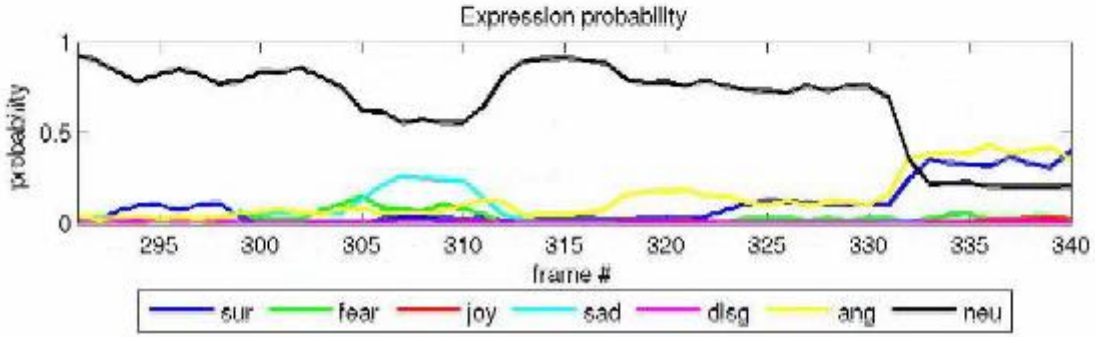
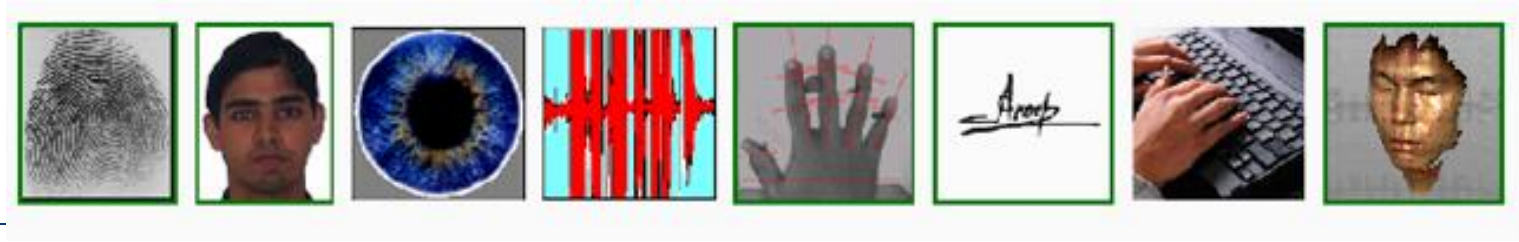


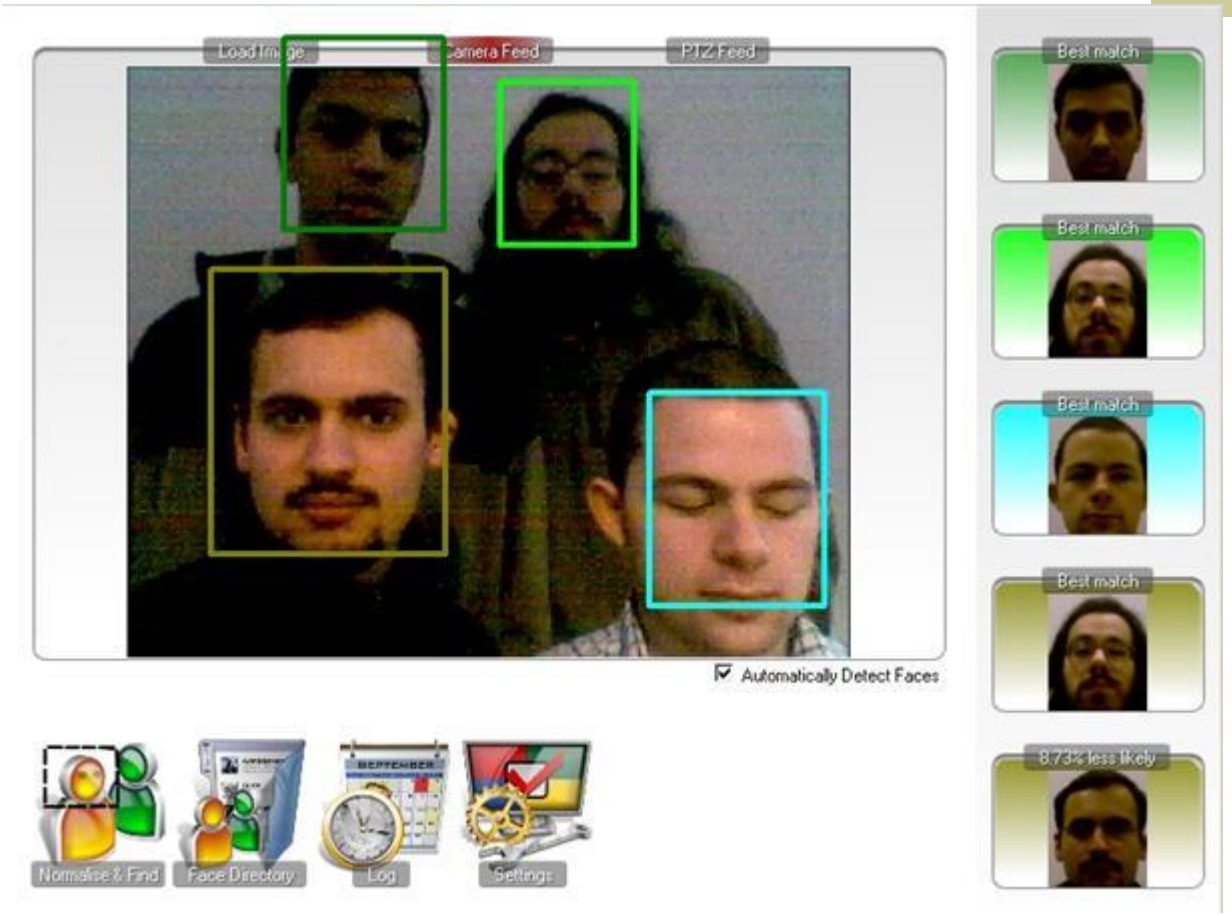


Examples: Biometrics

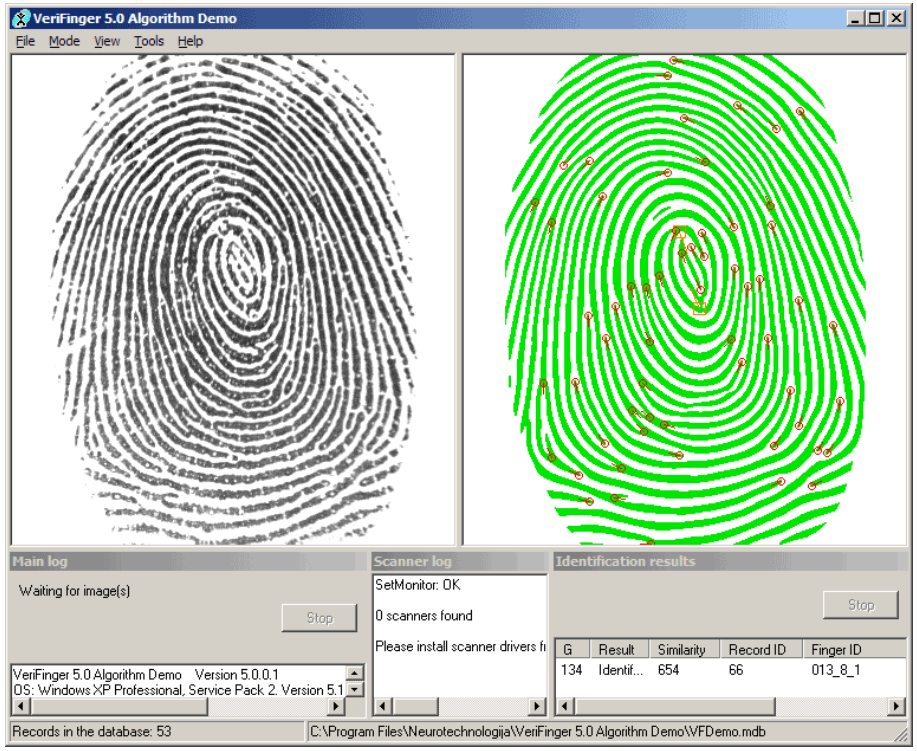
- Biometrics - Authentication techniques
- Physiological Biometrics
  - Face, IRIS, DNA, Finger Prints
- Behavioral Biometrics
  - Typing Rhythm, Handwriting, Gait



Examples: Biometrics – Face Recognition

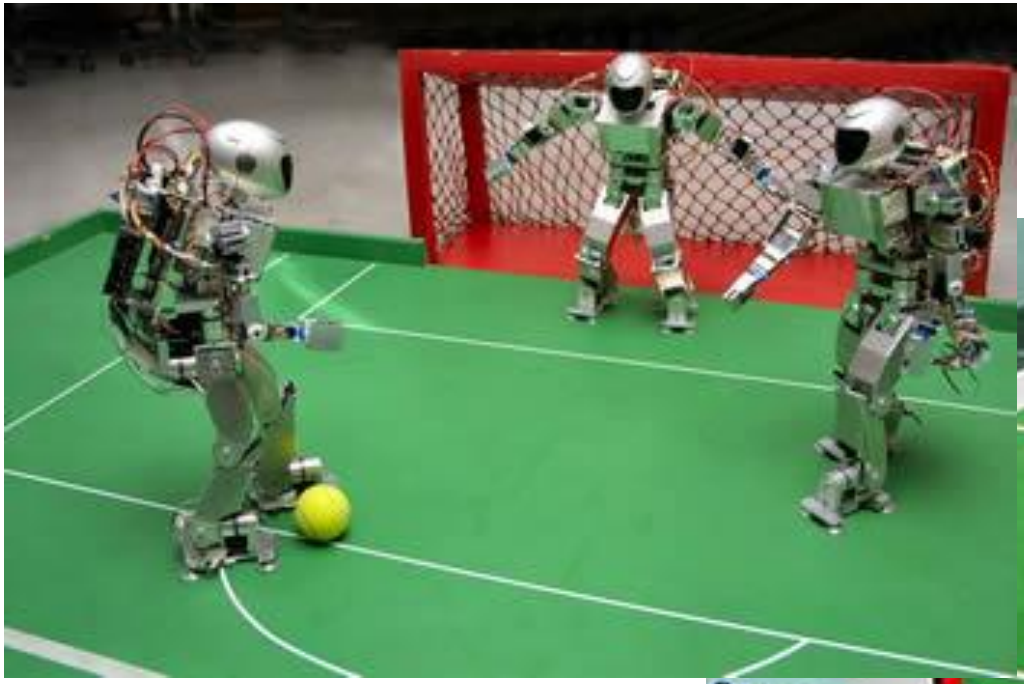


Examples: Biometrics – Finger Print Recognition



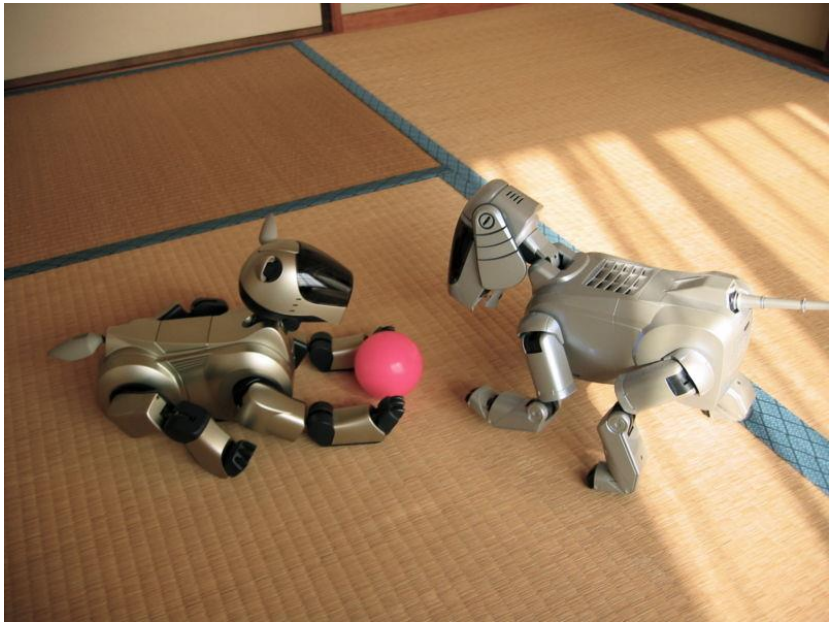
Examples: Biometrics – Signature Verification

Examples: Robotics



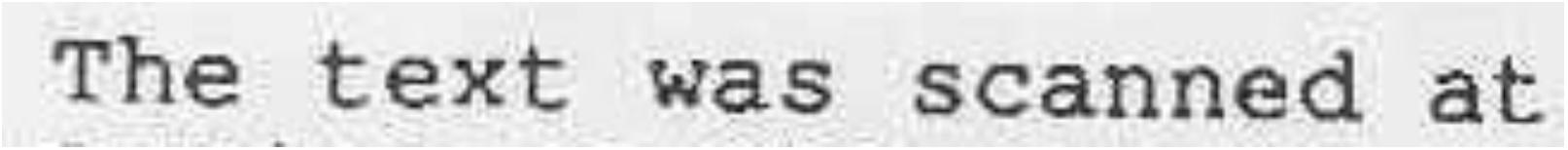
Examples: Robotics

- AIBO



Examples: Optical Character Recognition

- Convert document image into text (CAMScanner)



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Examples: Optical Character Recognition

- Indexing and Retrieval

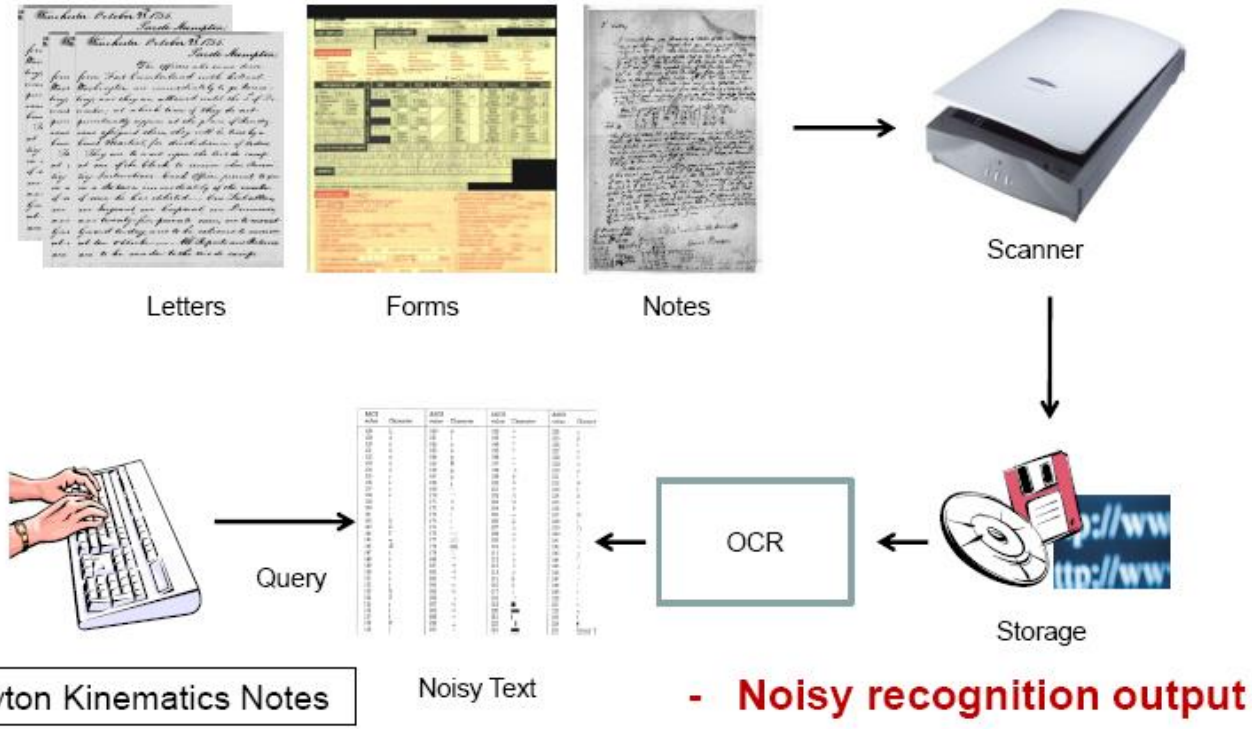


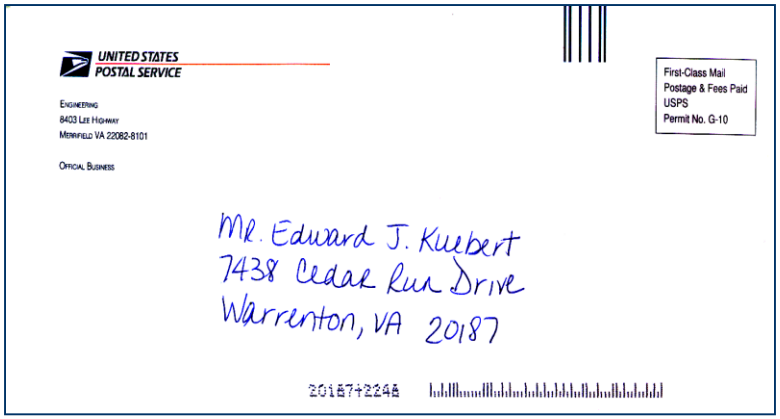
Image Source: CEDAR

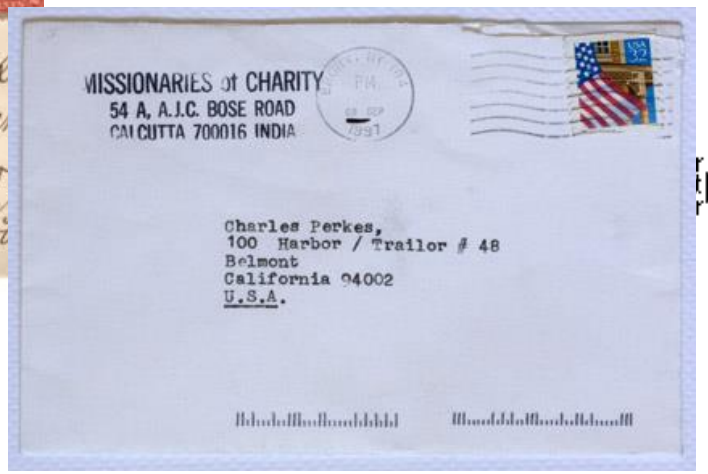
Examples: Optical Character Recognition

- License Plate Recognition

Examples: Optical Character Recognition

- Automatic Mail Sorting





Summary of Applications

Problem Domain	Application	Input Pattern	Output Class
Document Image Analysis	Optical Character Recognition	Document Image	Characters/words
Document Classification	Internet search	Text Document	Semantic categories
Document Classification	Junk mail filtering	Email	Junk/Non-Junk
Multimedia retrieval	Internet search	Video clip	Video genres
Speech Recognition	Telephone directory assistance	Speech waveform	Spoken words
Natural Language Processing	Information extraction	Sentence	Parts of Speech
Biometric Recognition	Personal identification	Face, finger print, Iris	Authorized users for access control
Medical	Computer aided diagnosis	Microscopic Image	Healthy/cancerous cell
Military	Automatic target recognition	Infrared image	Target type
Industrial automation	Fruit sorting	Images taken on conveyor belt	Grade of quality
Bioinformatics	Sequence analysis	DNA sequence	Known types of genes

Acknowledgements

- Statistical Pattern Recognition: A Review – A.K Jain et al., PAMI (22) 2000
- Pattern Recognition and Analysis Course – A.K. Jain, MSU
- *Pattern Classification"* by Duda et al., John Wiley & Sons.
- Digital Image Processing", Rafael C. Gonzalez & Richard E. Woods, Addison-Wesley, 2002
- Machine Vision: Automated Visual Inspection and Robot Vision", David Vernon, Prentice Hall, 1991
- www.eu.aibo.com/
- Advances in Human Computer Interaction, Shane Pinder, InTech, Austria, October 2008

Material in these slides has been taken from, the following resources