Digital Image Processing

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References

- Digital Image Processing, Second Edition (Text Book) Rafael C. Gonzalez and Richard E. Woods.
- Fundamentals of Digital Image Processing, A. K. Jain,
- *Digital Image Processing: Third Edition.* William K. Pratt, 2001 John Wiley & Sons.
- Theory and Application of Digital Image Processing, A. Erhard-Ferron, University of Offenburg.
- Digital Image Processing *with Application to Digital Cinema*, By K. S. Thyagarajan, Focal Press, Elsevier.

Evaluation

- Assignments 5 Point
- Final exam 10 Point
- Final Project 5 Point

Definitions

- Image Processing
- Computer Vision
- Low Level Processes: Primitive operations such as image preprocessing to reduce noise, contrast enhancement and image sharpening (input and output of this stage are image).
- Mid-Level Processes: segmentation, description and recognition (classification). (input is image and output is extracted attribute of image in this stage).
- High Level Processes: understanding groups of objects (making sense).

Image Formation

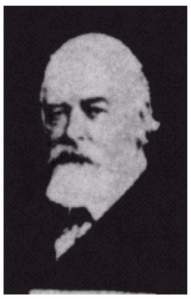
World → Optics → Sensor →
Signal → Digitizer →
Digital Representation

World	reality
Optics	focus {light} from world on sensor
Sensor	converts {light} to {electrical energy}
Signal	representation of incident light as continuous electrical energy
Digitizer	converts continuous signal to discrete signal
Digital Rep.	final representation of reality in computer memory

Initial Examples of Imagery

FIGURE 1.1 A digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces. (McFarlane.)

FIGURE 1.2 A digital picture made in 1922 from a tape punched after the signals had crossed the Atlantic twice. Some errors are visible. (McFarlane.)



Digital Image Processing

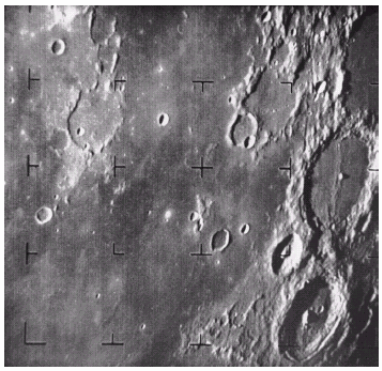


FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9:09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

The electromagnetic spectrum

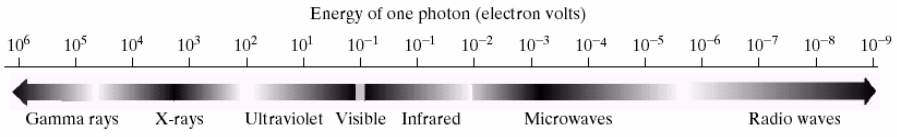
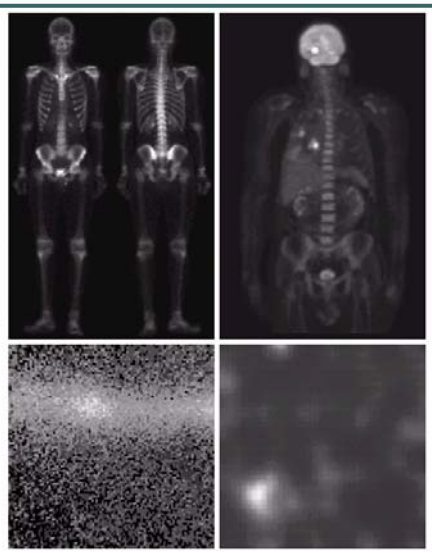


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

- Gamma-Ray Imaging.
- X-Ray Imaging.
- Ultraviolet Imaging.
- Visible and Infrared Imaging.
- Microwave Imaging (Radar).
- Radio band Imaging.
- Other Imaging Modalities (Sound).

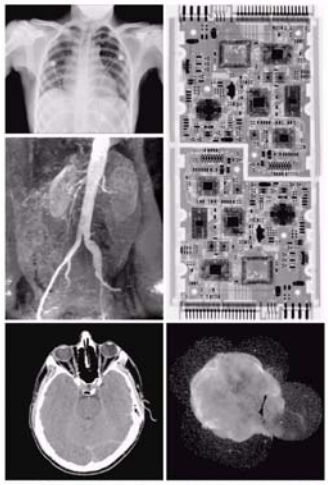
Example of Gamma-Ray Imaging



a b
c d

FIGURE 1.6 Examples of gamma-ray imaging. (a) Bone scan. (b) PET image. (c) Cygnus Loop. (d) Gamma radiation (bright spot) from a reactor valve. (Images courtesy of (a) G.E. Medical Systems, (b) Dr. Michael E. Casey, CTI PET Systems, (c) NASA, (d) Professors Zhong He and David K. Wehe, University of Michigan.)

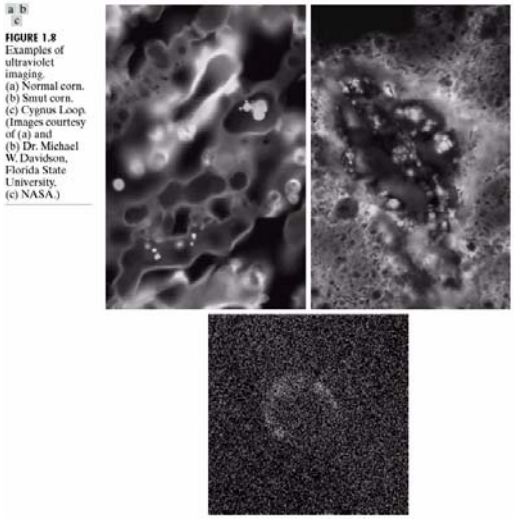
Example of X-Ray Imaging.



a d
b e
c

FIGURE 1.7 Examples of X-ray imaging. (a) Chest X-ray. (b) Aortic angiogram. (c) Head CT. (d) Circuit boards. (e) Cygnus Loop. (Images courtesy of (a) and (c) Dr. David R. Pickens, Dept. of Radiology & Radiological Sciences, Vanderbilt University Medical Center. (b) Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School. (d) Mr. Joseph E. Pascente, Lixi, Inc., and (e) NASA.)

Example of Ultraviolet Imaging



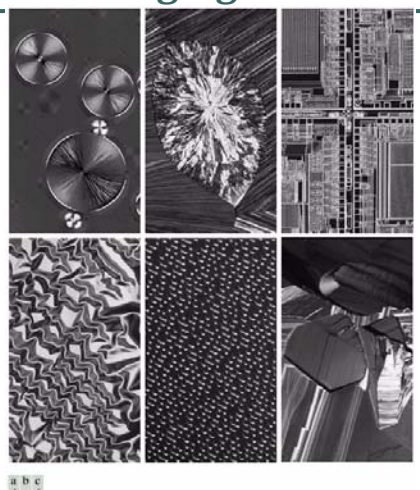
a b
c

FIGURE 1.8 Examples of ultraviolet imaging. (a) Normal corn. (b) Smut corn. (c) Cygnus Loop. (Images courtesy of (a) and (b) Dr. Michael W. Davidson, Florida State University. (c) NASA.)

Spectral image of normal and abnormal corn

Example of Visible Imaging

Microscopic Images of Biologic material



a b c
d e f

FIGURE 1.9 Examples of light microscopy images. (a) Taxol (anticancer agent), magnified 250×. (b) Cholesterol—40×. (c) Microprocessor—60×. (d) Nickel oxide thin film—600×. (e) Surface of audio CD—1750×. (f) Organic superconductor—450×. (Images courtesy of Dr. Michael W. Davidson, Florida State University.)

Example of Infrared Imaging

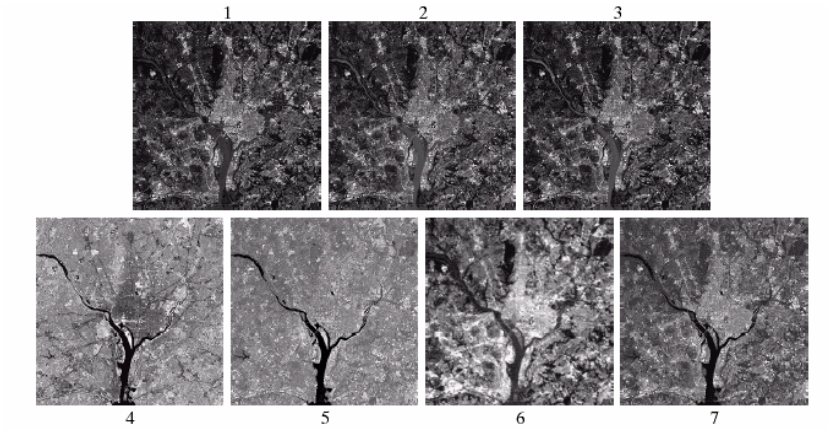
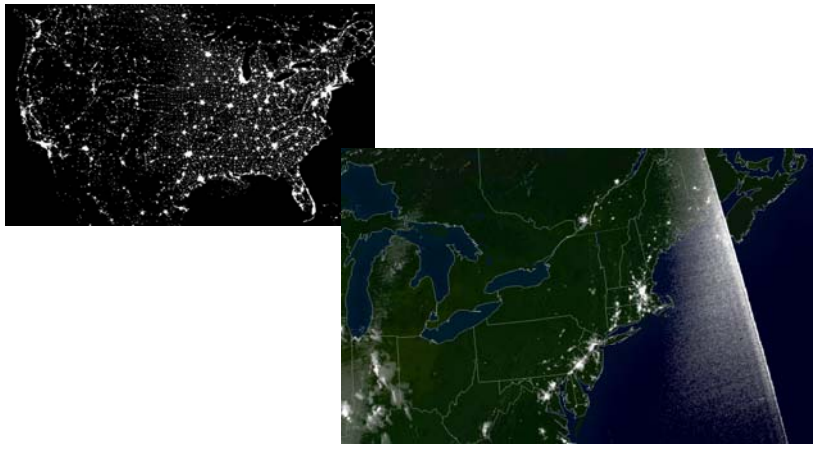


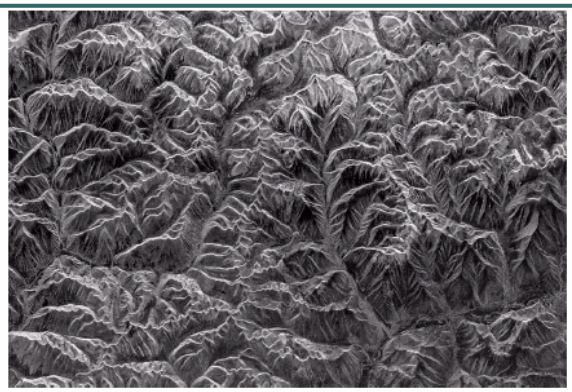
FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)

Example of Infrared Imaging



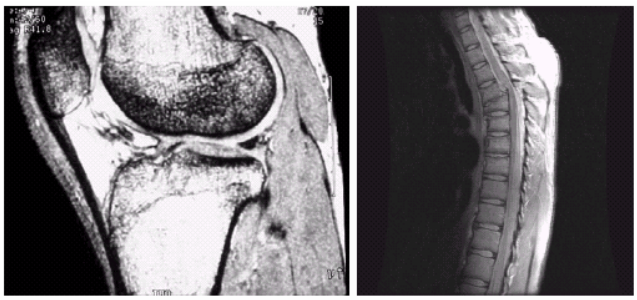
Example of Microwave Imaging (Radar)

FIGURE 1.16 Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)



- The unique feature of imaging radar is its ability to collect data over virtually any region at any time, regardless of weather or ambient lighting conditions.

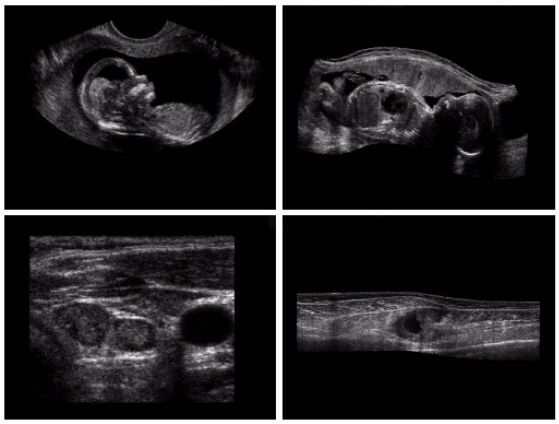
Radio band Imaging



a b

FIGURE 1.17 MRI images of a human (a) knee, and (b) spine. (Image (a) courtesy of Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School, and (b) Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

Other Imaging Modalities (Ultrasound)



a b
c d

FIGURE 1.20 Examples of ultrasound imaging. (a) Baby. (2) Another view of baby. (c) Thyroids. (d) Muscle layers showing lesion. (Courtesy of Siemens Medical Systems, Inc., Ultrasound Group.)

- Ultrasound imaging in geological exploration, industry and medicine.

Important Stages in Image Processing

- Image Acquisition
- Preprocessing (Enhancement and Restoration):
  - Enhancement is subjective.
  - Restoration is objective.
- Segmentation
- Representation and Description
- Recognition and Interpretation
- Knowledge base

Important Stages in Image Processing

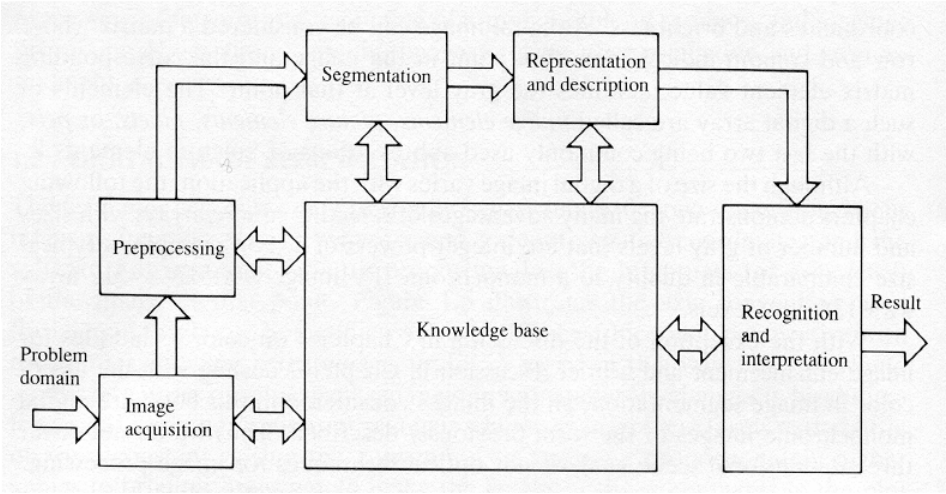


Image Acquisition

- Imaging sensor & capability to digitize the signal collected by the sensor:
  - Video camera
  - Digital camera
  - Conventional camera & analog-to-digital converter

Preprocessing

- To improve the image to ensure the success of further processes.
- e.g.
  - enhancing contrast
  - removing noise
  - identifying information-rich areas.

Segmentation

- To partition the image into its constituent parts (objects)
  - Autonomous segmentation (very difficult)
    - Can facilitate or disturb subsequent processes.
  - Output (representation):
    - Raw pixel data, depicting either boundaries or whole regions (corners vs. texture for example).
    - Need conversion to a form suitable for computer processing.

Representation & Description

- Feature selection (description) deals with extracting:
  - features that result in quantitative information of interest or
  - features that are important for differentiating one class of objects from another.

Recognition & Interpretation

- Recognition:
  - To assign a label to an object based on information provided by the descriptors.
- Interpretation:
  - To assign meaning to a group of recognized objects.

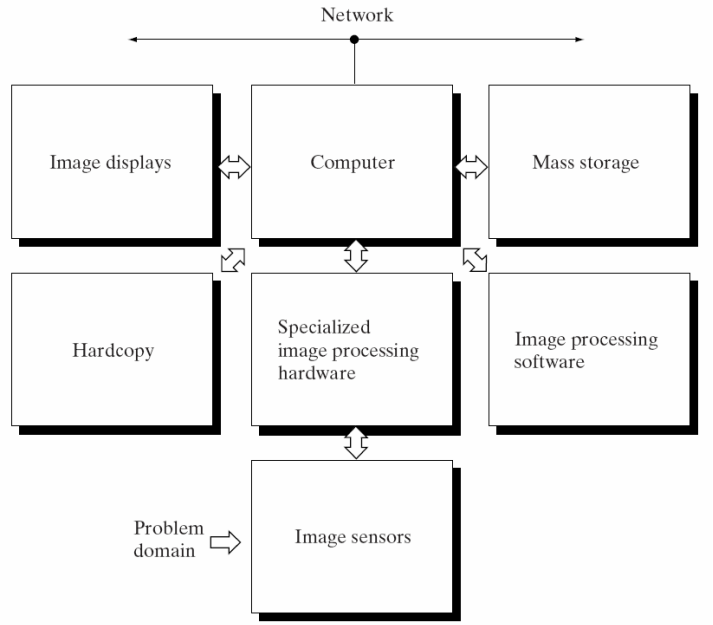
Knowledge-Base

- Knowledge-base Image Processing
  - Guides the operation of each processing module and controls the interaction between modules.
  - Interpret and deduce high level information (semantic features) from low level information feature (visual features).

Comments

- Image enhancement for human visual interpretation usually stops at preprocessing.
- Recognition and interpretation are associated with image analysis applications where the objective is automation (automated extraction of information from images).

Components of a Image Processing System



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Fundamental steps in digital Image processing