Image Processing

Introduction

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- Textbook: Digital Image Processing, R. C. Gonzalez, R. E. Woods
- Course website: http://www.ece.uprm.edu/~manian
- Digital Image Processing: Anil K. Jain
Topics

• Multiresolution Analysis
• Wavelets
• Morphological image processing
• Image segmentation and object recognition
• Texture, invariant analysis
• Image restoration
• Image descriptors
• Fuzzy sets
What is digital image processing

• An image is a 2-D function \( f(x,y) \) \( x \) and \( y \) are spatial coordinates
• Amplitude \( f \) at row \( x \) and column \( y \) is called the intensity or gray level at that point
• Digital image: Intensity values are finite, discrete quantities
• Digital image processing: processing of digital images using a digital computer
• Elements of an image: picture elements or pixels
• Image processes – low, mid and high level
• Low level Input: image, Output: image
• Mid level Input: image, Output: attributes such as edges, contours and identity of objects
• High level Input: attributes, Output: description recognition of objects, cognitive functions of vision
Electromagnetic spectrum

![Energy of one photon (electron volts)]

Gamma rays  X-rays  Ultraviolet  Visible  Infrared  Microwaves  Radio waves

**FIGURE 1.5** The electromagnetic spectrum arranged according to energy per photon.
Image Processing Applications

• Gamma-ray imaging-nuclear medicine and astronomical applications

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.)
Image Processing Applications

• X-ray imaging – medical diagnostics
Image Processing Applications

• Ultraviolet imaging – fluorescent microscopy

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.)
Image Processing Applications

• Visible and Infrared imaging – remote sensing

**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.)
Image Processing Applications

• Automated inspection of manufactured goods

![Figure 1.14](image)

**FIGURE 1.14**
Some examples of manufactured goods often checked using digital image processing.
(a) A circuit board controller.
(b) Packaged pills.
(c) Bottles.
(d) Air bubbles in a clear-plastic product.
(e) Cereal.
(f) Image of intraocular implant.
(Fig. (f) courtesy of Mr. Pete Sites, Perceptics Corporation.)
Imaging in the microwave band

FIGURE 1.16
Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)
Imaging in the radio band

- In medicine – Magnetic resonance image
Ultrasound Imaging

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.)
Computer graphic images

**FIGURE 1.22**
(a) and (b) Fractal images. (c) and (d) Images generated from 3-D computer models of the objects shown. (Figures (a) and (b) courtesy of Ms. Melissa D. Binde, Swarthmore College. (c) and (d) courtesy of NASA.)
Fundamental steps in image processing

Outputs of these processes generally are images

CHAPTER 6
Color image processing

CHAPTER 5
Image restoration

CHAPTERS 3 & 4
Image filtering and enhancement

CHAPTER 2
Image acquisition

CHAPTER 7
Wavelets and multiresolution processing

CHAPTER 8
Compression

CHAPTER 9
Morphological processing

CHAPTER 10
Segmentation

CHAPTER 11
Representation & description

CHAPTER 12
Object recognition

Knowledge base

Problem domain

Outputs of these processes generally are image attributes
Components of a general-purpose image processing system
References

  – http://www.ieeexplore.org
• Pattern Recognition , PR letters
• Computer vision and image understanding
• SPIE Optical Engineering
• Journal of Electronic Imaging
• Science Direct