Digital Image Processing

Lecture # 01

Introduction

Autumn 2012
Agenda

► Why image processing?
► Image processing examples
► Course plan
► History of imaging
► Fundamentals of image processing
► Components of image processing system
Why do we process images?

► Acquire an image
► Prepare for display and printing
► Facilitate picture storage and transmission
► Enhance and restore images
► Extract information from images
Image Processing Examples

- Restoration of image from Hubble Space Telescope

Source: IVPL Northwestern University, Chicago
Image Processing Examples

- Color photo enhancement
Image Processing Examples

► Noise Reduction

Noisy Image

BayesJoint Estimator - QMF
Image Processing Examples

► Special Effects

Photo
Simulated color pencils
Simulated oil painting
Image Processing Examples

► Pseudocolor enhancement

**FIGURE 6.24** Pseudocolor enhancement by using the gray-level to color transformations in Fig. 6.25. (Original image courtesy of Dr. Mike Hurwitz, Westinghouse.)
Image Processing Examples

- Extraction of settlement area from an aerial image

source: INRIA, Sophia-Antipolis, France
Image Processing Examples

► Face Detection
Image Processing Examples

► Face blurring for privacy detection
Image Processing Examples

► Image Mosaicing
Image Processing Examples

Handwriting Recognition

[Image showing handwritten characters and corresponding digit recognitions]
Image Processing Examples

License Plate Recognition
Image Processing Examples

► Fingerprint Recognition

1. Original fingerprint
2. Binarization
3. Minutia Extraction
4. Minutia candidate
5. Block method
6. Thinning
7. Binary fingerprint
8. Thinning fingerprint
Image Processing Examples

Iris Recognition
Image Processing and Related Fields

Course Plan

► Objectives

- Develop an overview of the field of image processing.
- To introduce underlying concepts involved in processing digital images.
- Understand the fundamental algorithms and how to implement them.
- Gain experience in applying image processing algorithms to real-world problems

► Pre-requisite

- Analysis of algorithms and linear algebra
- Programming experience, preferably in matlab, and/or C/C++/C#
Course Plan

► Text Book

► Reference Book
Course Plan

► Course Syllabus

- Introduction to Digital Image Processing, Applications
- Digital Image Representation
- Image Enhancement
- Morphological Image Processing
- Image Segmentation
- Color Image Processing
- Image Restoration (Subject to time availability)
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Course Plan

► Grading Criteria

- Quizzes: 10 Marks
- Assignments: 10 Marks
- Lab Sessions: 12 Marks
- Semester Projects: 08 Marks
- Mid Semester: 20 Marks
- End Semester: 40 Marks

► Plagiarism Policy: Students are encouraged to discuss Assignments and projects with each other. However, everything that is turned in for each assignment and/or project, must be your own work. In particular, it is not acceptable to: Copy in part or in totality another person's assignment and submit it as your own work; Get someone else to do all or a part of the work for you; Submit the work of a group as your own work. These acts are plagiarism and will not be tolerated in this course.
Course Plan

► Course Webpage
  ▪ To be announced later

► Office Hours
  ▪ Thursday 11.00 AM → 1.00 PM

► Contact
  ▪ Email: tra_haroon@yahoo.com
  ▪ Ph. #: 051-9047574
Digital Image
— a two-dimensional function $f(x, y)$
  $x$ and $y$ are spatial coordinates
  The amplitude of $f$ is called intensity or gray level at the point $(x, y)$

Digital Image Processing
— process digital images by means of computer, it covers low-, mid-, and high-level processes
  low-level: inputs and outputs are images
  mid-level: outputs are attributes extracted from input images
  high-level: an ensemble of recognition of individual objects

Pixel
— the elements of a digital image
Origins of Digital Image Processing

Sent by submarine cable between London and New York, the transportation time was reduced to less than three hours from more than a week.
Origins of 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.)
Sources for Images

- Electromagnetic (EM) energy spectrum
- Acoustic
- Ultrasonic
- Electronic
- Synthetic images produced by computer
Electromagnetic (EM) energy spectrum

Energy of one photon (electron volts)

10^6 10^5 10^4 10^3 10^2 10^1 10^0 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9}

Gamma rays X-rays Ultraviolet Visible Infrared Microwaves Radio waves

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

Major uses

**Gamma-ray imaging**: nuclear medicine and astronomical observations

**X-rays**: medical diagnostics, industry, and astronomy, etc.

**Ultraviolet**: lithography, industrial inspection, microscopy, lasers, biological imaging, and astronomical observations

**Visible and infrared bands**: light microscopy, astronomy, remote sensing, industry, and law enforcement

**Microwave band**: radar

**Radio band**: medicine (such as MRI) and astronomy
Examples: Gama-Ray Imaging

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.)
Examples: X-Ray Imaging

**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 L. Pascente, Lixi, Inc.; and (e) NASA.)
Examples: Ultraviolet Imaging

![Image of ultraviolet imaging examples]

**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.)
Examples: Light Microscopy Imaging

**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.)
Examples: Visual and 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.)
Examples: Visual and Infrared Imaging

**TABLE 1.1**

Thematic bands in NASA’s LANDSAT satellite.

<table>
<thead>
<tr>
<th>Band No.</th>
<th>Name</th>
<th>Wavelength (μm)</th>
<th>Characteristics and Uses</th>
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<tr>
<td>1</td>
<td>Visible blue</td>
<td>0.45–0.52</td>
<td>Maximum water penetration</td>
</tr>
<tr>
<td>2</td>
<td>Visible green</td>
<td>0.52–0.60</td>
<td>Good for measuring plant vigor</td>
</tr>
<tr>
<td>3</td>
<td>Visible red</td>
<td>0.63–0.69</td>
<td>Vegetation discrimination</td>
</tr>
<tr>
<td>4</td>
<td>Near infrared</td>
<td>0.76–0.90</td>
<td>Biomass and shoreline mapping</td>
</tr>
<tr>
<td>5</td>
<td>Middle infrared</td>
<td>1.55–1.75</td>
<td>Moisture content of soil and vegetation</td>
</tr>
<tr>
<td>6</td>
<td>Thermal infrared</td>
<td>10.4–12.5</td>
<td>Soil moisture; thermal mapping</td>
</tr>
<tr>
<td>7</td>
<td>Middle infrared</td>
<td>2.08–2.35</td>
<td>Mineral mapping</td>
</tr>
</tbody>
</table>
Examples: Infrared Satellite Imaging
Examples: Automated Visual Inspection

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.)
Examples: Automated Visual Inspection

Results of automated reading of the plate content by the system.

The area in which the imaging system detected the plate.

FIGURE 1.15
Some additional examples of imaging in the visual spectrum. (a) Thumb print. (b) Paper currency. (c) and (d) Automated license plate reading. (Figure (a) courtesy of the National Institute of Standards and Technology. Figures (c) and (d) courtesy of Dr. Juan Herrera, Perceptics Corporation.)
Example of Radar Image

**FIGURE 1.16**
Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)
Examples: MRI (Radio Band)

**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.)
Examples: 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.)
Fundamental Steps in DIP

- Improving the appearance
- Extracting image components
- Result is more suitable than the original
- Partition an image into its constituent parts or objects
- Represent image for computer processing
Components of Image Processing System

- Image displays
- Computer
- Mass storage
- Hardcopy
- Specialized image processing hardware
- Image processing software
- Image sensors
- Problem domain