Image Processing and Analysis
Lecture 1、Introduction

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Course Overview

- Teaching Goals
- Text Books and References
- What We Learn from the Course
- Ways in Teaching
- Grade Evaluation
- Some Suggestions and Contact Information

Teaching goals

- As an introductory course for senior content of computer vision, extensive fundamental techniques of image processing and analysis are presented
- Besides introducing fundamental theories and approaches, an important programming language Matlab is also introduced, and more attention is paid to one of its toolbox-image processing toolbox (IPT).
- For a student learning the course, he will set up a solid foundation, for further learning computer vision in the next semester, and the programming skills using Matlab will make him benefit more and more in the study of other courses and future thesis research.

Text Books

- ”Digital Image Processing” (2nd Edition), R.C. Gonzalez, R.E. Woods, Prentice,电子工业出版社
- ”Digital Image Processing Using MATLAB”, R.C. Gonzalez, R.E. Woods, S.L. Eddins, Prentice, Gatesmark Publishing

References

- 图像处理基础(2nd edition), Maria Petrou, Costas Petrou, 清华大学出版社
- 图像处理、分析与机器视觉, Milan Sonka, Vaclav Hlavac, Roger Boyle,清华大学出版社
- "Computer vision: a Modern Approach", David A.Forsyth, Jean Ponce, Prentice,电子工业出版社
- 数字图像处理，王桥编著，科学出版社
- ....

What We Learn from the Course

- Introduction+Matlab tutorial 1.5 week
- Image enhancement 3 weeks
- Image restoration 2 weeks
- Color image processing 1.5 week
- Wavelets and Multiresolution Processing(algorithm) 3 weeks
- Image Compression 1 week
- Morphological Image Processing 0.75 week
- Image Segmentation 0.75 week
- Representation and description 0.5 week
- show time and review 0.5 week

What We Learn from the Course I

- Introduction+Matlab tutorial 1.5 week
  read, write, show an image, basics of Matlab programming
- Image enhancement 3 weeks
  intensity transform, histogram equalization and matching, spatial filters and convolution , smoothing linear filter, order-statistics filters, Laplacian operator
  Fourier transform and some properties, spatial domain and frequency domain, low-pass and high-pass filter, homomorphic filter
- Image restoration 2 weeks
  degradation model, noise model, noise reduction, linear position-invariant system, inverse filtering, Wiener filtering, Geometric transformations

What We Learn from the Course II

- Color image processing 1.5 week
  color,color space, color image processing (smoothing and sharpening), segmentation
- Wavelets and Multiresolution Processing(algorithm) 3 weeks
  image pyramids, subband coding, Haar transform, multiresolution analysis, scale and wavelet function, wavelet transform, fast wavelet transform, wavelet packet
- Image Compression 1 week
  elements of information theory, DCT transform and other famous transforms
- Morphological Image Processing 0.75 week
  dilation and erosion, opening and closing operator, Hit-or-missing transform, some basic morphological algorithms

What We Learn from the Course II

- Image Segmentation 0.75 week
  edge detection, Hough transform, thresholding, region segmentation, watershed segmentation algorithm
- Representation and description 0.5 week
  representation (chain codes,..., skeletons), descriptors(Fourier descriptor, statistics moments,....), texture, principal components,....
- show time and review 0.5 week

Ways in Teaching

- Deliver lectures in Chinese, while PPT in English, discuss some problems
- Homework
  2-3 problems each week,
  Complete electronically, and submit through course web
  plagiarism will be punished
- Final exam
  highly relevant to homeworks, so...

Grade Evaluation

- Homeworks 5%
- Programming Practice 20%
  - Grouping: 5 students form a group.
  - Each week I will release a programming task and 5 groups will be randomly selected to finish the target task within two weeks.
  - The graphics interface is encouraged
- Final exam 75%

Additional Requirements for Programming Practice

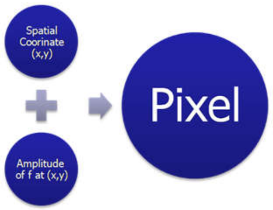
- The python language is expected.
- We will set the version requirement.
- The students are encouraged to complete all the tasks, though only one task is used to evaluate their performance.
- Some optional task can be released to promote the programming score.
- Grading Levels:
  - Excellent: 17-20
  - Good: 14-16
  - Average: 10-13
  - Poor: 0-9

Some suggestions and contact Information

- Suggestions
  - Accomplish various assignments Independently, carefully, actively.
  - Practice what you have learned from the lectures actively using matlab.
- Contact information
  - Email :wqwang@ucas.ac.cn

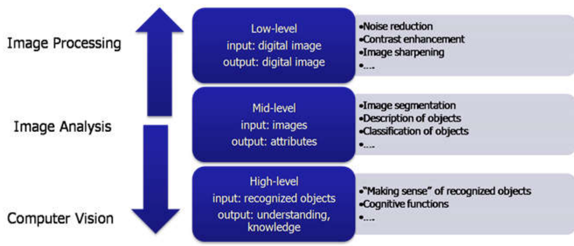
Basic Conceptions

- Image
  Two-dimensional function $f(x,y)$
  x,y : Spatial coordinates
  Amplitude of f at (x,y) : intensity, gray level
- Digital Image
  x,y and $f(x,y)$ are all finite and discrete quantities
- Pixels are the basic elements of a digital image



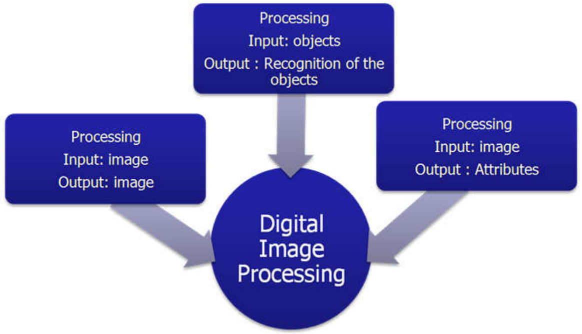
Digital Image Processing (DIP)

- Digital image processing is to process digital images using digital computer.
- Digital images cover almost the entire electromagnetic spectrum, i.e., DIP can operate on images generated by various sources including ultrasound, electron microscopy, and computer-generated images
- Big picture



Digital Image Processing (DIP)(Cont.)

- Digital Image Processing in this course



The Origin of Digital Image Processing

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

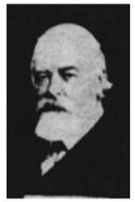


FIGURE 1.2 A digital picture made in 1922 from a tape punched after the signals had crossed the Atlantic twice. Some errors are visible.

FIGURE 1.3 Unretouched cable picture of Generals Pershing and Foch, transmitted in 1929 from London to New York by 15-tone equipment.

The Origin of Digital Image Processing (cont.)

1. 1960s, improving images from a space probe
2. Late 1960s to early 1970s, medical imaging, remote earth resources observations, and astronomy

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.

Applications I: Gamma-Ray Imaging

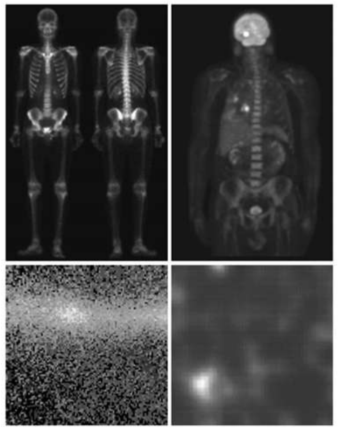


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FIGURE 1.6 Examples of gamma-ray imaging. (a) Bone scan. (b) PET image. (c) Cygnus Loop. (d) Gamma radiation (bright spot) from a reactor valve. (Images courtesy of (a) G.E. Medical Systems, (b) Dr. Michael E. Casey, CTI PET Systems, (c) NASA, (d)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

Applications II: Imaging in the Ultraviolet Band

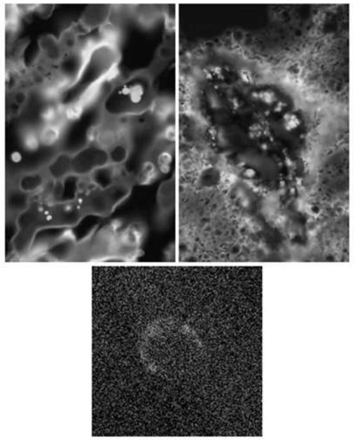

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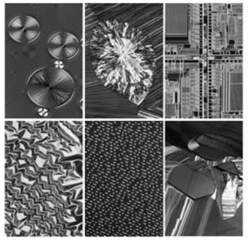
FIGURE 1.8 Examples of ultraviolet imaging. (a) Normal corn. (b) Smut corn. (c) Cygnus Loop. (Images courtesy of (a) and (b) Dr. Michael W. Davidson, Florida State University, (c) NASA.)

Applications III: Imaging in the Visible and Infrared Bands(1)



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.)

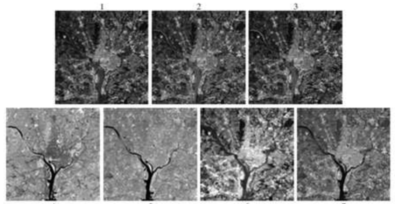


FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)

Applications III: Imaging in the Visible and Infrared Bands(2)

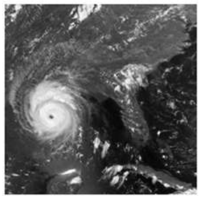


FIGURE 1.11 Multispectral image of Hurricane Andrew taken by NOAA GEOS (Geostationary Environmental Operational Satellite) sensors. (Courtesy of NOAA.)

FIGURE 1.12 Infrared satellite images of the Americas. The small gray map is provided for reference. (Courtesy of NOAA.)

Applications III: Imaging in the Visible and Infrared Bands(3)

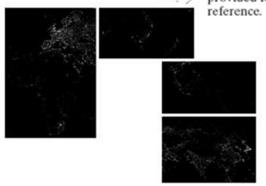
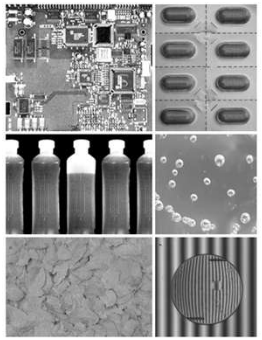


FIGURE 1.13 Infrared satellite images of the remaining populated part of the world. The small gray map is provided for reference.

a b
c d
e f

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) Bubbles in clear-plastic product. (e) Cereal. (f) Image of intraocular implant. (Fig. (f) courtesy of Mr. Pete Sites, Perceptics Corporation.)



Applications III: Imaging in the Visible and Infrared Bands(4)

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c
d

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.)

Applications IV: Imaging in the Microwave Band

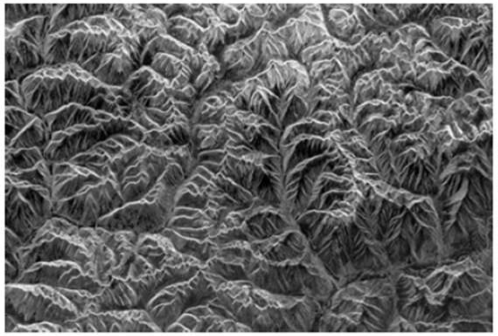

FIGURE 1.16 Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)

Applications V: Imaging in the Radio Band

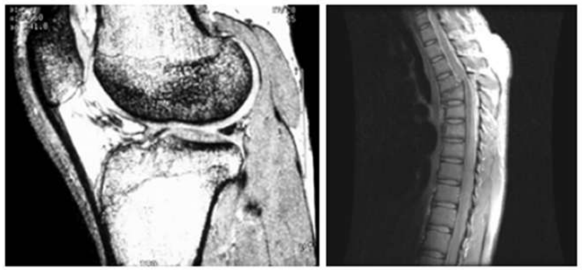

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FIGURE 1.17 MRI images of a human (a) knee, and (b) spine. (Image (a) courtesy of Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School, and (b) Dr. David R. Pickens, Department of Radiology and Radiological Sciences,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

Applications VI: Other Imaging Modalities

FIGURE 1.19 Cross-sectional image of a seismic model. The arrow points to a hydrocarbon (oil and/or gas) trap. (Courtesy of Dr. Curtis Ober, Sandia National Laboratories.)

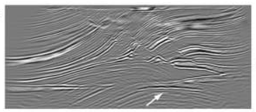

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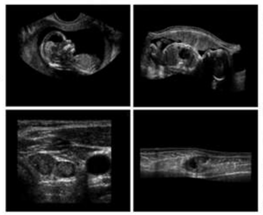
FIGURE 1.20 Examples of ultrasound imaging. (a) Baby. (2) Another view of baby. (c) Thyroids. (d) Muscle layers showing lesion. (Courtesy of Siemens Medical Systems, Inc., Ultrasound Group.)



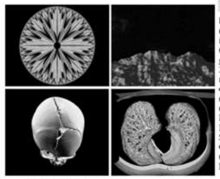


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FIGURE 1.22 (a) and (b) Fractal images. (c) and (d) Images generated from 3-D computer models of the objects shown. (Figures (a) and (b) courtesy of Ms. Melissa D. Binde, Swarthmore College, (c) and (d) courtesy of NASA.)

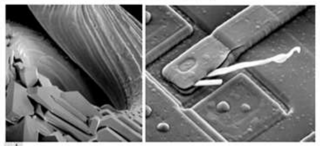

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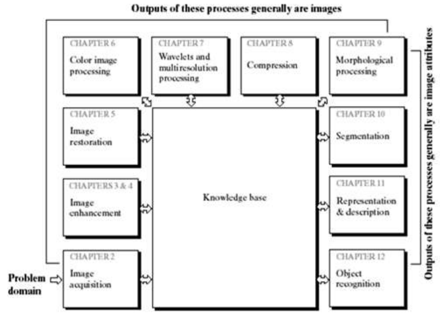
FIGURE 1.21 (a) 250× SEM image of a tungsten filament following thermal failure. (b) 2500× SEM image of damaged integrated circuit. The white fibers are oxides resulting from thermal destruction. (Figure (a) courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene; (b) courtesy of Dr. J. M. Hudak, McMaster University, Hamilton, Ontario, Canada.)

Basic steps of digital image processing

FIGURE 1.23 Fundamental steps in digital image processing.



Components of an image processing system

- Image sensors
- Specialized image processing hardware
- Computer
- Image processing software
- Mass storage
- Image displays
- Hardcopy
  Laser printers, file cameras···
- Network