Digital Image Processing & its Applications

Wenming YANG

Graduate School at Shenzhen, Tsinghua University

Office: F402A Tel: 26036461 18038153086

yangelwm@163.com

Teaching Assistant: Juncheng Zhang

Office: H205B Tel:18328580480

Contents

Reference

1. Digital Image Processing, third edition, Rafael C. Gonzalez, Richard E. Woods, Prentice-Hall, 2010.
2. Fundamentals of Digital Image Processing , A. K. Jain , Prentice-Hall, 1989.
3. Digital Video Processing, A. Murat, Tekalp, Prentice-Hall, 1996.
4. 《数字图像处理学》，阮秋琦，电子工业出版社，2001年。
5. 《图像工程（上册）：图像处理》，第2版，章毓晋，清华大学出版社，2006年。
6. 《图像工程（中册）：图像分析》，第2版，章毓晋，清华大学出版社，2005年。

Notes

1. Lesson
2. Written examination in the end of course
3. Enquiry & Suggestion:
   - email to me: courses taken, expectation……
4. Knowledge a priori:
   - Signal & System, Linear algebra, C/C++ Language
5. Project(Programing of DIP using VC++/.net)
6. Questions?

Chapter 1 Introduction

One picture is worth more than ten thousand words.

1.1 What Is Digital Image Processing

1.2 The Origins of Digital Image Processing

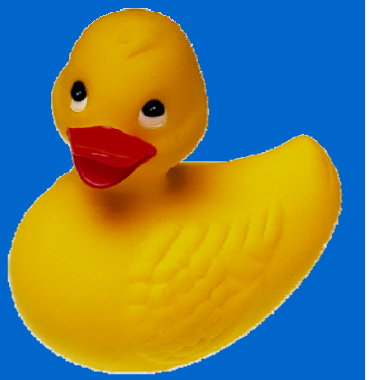
1.3 Examples of Fields that Use Digital Image Proc.

1.4 Fundamental Steps in Digital Image Processing

1.5 Components of an Image Processing System

1.1 What Is Digital Image Processing?

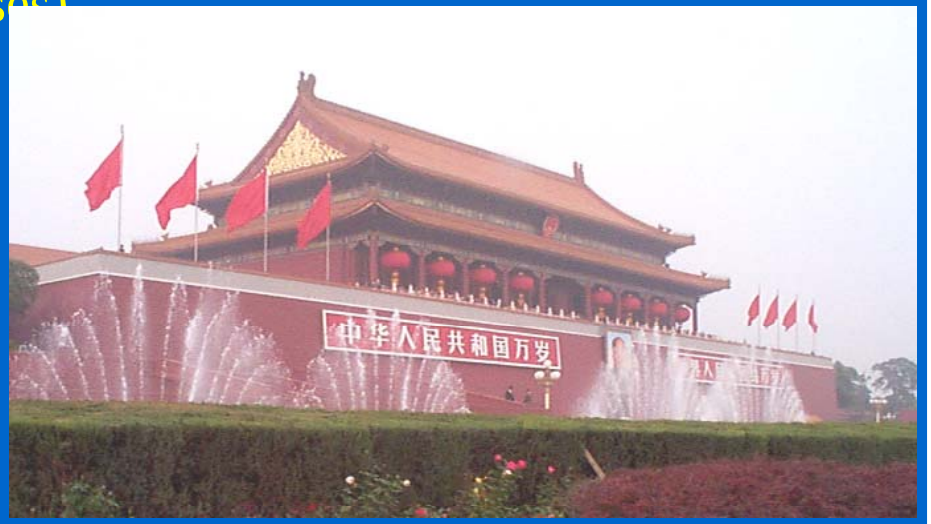
- Definition: $f(x,y)$
  - *intensity/gray level-amplitude*
  - *pixel* (picture element)-coordinate
- Image, Picture v.s. Graphics
  - Created by camera scanner/pixels
  - Created by computer/geometry/vector
  - Paint, Brush, Photoshop
  - AutoCAD,ProE, 3DMax

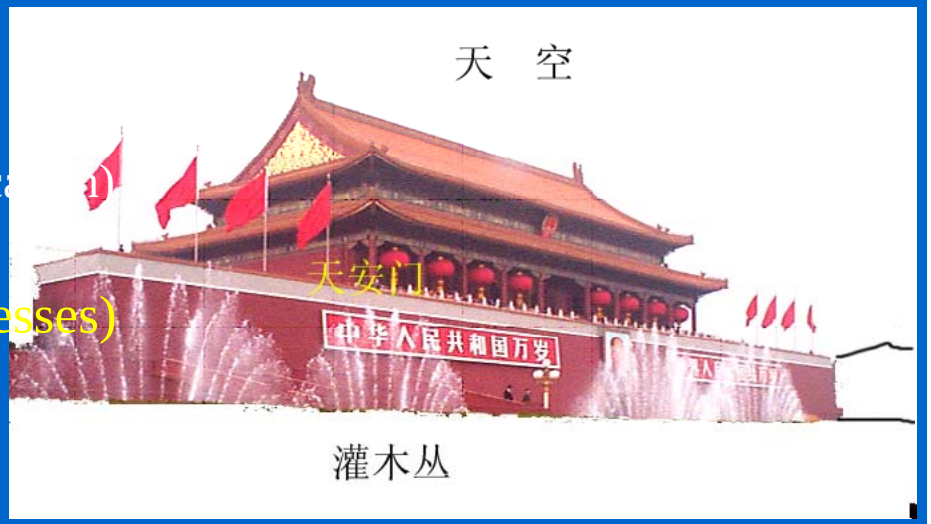


- Image Processing (Low-level processes)
  - ***image in ⇒ image out***
  - Primitive operations:
    image preproc. to reduce noise,
    contrast enhancement,
    image sharpening.

- Image Analysis (Mid-level processes)
  - ***image in ⇒ measurements out***
  - segmentation
  - description of objects (edges)
  - identity of individual objects (classifica

- Image Understanding (High-level processes)
  - ***image in ⇒ description out***
  - Vision: “making sense” of
    an ensemble of recognized objects



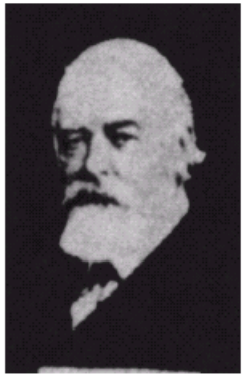


1.2 The Origins of Digital Image Processing

- Newspaper
- Bartlane system(电缆图片传输）
- Telegraph Printer(电报打印机）
- About one week to three hours!

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.)



- 1921 5 gray levels
- 1929 15 gray levels

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

- 1964 Ranger 7
- First Moon Image
- geometric correction

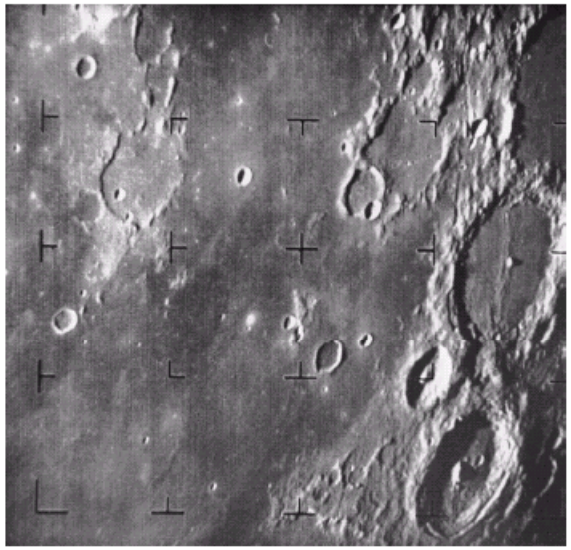


FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9:09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

1.3 Examples of Fields that Use Digital Image Processing

- Categories of images ⇐ source
  - Principal: electromagnetic energy spectrum

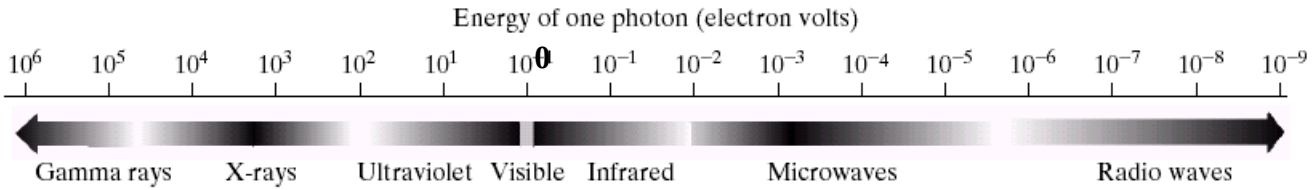


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

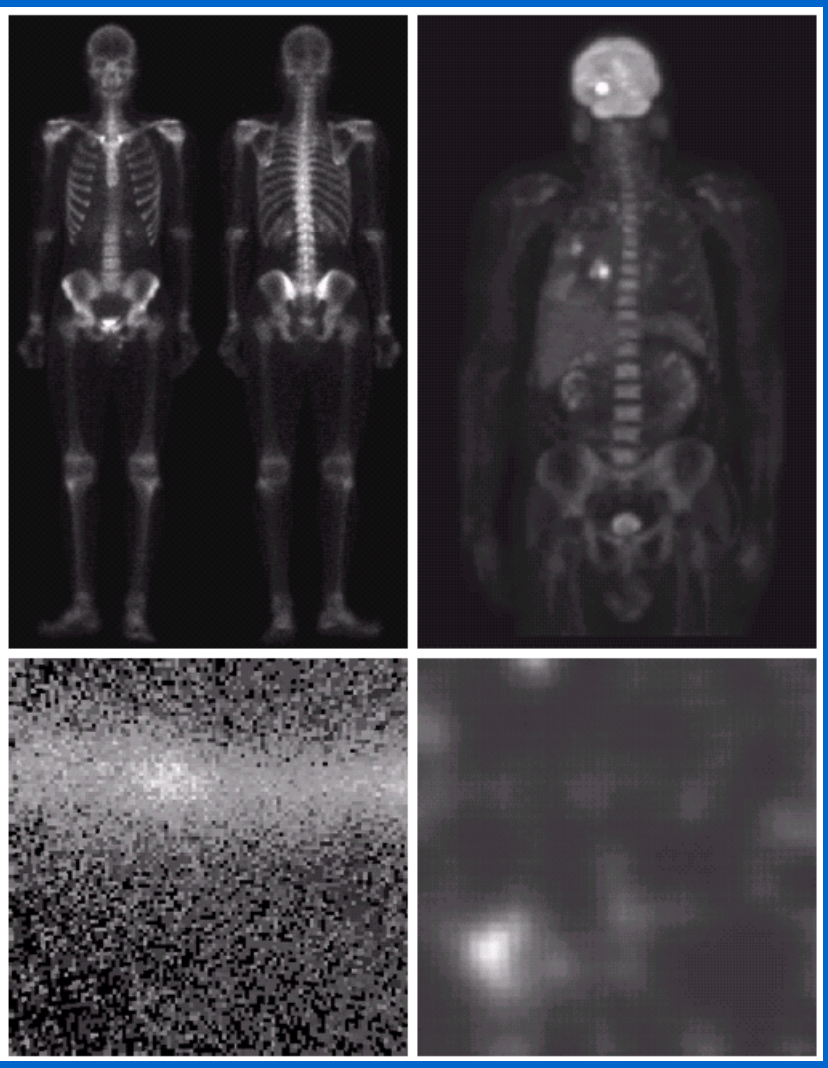
  - Other: acoustic, ultrasonic, and electronic (microscope).
  - Synthetic: computer.

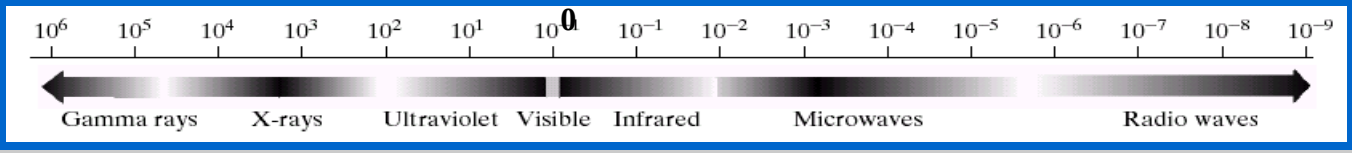
1.3.1 Gamma-Ray Imaging

PET(Positron Emission Computed Tomography，*PET*)的全称为正电子发射计算机断层扫描

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.)

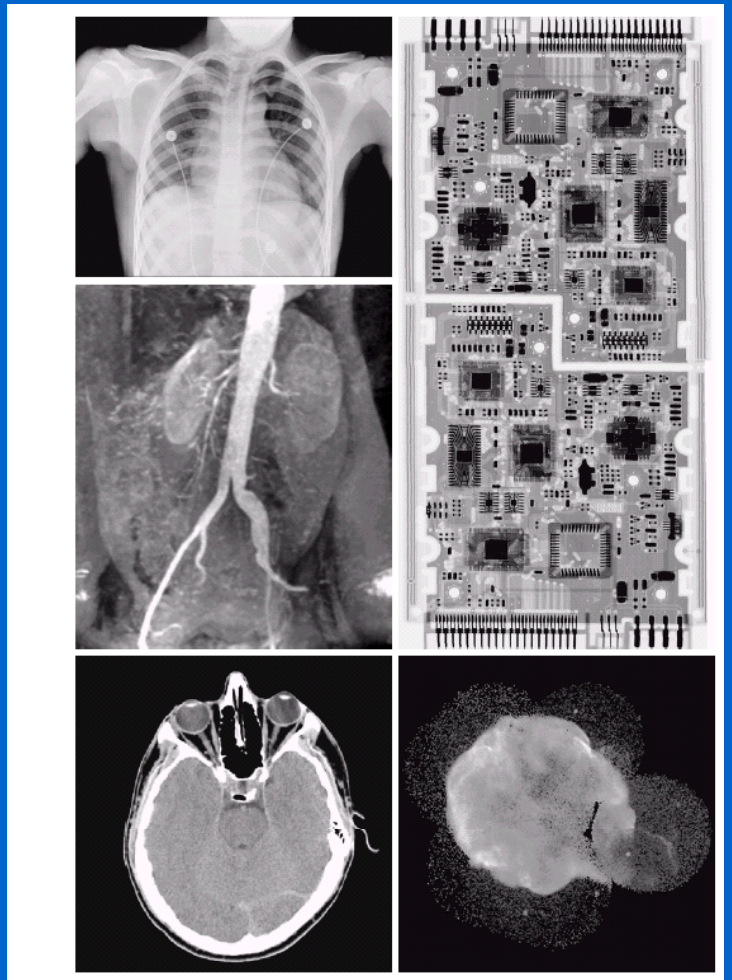




1.3.2 X-Ray Imaging

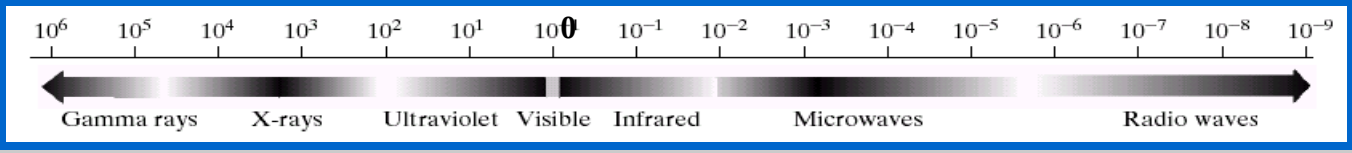
主动脉血管造影图像

血管中注入X射线介质



a d
b
c e

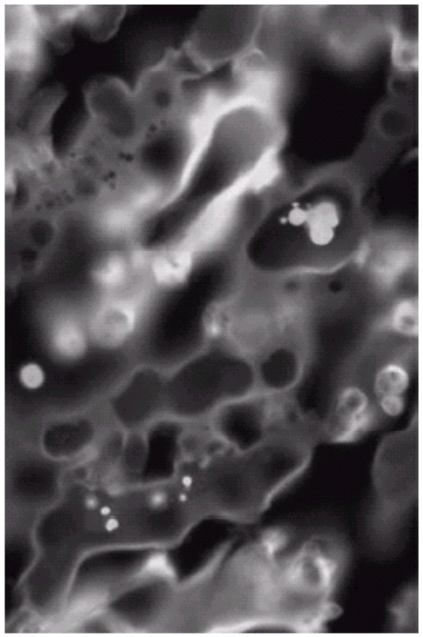
FIGURE 1.7 Examples of X-ray imaging. (a) Chest X-ray. (b) Aortic angiogram. (c) Head CT. (d) Circuit boards. (e) Cygnus Loop. (Images courtesy of (a) and (c) Dr. David R. Pickens, Dept. of Radiology & Radiological Sciences, Vanderbilt University Medical Center, (b) Dr. Thomas R. Gest, Division of Anatomical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

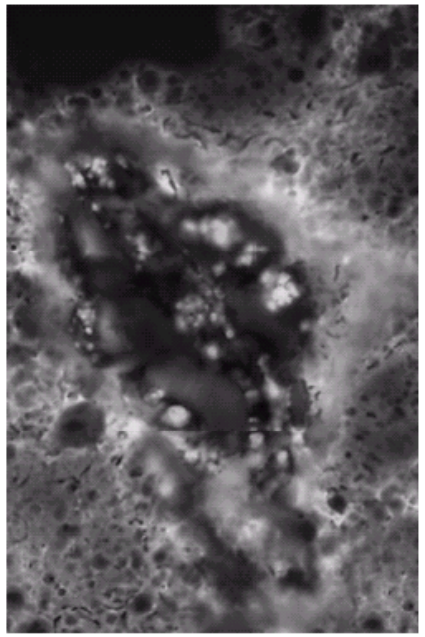


1.3.3 Imaging in the Ultraviolet Band

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.)

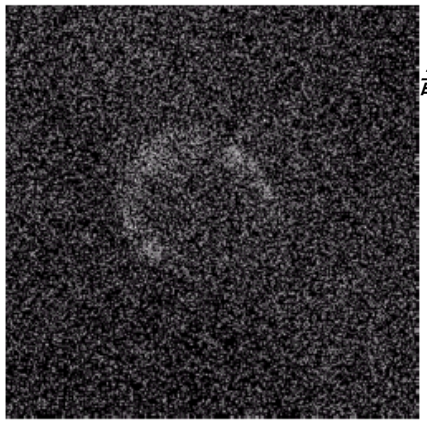


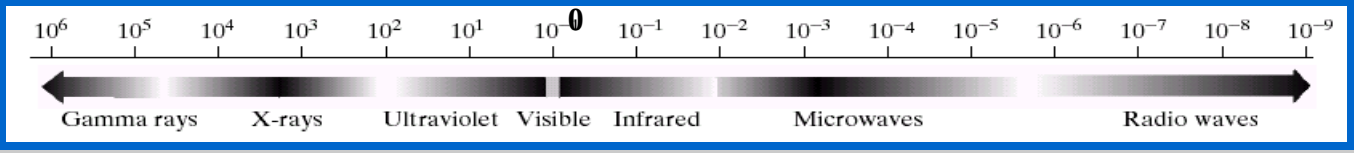


普通谷物

普通谷物被感染

天鹅星座环





1.3.4 Imaging in the Visible and Infrared Bands

紫杉酚（抗癌剂）

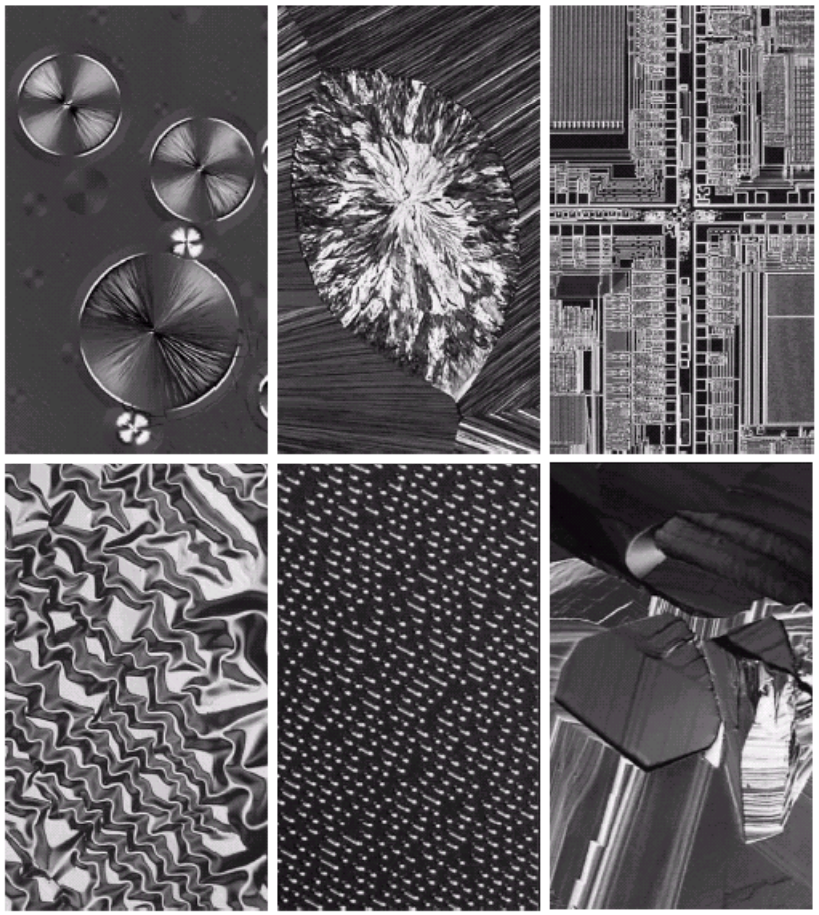
胆固醇

微处理器

镍氢化物

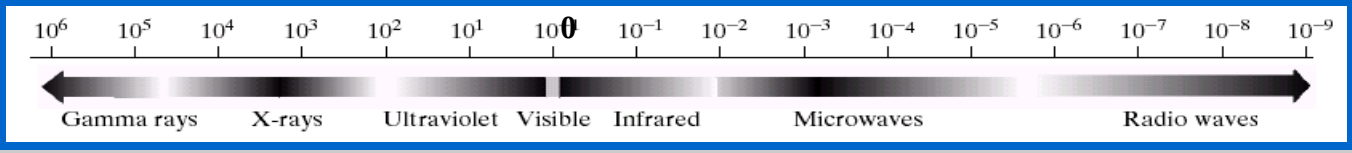
音频CD

有机超导



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.)



1.3.4 Imaging in the Visible and Infrared Bands

TABLE 1.1 Thematic bands in NASA's LANDSAT satellite.

Band No.	Name	Wavelength (μm)	Characteristics and Uses
1	Visible blue	0.45–0.52	Maximum water penetration
2	Visible green	0.52–0.60	Good for measuring plant vigor
3	Visible red	0.63–0.69	Vegetation discrimination
4	Near infrared	0.76–0.90	Biomass and shoreline mapping
5	Middle infrared	1.55–1.75	Moisture content of soil and vegetation
6	Thermal infrared	10.4–12.5	Soil moisture; thermal mapping
7	Middle infrared	2.08–2.35	Mineral mapping

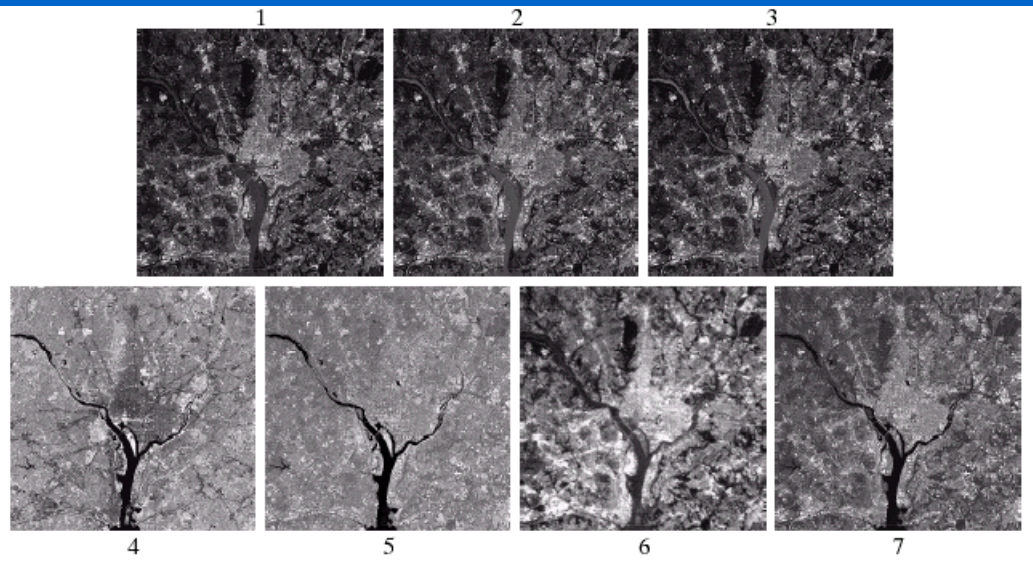
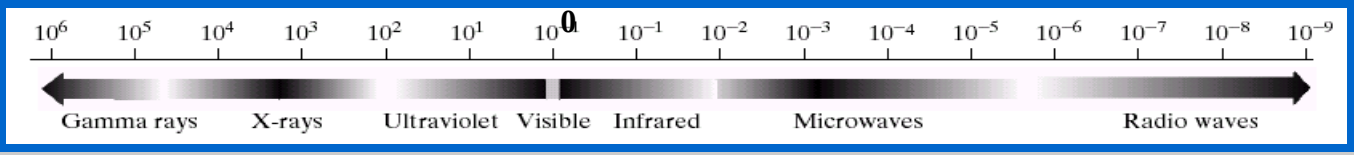
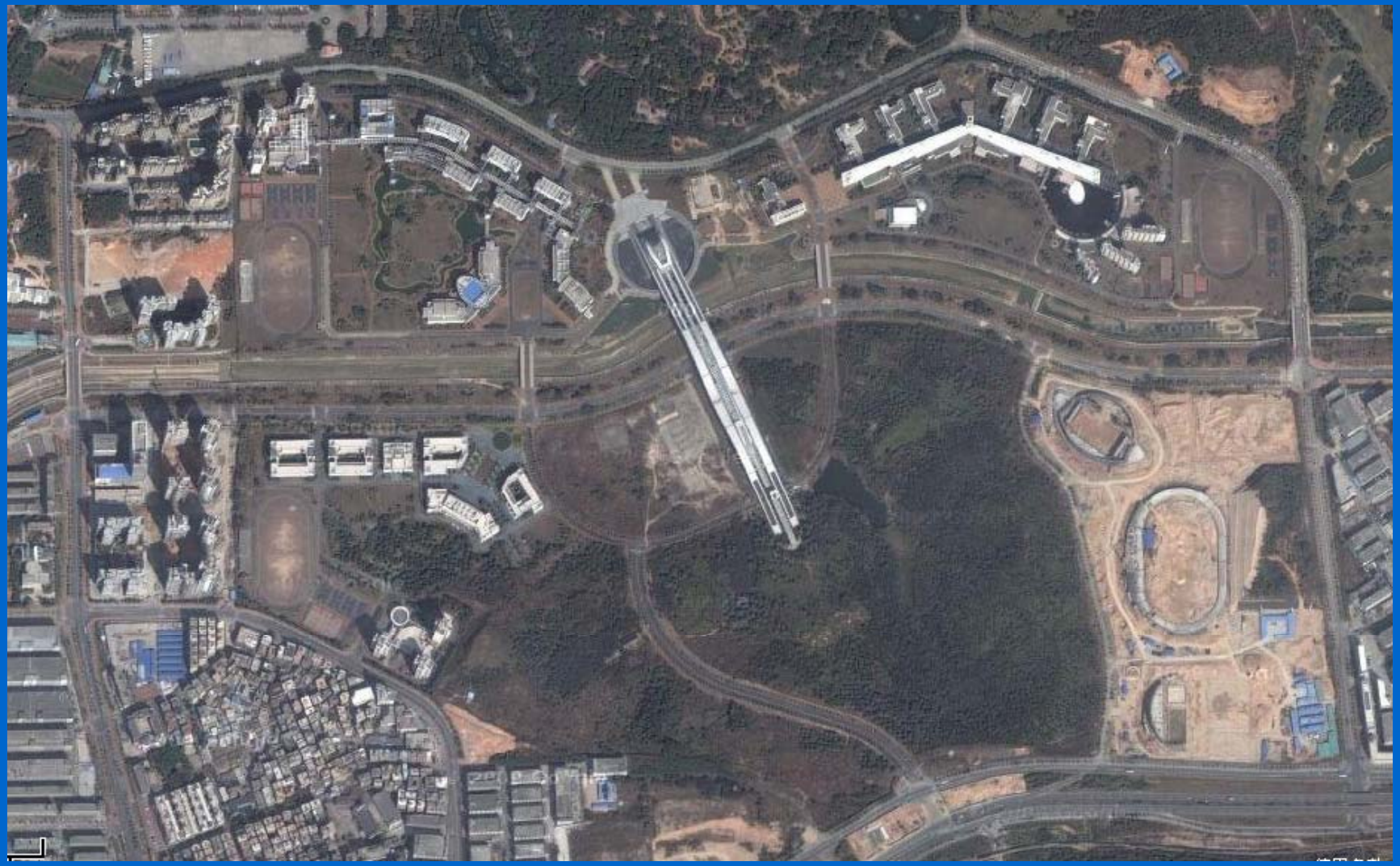
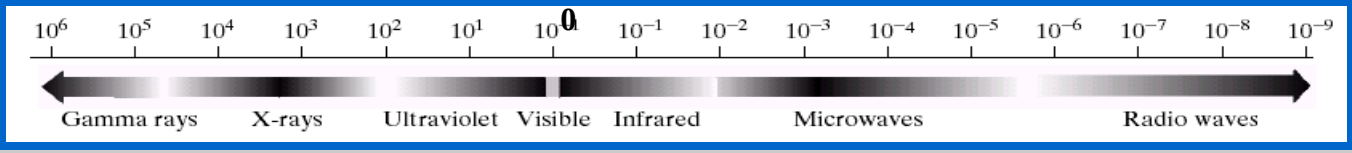


FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)






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

1.3.4 Imaging in the Visible and Infrared Bands

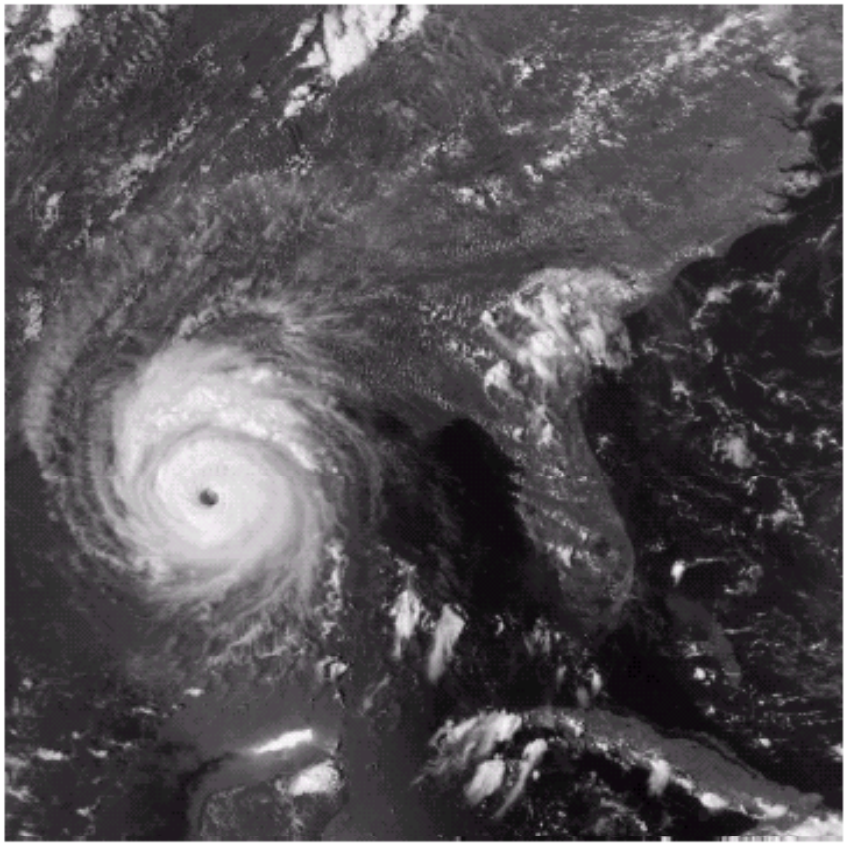
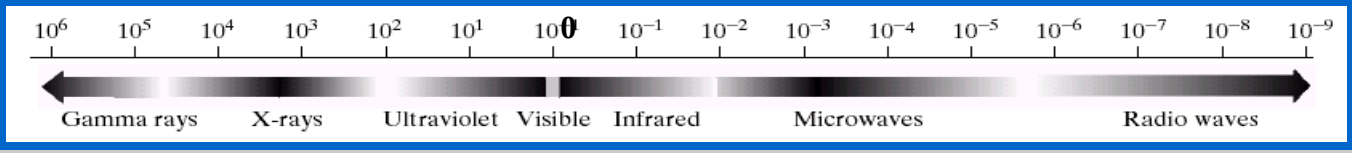


FIGURE 1.11 Multispectral image of Hurricane Andrew taken by NOAA GEOS (Geostationary Environmental Operational Satellite) sensors. (Courtesy of NOAA.)



1.3.4 Imaging in the Visible and Infrared Bands

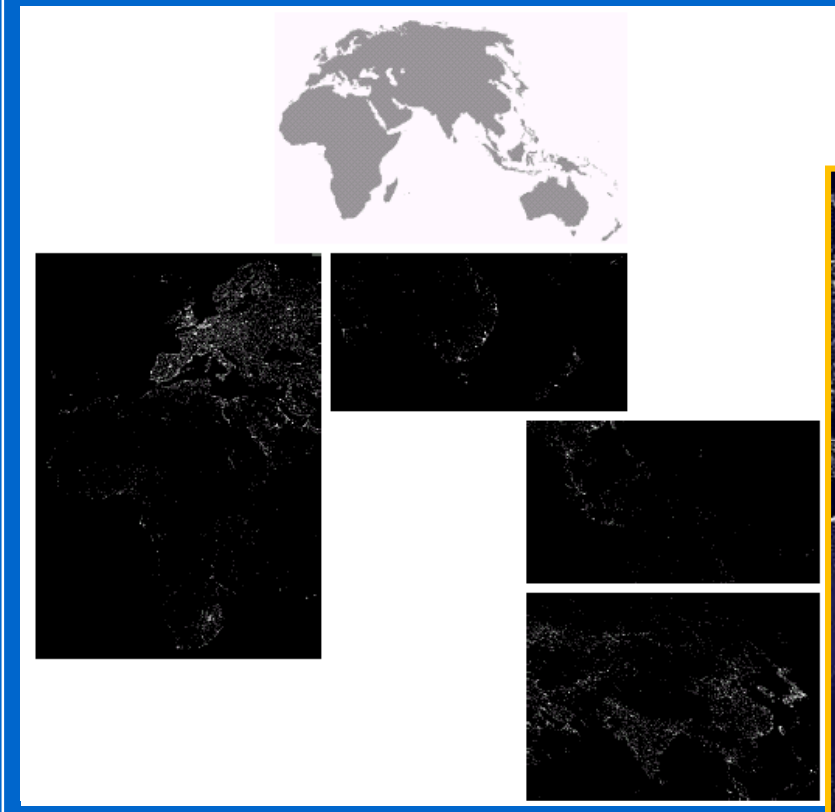
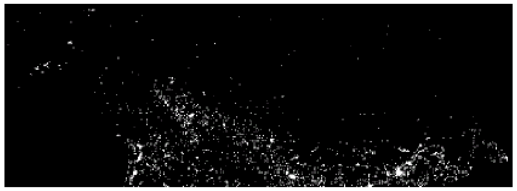
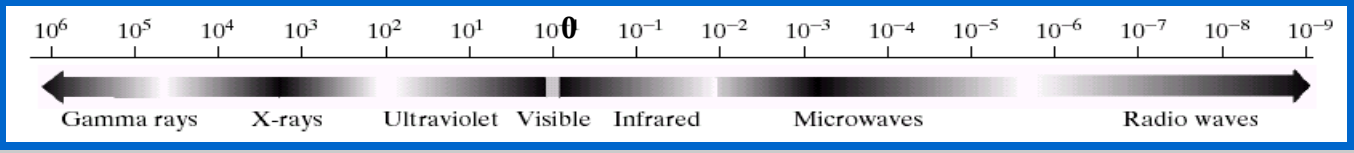


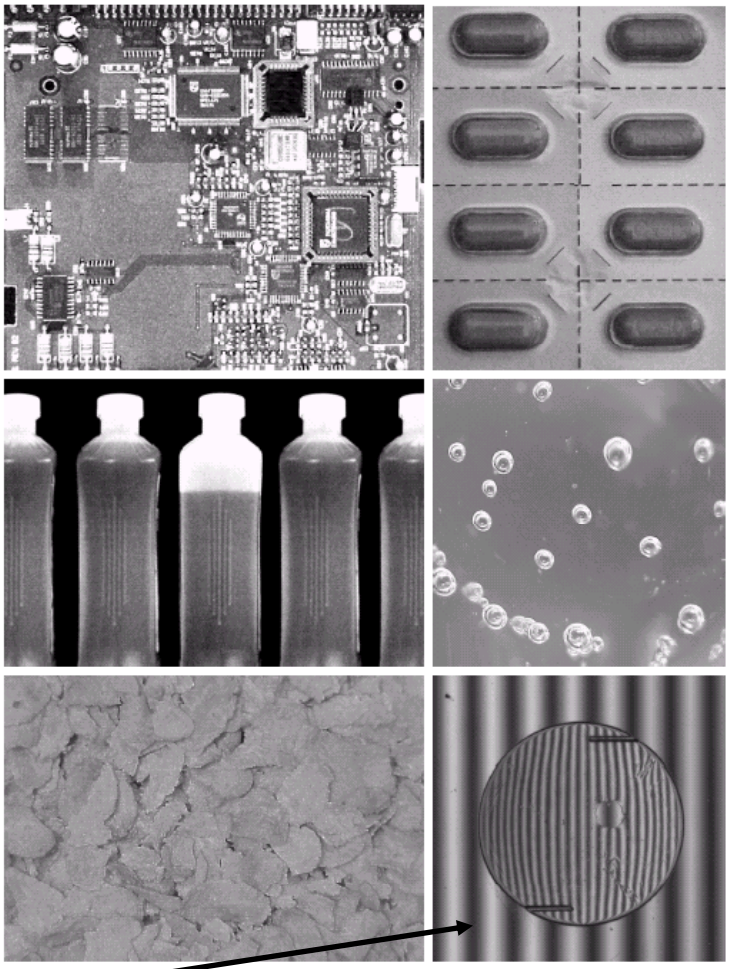
FIGURE 1.13 Infrared satellite images of the remaining populated part of the world. The small gray map is

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





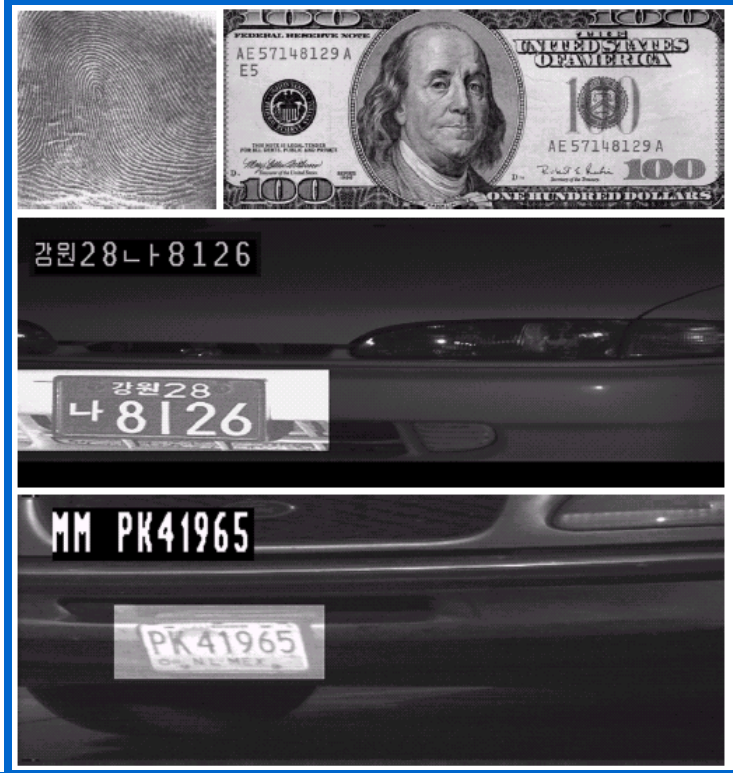
1.3.4 Imaging in the Visible and Infrared Bands



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.)

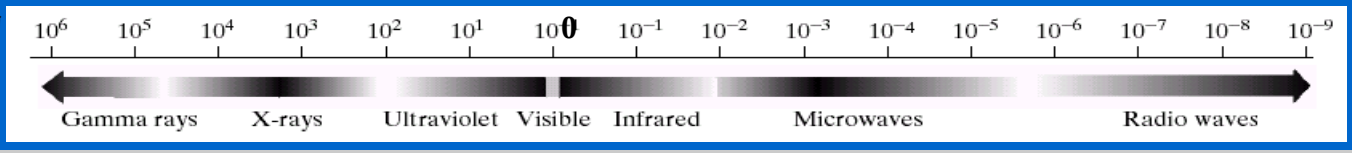
谷物



a b
c
d

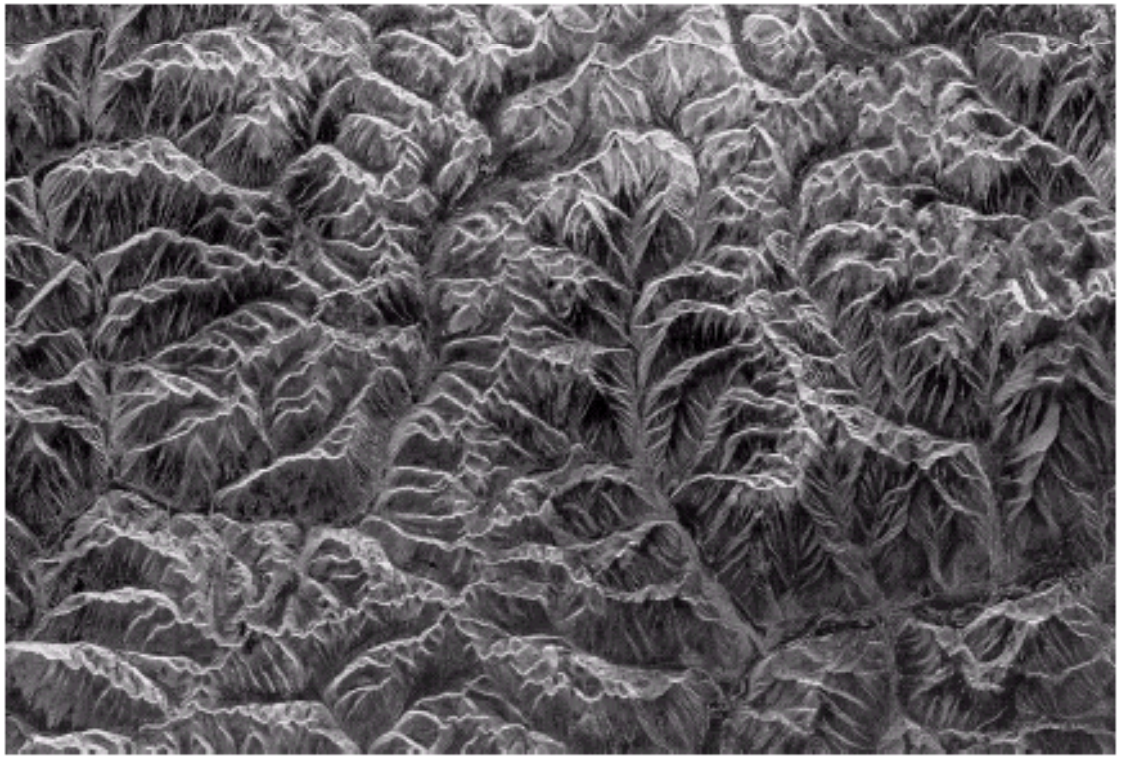
FIGURE 1.15
Some additional examples of imaging in the visual spectrum. (a) Thumb print. (b) Paper currency. (c) and (d). Automated license plate reading. (Figure (a) courtesy of the National Institute of Standards and Technology. Figures (c) and (d) courtesy of Dr. Juan Herrera, Perceptics Corporation.)

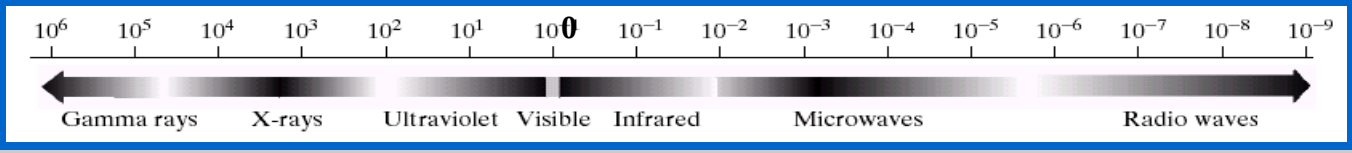
目镜掺杂物



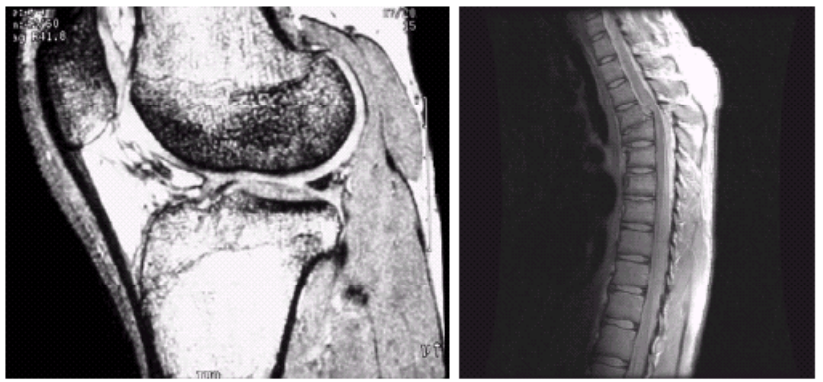
1.3.5 Imaging in the Microwave Band

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



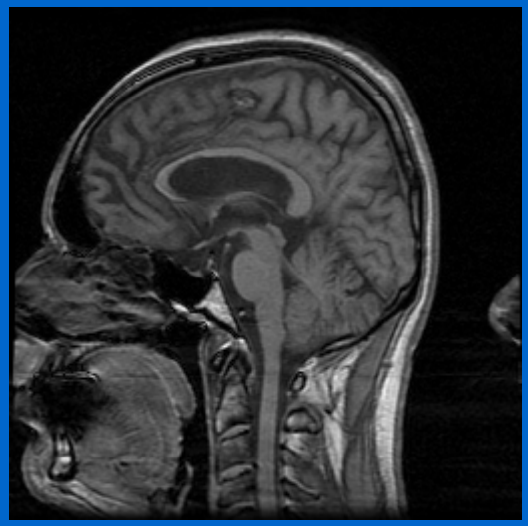


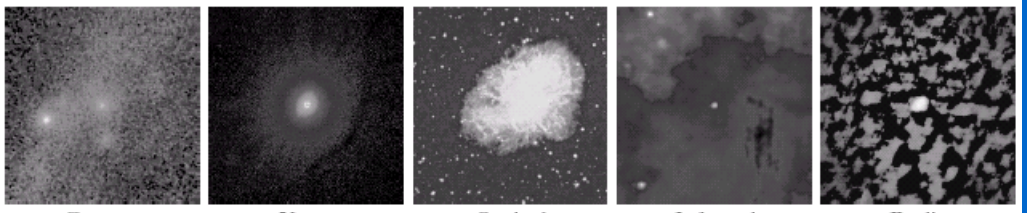
1.3.6 Imaging in the Radio Band



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.)

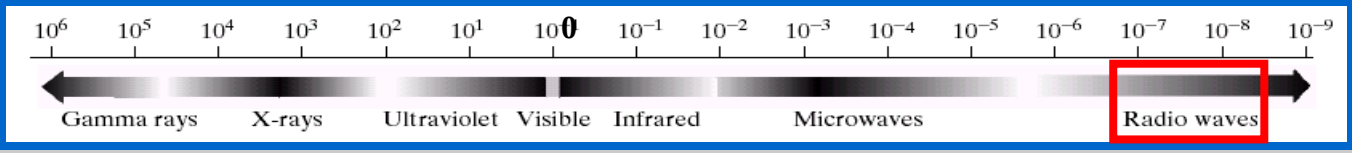




Gamma X-ray Optical Infrared Radio

FIGURE 1.18 Images of the Crab Pulsar (in the center of images) covering the electromagnetic spectrum. (Courtesy of NASA.)

蟹状脉冲星



1.3.7 Examples in which Other Imaging Modalities Are Used

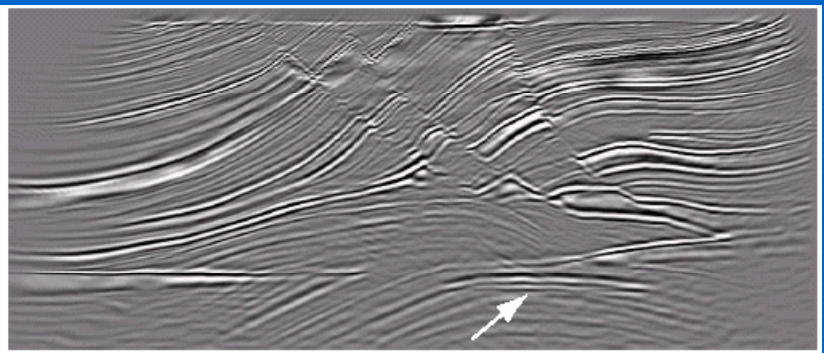
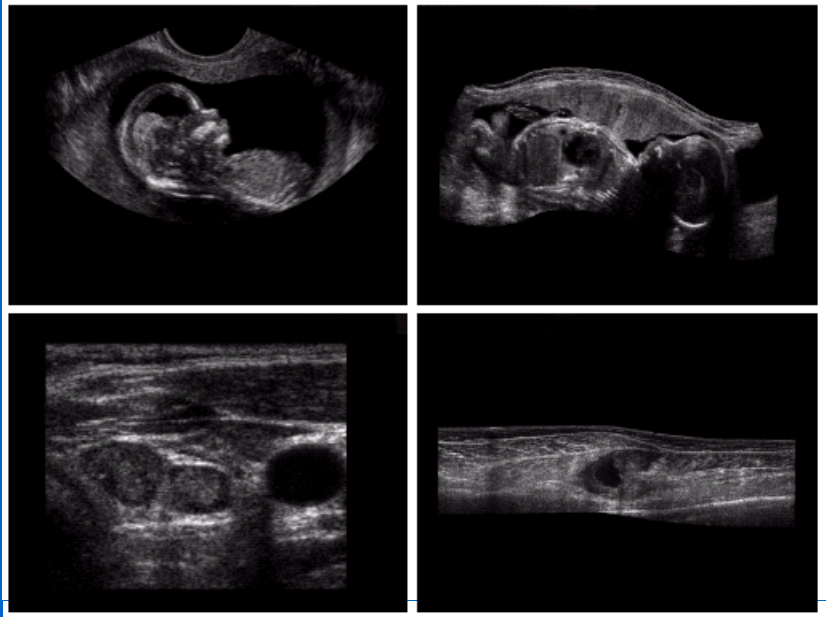


FIGURE 1.19 Cross-sectional image of a seismic model. The arrow points to a hydrocarbon (oil and/or gas) trap. (Courtesy of Dr. Curtis Ober, Sandia National Laboratories.)

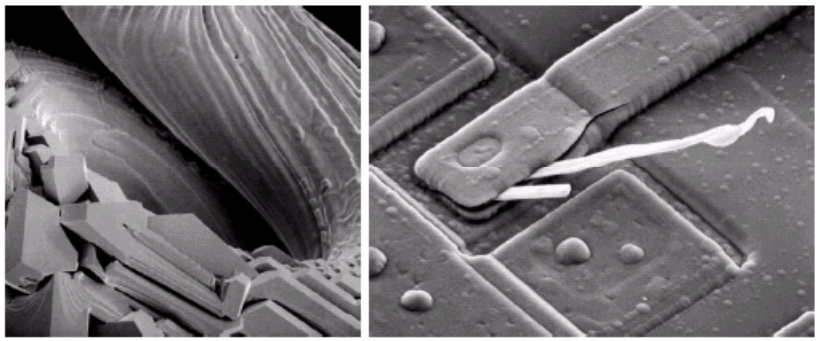


a b
c d

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

Ultrasonic

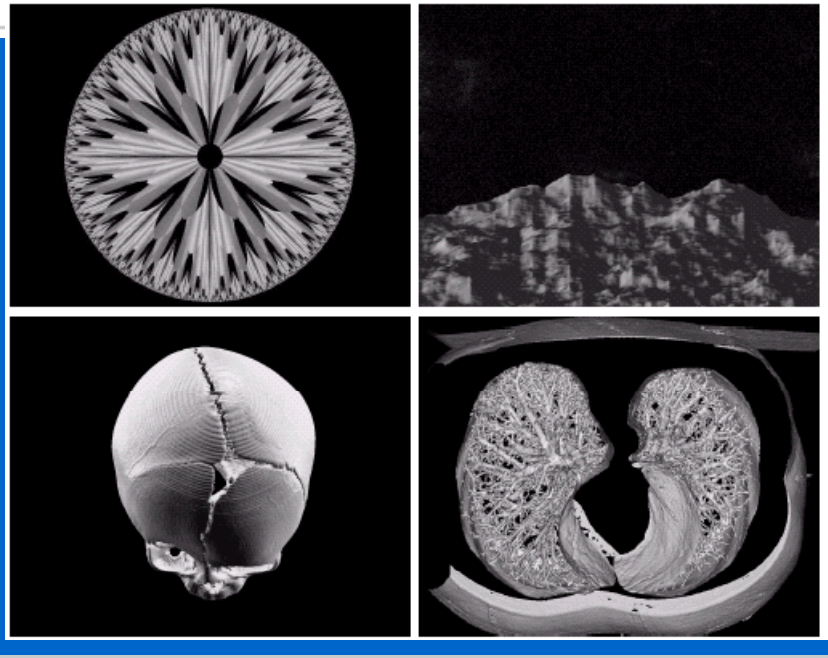
1.3.7 Examples in which Other Imaging Modalities Are Used



a b

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.)

SEM扫描电镜



a b
c d

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.)

1.4 Fundamental Steps in Digital Image Processing

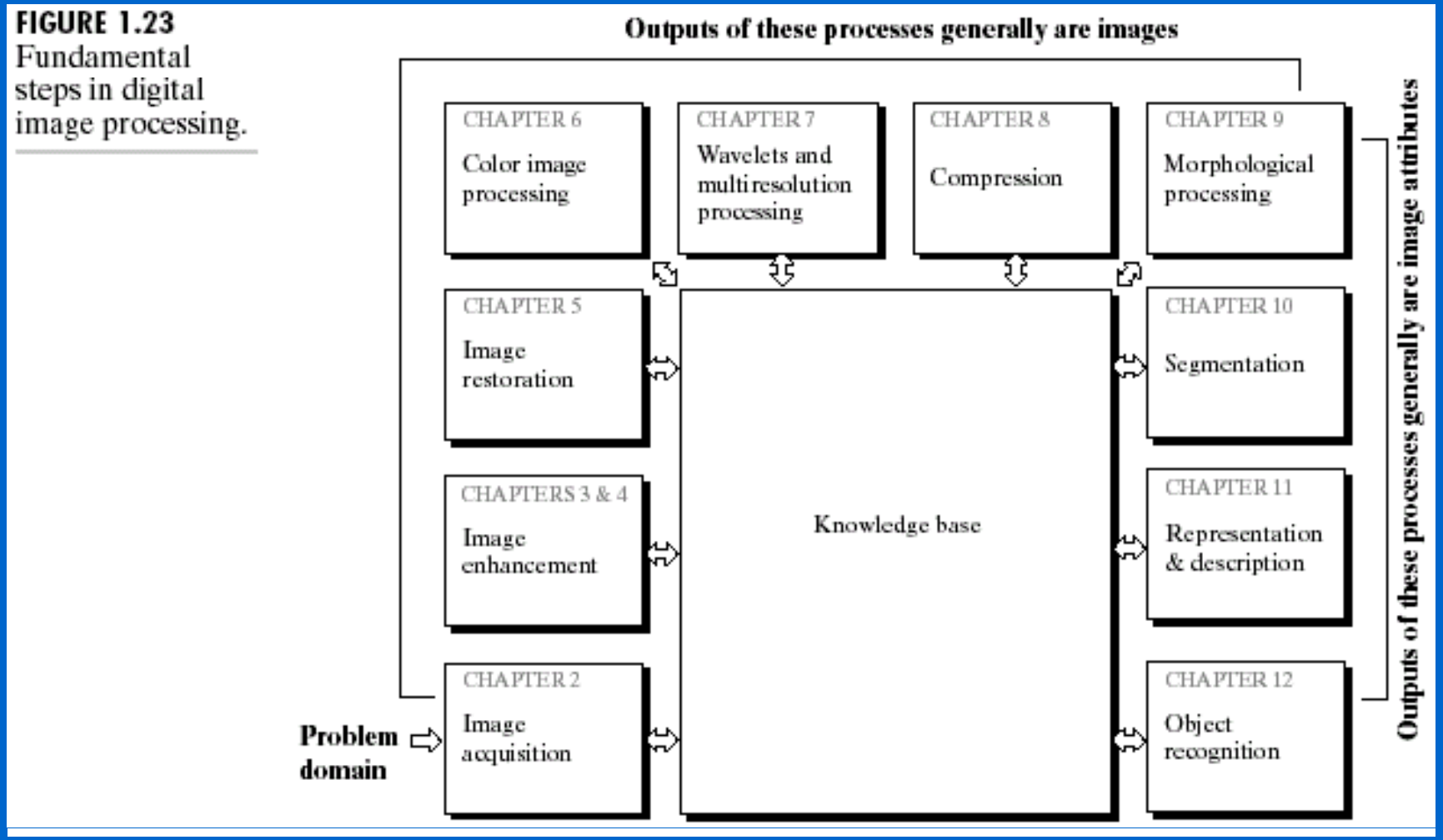


FIGURE 1.23 Fundamental steps in digital image processing.

1.5 Components of an Image Processing System

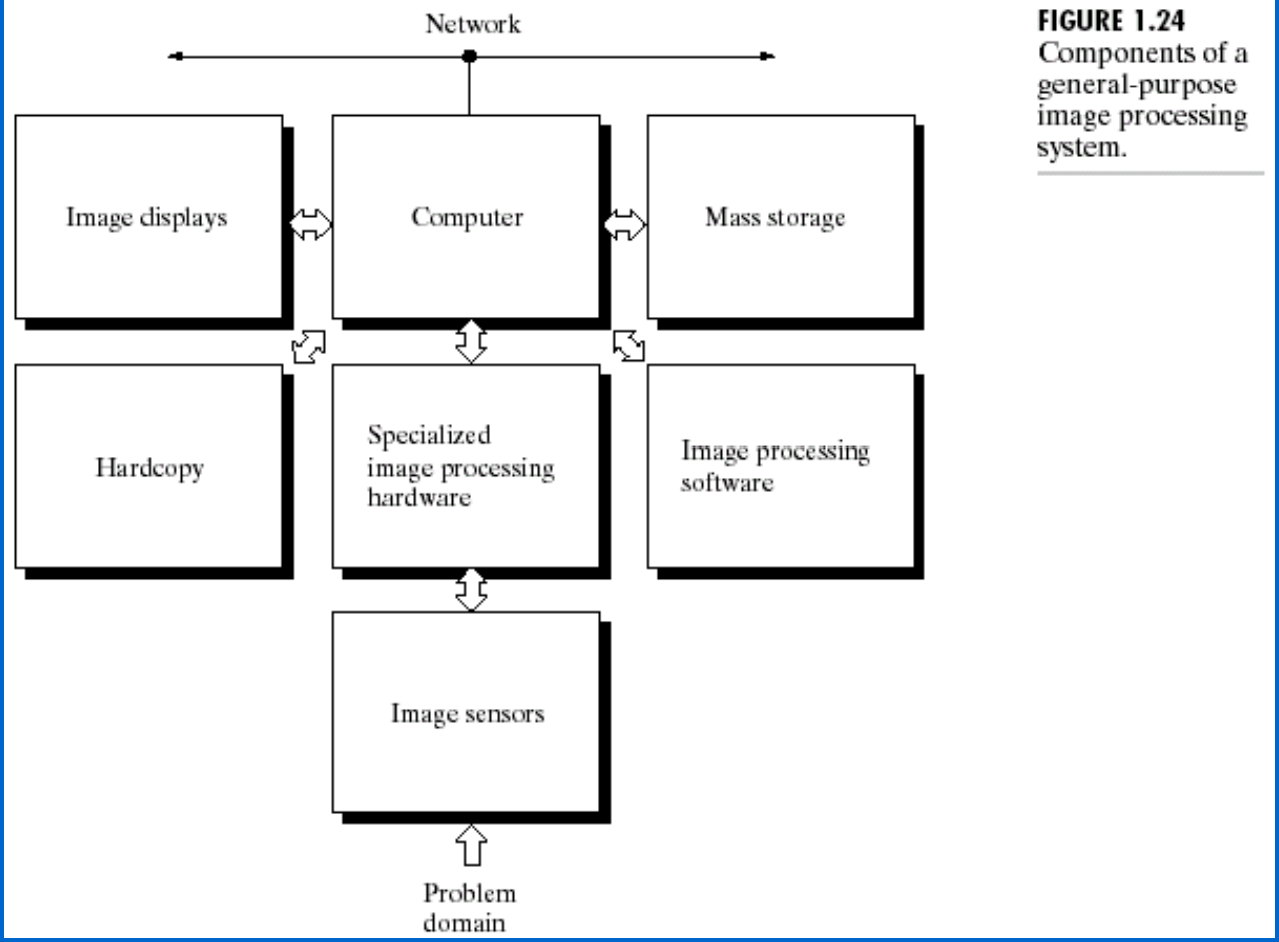


FIGURE 1.24 Components of a general-purpose image processing system.

Summary of the Chapter 1

- What Is Digital Image Processing
  - Definition
  - Image (Picture) vs. Graphics
  - 3 levels: low, middle, high.
- The Origins of Digital Image Processing
- Examples of Fields that Use Digital Image Proc.
- Fundamental Steps in Digital Image Processing
  - General process
- Components of an Image Processing System