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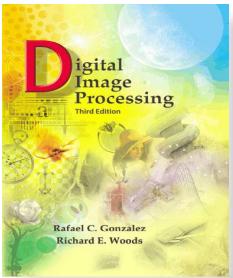
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Chapter 1
Introduction

PROCESSAMENTO DE IMAGEM E BIOMETRIA

IMAGE PROCESSING AND BIOMETRICS

2. DIGITAL IMAGE PROCESSING CONCEPTS



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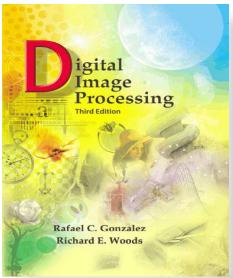
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FIGURE 1.1 A digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces. (McFarlane.[†])

Telegraph printer
fitted with typefaces
simulating a halftone
pattern

- Newspaper industry. Pictures sent by submarine cable between London and New York
- The Bartlane cable picture transmission system in the early 1920s reduced the time required to transport a picture across the Atlantic from more than a week to less than three hours



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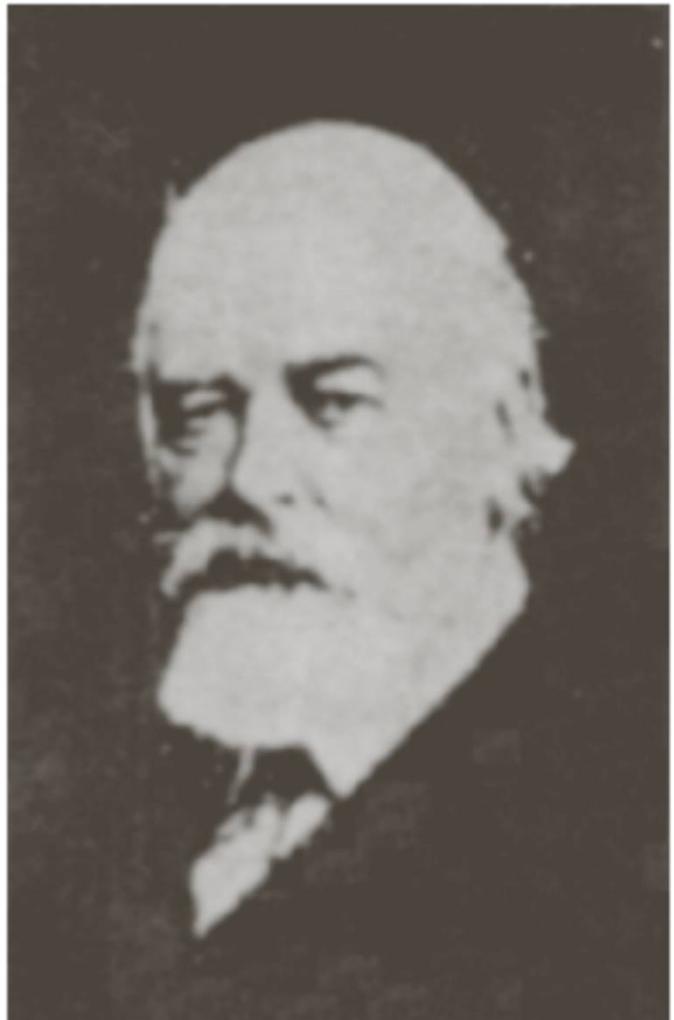
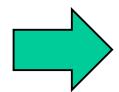
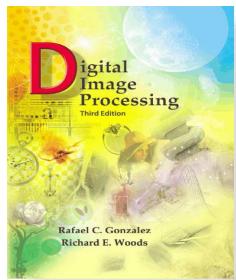


FIGURE 1.2 A digital picture made in 1922 from a tape punched after the signals had crossed the Atlantic twice.
(McFarlane.)

- The early Bartlane systems were capable of coding images in **five distinct levels of gray**



Reproduction made from tapes perforated at the telegraph receiving terminal



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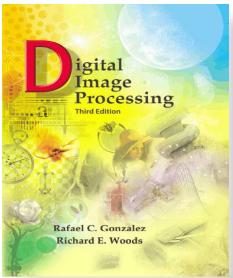
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→ 15-levels equipment

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



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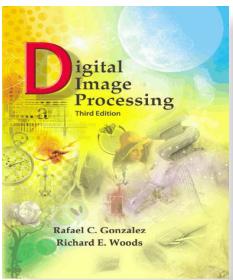
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The first image of the moon taken by Ranger 7 on July 31, 1964 at 9:09 A.M. Eastern Daylight Time (EDT), about 17 minutes before impacting the lunar surface

The birth of Digital Image Processing (DIP)

- The first computers powerful enough to carry out meaningful image processing tasks appeared in the early 1960s.
- DIP arises with the first computers and the onset of the space program during that period
- The combination of those two developments bring into focus the potential of DIP concepts



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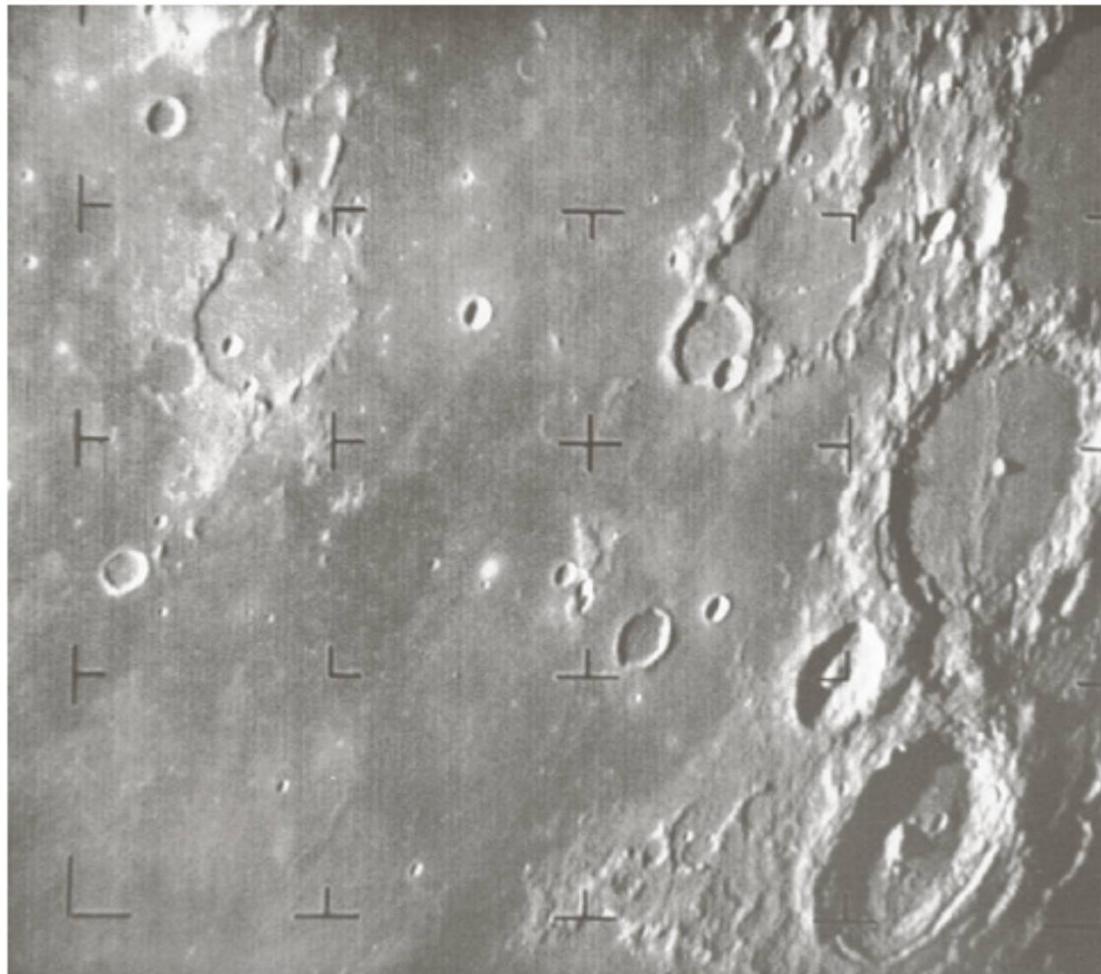
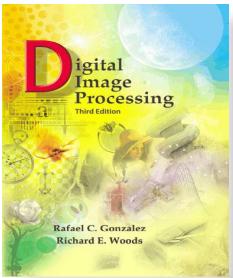


FIGURE 1.4 The first picture of the moon by a U.S. spacecraft. *Ranger* 7 took this image on July 31, 1964 at 9 : 09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)



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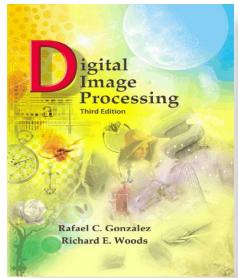
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- Computer techniques for improving images from a space probe at the Jet Propulsion Laboratory in 1964
- Pictures of the moon transmitted by *Ranger* 7 were processed by a computer to correct various types of image distortion inherent in the on-board television camera
- The markers, called *reseau* marks, are used for geometric corrections



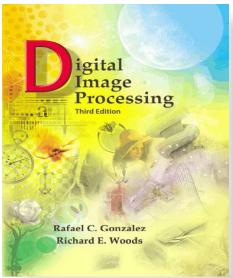
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- In parallel with space applications, DIP techniques began in the late 1960s and early 1970s to be used in:
 - medical imaging
 - remote earth resources observations
 - astronomy
- The invention in the early 1970s of Computerized Axial Tomography (CAT), also called Computerized Tomography (CT) for short, is one of the most important events in the application of image processing in medical diagnosis



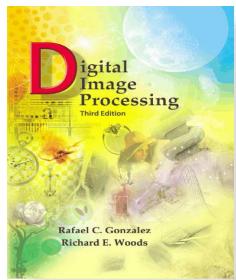
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- Computerized axial tomography is a process in which a ring of detectors encircles an object (or patient) and an X-ray source, concentric with the detector ring, rotates about the object
- The X-rays pass through the object and are collected at the opposite end by the corresponding detectors in the ring. As the source rotates, this procedure is repeated
- Tomography consists of algorithms that use the sensed data to construct an image that represents a “slice” through the object



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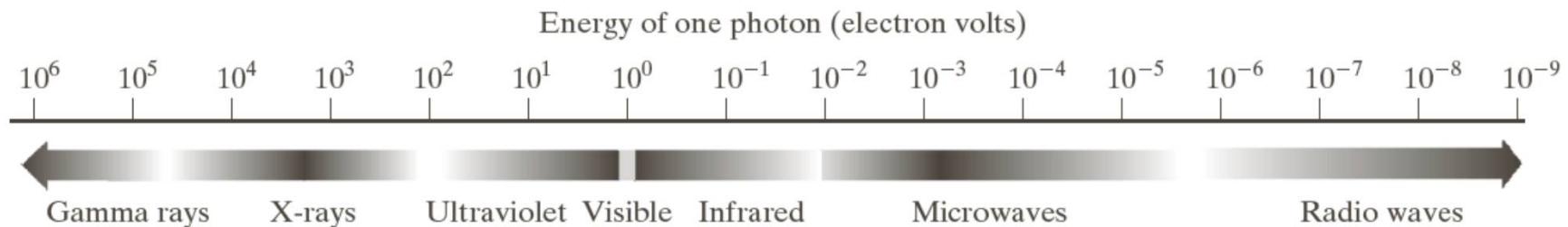
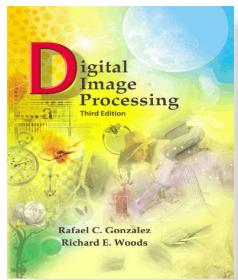


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

- Gamma-Ray Imaging
- X-ray Imaging
- Imaging in the Ultraviolet Band
- Imaging in the Visible and Infrared Bands
- Imaging in the Microwave Band (RADAR)
- Imaging in the Radio Band

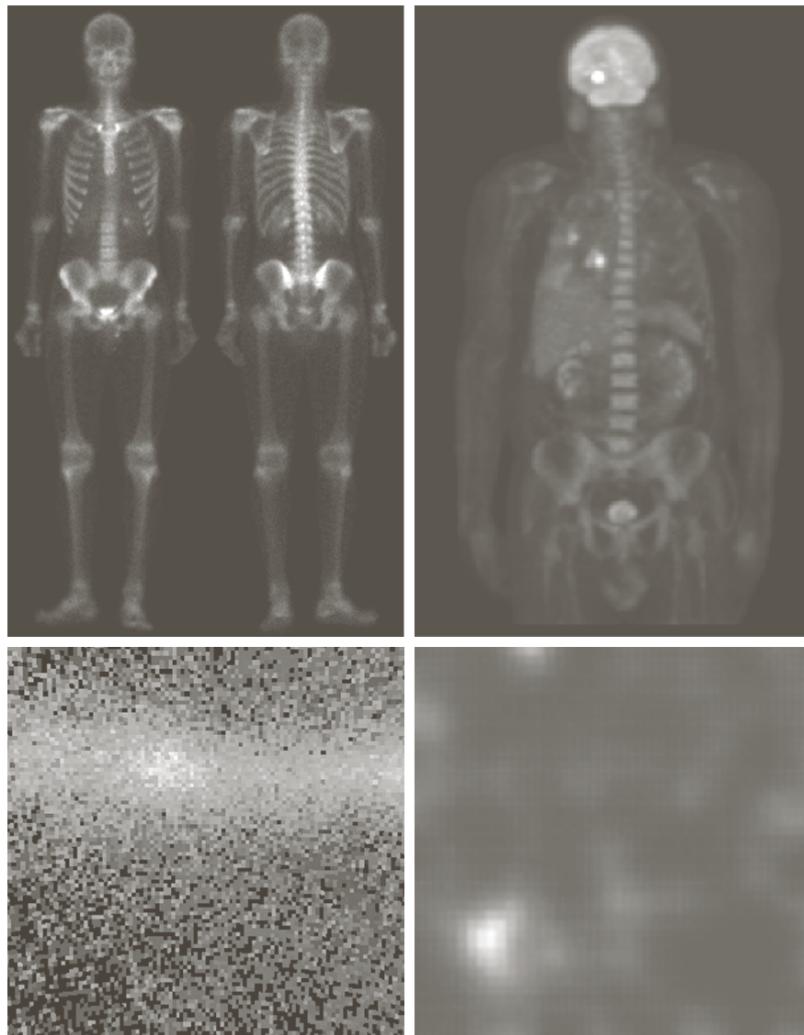


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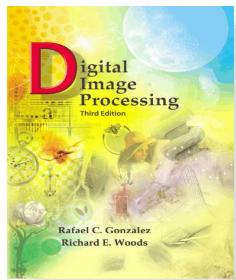
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a b
c d

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.)

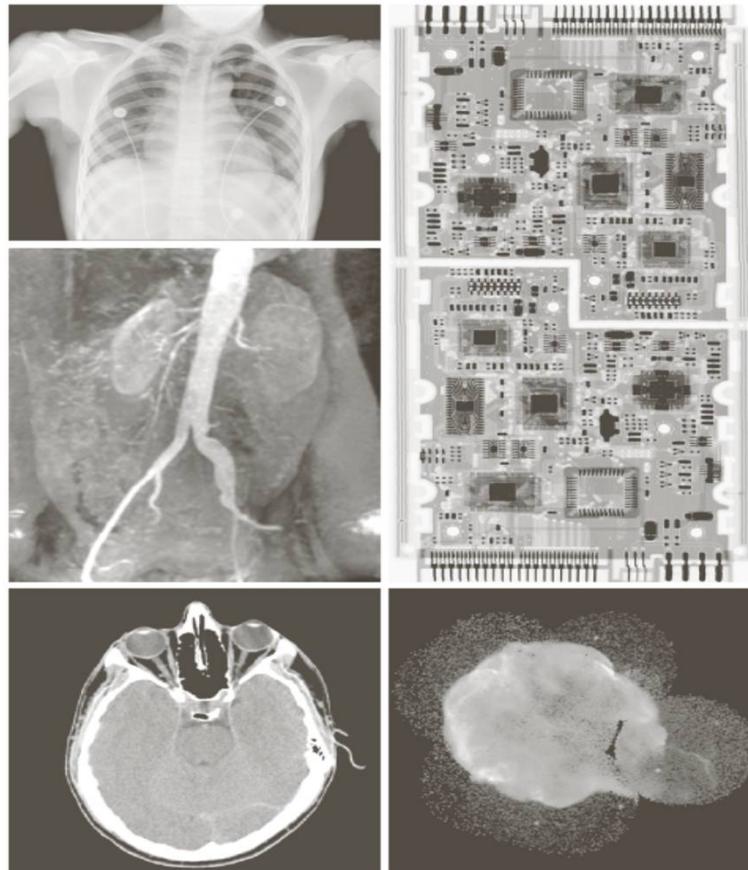


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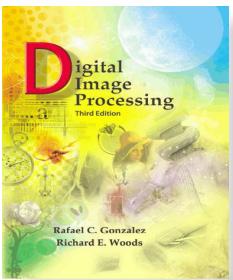
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a
b
c
d
e

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.)

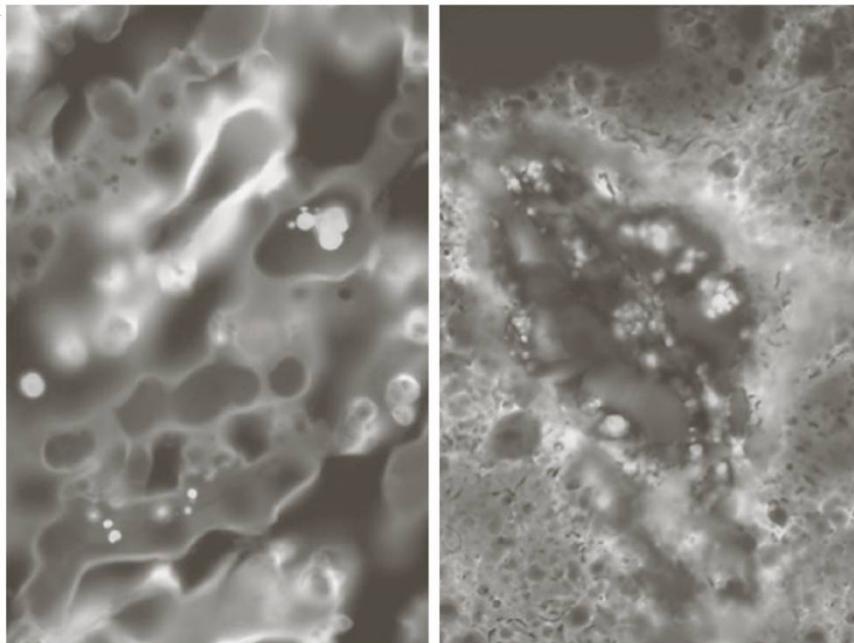


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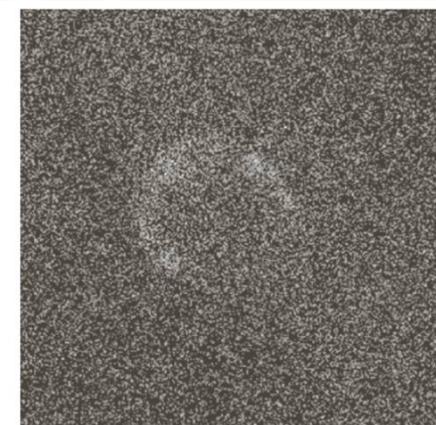


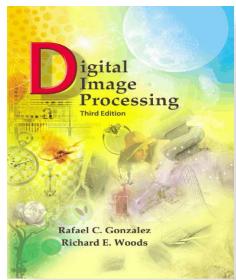
a b
c

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.)





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Chapter 1 Introduction

a b c
d e f

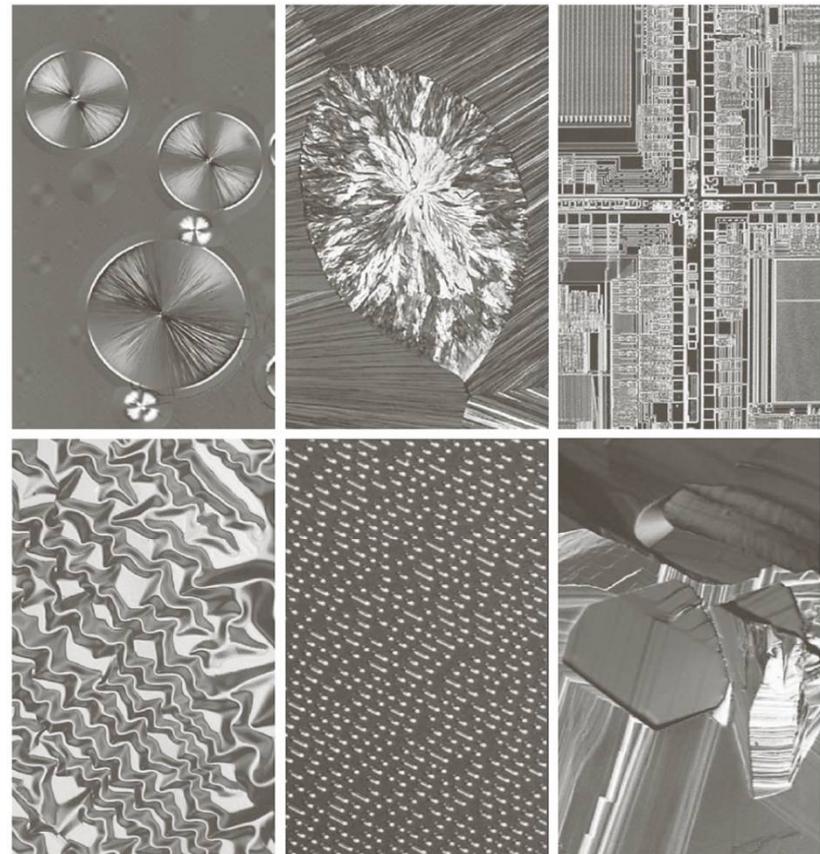
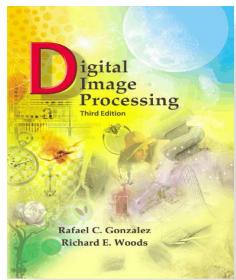


FIGURE 1.9 Examples of light microscopy images. (a) Taxol (anticancer agent), magnified 250 \times . (b) Cholesterol—40 \times . (c) Microprocessor—60 \times . (d) Nickel oxide thin film—600 \times . (e) Surface of audio CD—1750 \times . (f) Organic superconductor—450 \times . (Images courtesy of Dr.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



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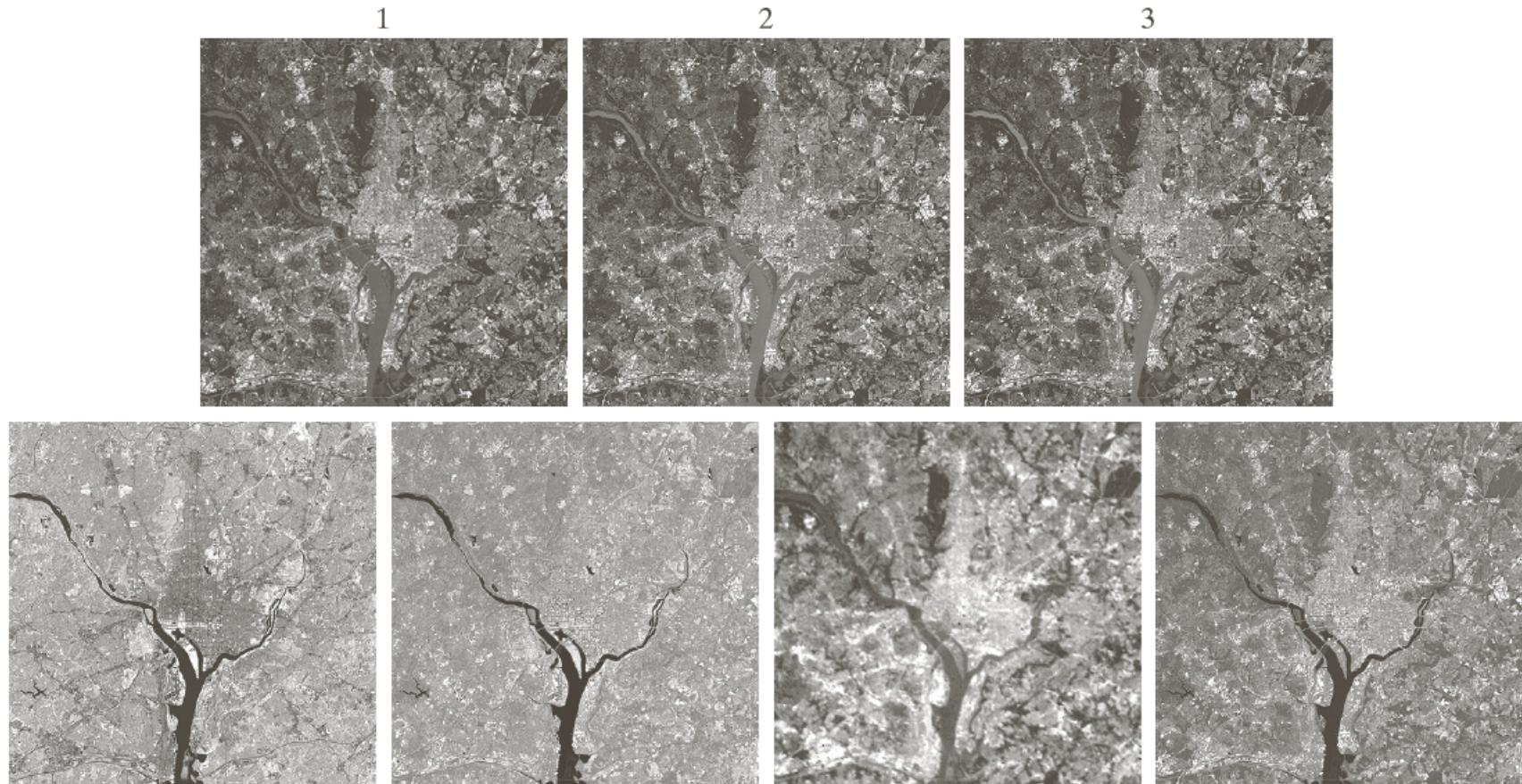
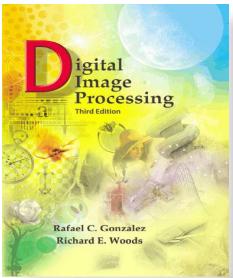


FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)



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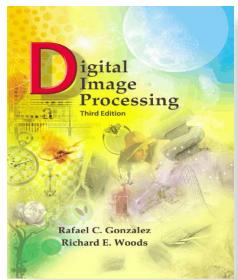
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| Band No. | Name | Wavelength (μm) | Characteristics and Uses |
|----------|------------------|------------------------------|---|
| 1 | Visible blue | 0.45–0.52 | Maximum water penetration |
| 2 | Visible green | 0.52–0.60 | Good for measuring plant 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 |

TABLE 1.1
Thematic bands
in NASA's
LANDSAT
satellite.



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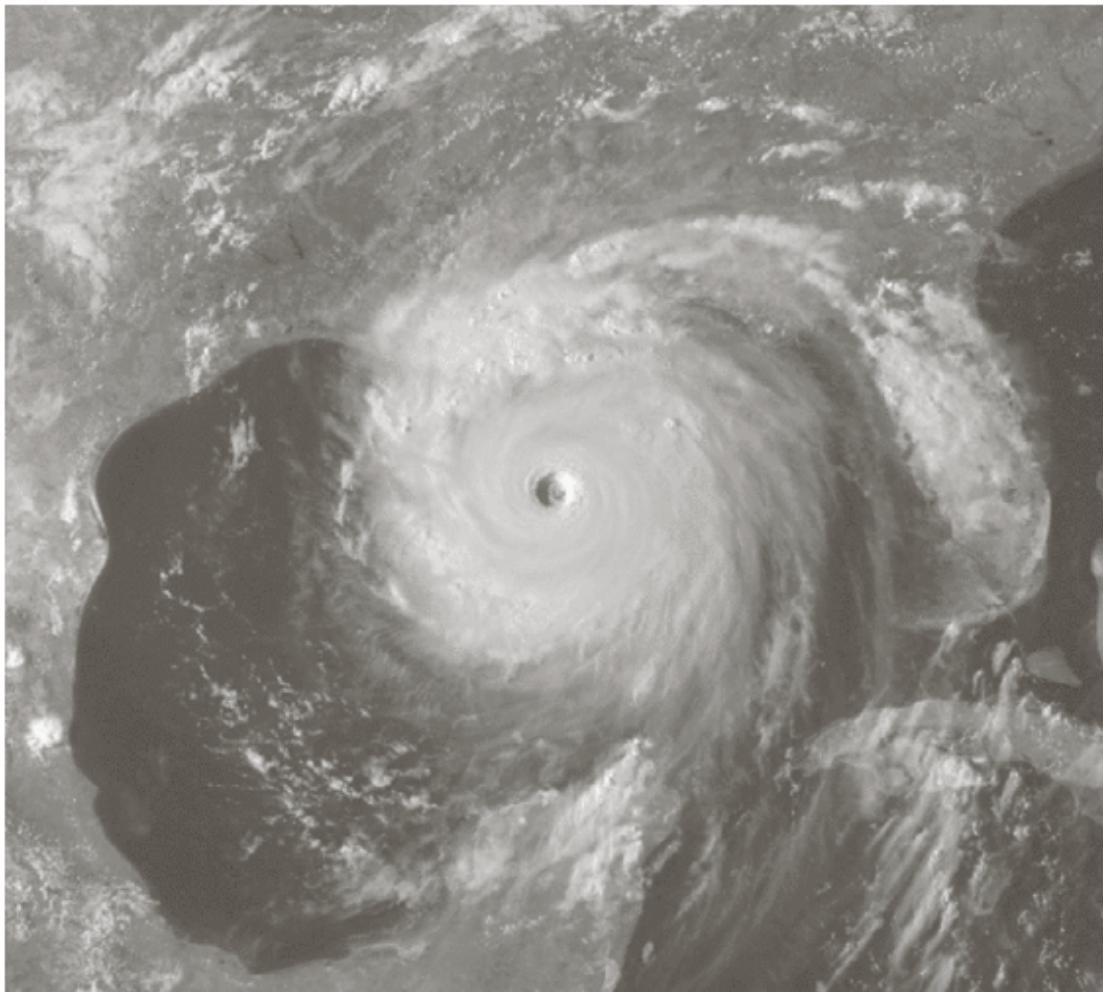
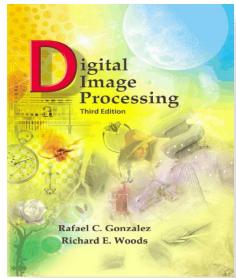


FIGURE 1.11
Satellite image
of Hurricane
Katrina taken on
August 29, 2005.
(Courtesy of
NOAA.)



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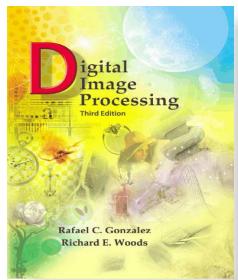
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FIGURE 1.12

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



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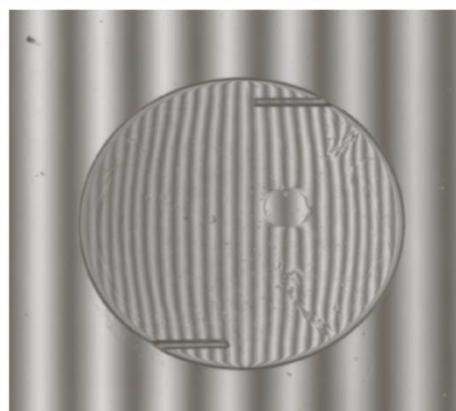
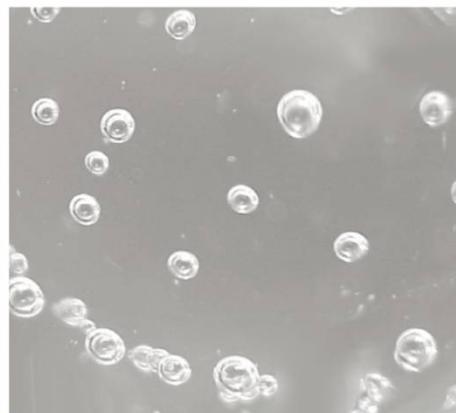
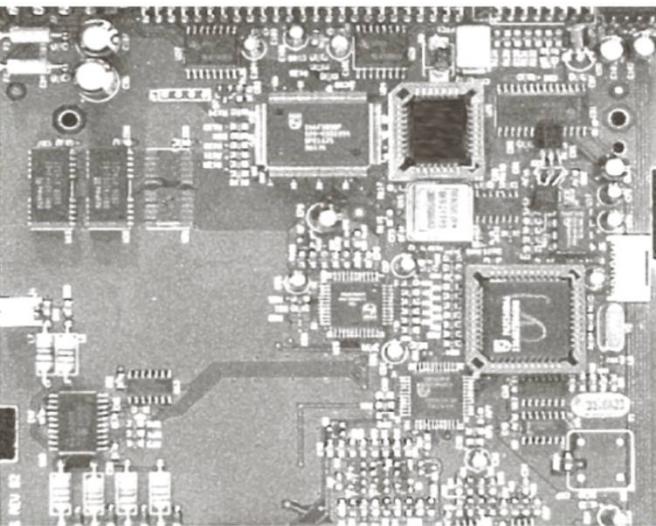
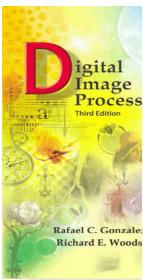
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FIGURE 1.13

Infrared satellite images of the remaining populated part of the world. The small gray map is provided for reference.
(Courtesy of NOAA.)



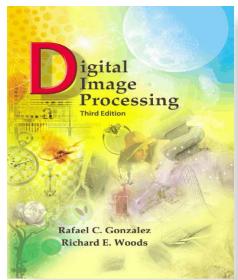
a b
c d
e f

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



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.)



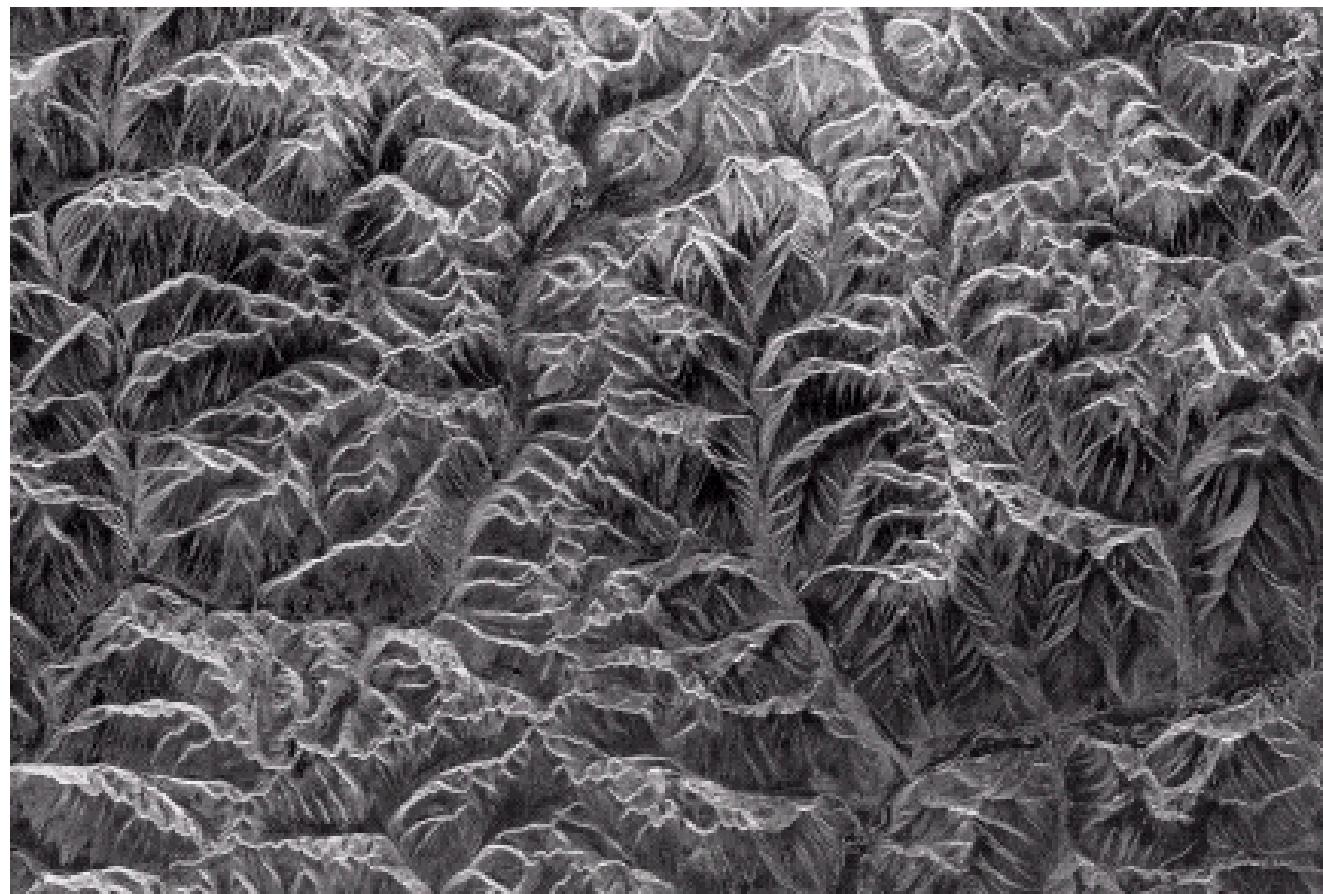
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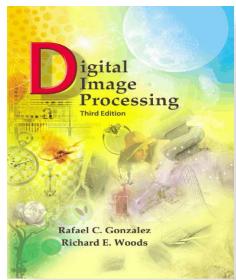
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FIGURE 1.16
Spaceborne radar
image of
mountains in
southeast Tibet.
(Courtesy of
NASA.)



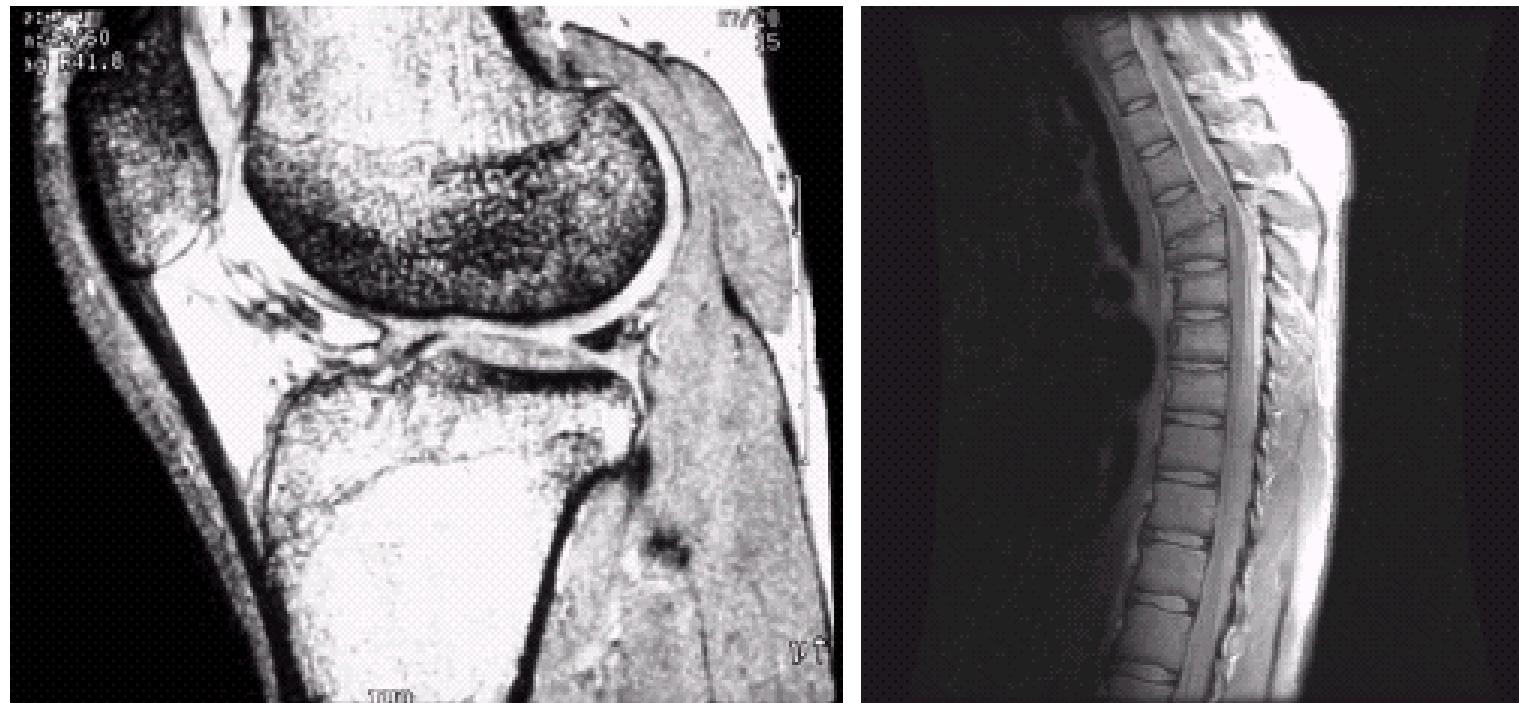


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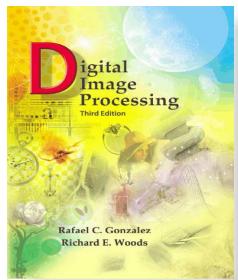
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Chapter 1 Introduction



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.)

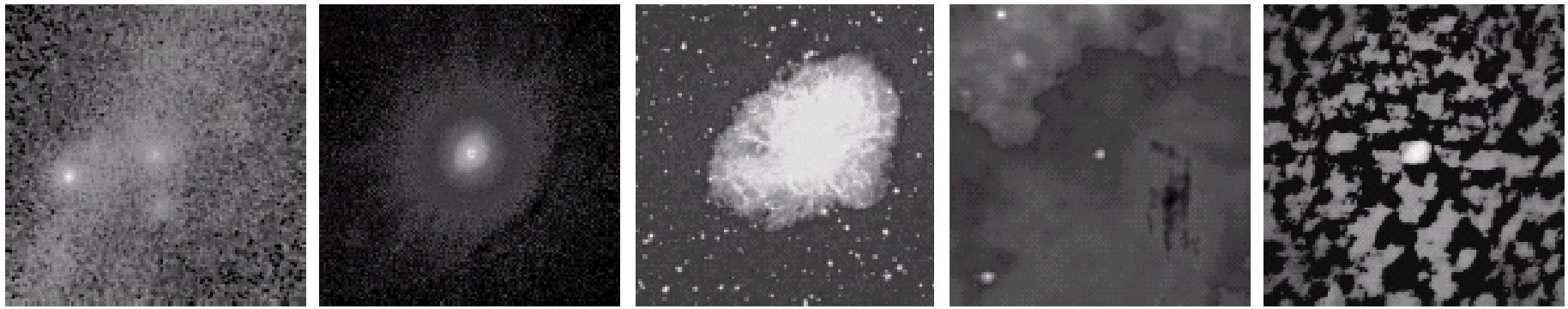


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Gamma

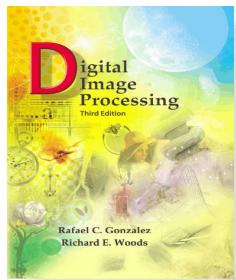
X-ray

Optical

Infrared

Radio

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



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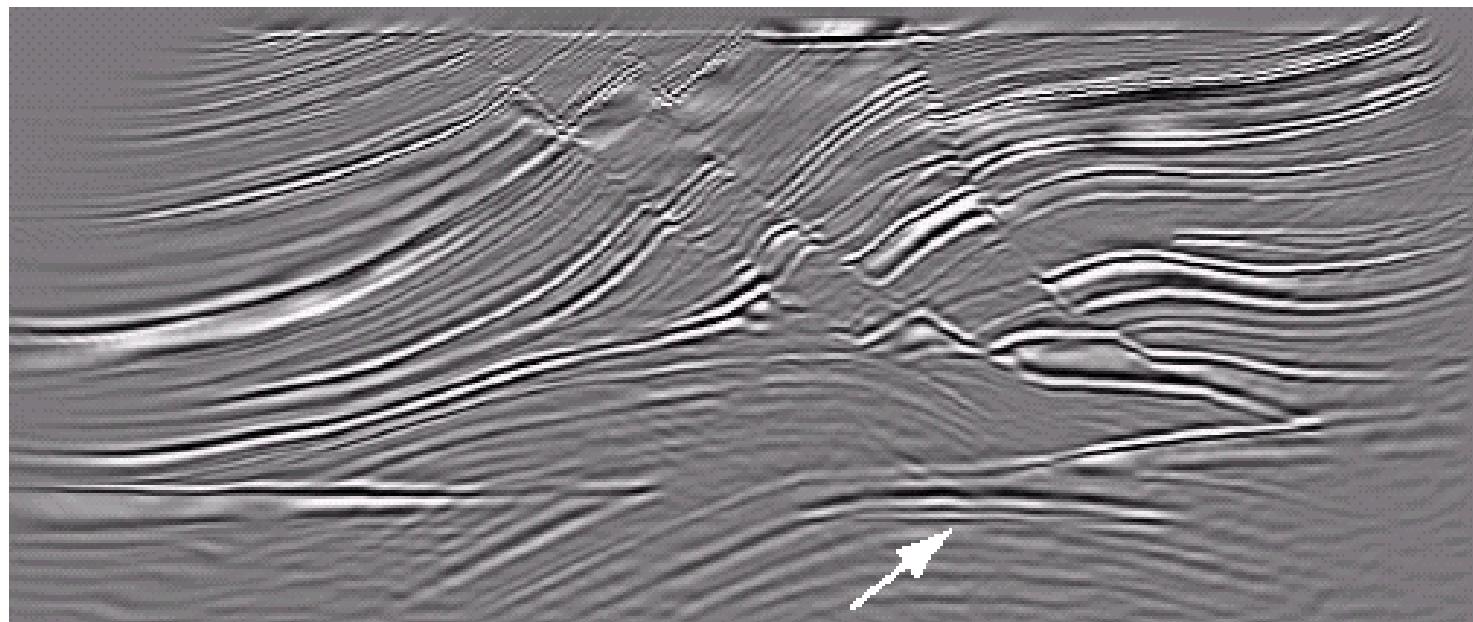
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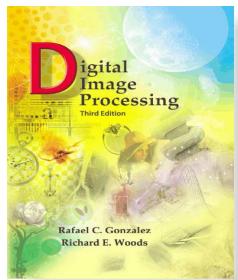
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FIGURE 1.19

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.)



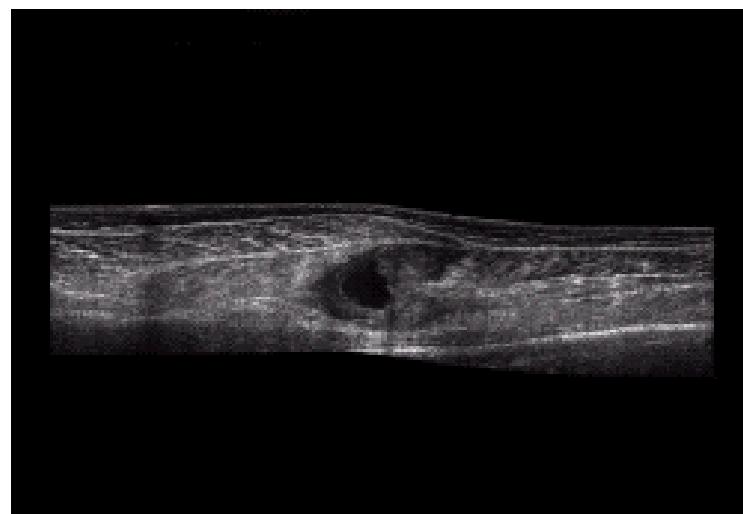
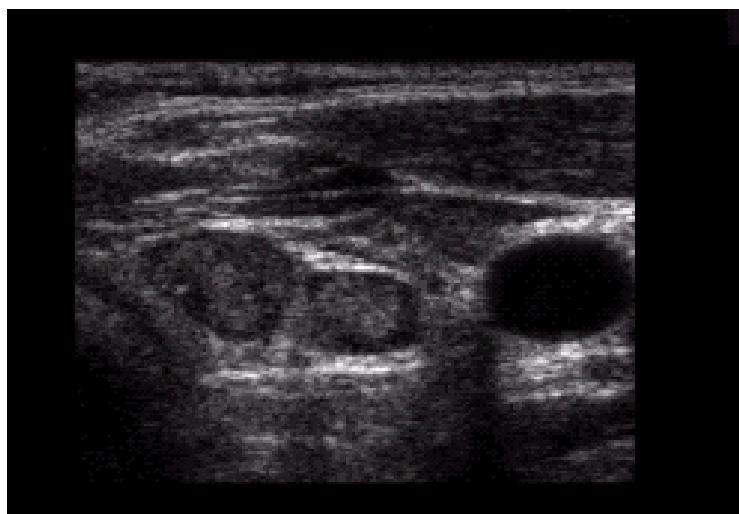


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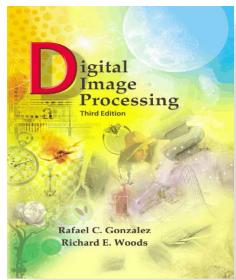
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Chapter 1 Introduction



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.)



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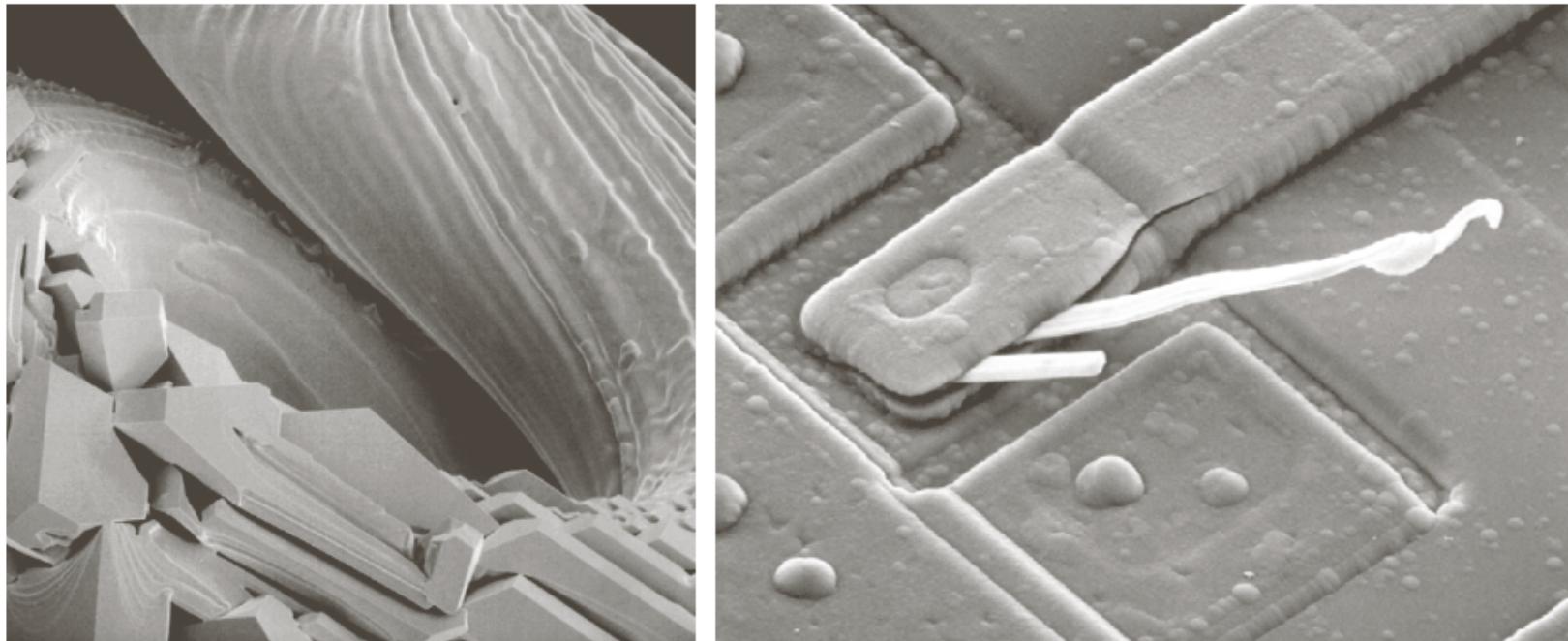
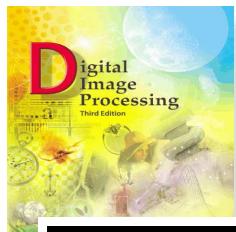


FIGURE 1.21 (a) $250\times$ SEM image of a tungsten filament following thermal failure (note the shattered pieces on the lower left). (b) $2500\times$ SEM image of damaged integrated circuit. The white fibers are oxides resulting from thermal destruction. (Figure (a) courtesy of Mr. Michael Shaffer,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

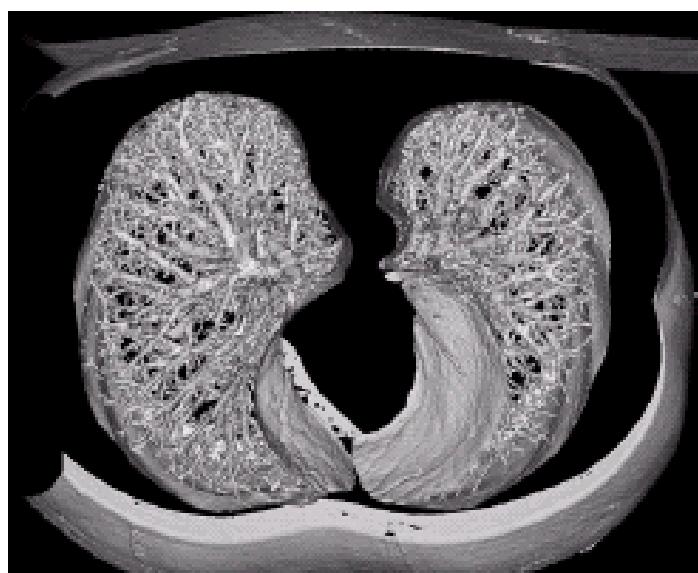
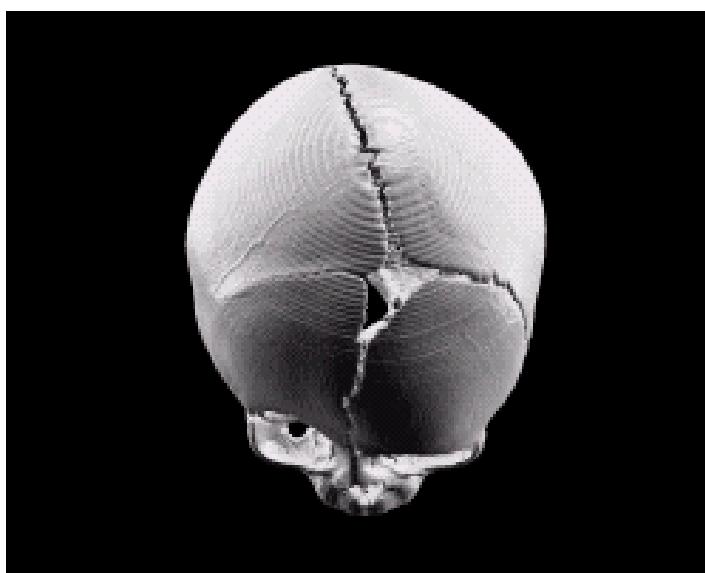
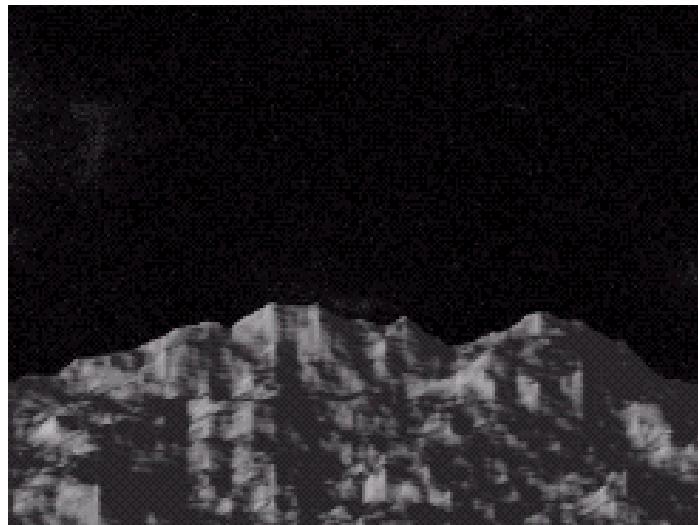
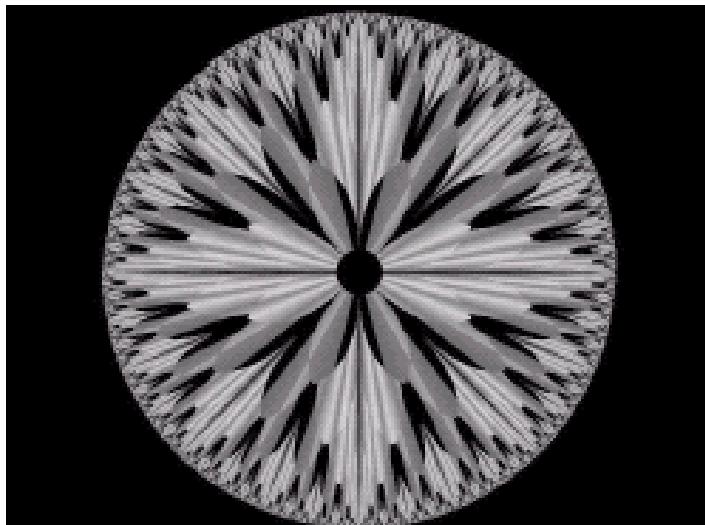


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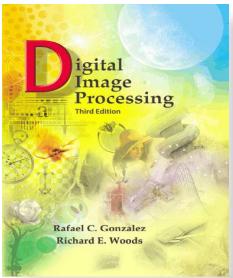
Chapter 1



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.)



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Chapter 1 Introduction

Outputs of these processes generally are images

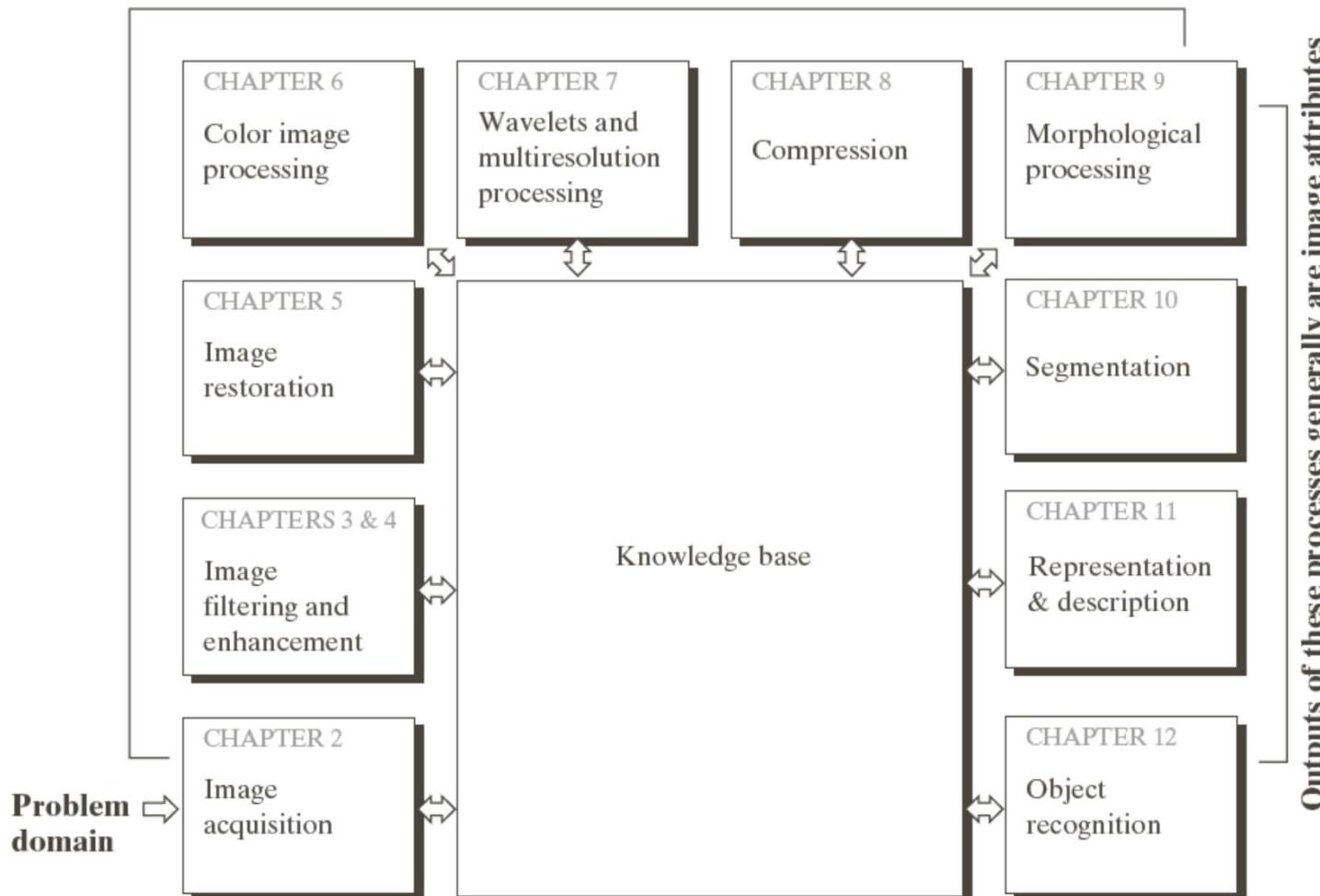
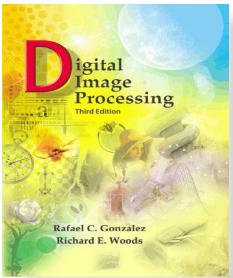


FIGURE 1.23
Fundamental steps in digital image processing. The chapter(s) indicated in the boxes is where the material described in the box is discussed.



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Chapter 1

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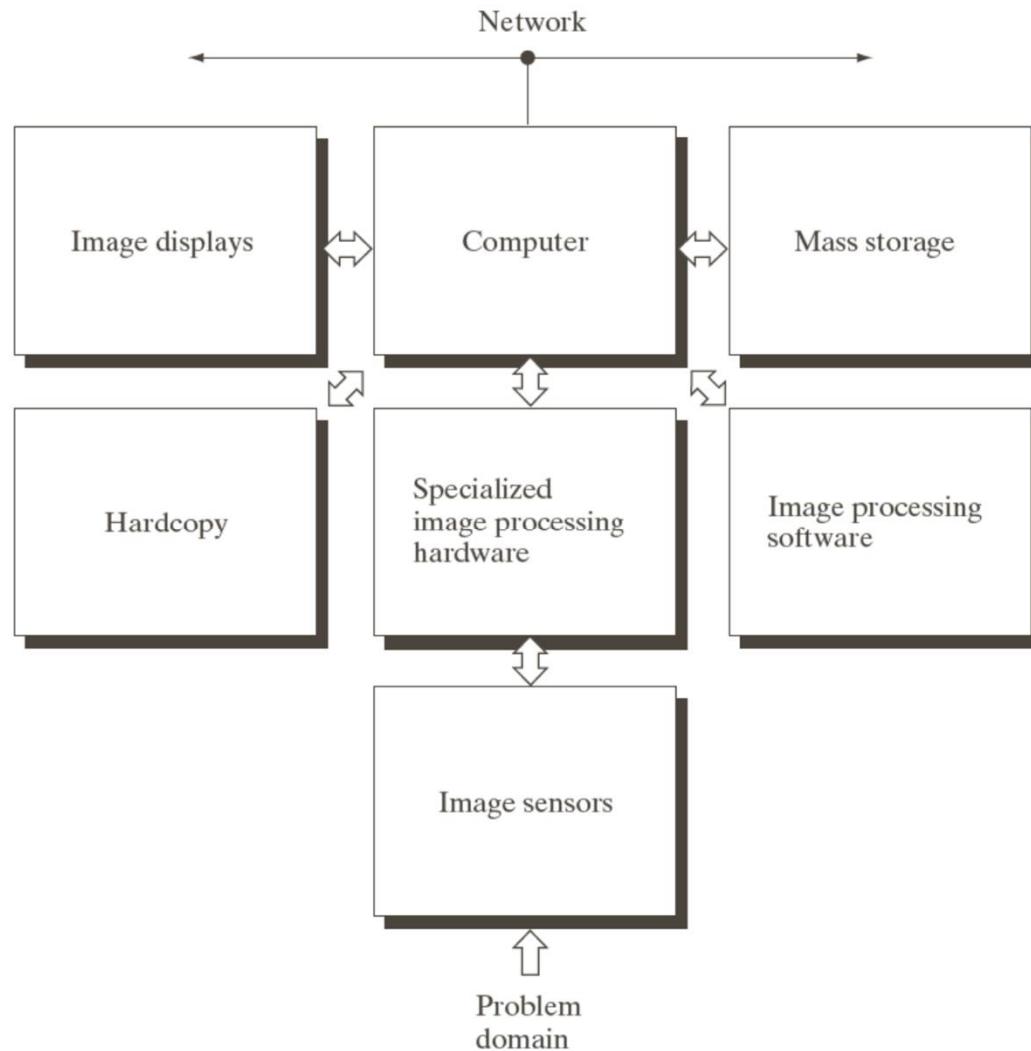


FIGURE 1.24
Components of a
general-purpose
image processing
system.