



# *Digital Image Processing, 3rd ed.*

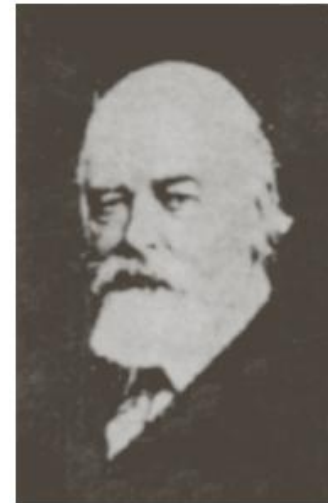
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## Chapter 1 Introduction



**FIGURE 1.1** A digital picture produced in 1921 from a coded tape by a telegraph printer with special type faces. (McFarlane.<sup>†</sup>)



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



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**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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**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.)

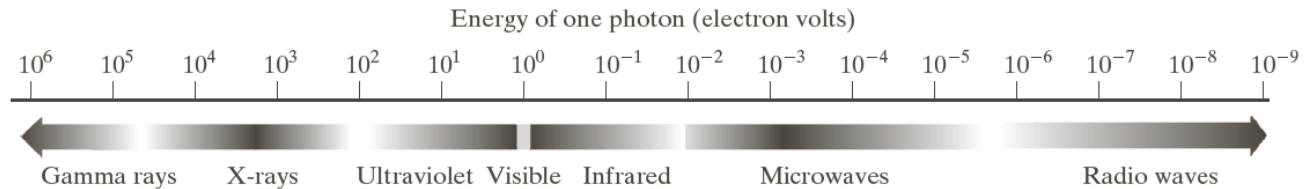


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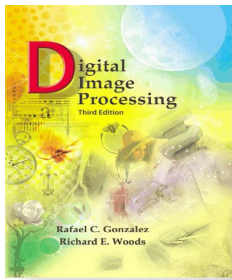
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**FIGURE 1.5** The electromagnetic spectrum arranged according to energy per photon.

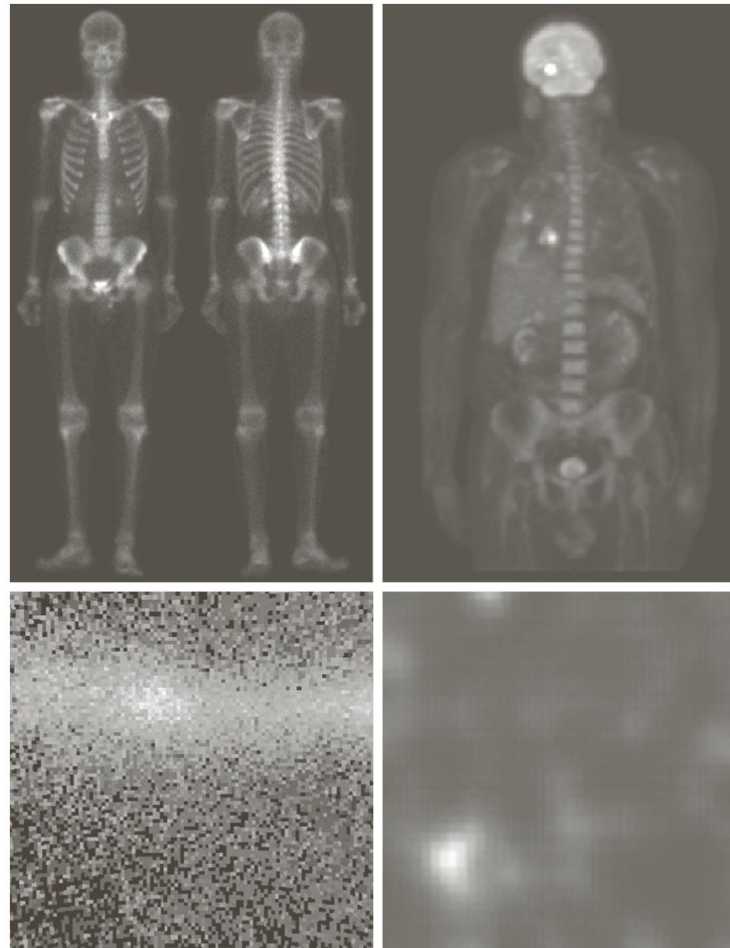


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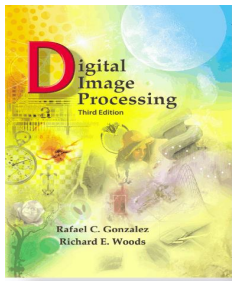
## Chapter 1 Introduction



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.)

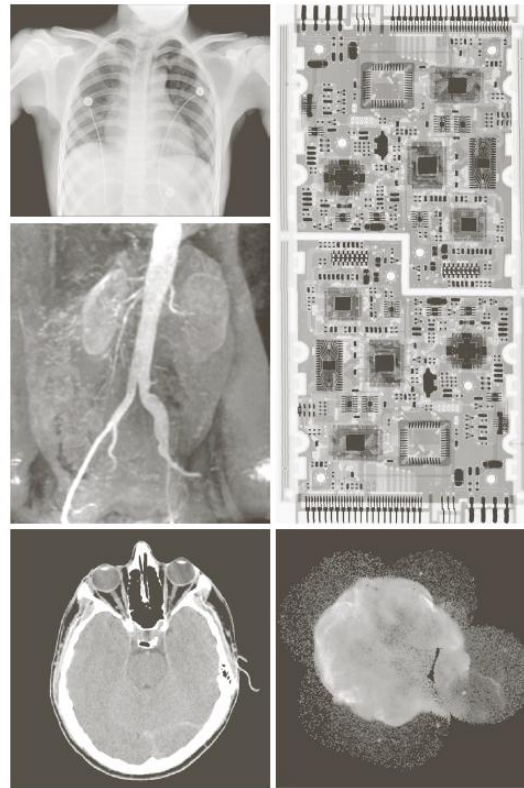


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**FIGURE 1.7** Examples of X-ray imaging. (a) Chest X-ray. (b) Aortic angiogram. (c) Head CT. (d) Circuit boards. (e) Cygnus Loop. (Images courtesy of (a) and (c) Dr. David R. Pickens, Dept. of Radiology & Radiological Sciences, Vanderbilt University 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.)



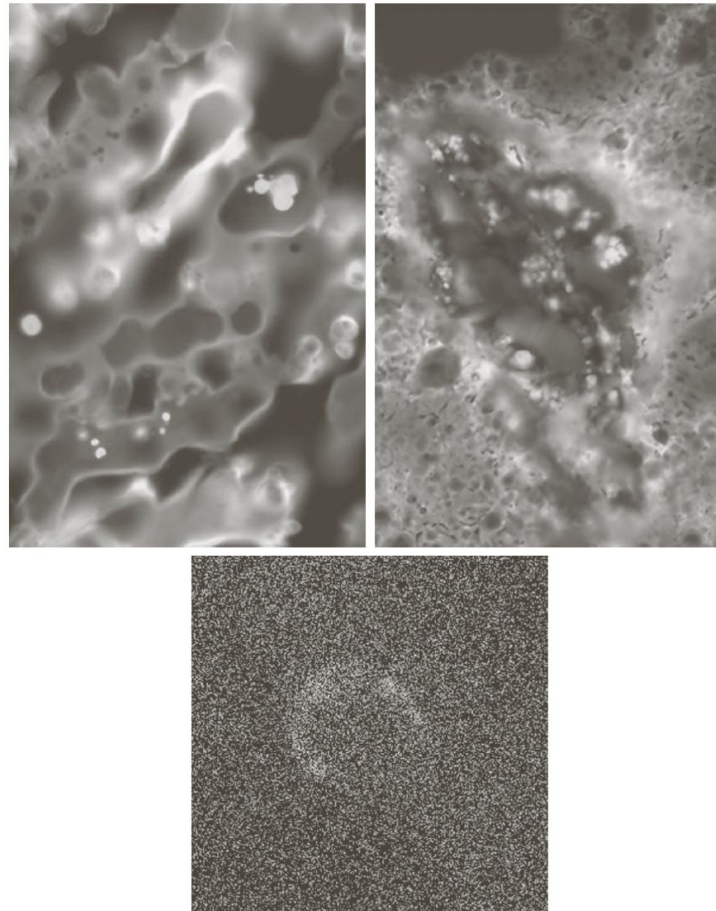


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## Chapter 1 Introduction



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.)

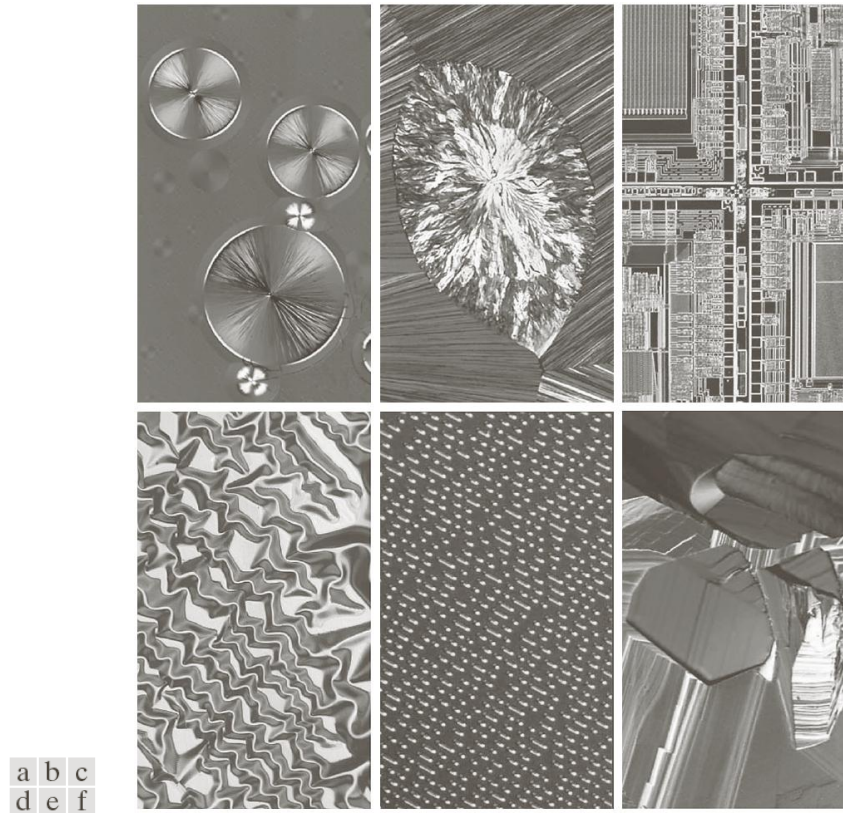


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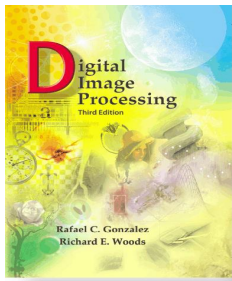
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**FIGURE 1.9** Examples of light microscopy images. (a) Taxol (anticancer agent), magnified 250 $\times$ . (b) Cholesterol—40 $\times$ . (c) Microprocessor—60 $\times$ . (d) Nickel oxide thin film—600 $\times$ . (e) Surface of audio CD—1750 $\times$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



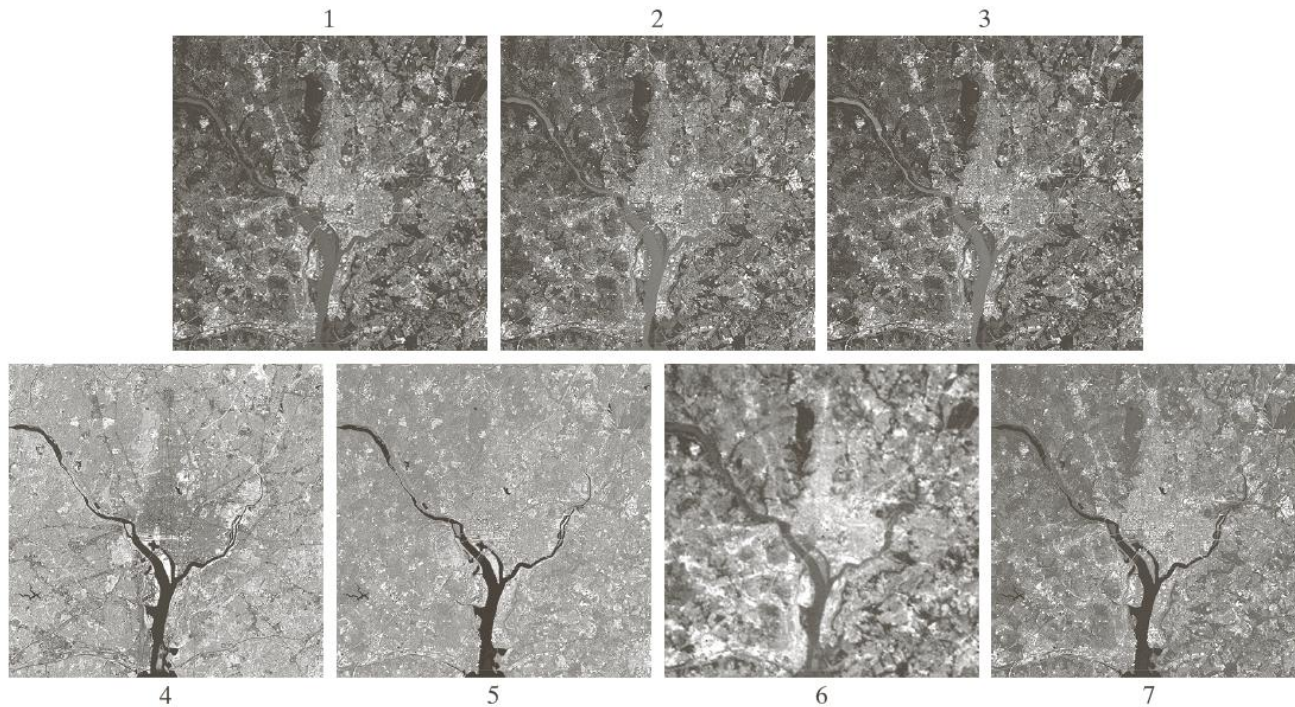


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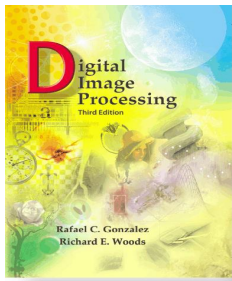
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**FIGURE 1.10** LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)



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Band No.	Name	Wavelength ( $\mu\text{m}$ )	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.

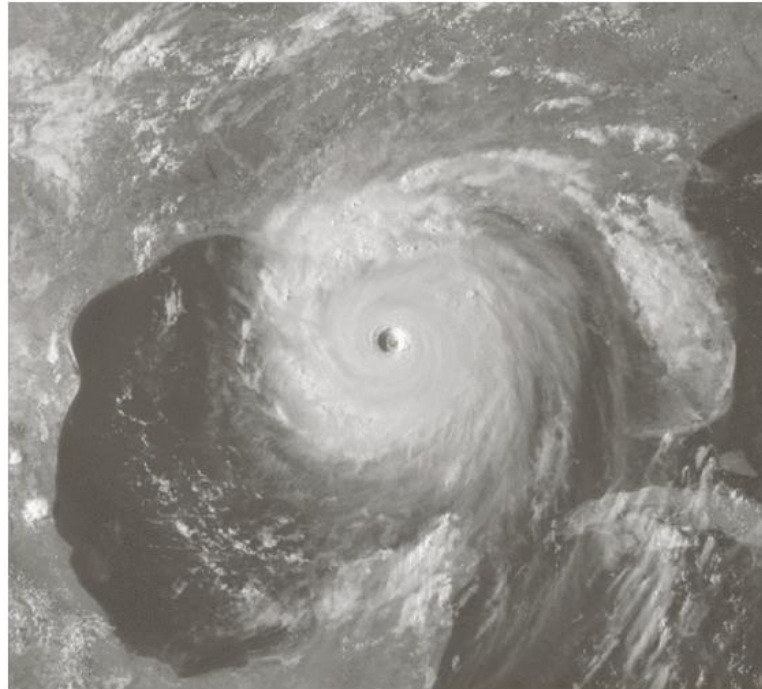


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**FIGURE 1.11**  
Satellite image  
of Hurricane  
Katrina taken on  
August 29, 2005.  
(Courtesy of  
NOAA.)

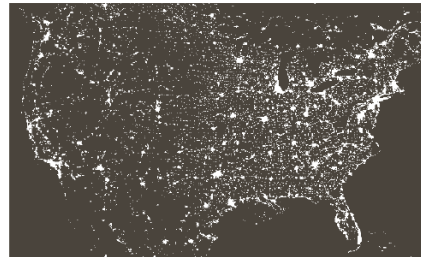


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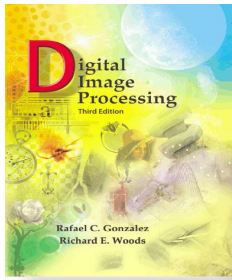
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**FIGURE 1.12**  
Infrared satellite  
images of the  
Americas. The  
small gray map is  
provided for  
reference.  
(Courtesy of  
NOAA.)



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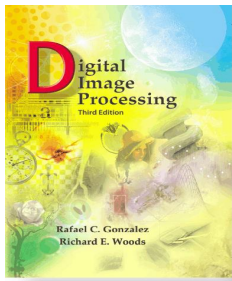
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**FIGURE 1.13**  
Infrared satellite  
images of the  
remaining  
populated part of  
the world. The  
small gray map is  
provided for  
reference.  
(Courtesy of  
NOAA.)



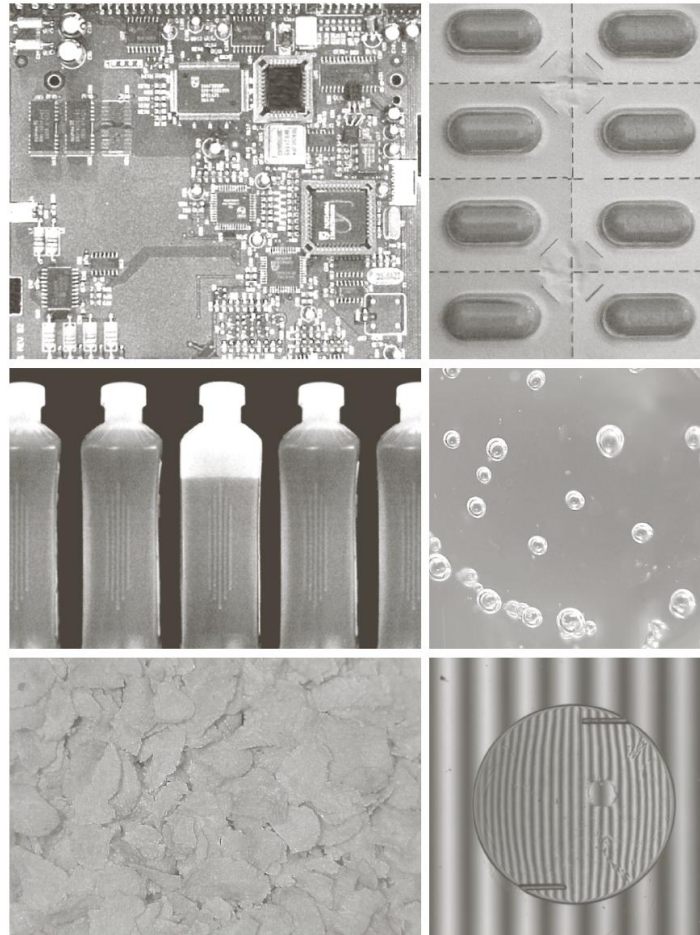


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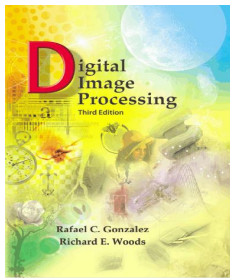
## Chapter 1 Introduction



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.)



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## Chapter 1 Introduction



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.)



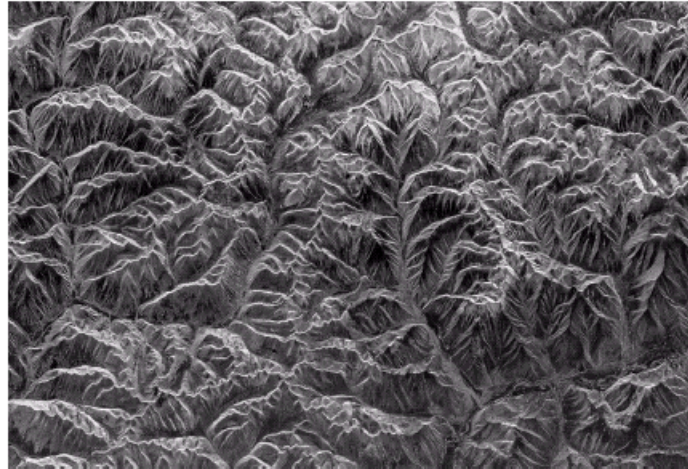
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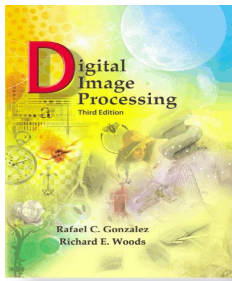
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**FIGURE 1.16**  
Spaceborne radar  
image of  
mountains in  
southeast Tibet.  
(Courtesy of  
NASA.)



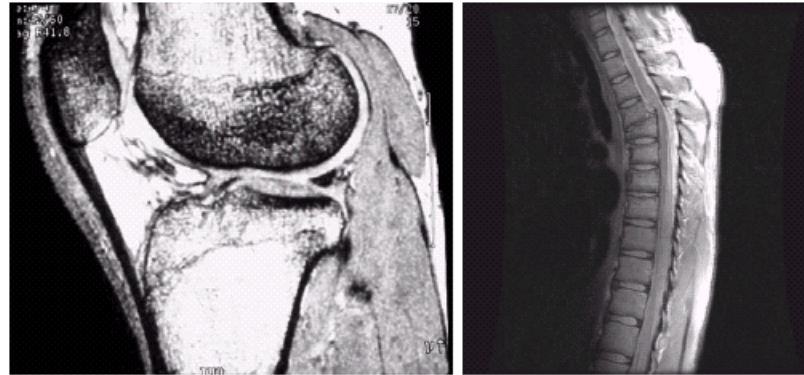


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a b

**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.)



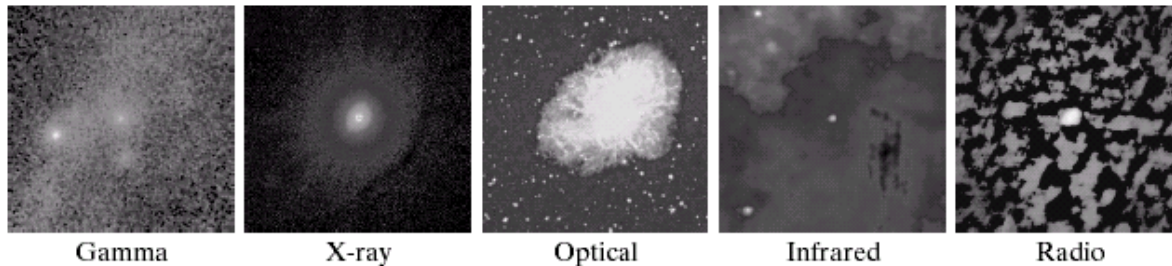


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**FIGURE 1.18** Images of the Crab Pulsar (in the center of images) covering the electromagnetic spectrum. (Courtesy of NASA.)





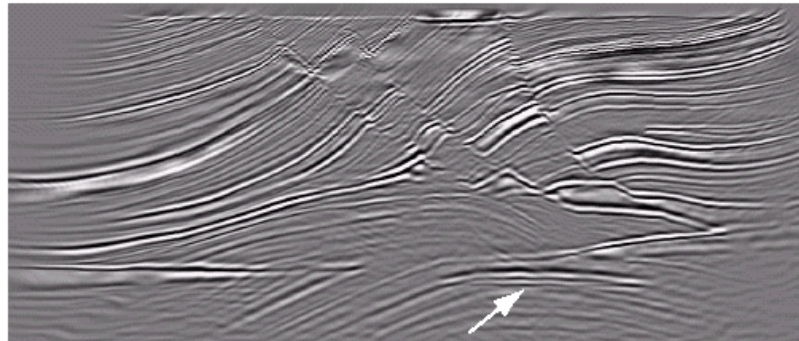
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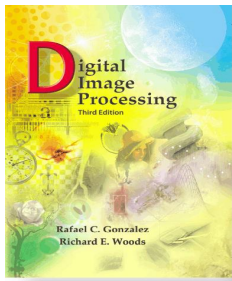
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**FIGURE 1.19**  
Cross-sectional  
image of a seismic  
model. The arrow  
points to a  
hydrocarbon (oil  
and/or gas) trap.  
(Courtesy of  
Dr. Curtis Ober,  
Sandia National  
Laboratories.)



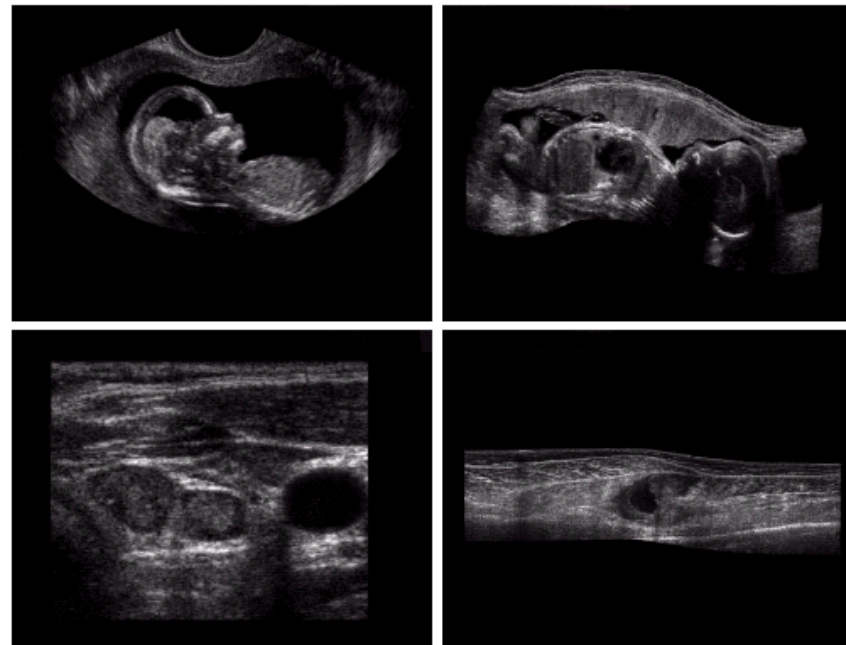


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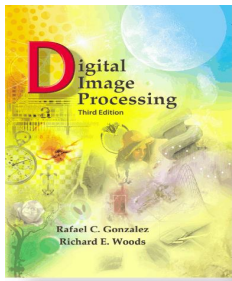
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a b  
c d

**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.)

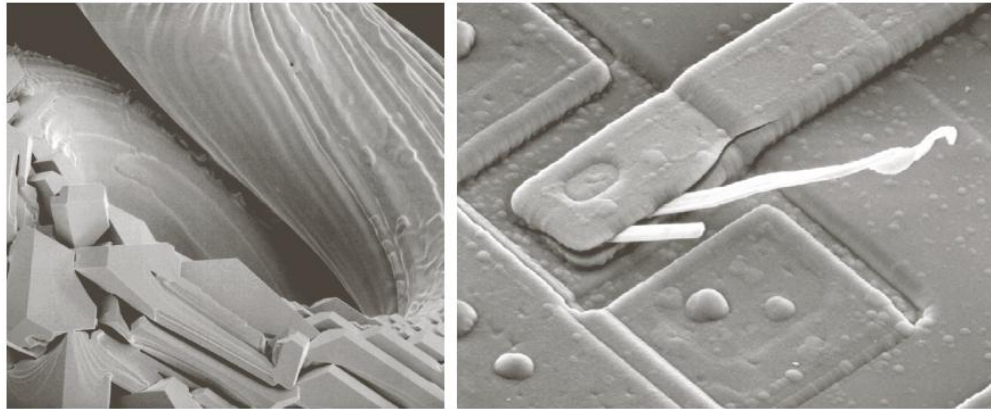


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a b

**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.)

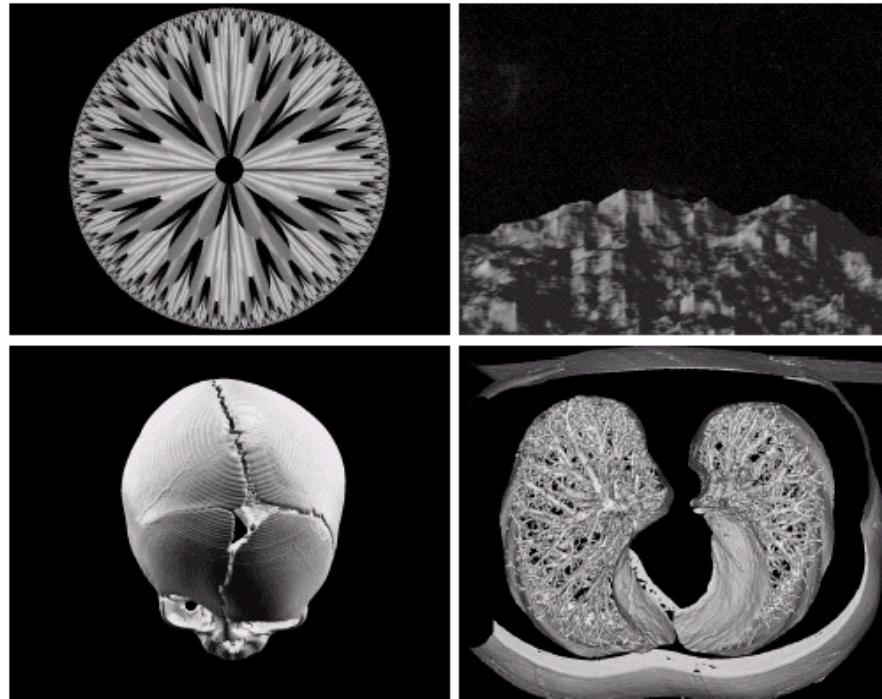


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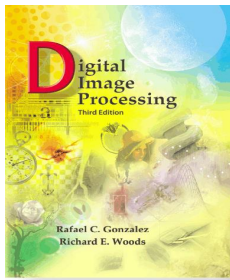
## Chapter 1 Introduction



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.)



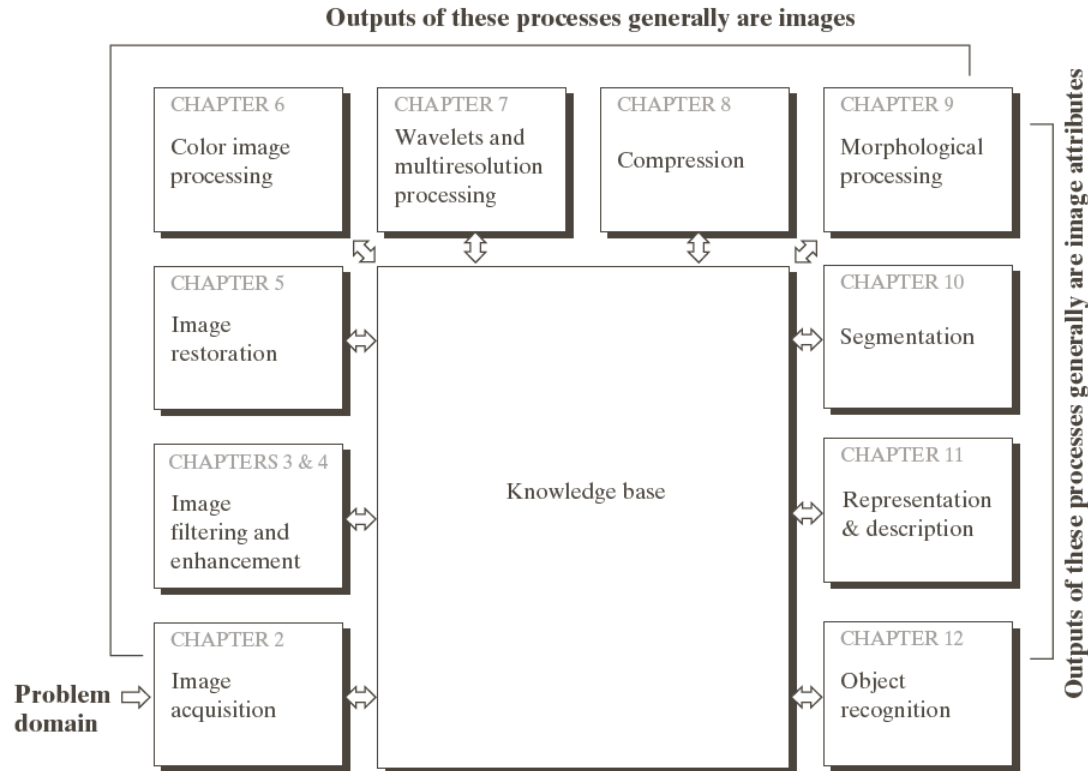
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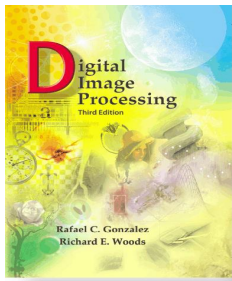
# Chapter 1

## Introduction



**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.



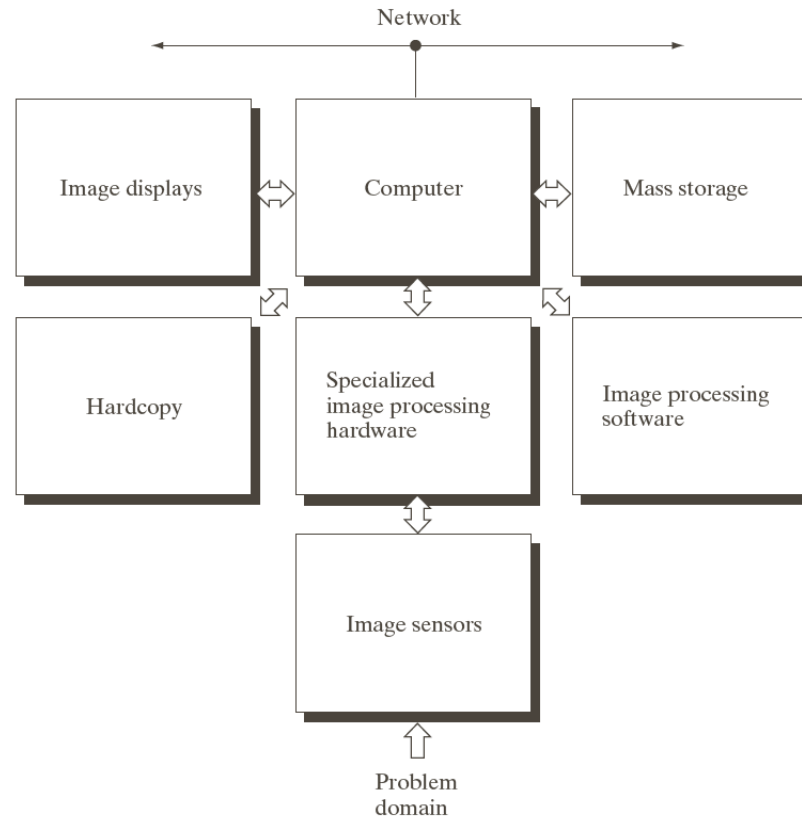


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**FIGURE 1.24**  
Components of a  
general-purpose  
image processing  
system.