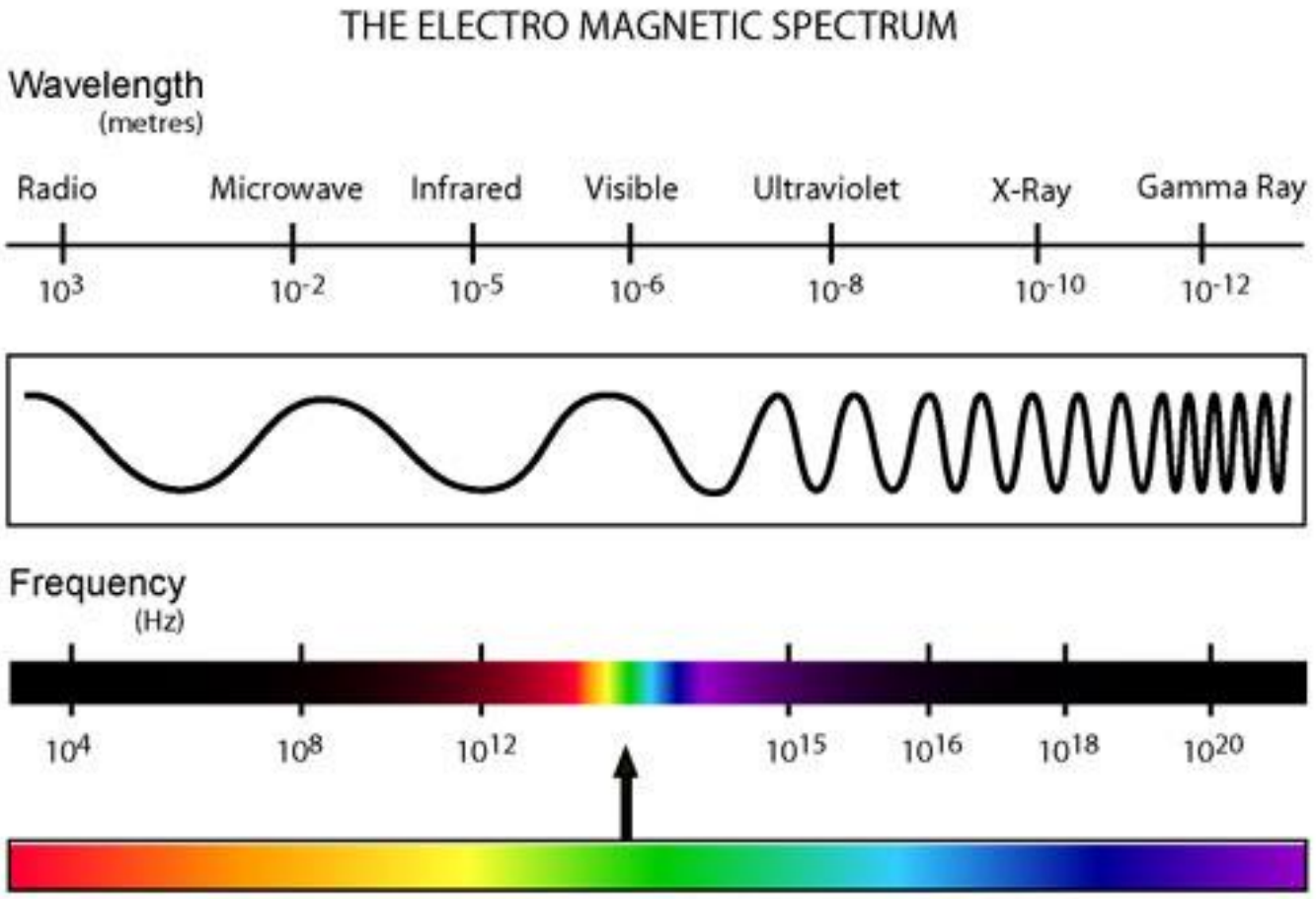
CSI 4133 Computer Methods in Picture Processing and Analysis

Fall 2024

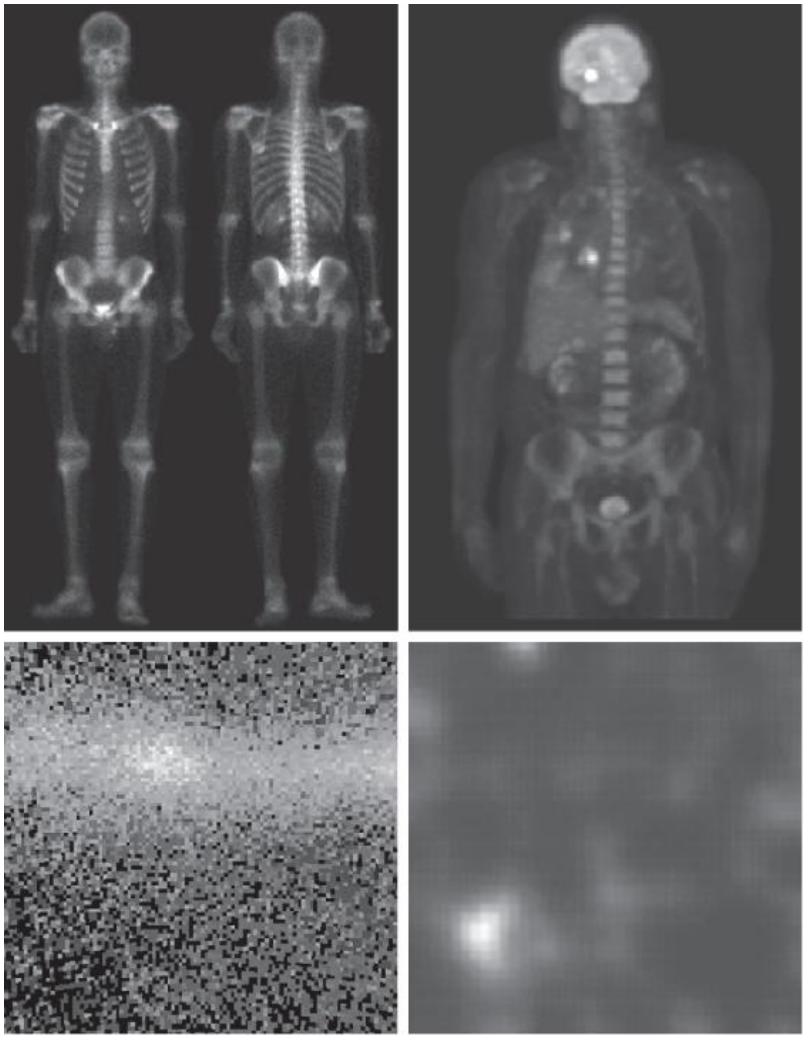
Pengcheng Xi, Ph.D.

Electromagnetic spectrum



Pengcheng Xi, U. of Ottawa

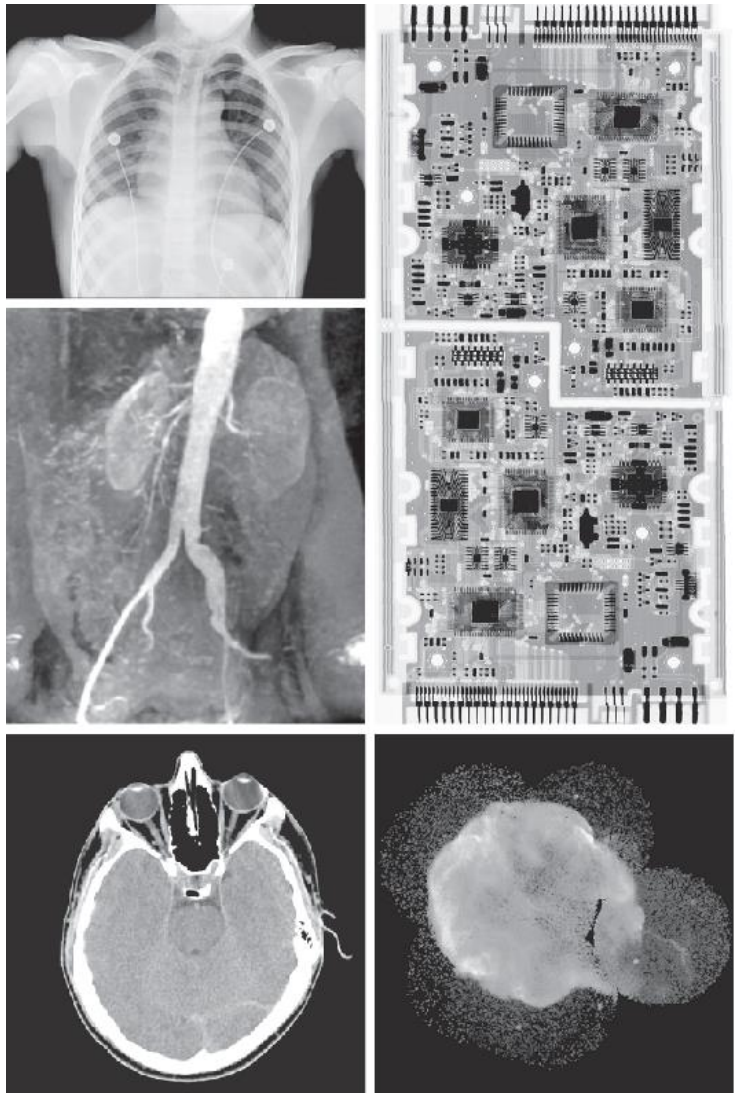
Gamma-ray imaging



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.)

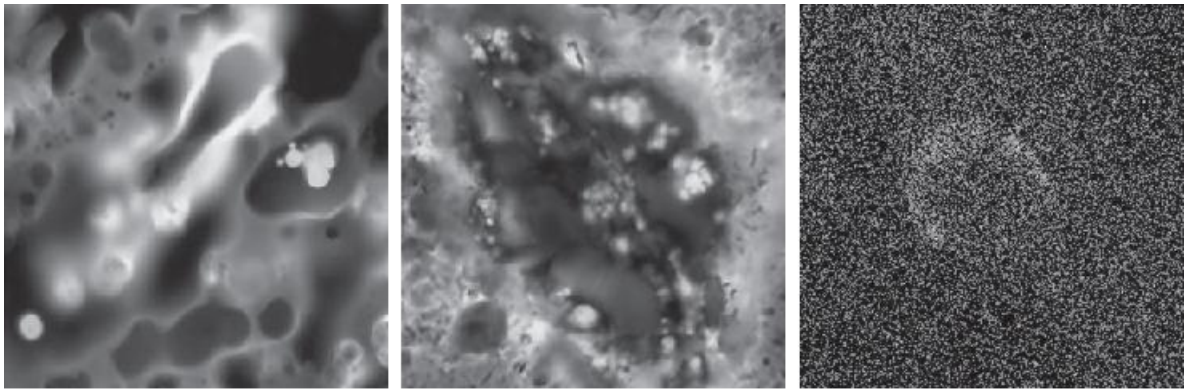
X-ray imaging



a c b 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, Univ. of Michigan Medical School; (d) Mr. Joseph E. Pascente, Lixi, Inc.; and (e) NASA.)

Ultraviolet imaging



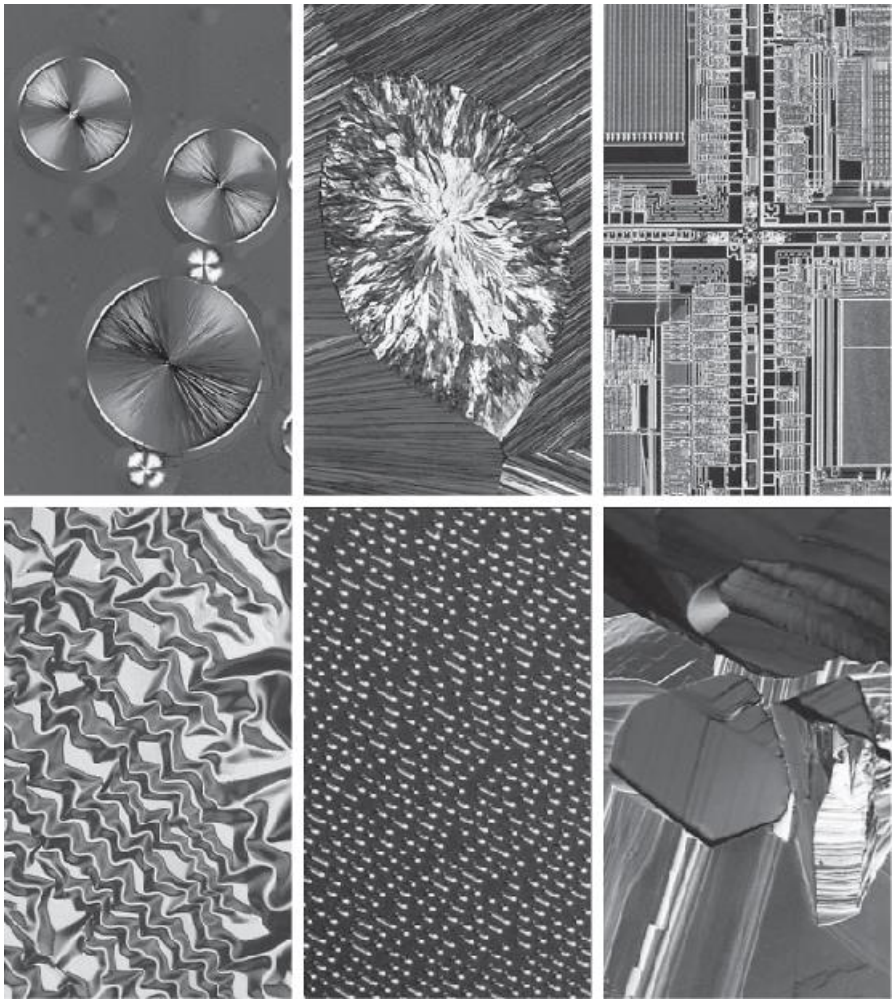
a b c

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

Light microscopy images

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.)



www.imageprocessingbook.com

Pengcheng Xi, U. of Ottawa

Visible and infrared imaging

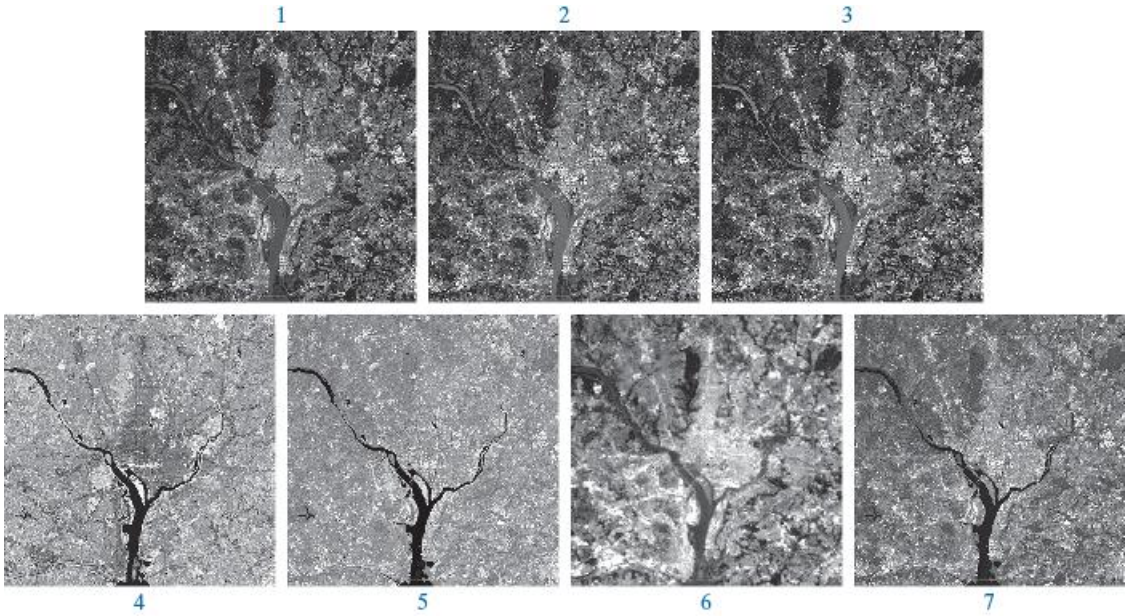


FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)

TABLE 1.1 Thematic bands of 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	0.53–0.61	Measures plant vigor
3	Visible red	0.63–0.69	Vegetation discrimination
4	Near infrared	0.78–0.90	Biomass and shoreline mapping
5	Middle infrared	1.55–1.75	Moisture content: soil/vegetation
6	Thermal infrared	10.4–12.5	Soil moisture; thermal mapping
7	Short-wave infrared	2.09–2.35	Mineral mapping

www.imageprocessingbook.com

Infrared satellite image

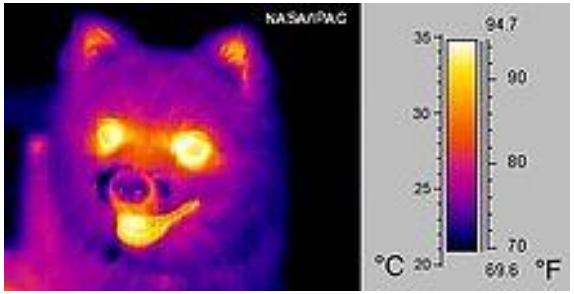
FIGURE 1.12
Infrared satellite images of the Americas. The small shaded map is provided for reference. (Courtesy of NOAA.)

www.imageprocessingbook.com

Pengcheng Xi, U. of Ottawa

More about infrared

- Near-infrared
  - Night vision devices such as night vision goggles
- Mid-wavelength infrared
  - ‘heat seeking’ missile technology
- Long-wavelength infrared
  - Thermal imaging



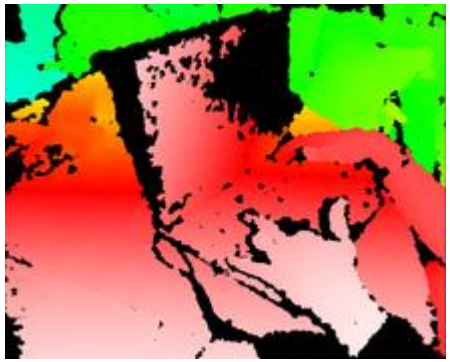
Earth at night

NASA | Earth at Night

https://www.youtube.com/watch?v=Q3YYwIsMHzw

Pengcheng Xi, U. of Ottawa

Infrared imaging in computer vision



How does it work?

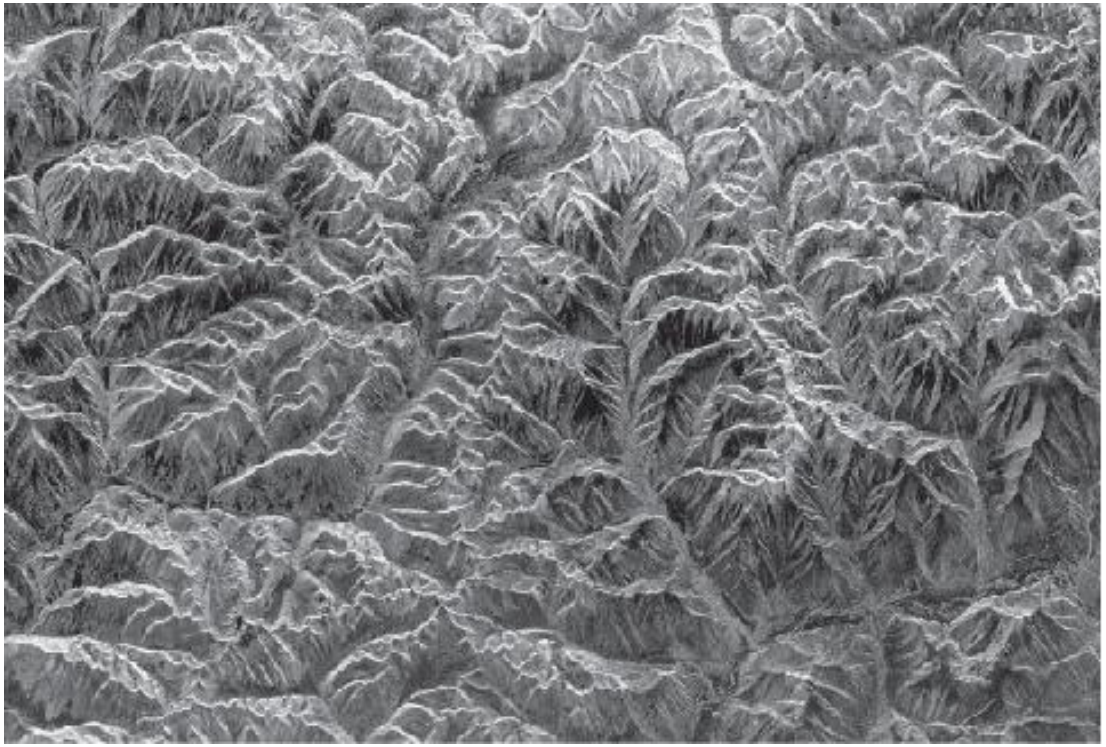
- structured light projection
  - An infrared projector emits a pattern of structured light, which is a grid of infrared dots
- infrared imaging
  - An infrared camera captures the reflected infrared light, which records how the structured light pattern has been deformed by objects
- depth sensing
  - Uses triangulation to determine depth
- Output both RGB video stream and a depth map

Pengcheng Xi, U. of Ottawa

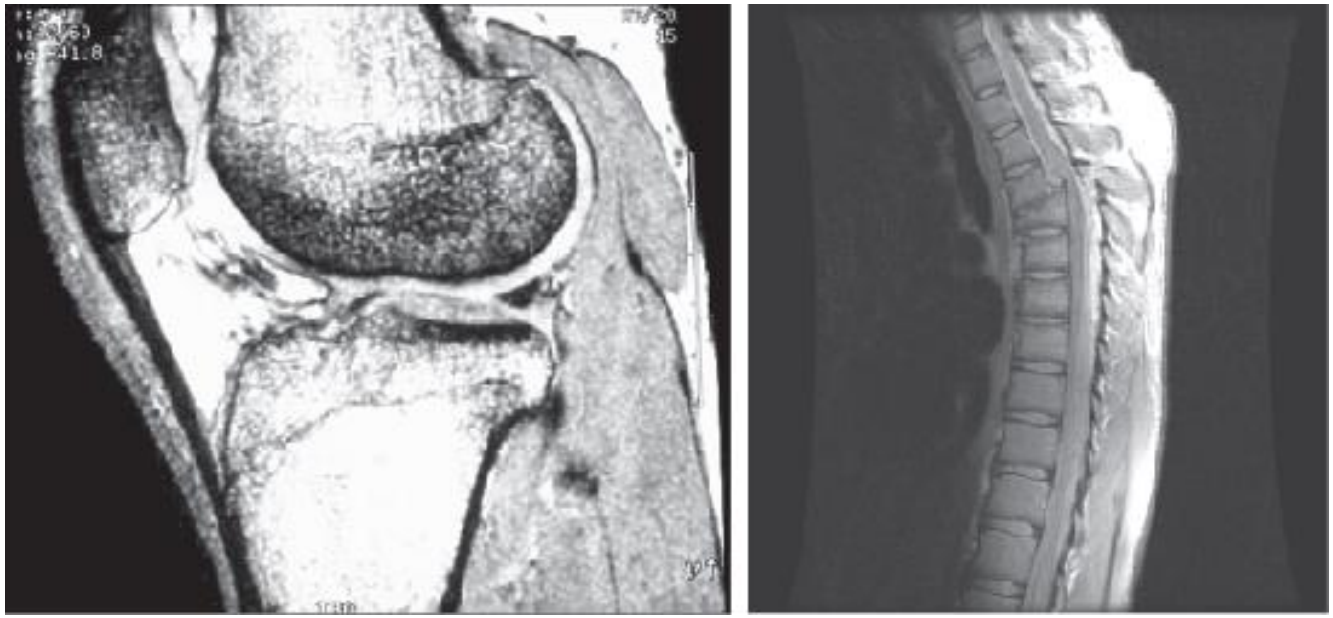
Pengcheng Xi, U. of Ottawa

Microwave band – radar imaging

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



Radio band – MRI imaging



a b

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

www.imageprocessingbook.com

Full spectrum imaging

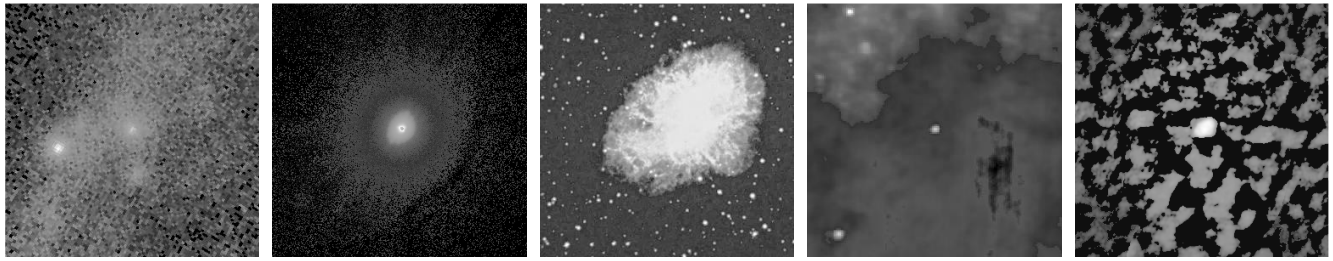
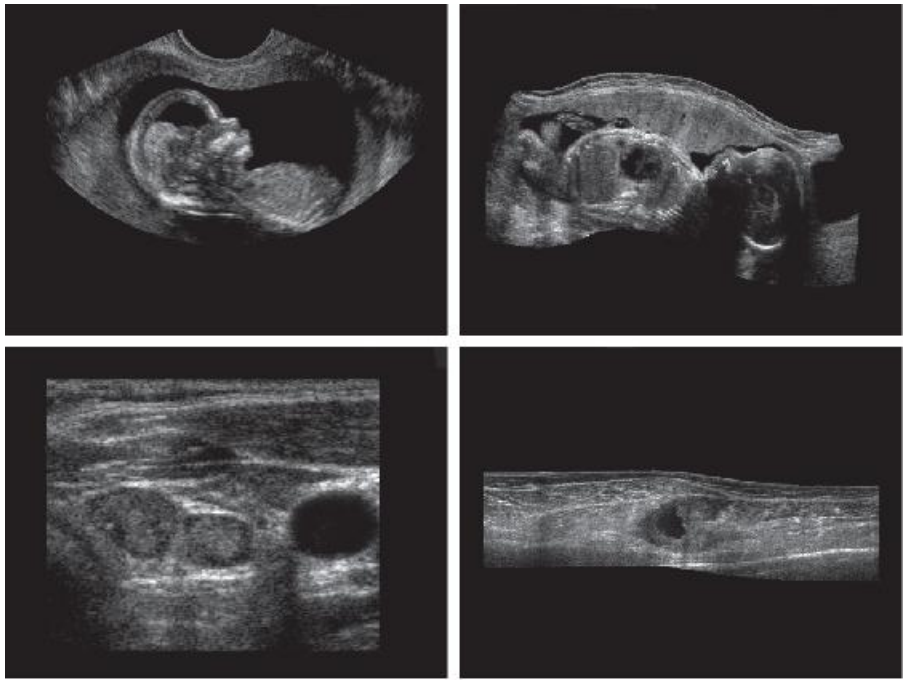


FIGURE 1.18 Images of the Crab Pulsar (in the center of each image) covering the electromagnetic spectrum. (Courtesy of NASA.)

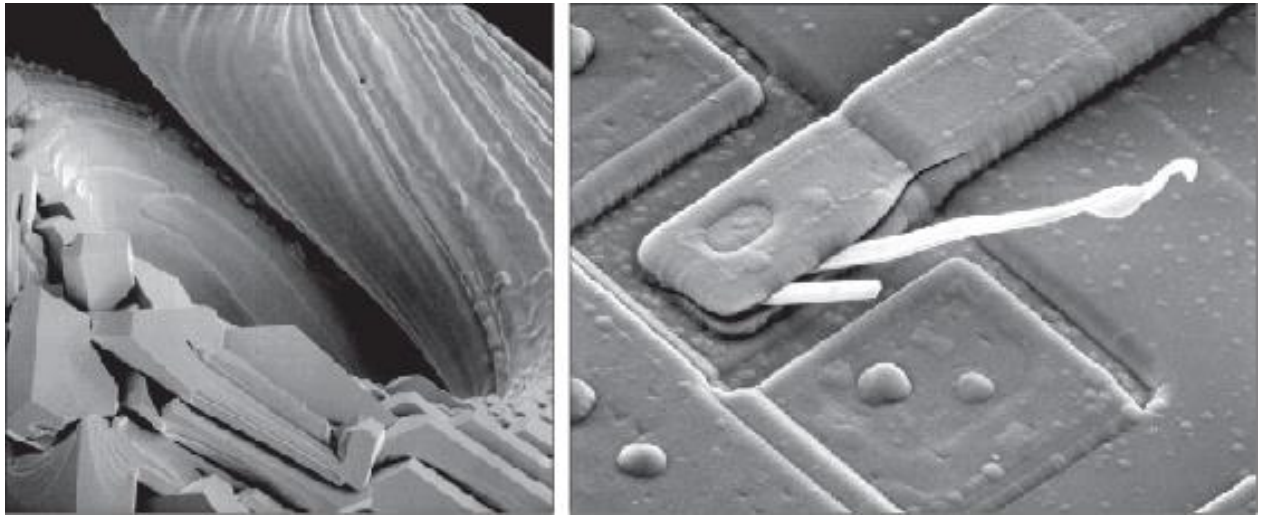
Other imaging modalities – acoustic imaging



a b
c d

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

Other imaging modalities – electron microscopy



a b

FIGURE 1.21 (a) 250× SEM image of a tungsten filament following thermal failure (note the shattered pieces on the lower left). (b) 2500× SEM image of a 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.)

www.imageprocessingbook.com