

Chapter 1 - Motivation

Computação Visual

Get CV_MATERIAL

(Download the material in the following link)

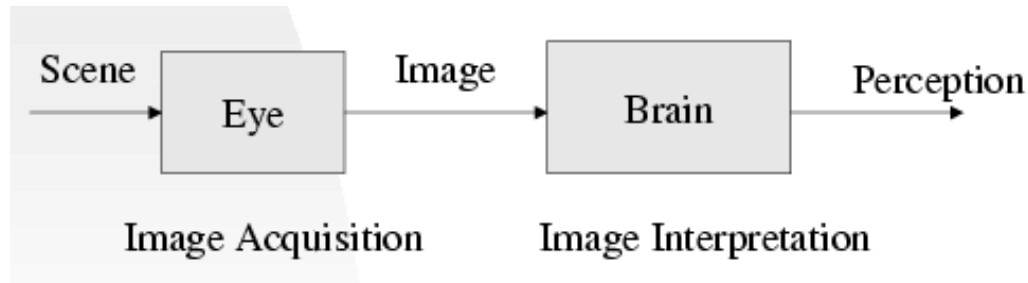
<https://github.com/JacintoCNascimento/ist-cv-2526>

Topics to be addressed

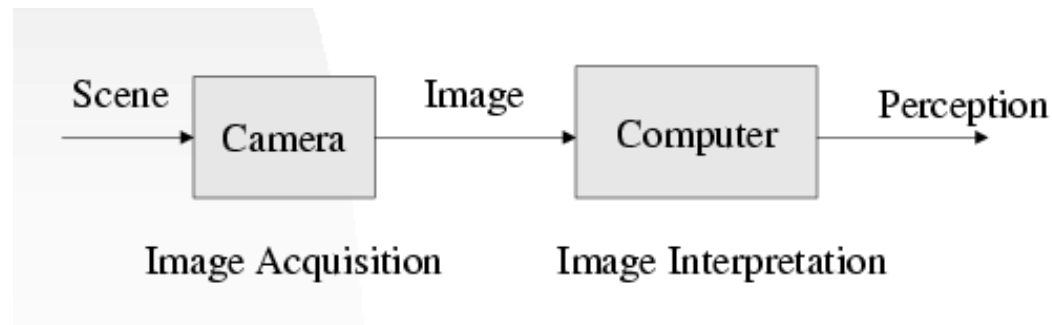
- What is the Image digital processing ?
- Digital images throughout the history;
- Applications (energy source):
 - Electromagnetic;
 - Acoustic;
 - Ultrasound;
 - Electronics (Electron beams /feixes de electrões);
- Components of the DIP (digital image processing);

What is the digital image processing ?

Vision is the most advanced human sensory system!



Naturally, we try to replicate these capacities using machines.



What is the digital image processing ?

An image can be defined by:

$f(x, y)$ where x, y are spatial coordinates and f defines the intensity or the color in that point.

If x, y and f are finite and discrete, the image can be considered as digital.

Thus, one possible definition for DIP :

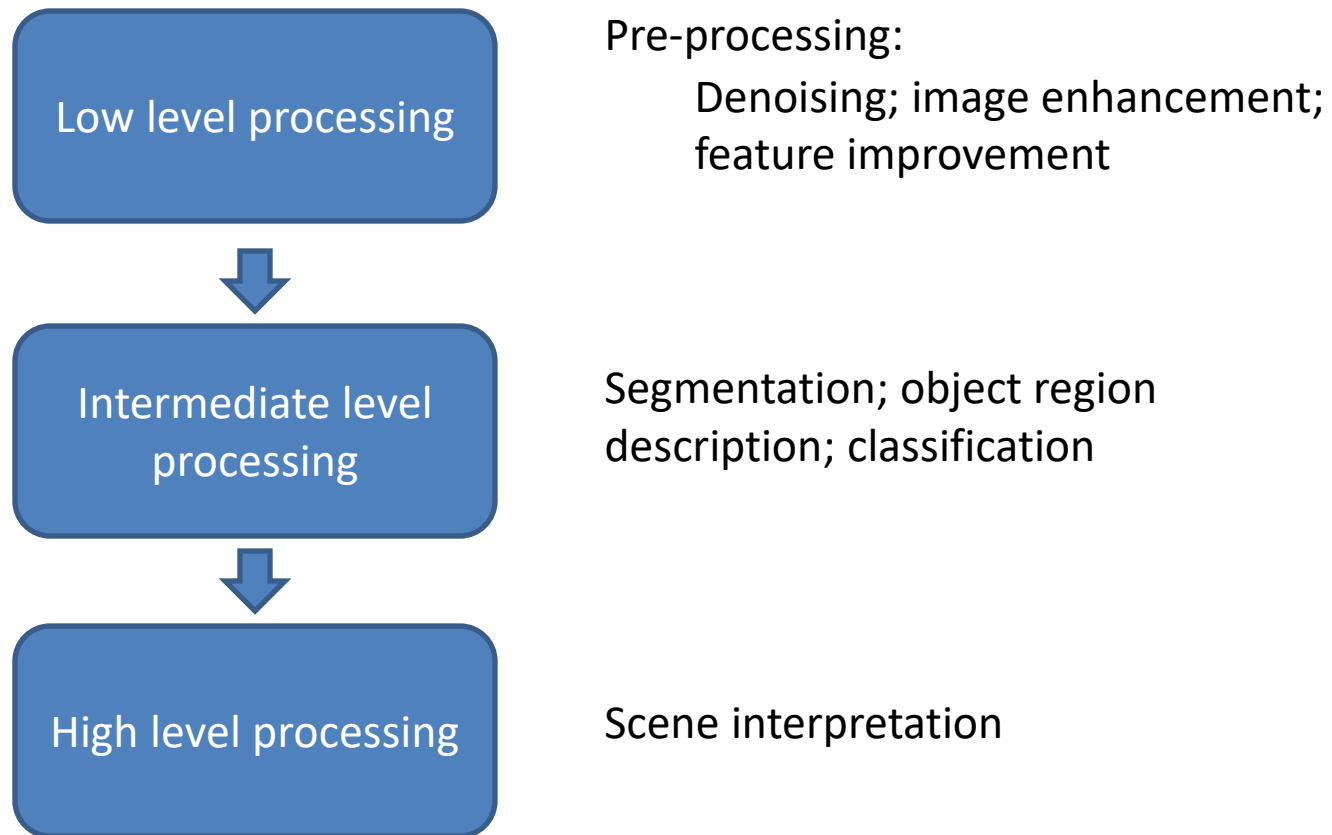
Encompasses processes whose inputs and outputs are images, also it encompasses processes of features extraction

Related research areas

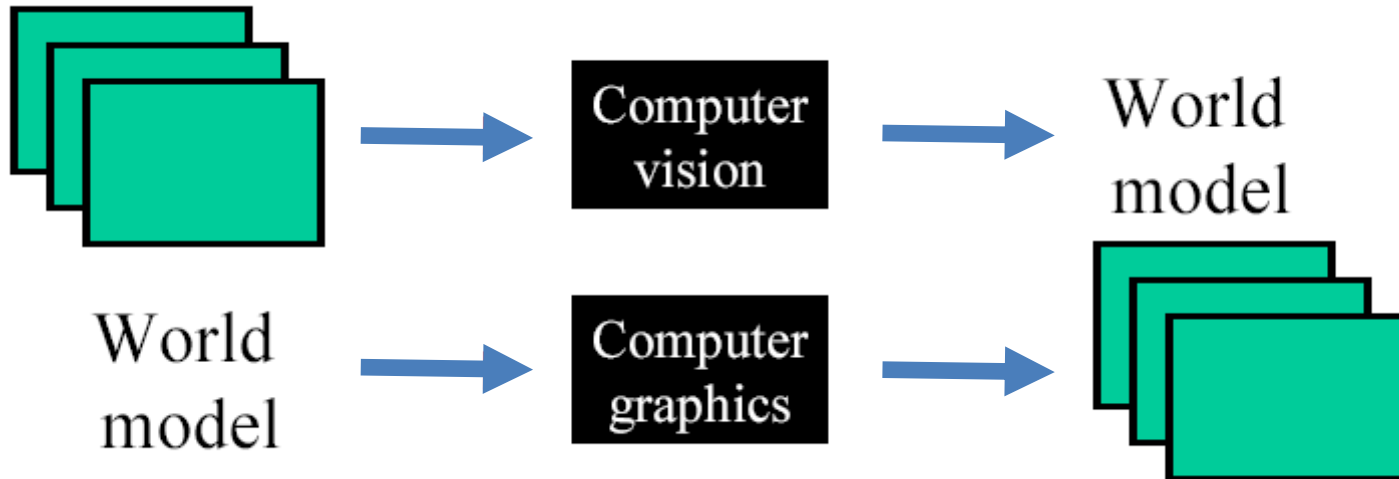
- *Image understanding*
- *Image Analysis*
- *Computer Vision*
- *Computer Graphics*
- Pattern Recognition
- *Artificial Intelligence*
- Etc...

Frontiers between CV and IP

- Fuzzy! (not well defined)



Computer Vision and Computer Graphics



Digital imaging: some history



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

Jet Propulsion Laboratory (Pasadena, California) -> *birth of the PDI*

Harry G. Bartholom
and
Maynard D. McFarlane



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.)

Digital images throughout history

- Landmark points in digital age

1940 - John von Neumann Machine (CPU);

1948 - Invention of the transistor (Bell Labs);

1950/60 – Language development such as COBOL e FORTRAN;

1958 – Invention of the integrated circuit (Texas);

1960 – Development of the operating systems;

1970 – Development of the microprocessors (Intel);

1981 – Introduction of the personal computers (IBM – International Business Machines);

1980 – Components miniaturisation (LI, VLSI, ULSI), for storing and visualization.

Digital images throughout history

- Landmark points in digital age

2000- GPU [GeForce GTX 1070 – Nvidia](#)

GPU [GeForce GTX 1080 – Nvidia](#)

GPU [NVIDIA TITAN X Graphics Card](#)

TPU [TENSOR Processor Unit](#)

Applications

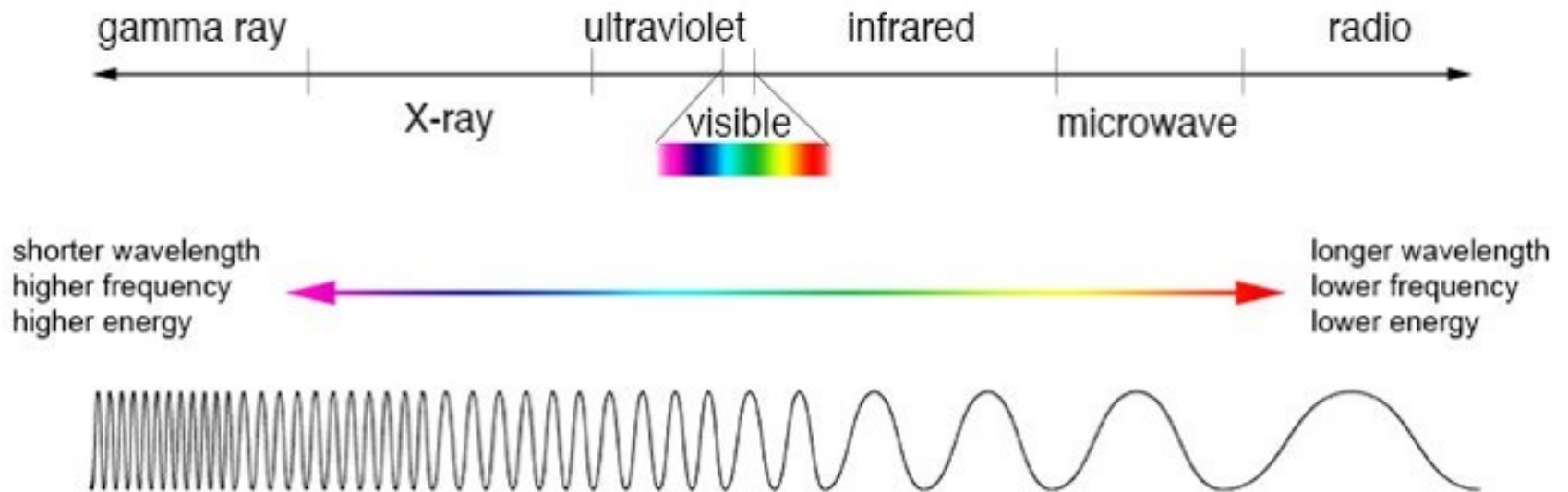
- Is there any area where image digital processing is not used?

One way to describe its application is to resort to the signal energy font:

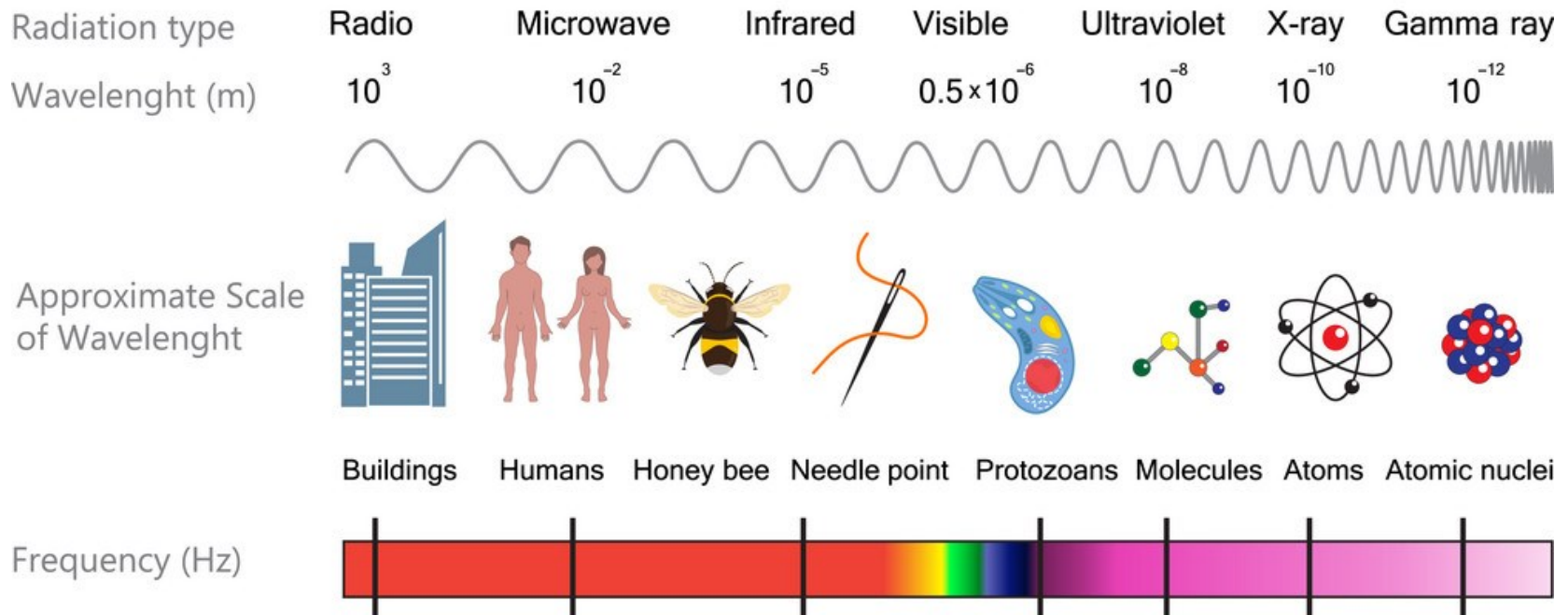
- Electromagnetic;
- Acoustic;
- Ultra-sound;
- Electronic;

Electromagnetic Spectrum

(the main source of energy for images in use)



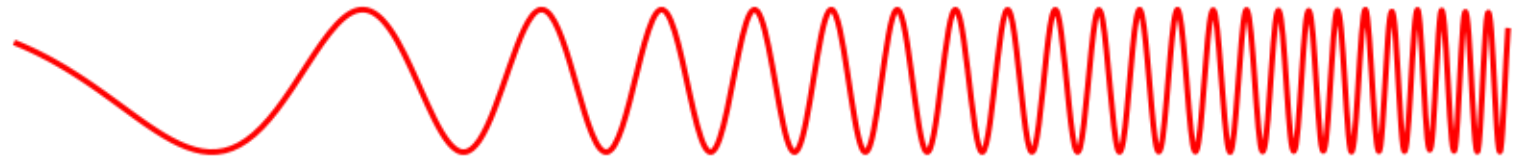
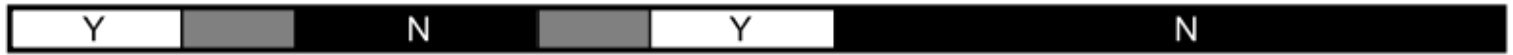
Electromagnetic Spectrum



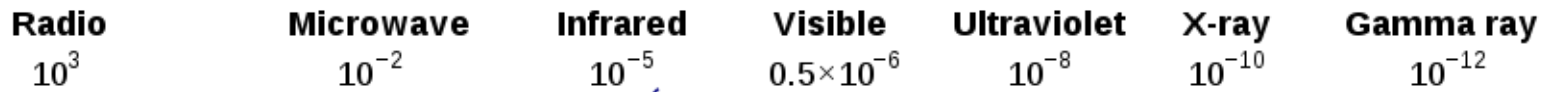
Electromagnetic Spectrum

(the main source of energy for images in use)

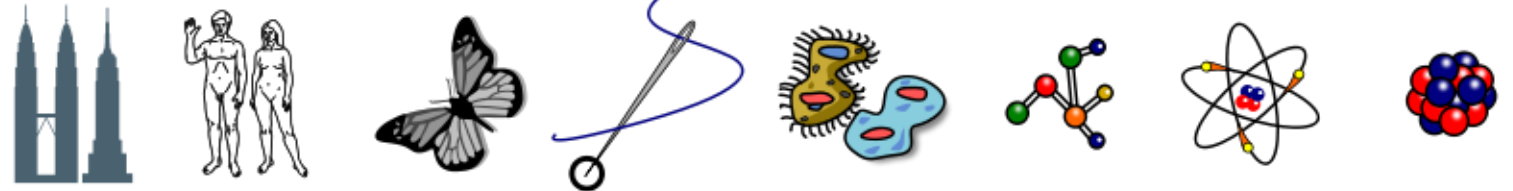
Penetrates Earth's Atmosphere?



Radiation Type
Wavelength (m)

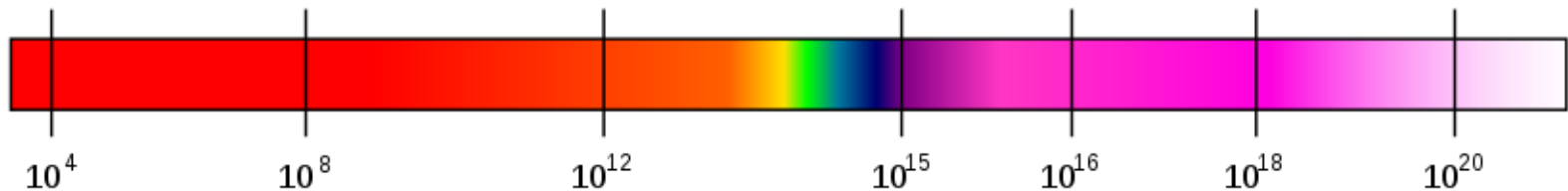


Approximate Scale
of Wavelength



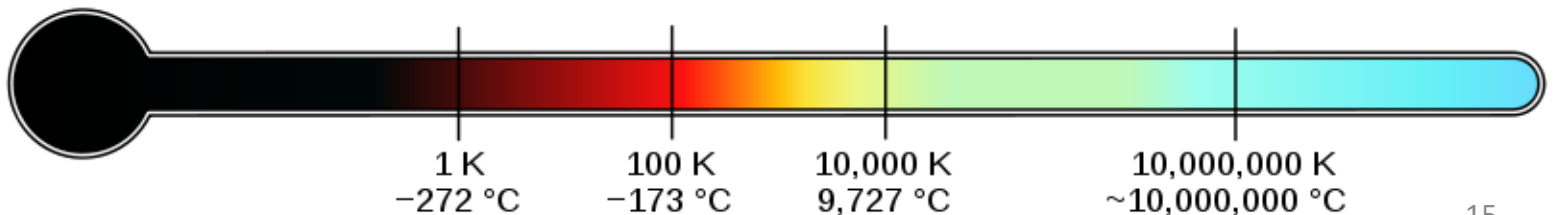
Buildings Humans Butterflies Needle Point Protozoans Molecules Atoms Atomic Nuclei

Frequency (Hz)



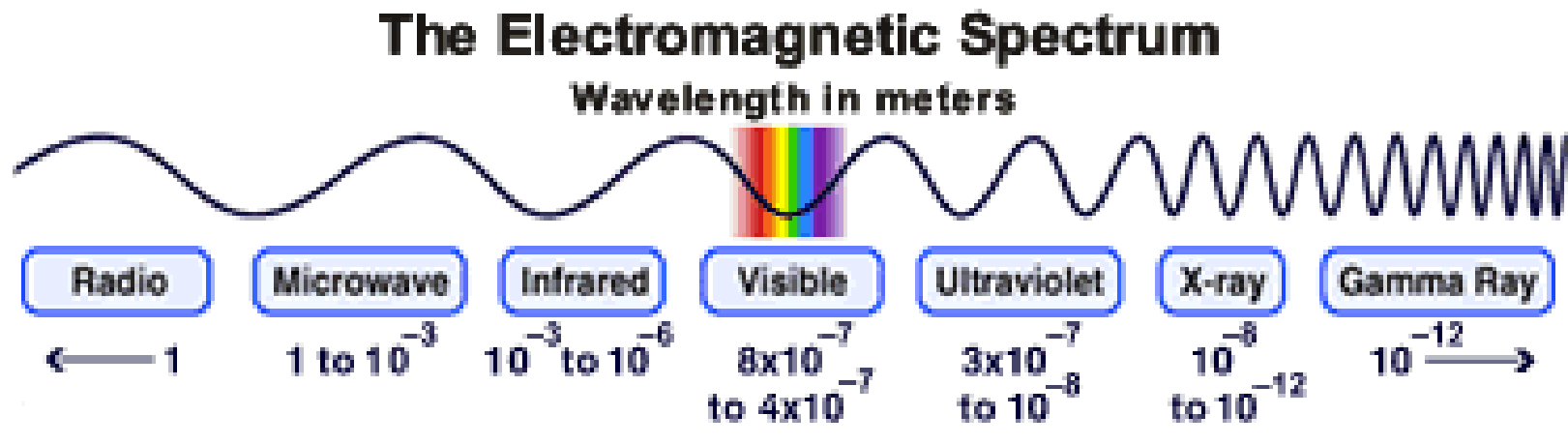
Temperature of
objects at which
this radiation is the
most intense
wavelength emitted

CVI

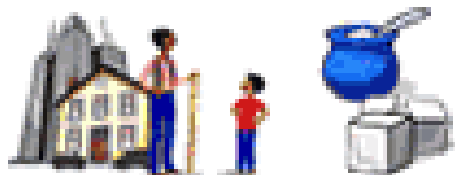


Electromagnetic Spectrum

(the main source of energy for images in use)



About the size of:



Buildings

Grains
of sugar



Protozoans



Bacteria



Molecules



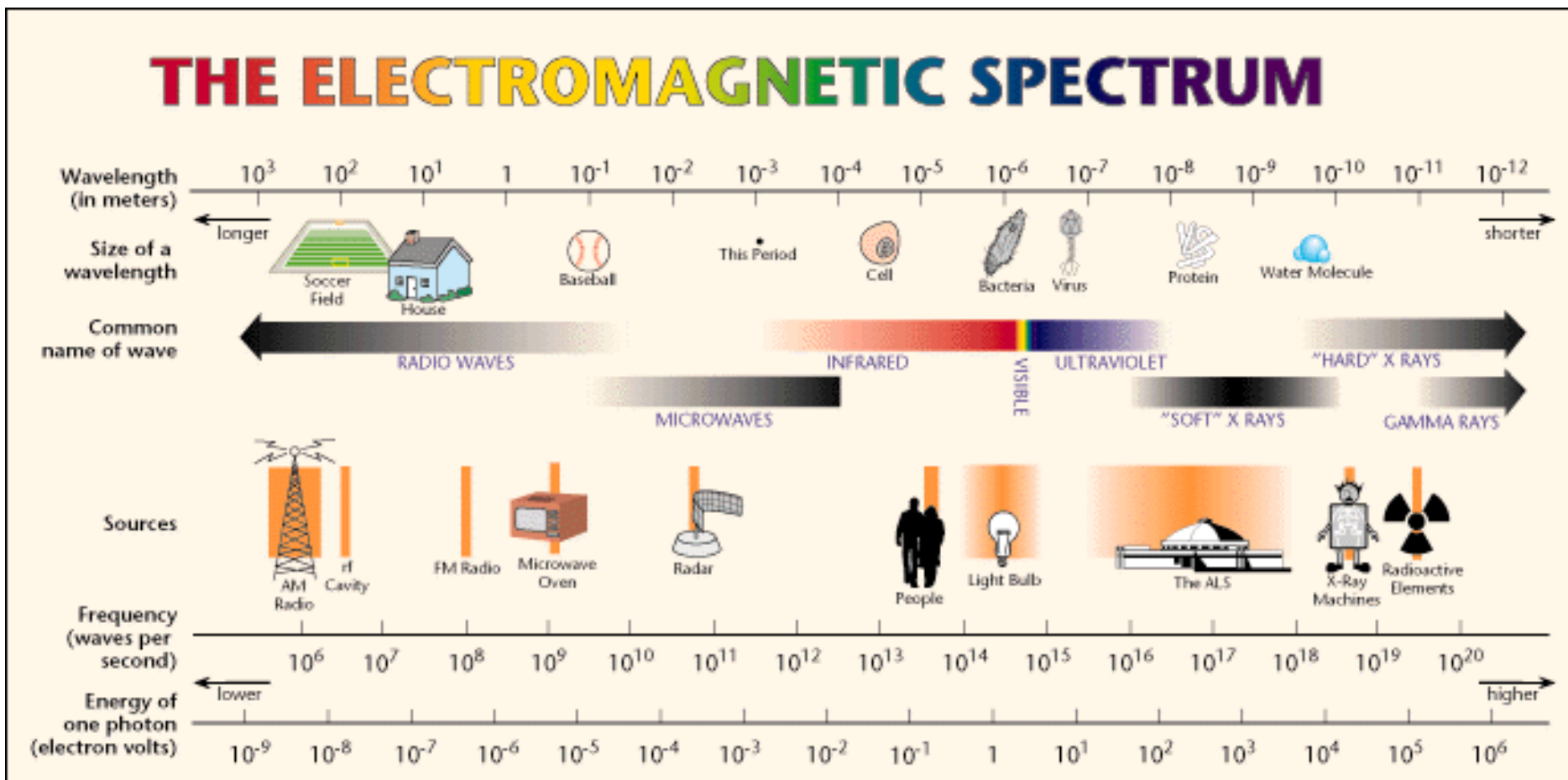
Atoms



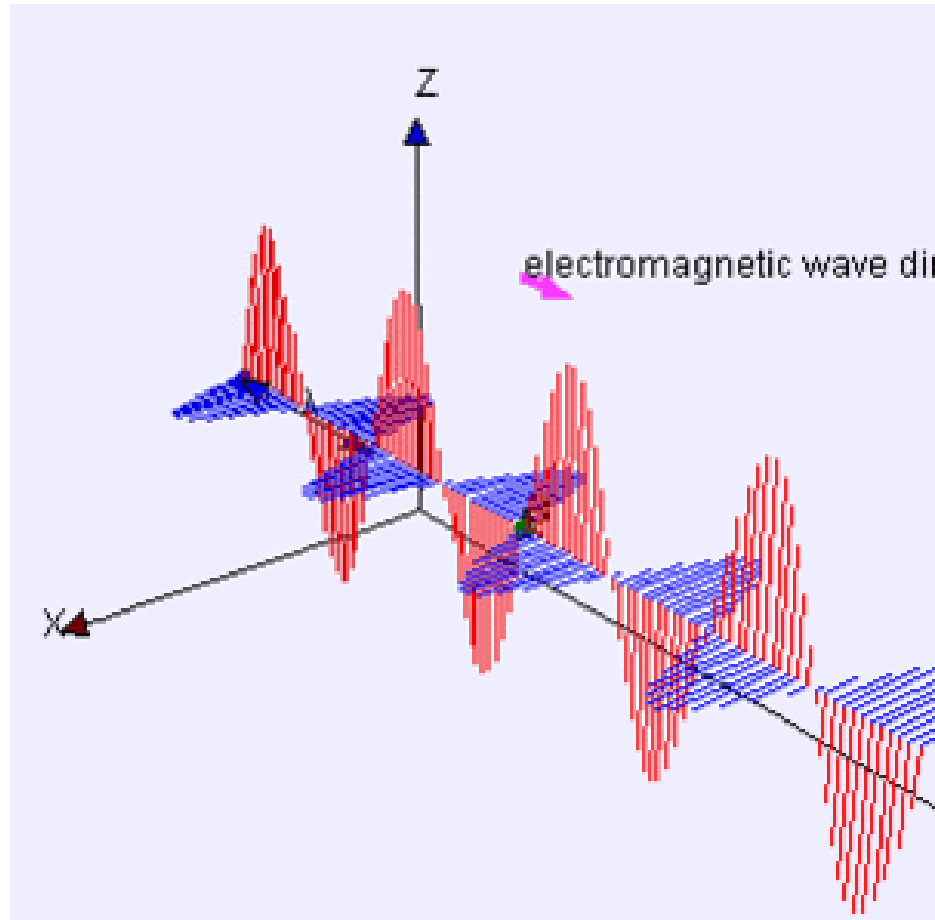
Atomic
nuclei

Electromagnetic Spectrum

(the main source of energy for images in use)



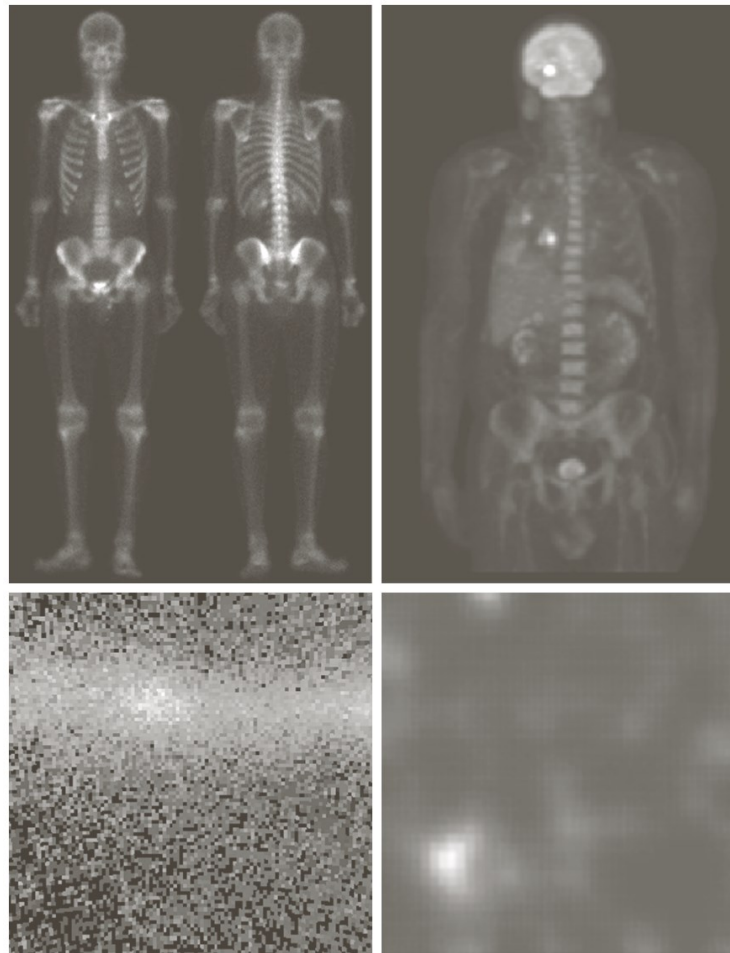
Behaviour of the Electromagnetic Waves



Imaging in Gamma ray

Applications in
Nuclear medicine

A star in the
constellation
of Cygnus
that exploded
generating
gas clouds



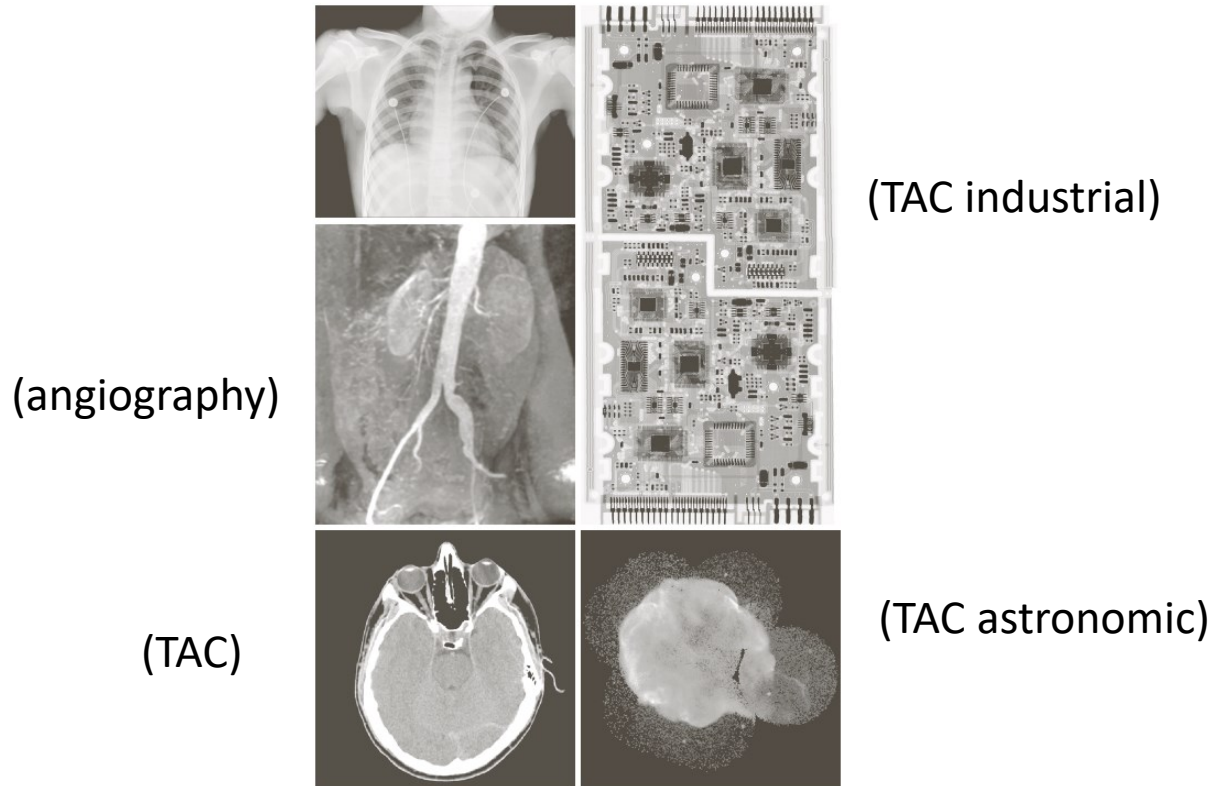
a b
c d

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.)

Image of gamma
radiation from a valve in
a nuclear reactor

Imaging in X ray

(are among the oldest sources of EM, best know use in medical diagnosis, e.g. Tomography)

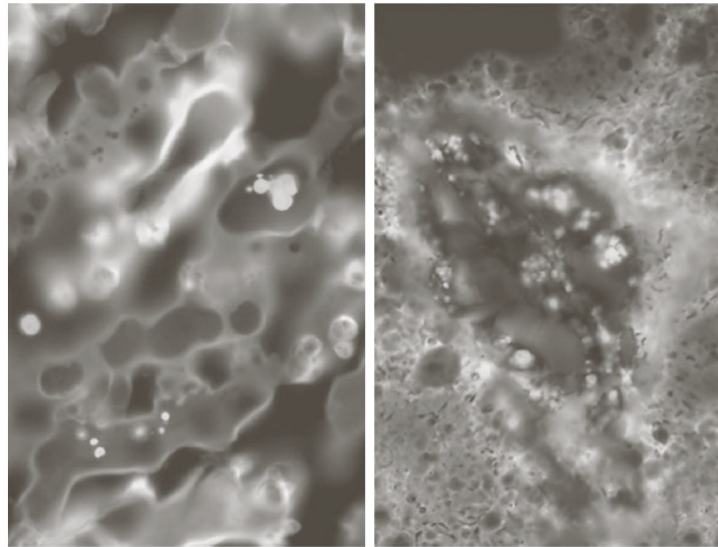


a	d
b	
c	e

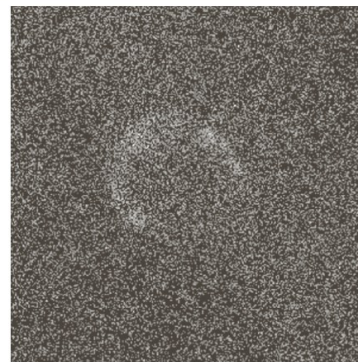
FIGURE 1.7 Examples of X-ray imaging. (a) Chest X-ray. (b) Aortic angiogram. (c) Head CT. (d) Circuit boards. (e) Cygnus Loop. (Images courtesy of (a) and (c) Dr. David R. Pickens, Dept. of Radiology & Radiological Sciences, Vanderbilt University Medical Center; (b) Dr. Thomas R. Gest, Division of Anatomical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

Imaging in the UV band

(fluorescent microscopy)



(astronomy)



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

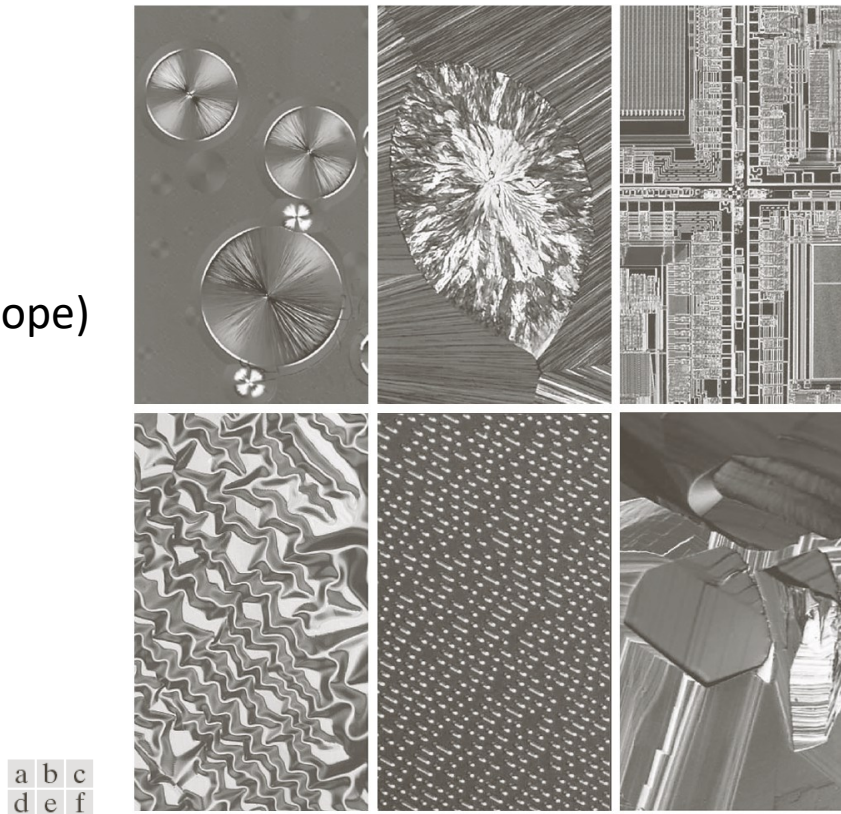
University,

(c) NASA.)

(Cygnus Loop in high-region of the ultraviolet band)

Imaging in the visible and infrared Band (1)

(Images obtained
with a light microscope)



These examples range from
Pharmaceutical and
Micro-inspection to material
characterization

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.)

Imaging in the visible band (2)

Satellite image with a hurricane

Weather observation and prediction

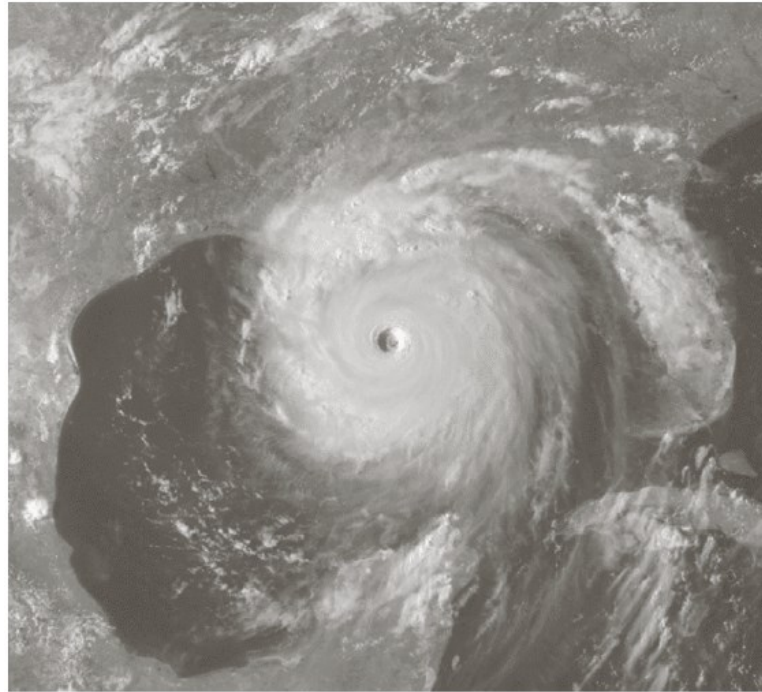
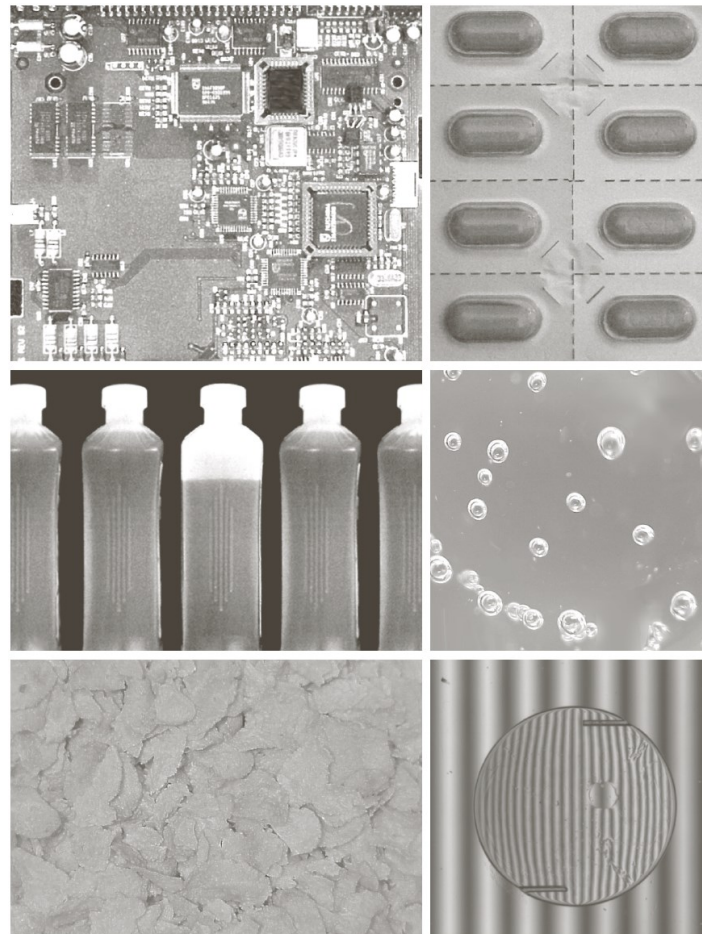


FIGURE 1.11
Satellite image
of Hurricane
Katrina taken on
August 29, 2005.
(Courtesy of
NOAA.)

Imaging in the visible band (3)

Automatic visual inspection



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.)

Imaging in the visible band (4)

(which we are more accustomed to seeing)



a b
c
d

FIGURE 1.15
Some additional examples of imaging in the visible 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.)

Imaging in infrared band (1)

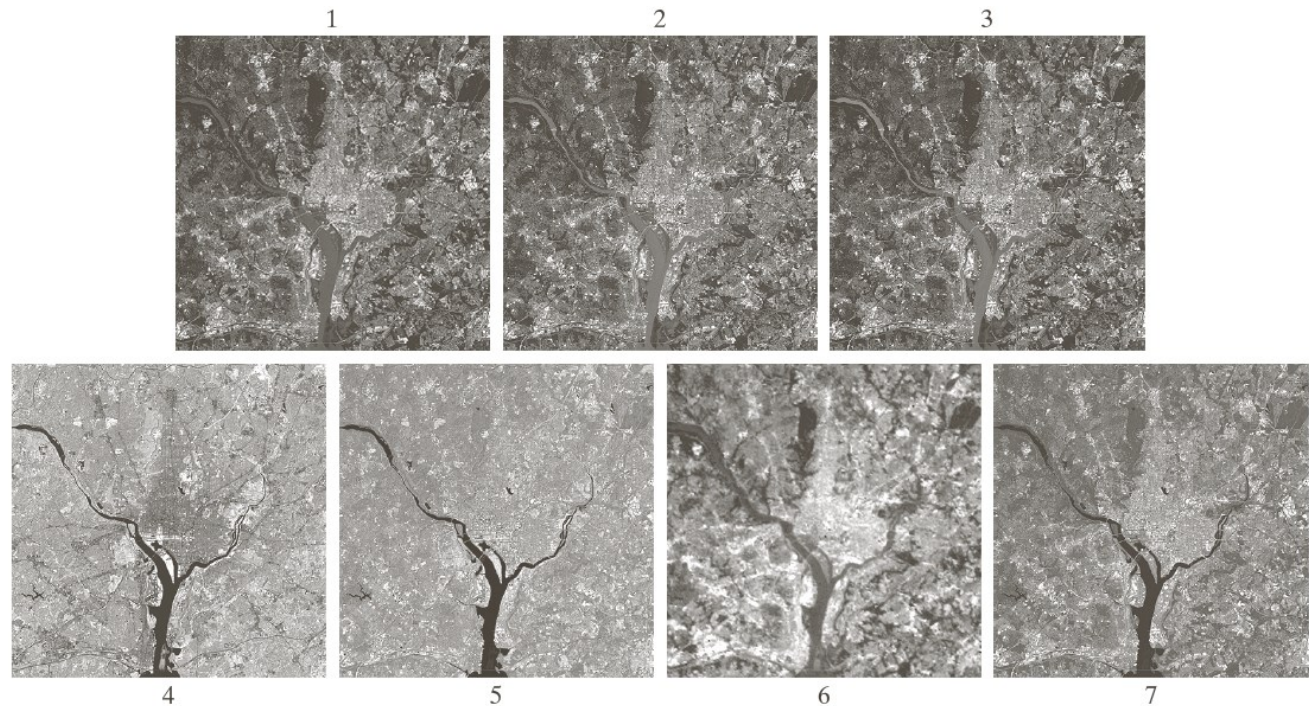


FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)

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.

Imaging in infrared band (2)

Unique capability
to observe faint
sources of
visible near
infrared emissions
presente on Earth.



Including cities, towns, villages,
gas flares and fires

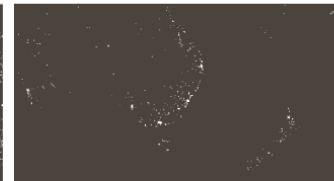
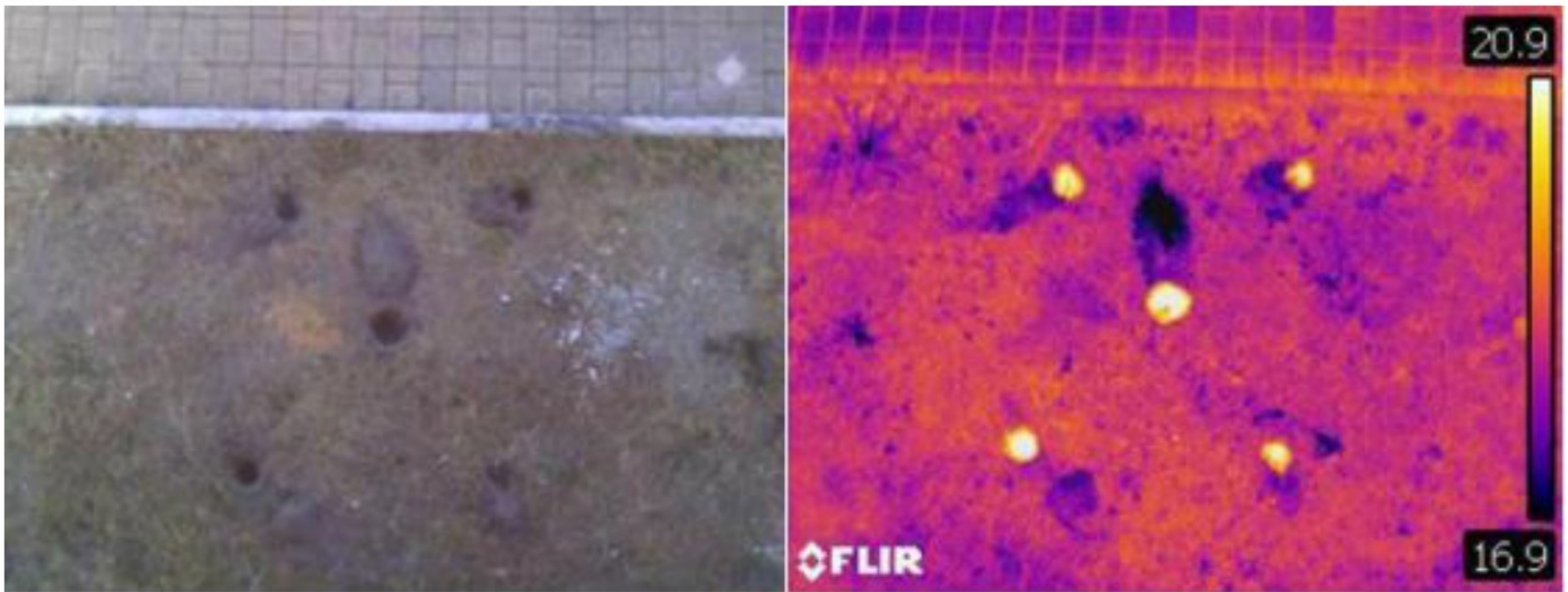


FIGURE 1.13
Infrared satellite
images of the
remaining
populated part of
the world. The
small gray map is
provided for
reference.
(Courtesy of
NOAA.)

Imaging in infrared band

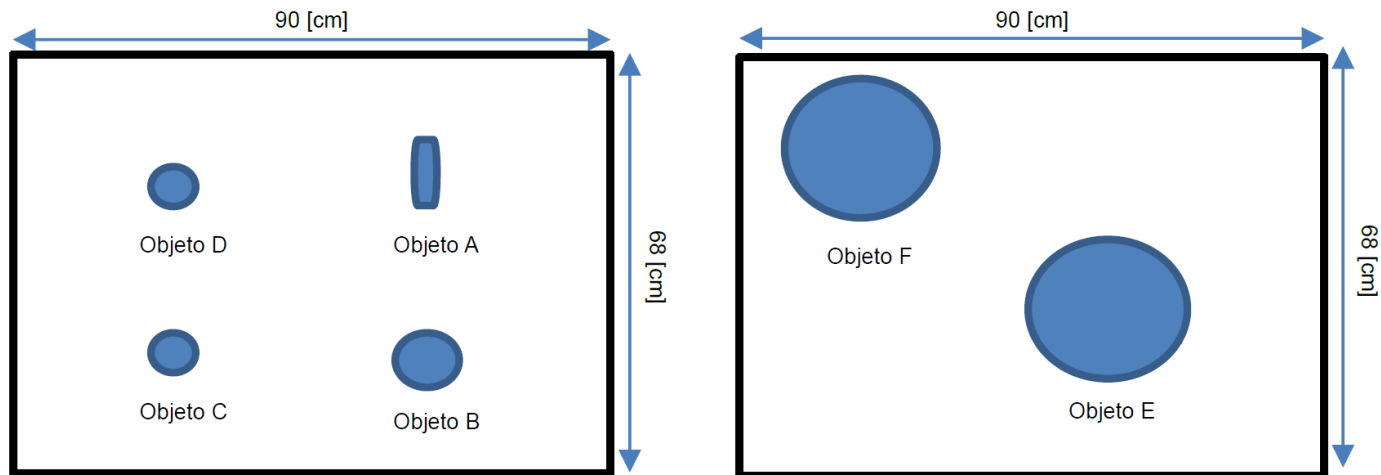
Mine detection



RGB image containing five mines under the ground (left), and the corresponding infra-red image (right)

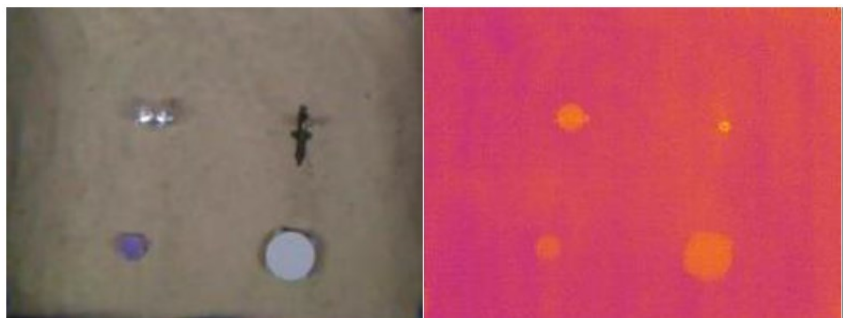
Imaging in infrared band

Mine detection – mine-laying diagram



Imaging in infrared band

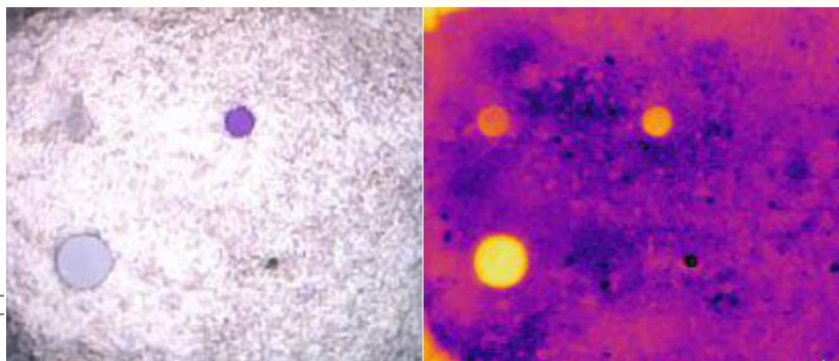
Mine detection – burying the mines



The mines are placed at the surface



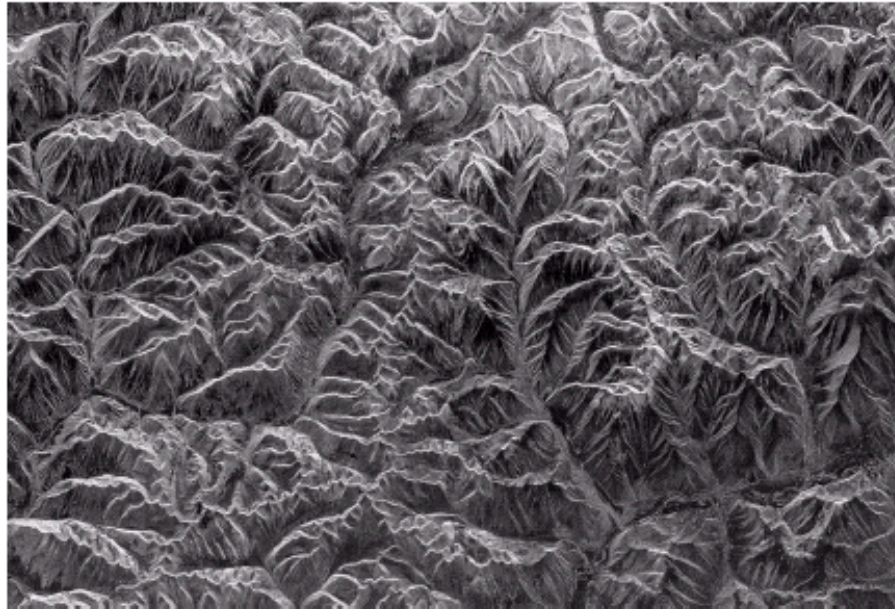
The mines are buried at 1-10 mm deeper



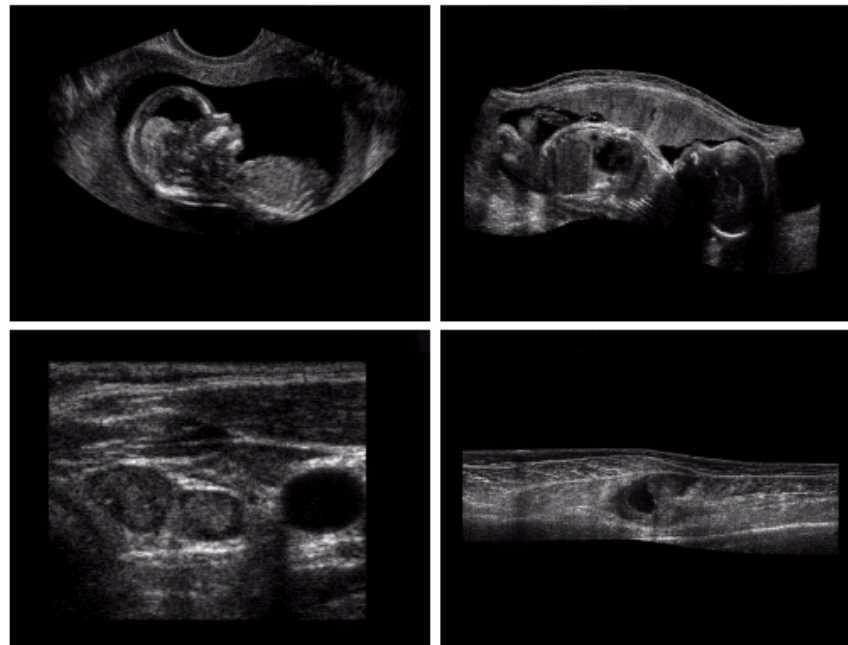
The mines are buried at 1-10 mm deeper

Imaging in the microwave band

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



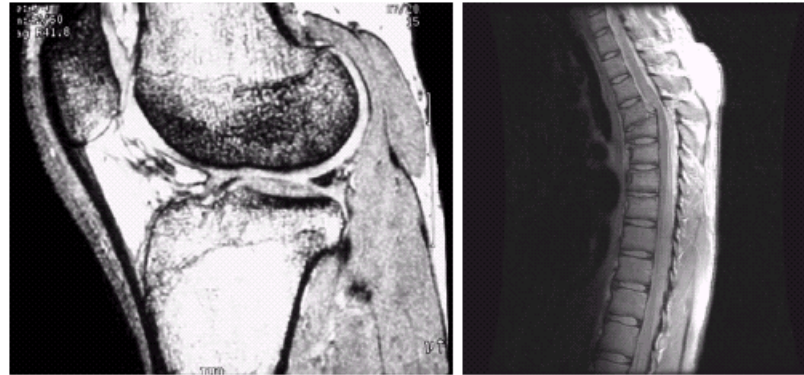
Imaging in Ultrasound



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.)

Imaging in the radio band (I)



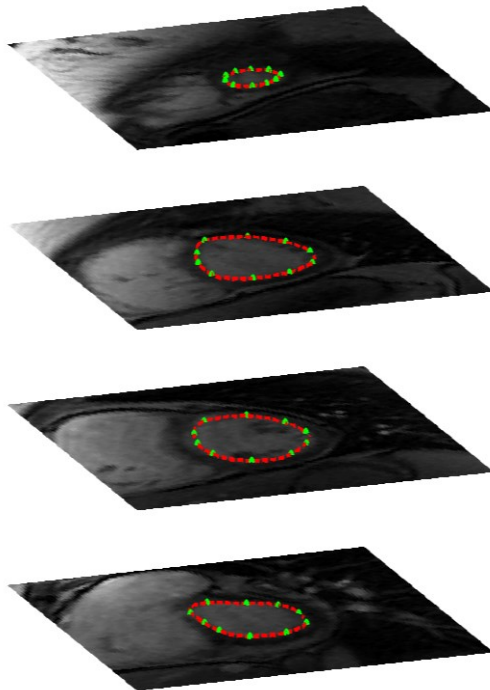
a b

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.)

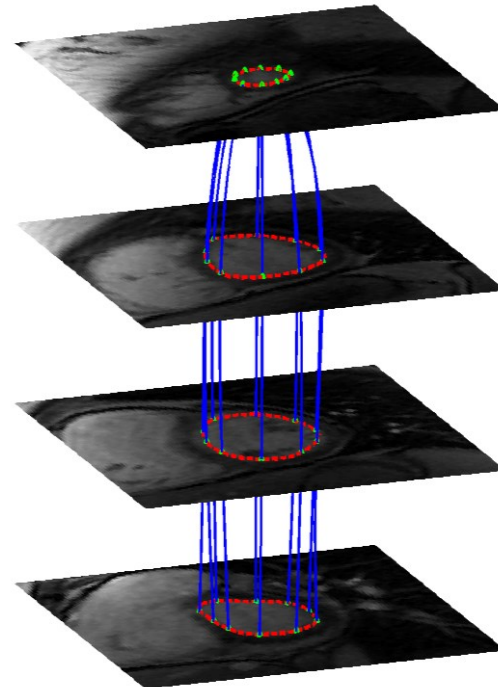
Human knee and spine (e.g.
chondromalacia in the knee)

Imaging in the radio band (II)

Available
Annotations

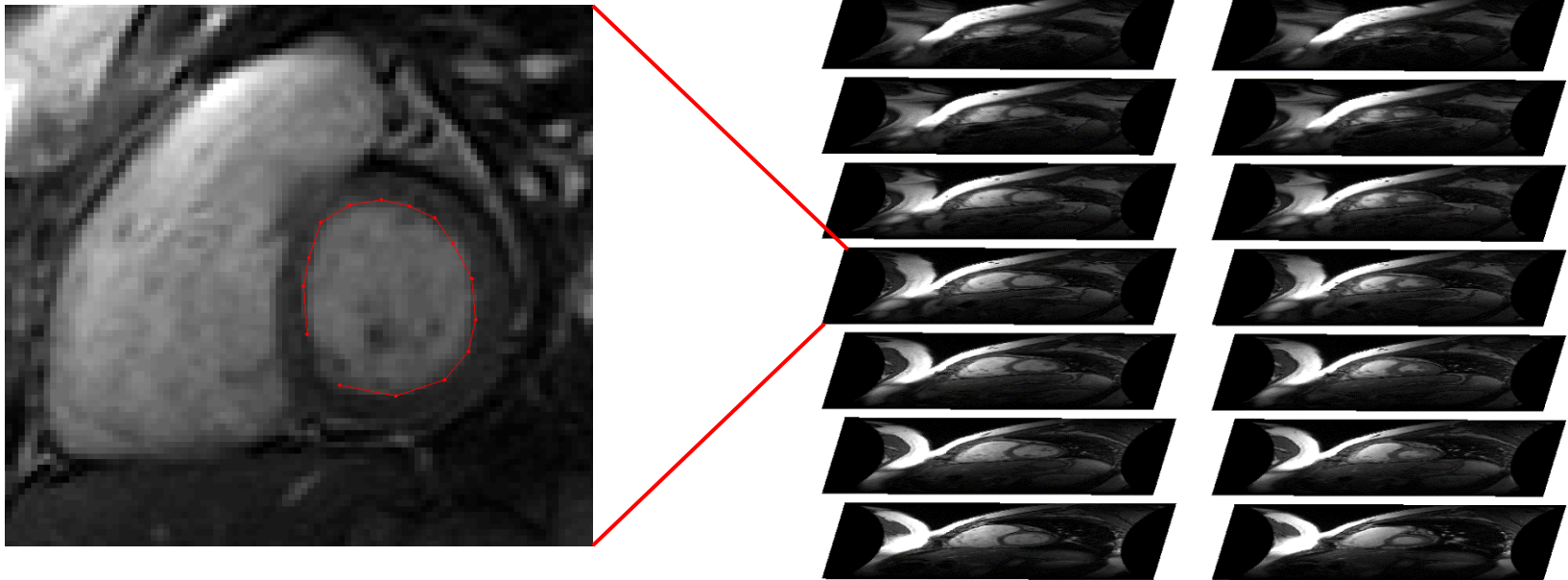


Interpolation
Model



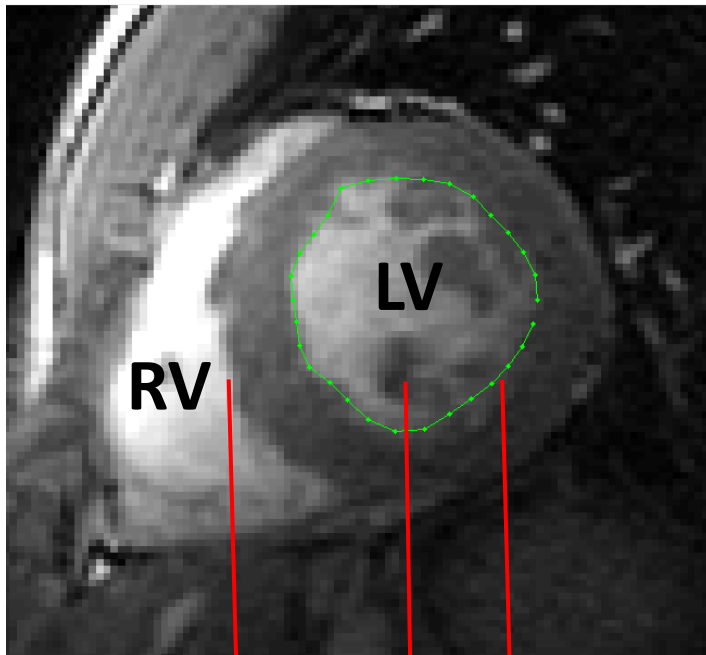
Imaging in the radio band (III)

Application to the segmentation of the endocardium of the left ventricle (in 3D)



Imaging in the radio band (IV)

Goal – Segmenting the endocardium of the LV

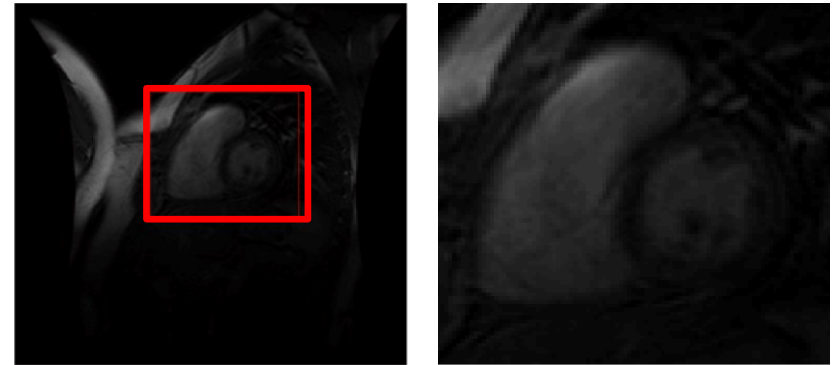


Epicardium

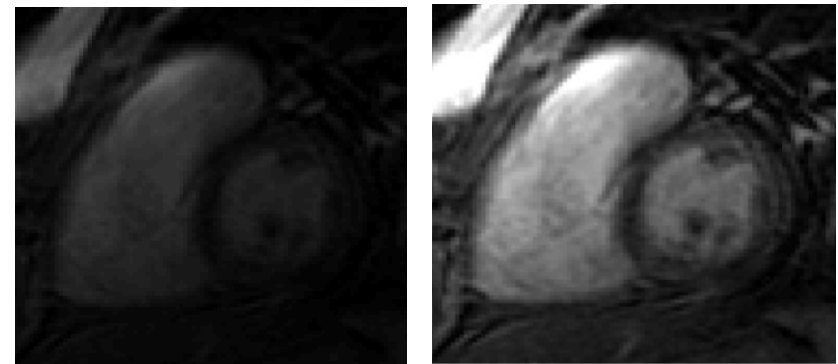
Endocardium

Papillary muscles

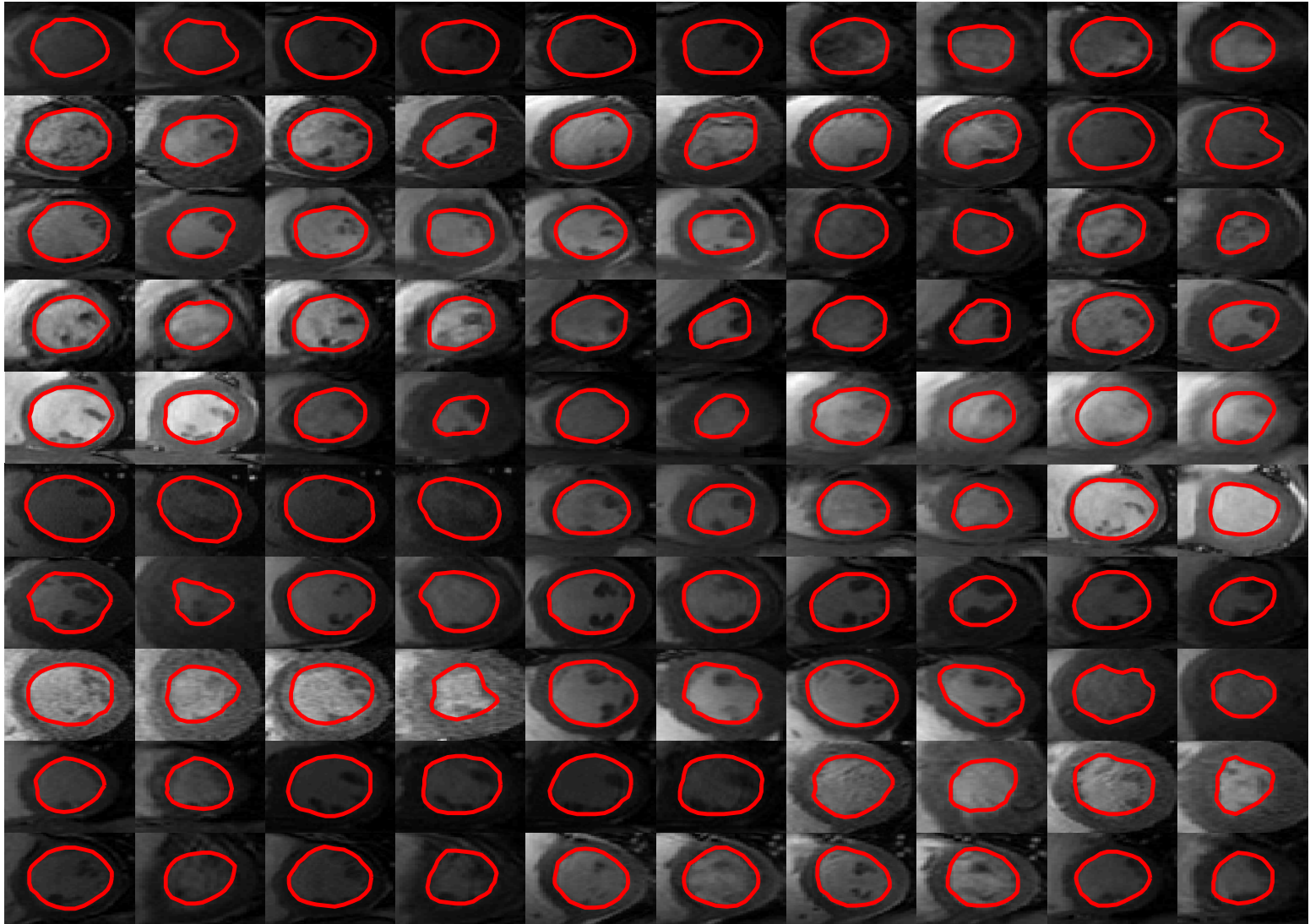
1) ROI (region of interest)



2) Adjustment of the intensity



Imaging in the radio band (V)



Imaging in several bands

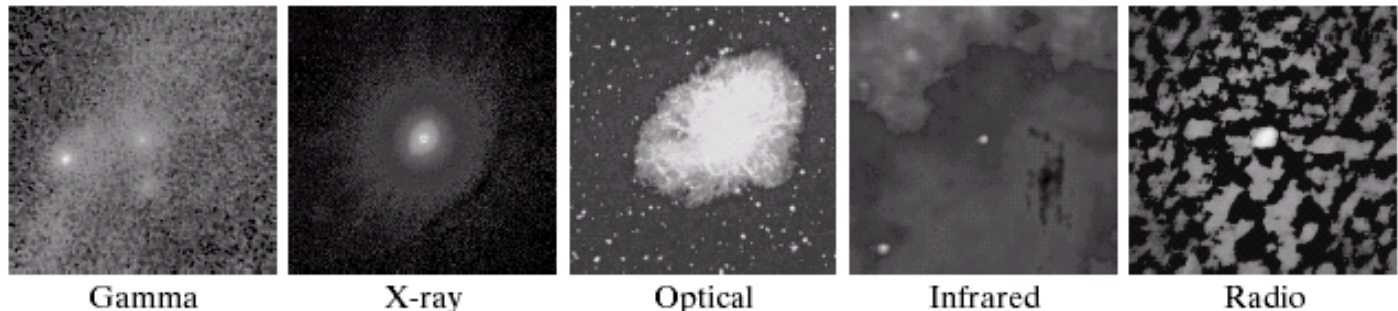
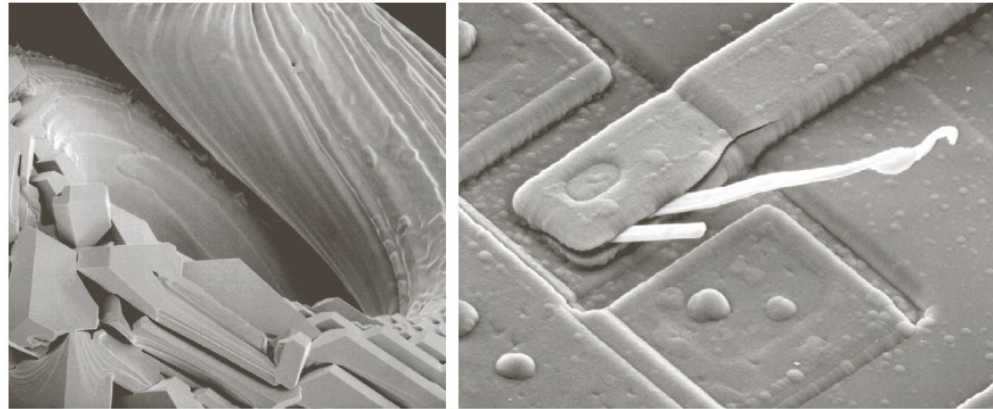


FIGURE 1.18 Images of the Crab Pulsar (in the center of images) covering the electromagnetic spectrum. (Courtesy of NASA.)

Images of the Crab Pulsar, that is a star. Notice that, there is a significant difference of the same region, if we change the image modality.

Image Scanning electron microscope (SEM)

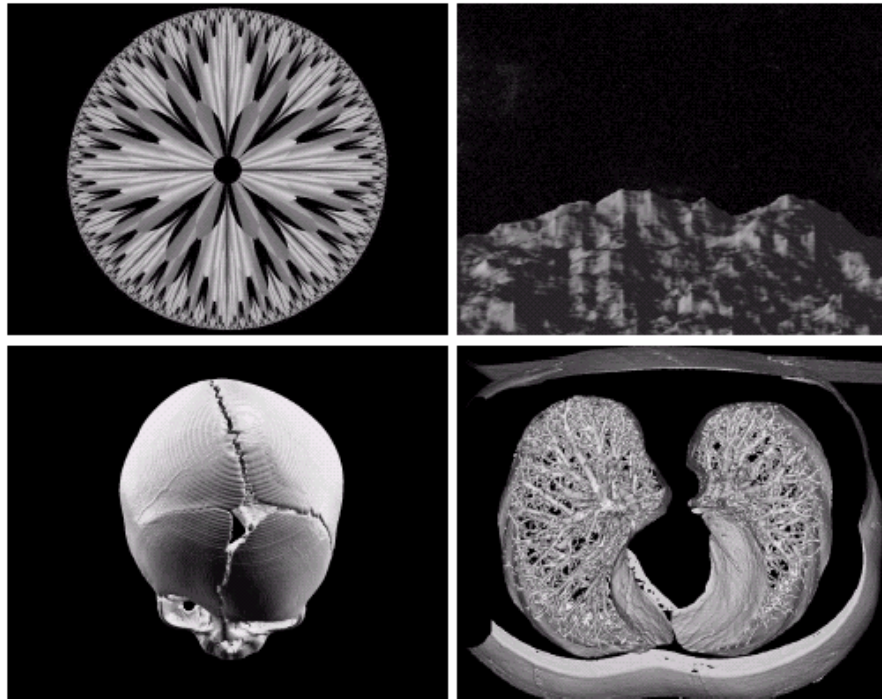


a b

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.)

Synthetic images

(Images that are not obtained from the physical properties of the objects)



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.)

Components of an Image Processing System

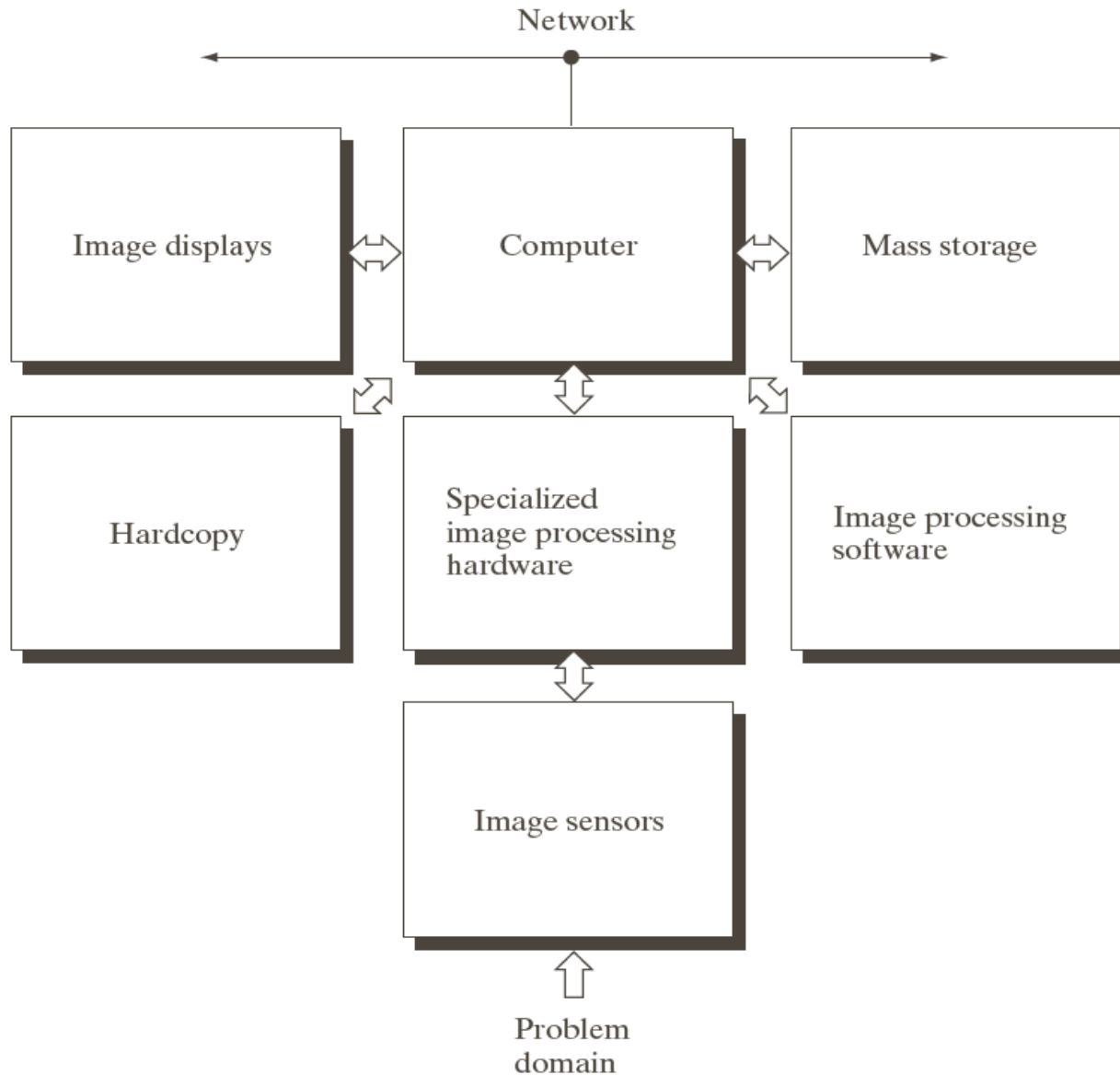


FIGURE 1.24
Components of a
general-purpose
image processing
system.

Readings

- Chapter 1 de R. Gonzalez, R. Woods, “Digital Image Processing”, 3rd edition, 2008.