# CAP 781
# MACHINE LEARNING

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# UNIT – IV
# Image Processing

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# Content

- Introduction to Digital Image Processing
- Image Enhancement Techniques
- Histogram Equalization
- Contrast Stretching, Filtering
- Image Segmentation
- Thresholding
- Region Based Segmentation
- Feature Extraction from Images
- Edge Detection
- Corner Detection
- Blob Detection
- Case Studies and Applications of Image Processing in Computer Vision

# Introduction

- What is Digital Image Processing?

**Digital Image**

— a two-dimensional function $f(x, y)$

*x* and *y* are spatial coordinates

The amplitude of *f* is called **intensity** or **gray level** at the point (x, y)

**Digital Image Processing**

— process digital images by means of computer, it covers low-, mid-, and high-level processes

low-level: inputs and outputs are images

mid-level: outputs are attributes extracted from input images

high-level: an ensemble of recognition of individual objects

**Pixel**

— the elements of a digital image

# Origins of Digital Image Processing

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

Sent by submarine cable between London and New York, the transportation time was reduced to less than three hours from more than a week

# Origins of Digital Image Processing

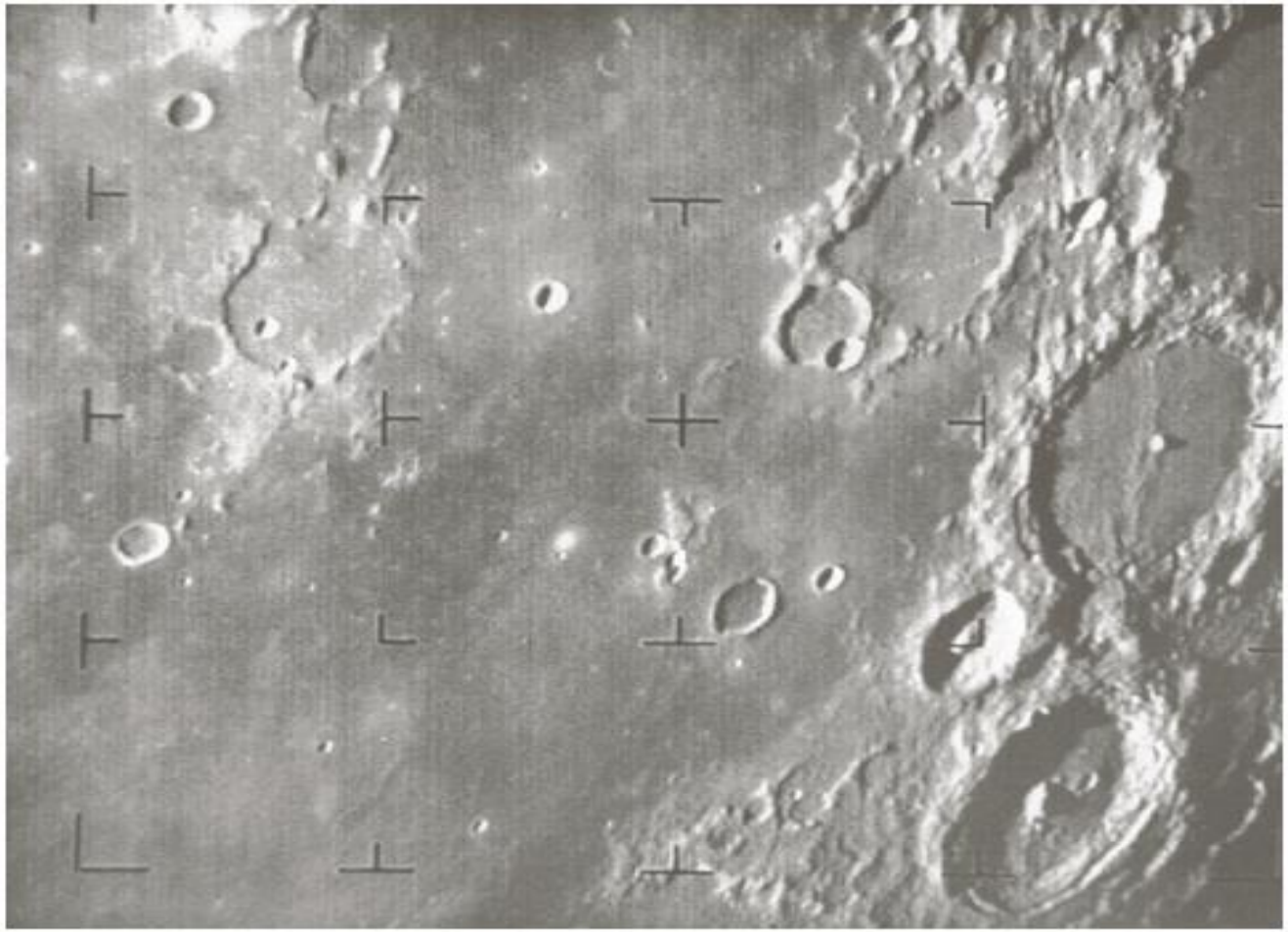
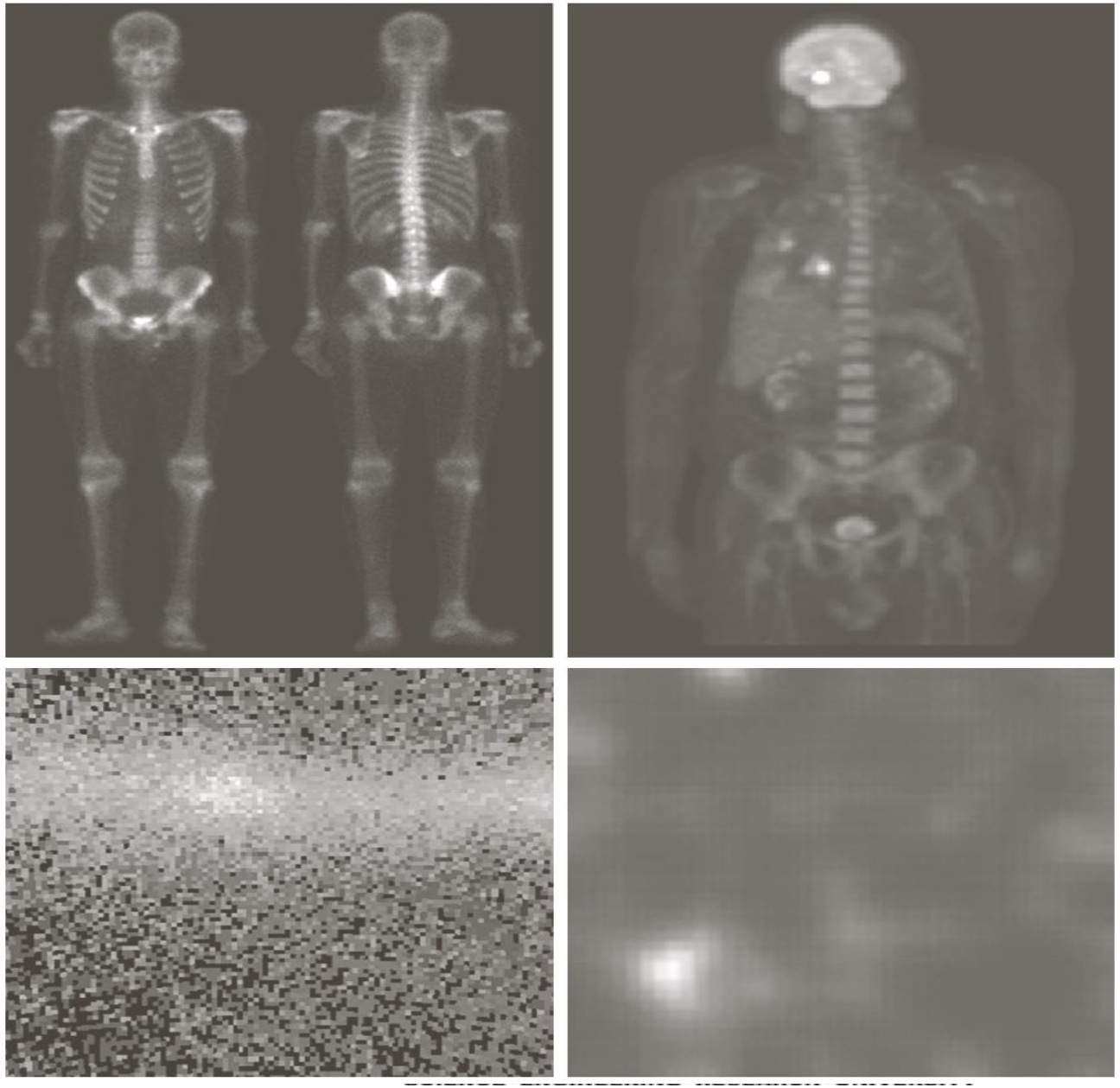


**FIGURE 1.4** The first picture of the moon by a U.S. spacecraft. *Ranger 7* took this image on July 31, 1964 at 9 : 09 A.M. EDT, about 17 minutes before impacting the lunar surface. (Courtesy of NASA.)

# Sources for Images

- Electromagnetic (EM) energy spectrum
- Acoustic
- Ultrasonic
- Electronic
- Synthetic images produced by computer

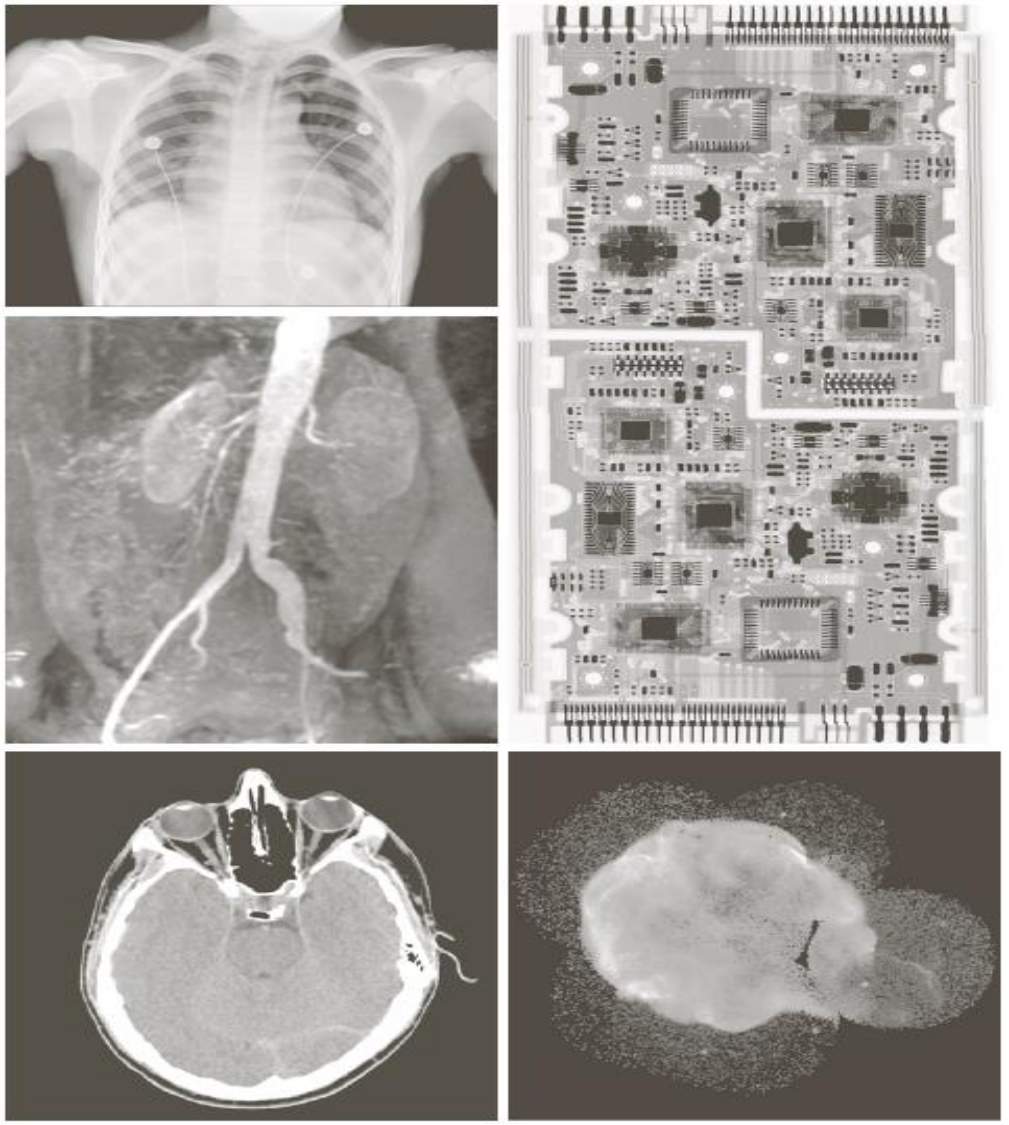
# Examples: Gama-Ray Imaging



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.)

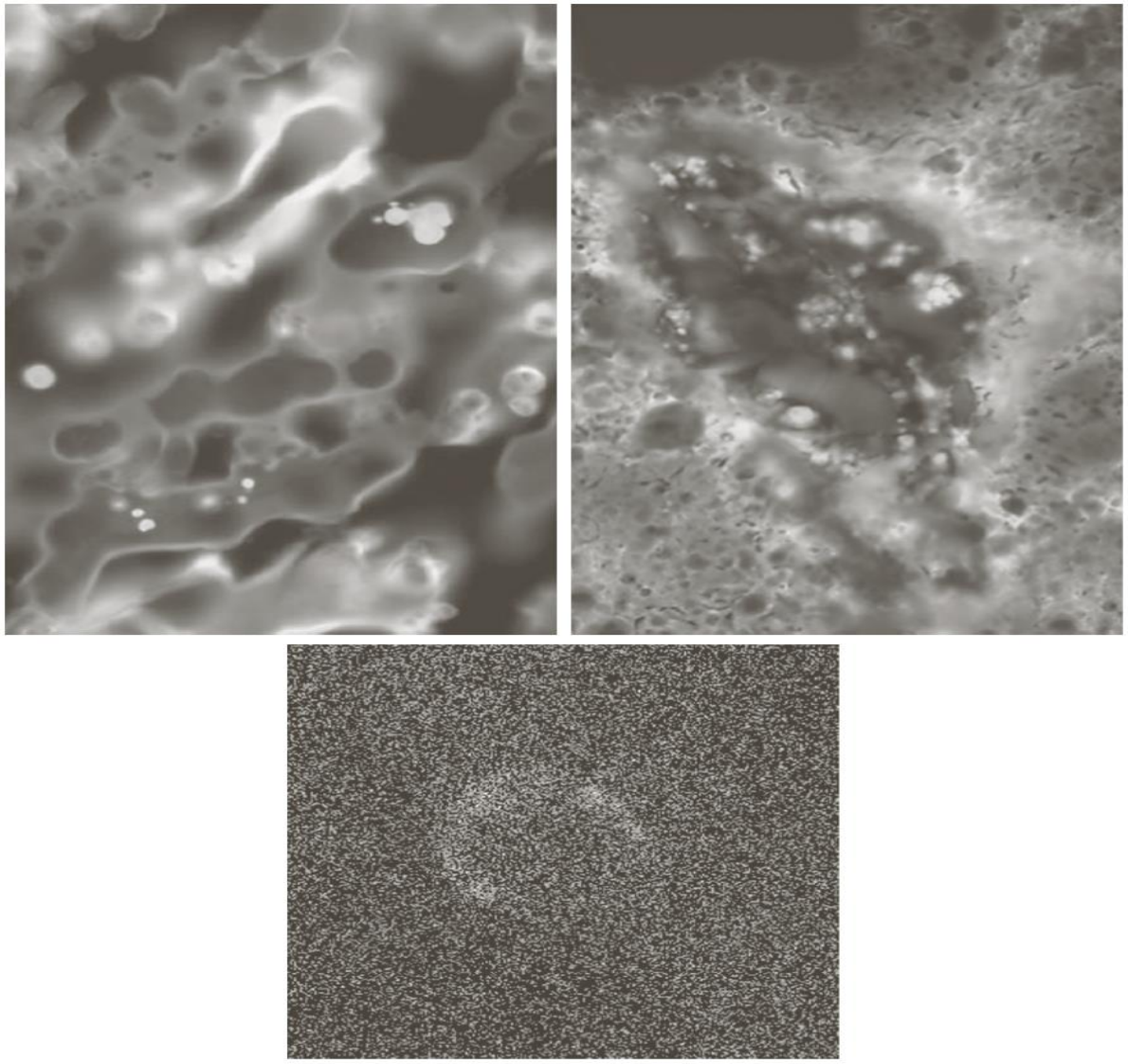
# Examples: X-Ray Imaging



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.)

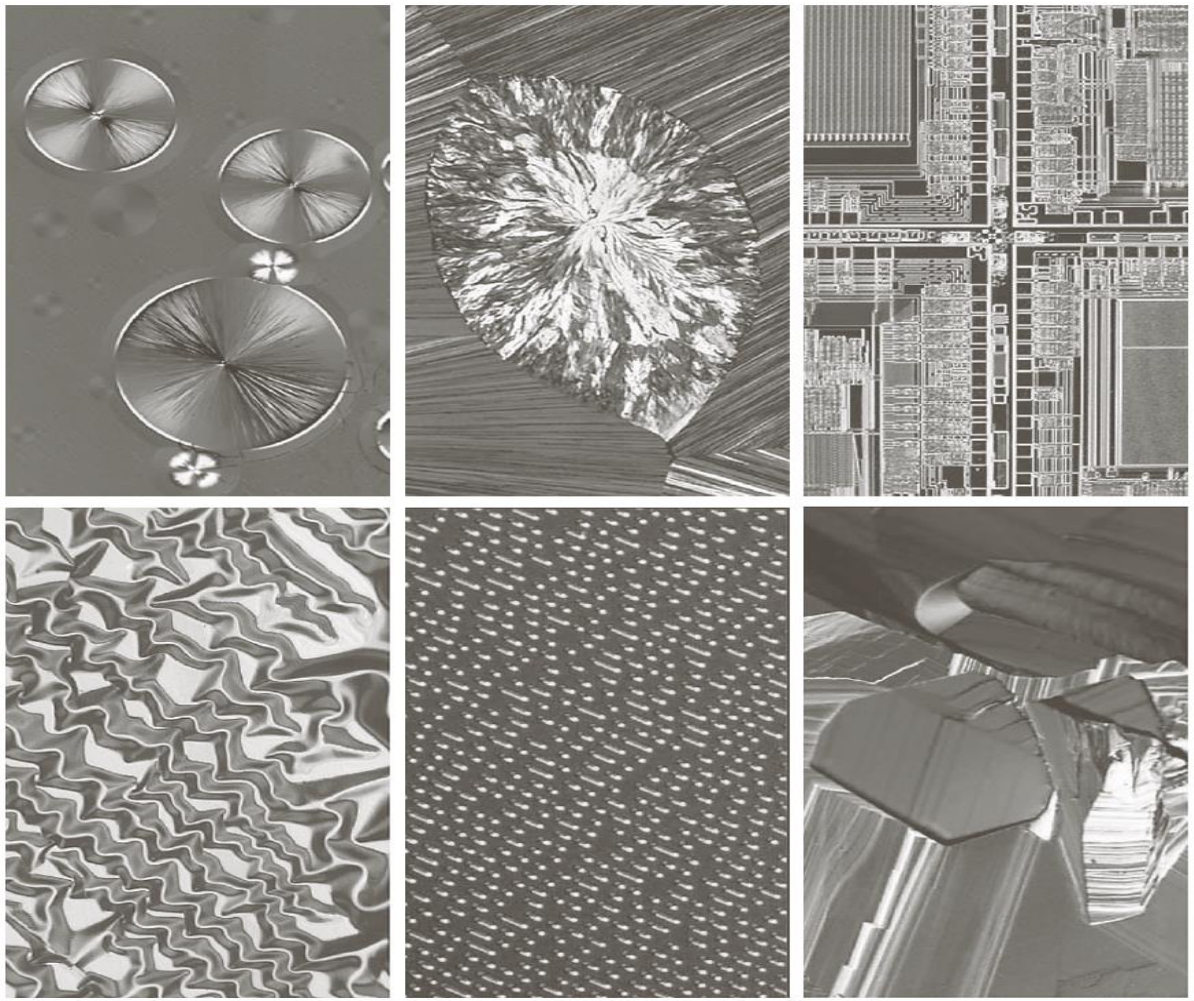
# Examples: Ultraviolet Imaging



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.)

# Examples: Light Microscopy Imaging



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.)

# Examples: Visual and Infrared Imaging

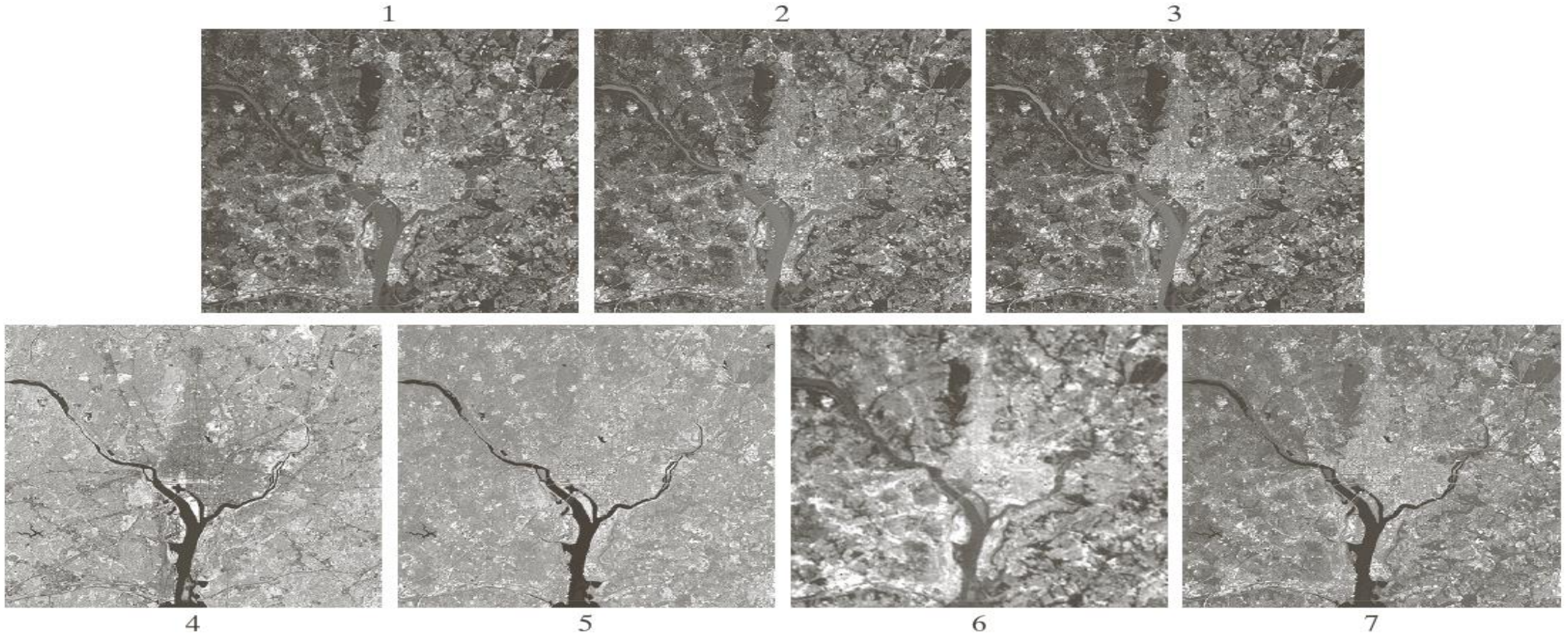
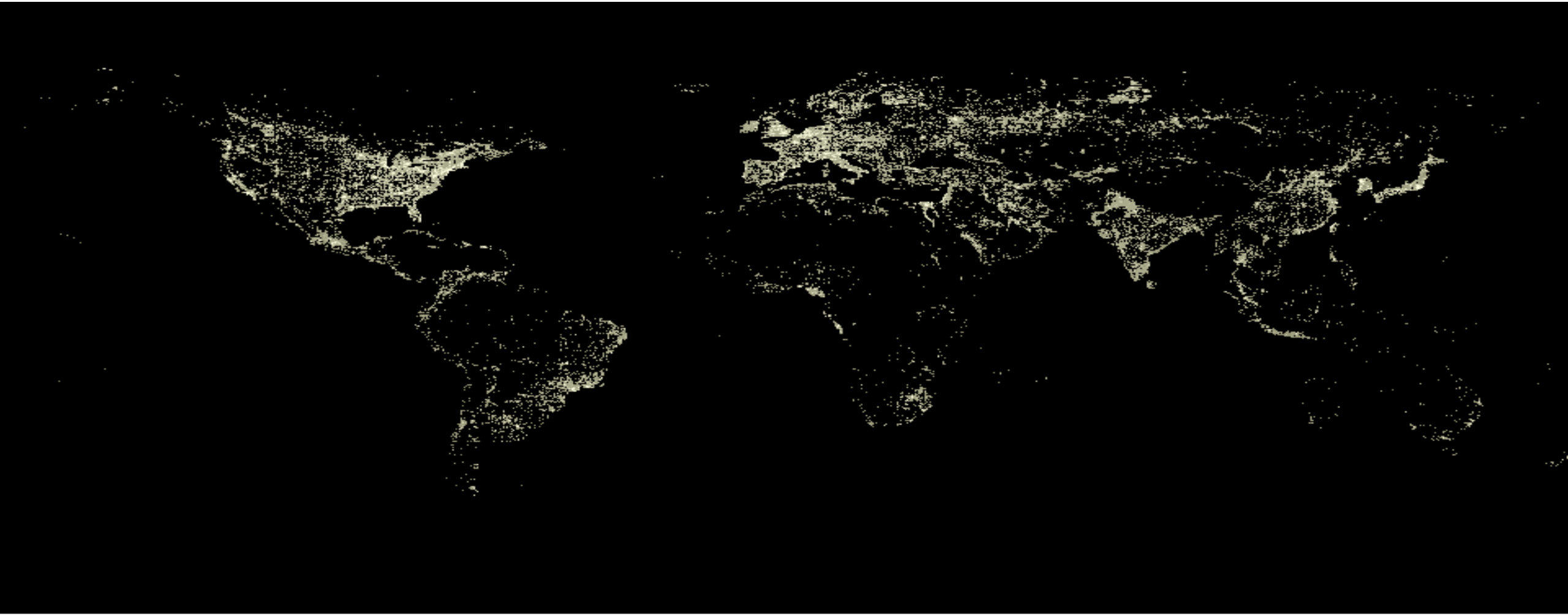


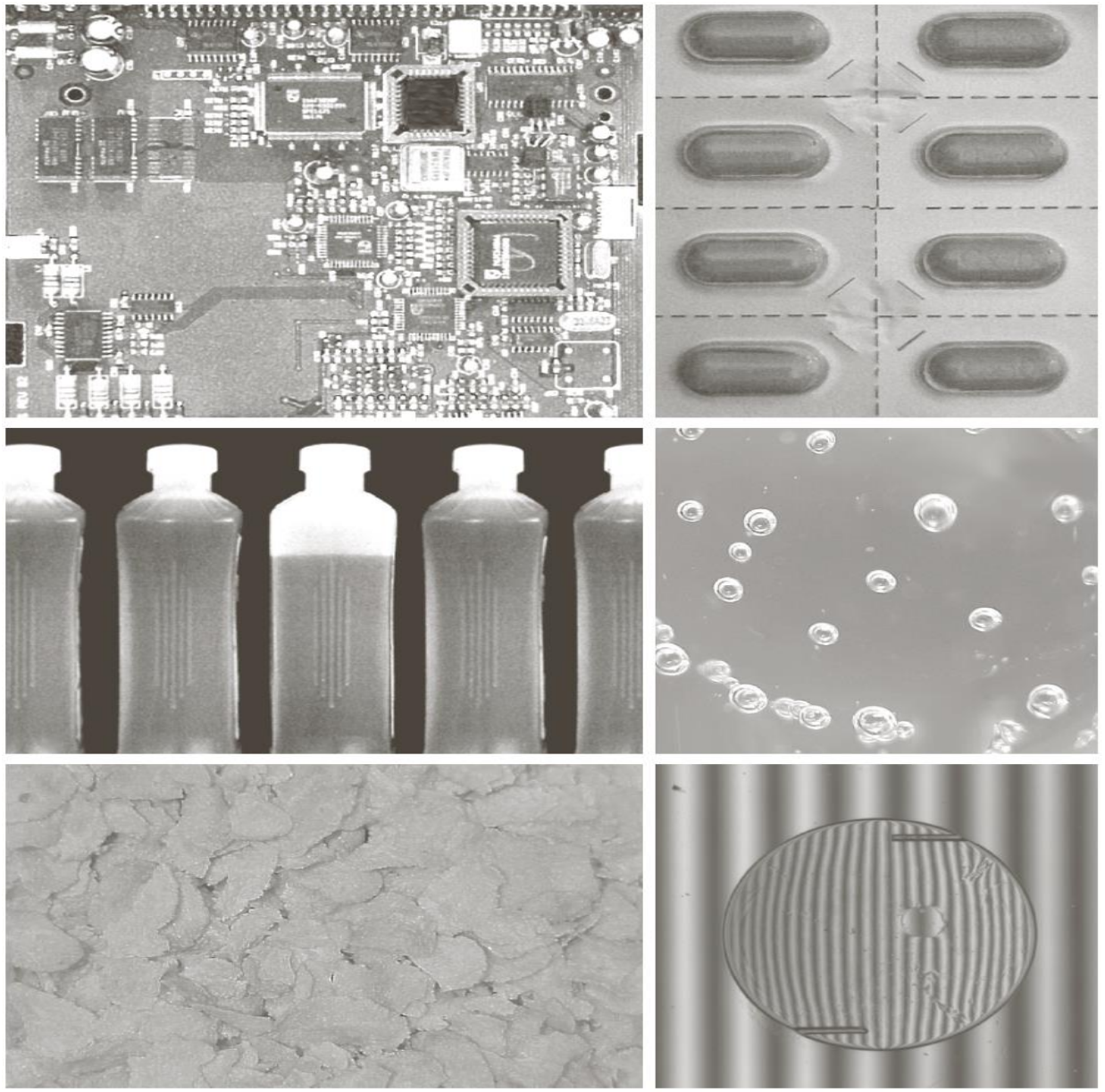

**FIGURE 1.10** LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)


USA 2003

# Examples: Infrared Satellite Imaging



# Examples: Automated 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.)

# Examples: Automated Visual Inspection


Results of automated reading of the plate content by the system

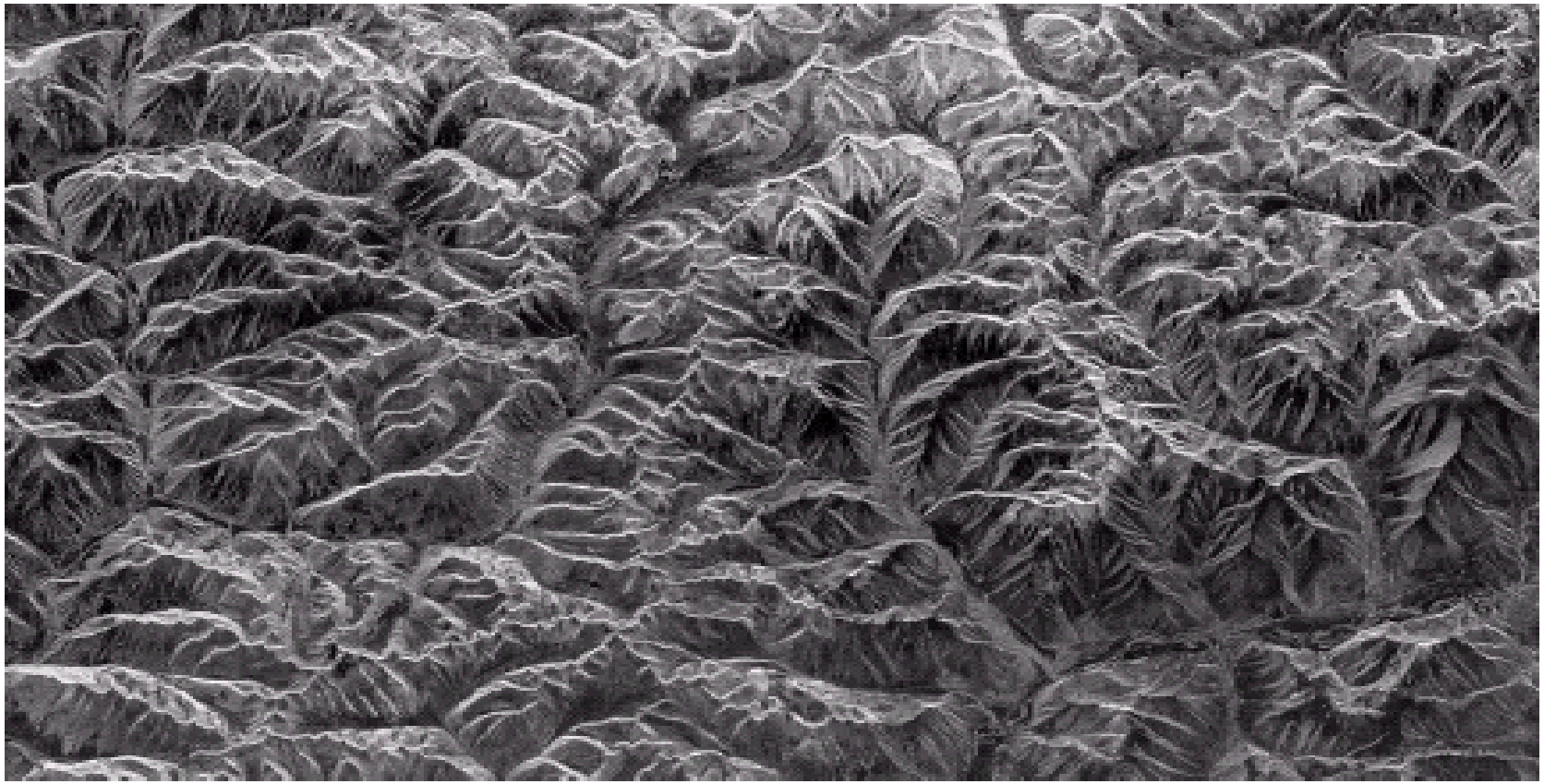
The area in which the imaging system detected the plate

a b
c
d

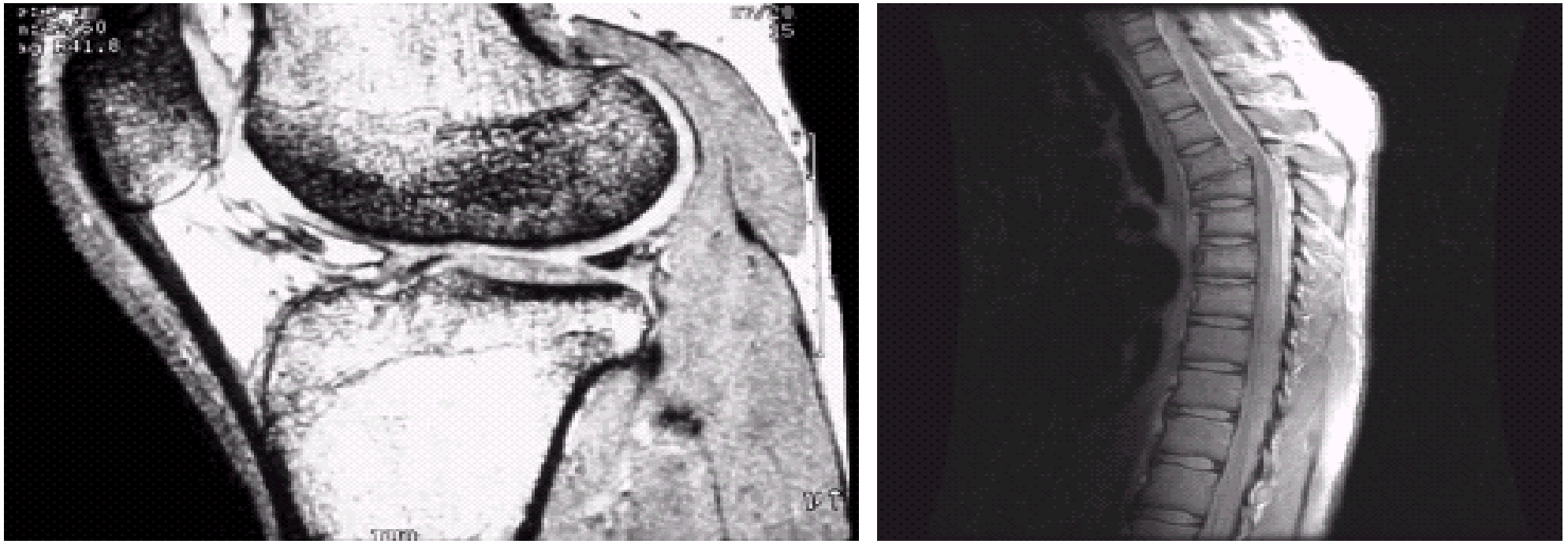
**FIGURE 1.15**
Some additional examples of imaging in the visual spectrum. (a) Thumb print. (b) Paper currency. (c) and (d) Automated license plate reading. (Figure (a) courtesy of the National Institute of Standards and Technology. Figures (c) and (d) courtesy of Dr. Juan Herrera, Perceptics Corporation.)

# Example of Radar Image

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



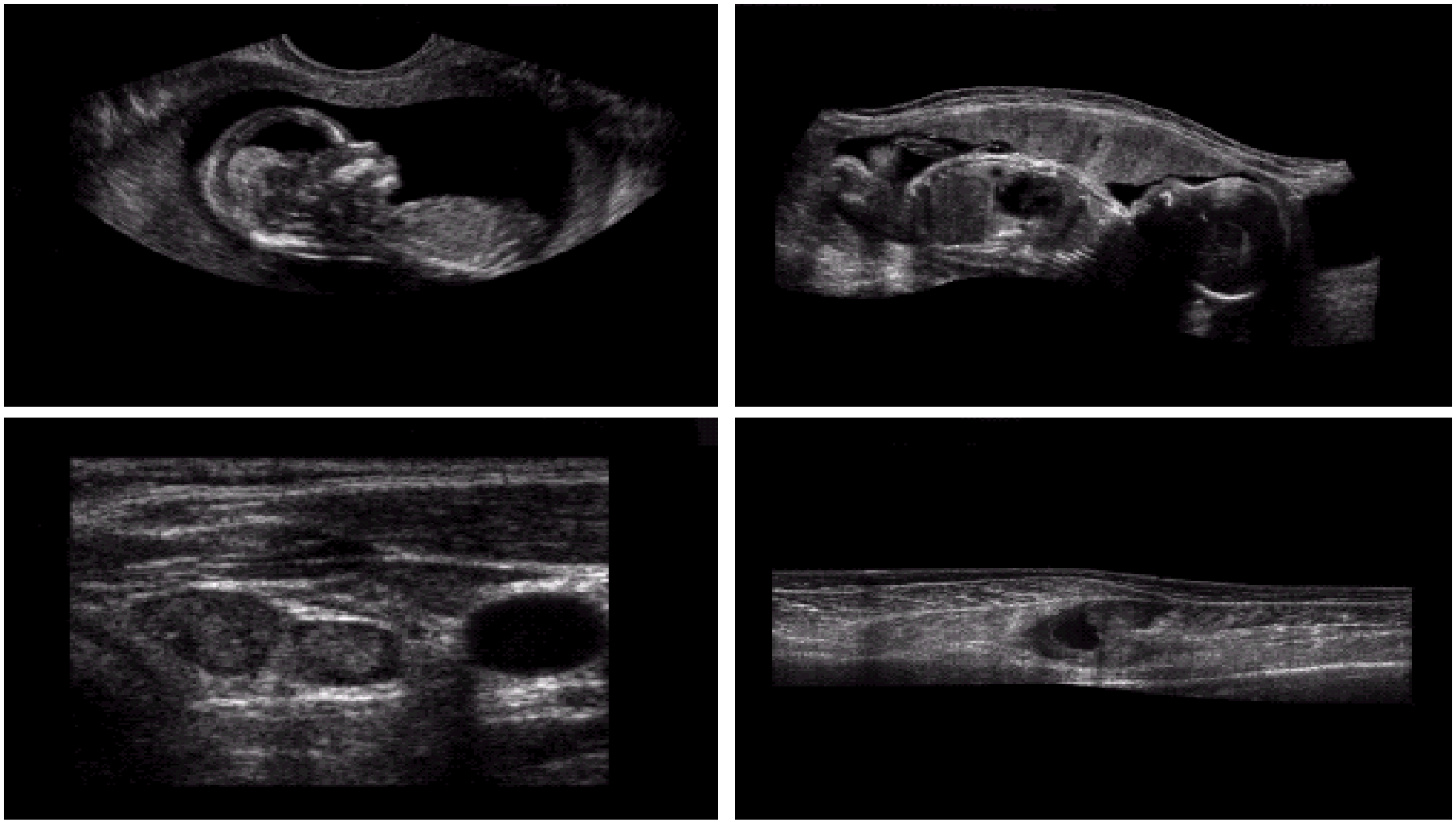
# Examples: MRI (Radio Band)



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.)

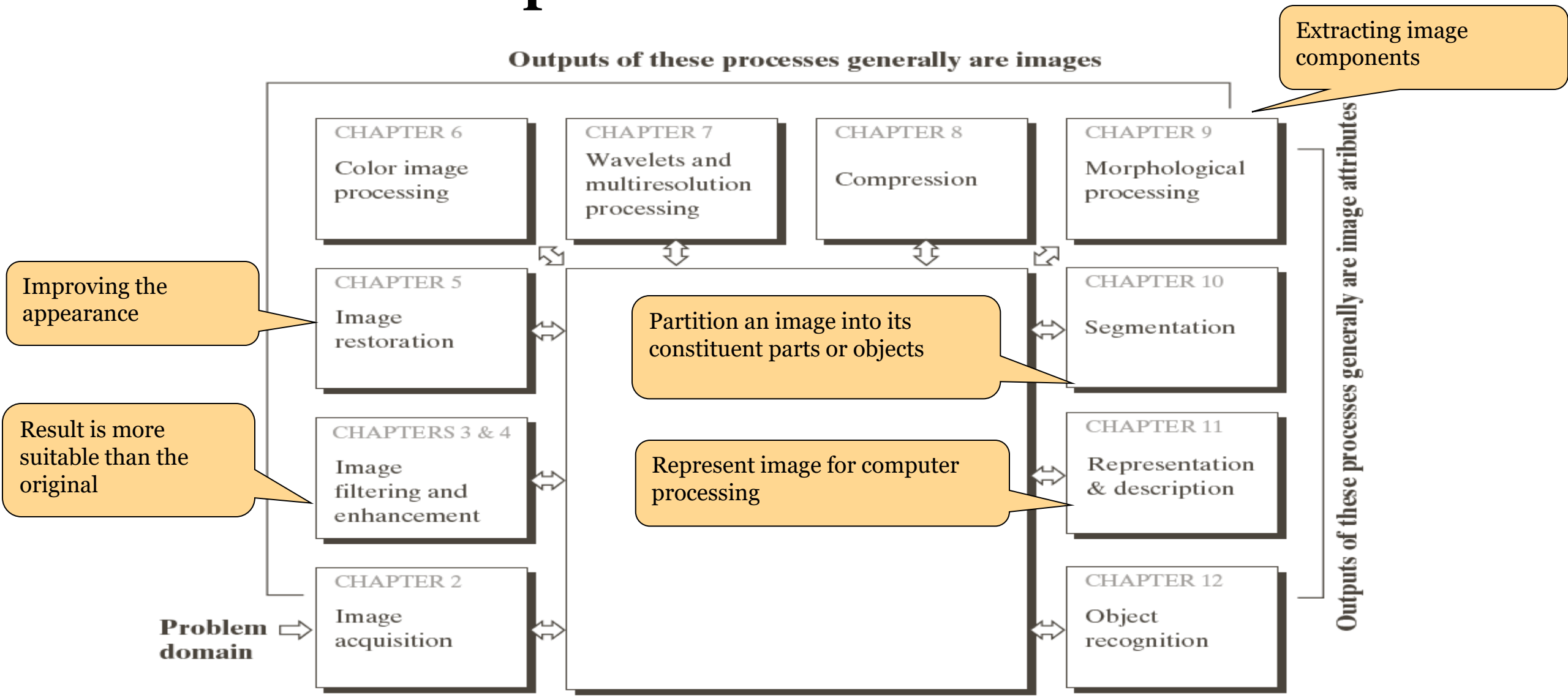
# Examples: Ultrasound Imaging



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.)

# Fundamental Steps in DIP

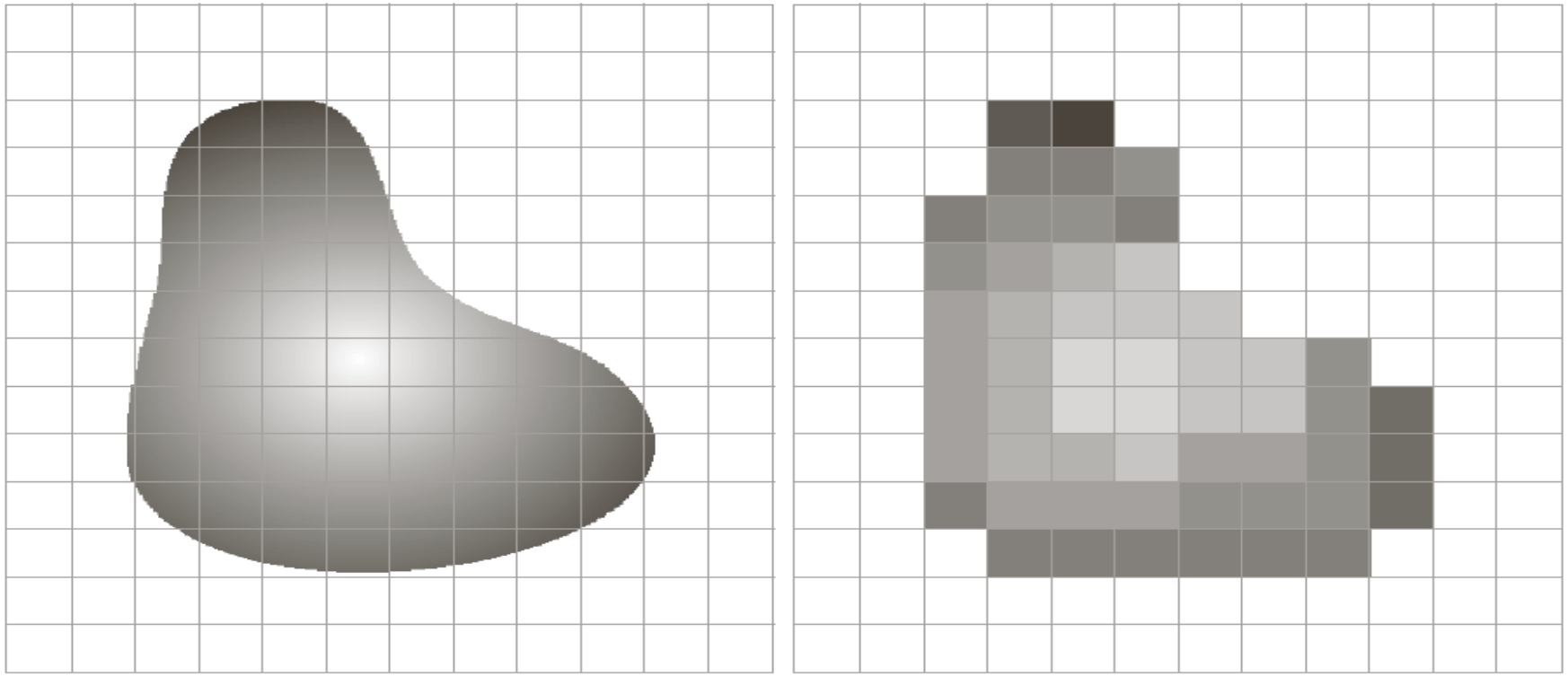


# Representing Digital Images

- The representation of an M×N numerical array as

$$A = \begin{bmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,N-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,N-1} \\ \cdots & \cdots & \cdots & \cdots \\ a_{M-1,0} & a_{M-1,1} & \cdots & a_{M-1,N-1} \end{bmatrix}$$

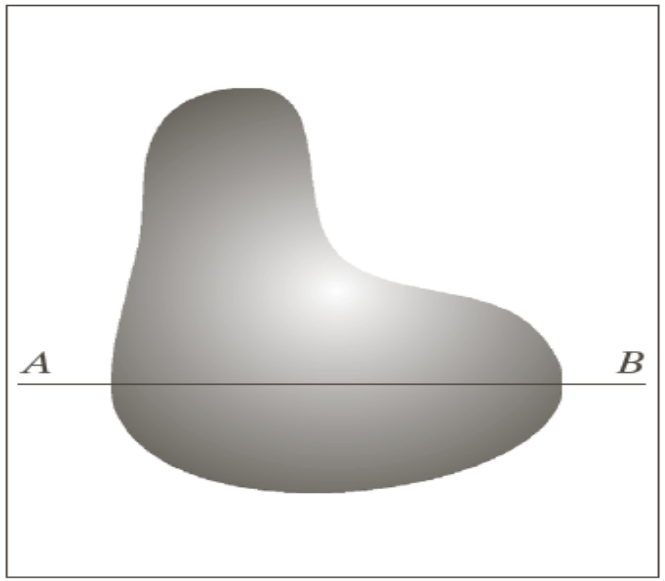
# Image Sampling and Quantization

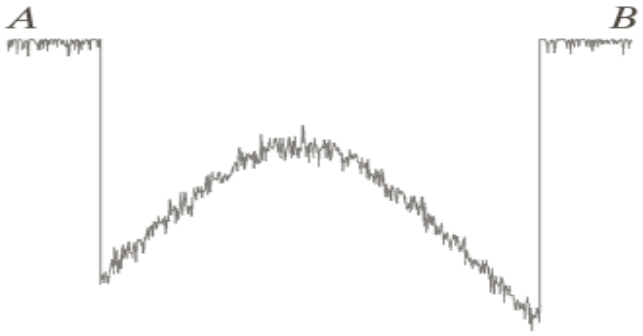


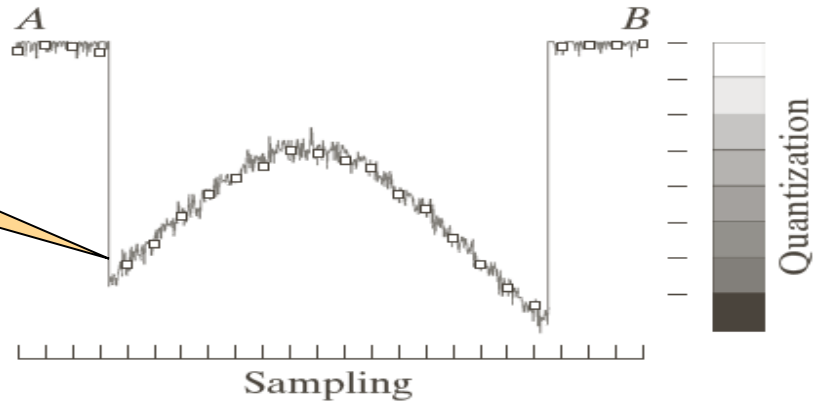
a b

**FIGURE 2.17** (a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.

# Image Sampling and Quantization

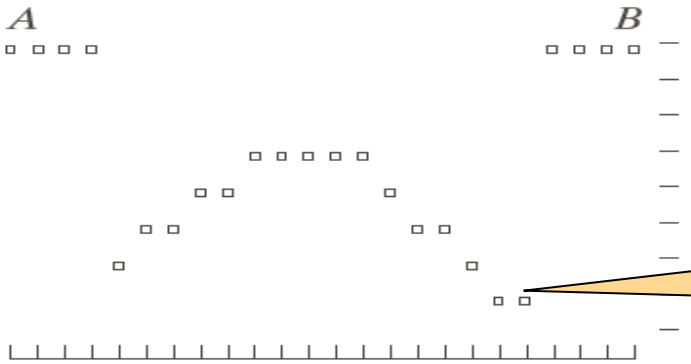









a b
c d

**FIGURE 2.16** Generating a digital image. (a) Continuous image. (b) A scan line from *A* to *B* in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

Digitizing the coordinate values

Digitizing the amplitude values

# Representing Digital Images

- Discrete intensity interval [0, L-1], $L=2^k$
- The number b of bits required to store a M × N digitized image

  $b = M \times N \times k$

# Spatial and Intensity Resolution

- **Spatial resolution**
  — A measure of the smallest discernible detail in an image
  — stated with *line pairs per unit distance, dots (pixels) per unit distance, dots per inch (dpi)*

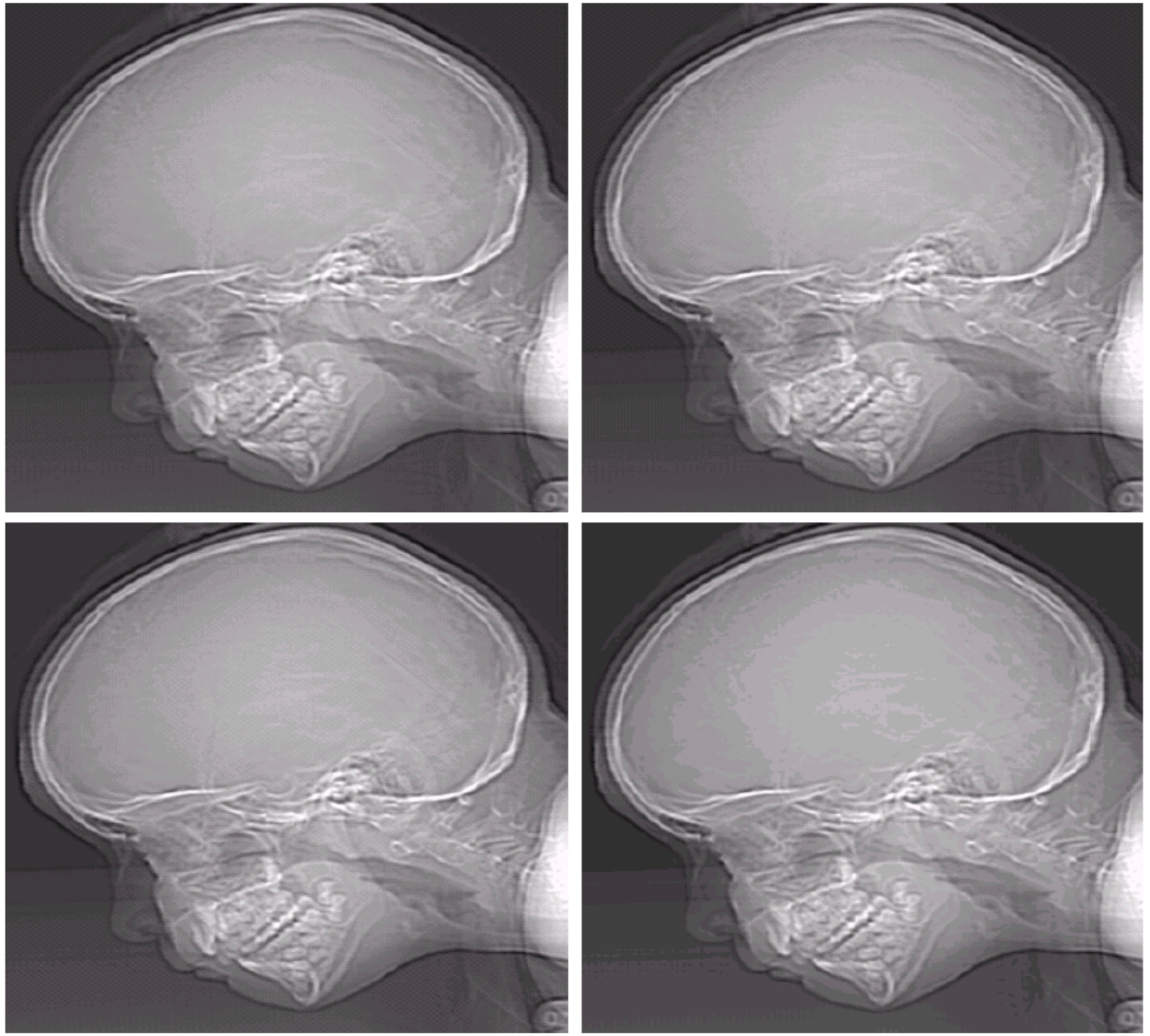
- **Intensity resolution**
  — The smallest discernible change in intensity level
  — stated with *8 bits, 12 bits, 16 bits, etc.*

# Spatial and Intensity Resolution

a b
c d

**FIGURE 2.20** Typical effects of reducing spatial resolution. Images shown at: (a) 1250 dpi, (b) 300 dpi, (c) 150 dpi, and (d) 72 dpi. The thin black borders were added for clarity. They are not part of the data.

# Spatial and Intensity Resolution



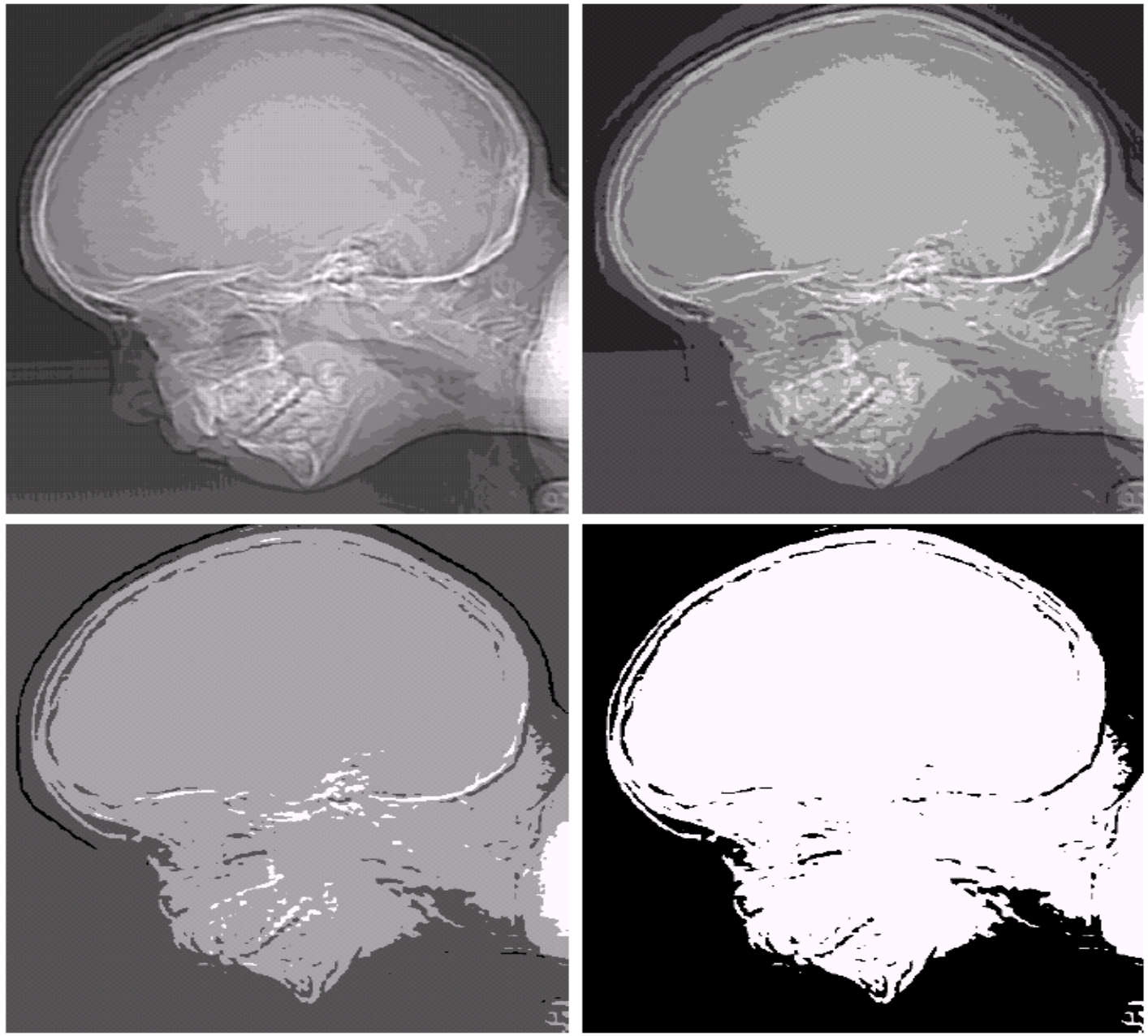
a b
c d

**FIGURE 2.21**
(a) 452 × 374, 256-level image. (b)–(d) Image displayed in 128, 64, and 32 gray levels, while keeping the spatial resolution constant.

# Spatial and Intensity Resolution

e f
g h

**FIGURE 2.21**
*(Continued)*
(e)–(h) Image displayed in 16, 8, 4, and 2 gray levels. (Original courtesy of Dr. David R. Pickens, Department of Radiology & Radiological Sciences, Vanderbilt University Medical Center.)



# Image Interpolation

- **Interpolation** — Process of using known data to estimate unknown values

  *e.g.*, zooming, shrinking, rotating, and geometric correction

- **Interpolation** (sometimes called ***resampling***) — an imaging method to increase (or decrease) the number of pixels in a digital image.

  Some digital cameras use interpolation to produce a larger image than the sensor captured or to create digital zoom

  http://www.dpreview.com/learn/?/key=interpolation