2020 Autumn 07010667

Digital Image Processing

Lecture 1: Course Overview and Introduction

Guoxu Liu
Weifang University of Science and Technology

Outline

- Course information
- Overview of digital image processing
- Digital image fundamentals

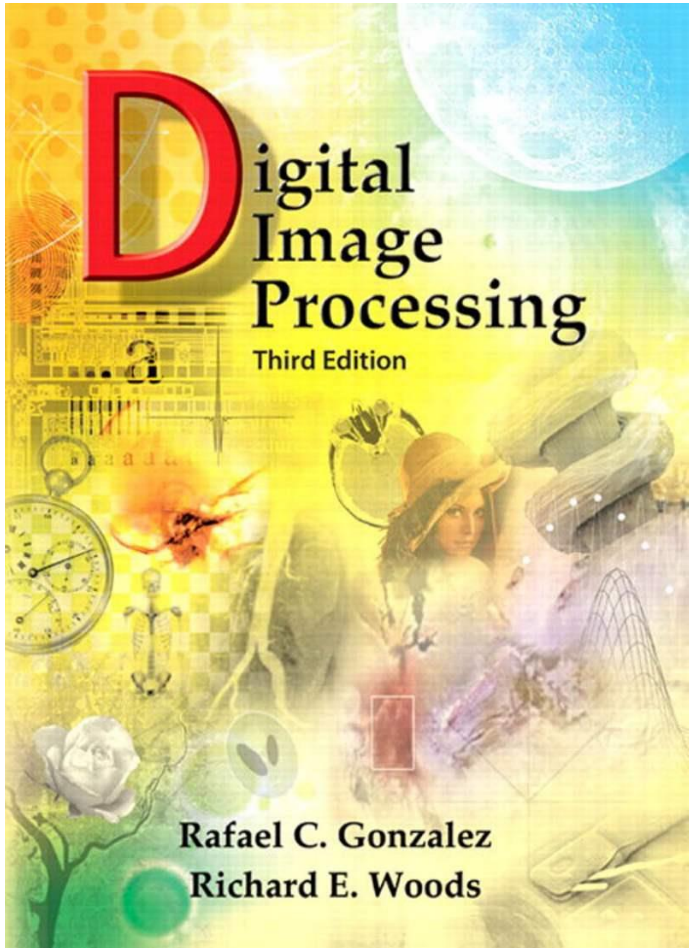
Course information

- Instructor: Guoxu Liu (liuguoxu@wfust.edu.cn)
- Time:
  - Wednesday (8:00 am – 9:40 am): two sessions with a 10-min break
  - Friday (10:00 am – 11:40 am): two sessions with a 10-min break
  - Course website:

    https://vlg-wfust.github.io/course/digital_image_processing/index_en.html
- Office hour: Wednesday 3:30 pm – 5:00 pm at Room ?

Textbook: Gonzalez and Woods

http://www.imageprocessingplace.com/



Prerequisites & Enrollment

- All enrolled students should have taken the Linear Algebra course, Probability course, and Digital Signal Processing course.
- Better to master a programming language (Matlab, Python, C, C++, Java, etc)

What we will cover

- Fundamentals of DIP: image acquisition, image sampling and quantization, image representation, mathematical tools in DIP, etc.
- DIP algorithms: spatial and frequency filtering, restoration and reconstruction, segmentation, etc
- High level applications: object recognition

Course objective

- Knowledge on the foundation and practice of DIP
- Basic capacity for dealing with digital image processing problems

Grading

- Attendance: 20%
- 3 assignments: 30%
- Exam: 50%

Course Schedule

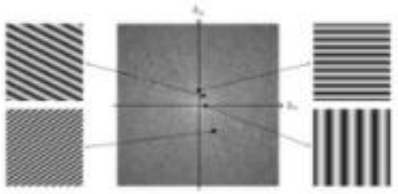
website

2020-2021 1st Term

[Chinese]

Digital Image Processing

[Home | Schedule | Final Project]

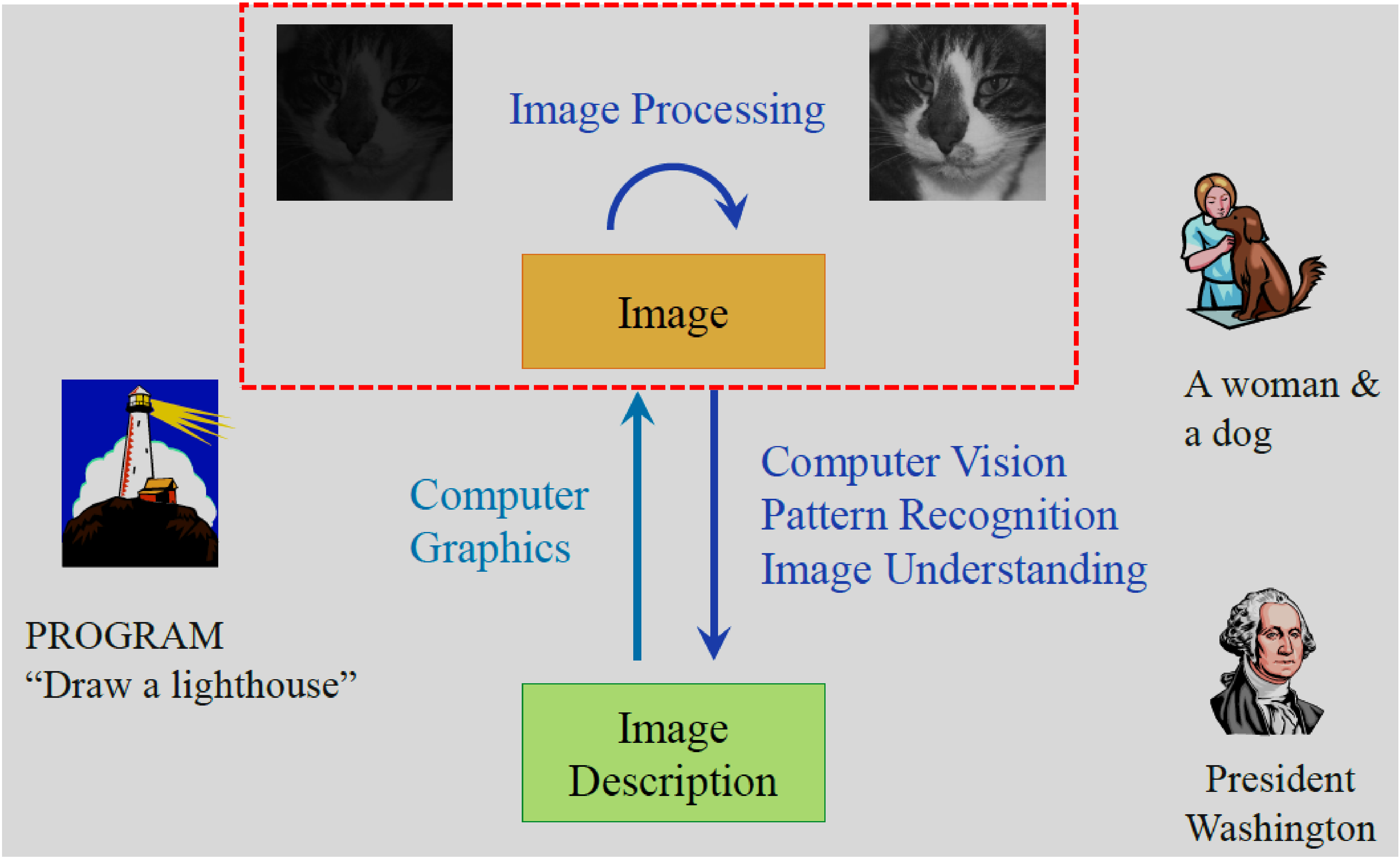


Course Overview

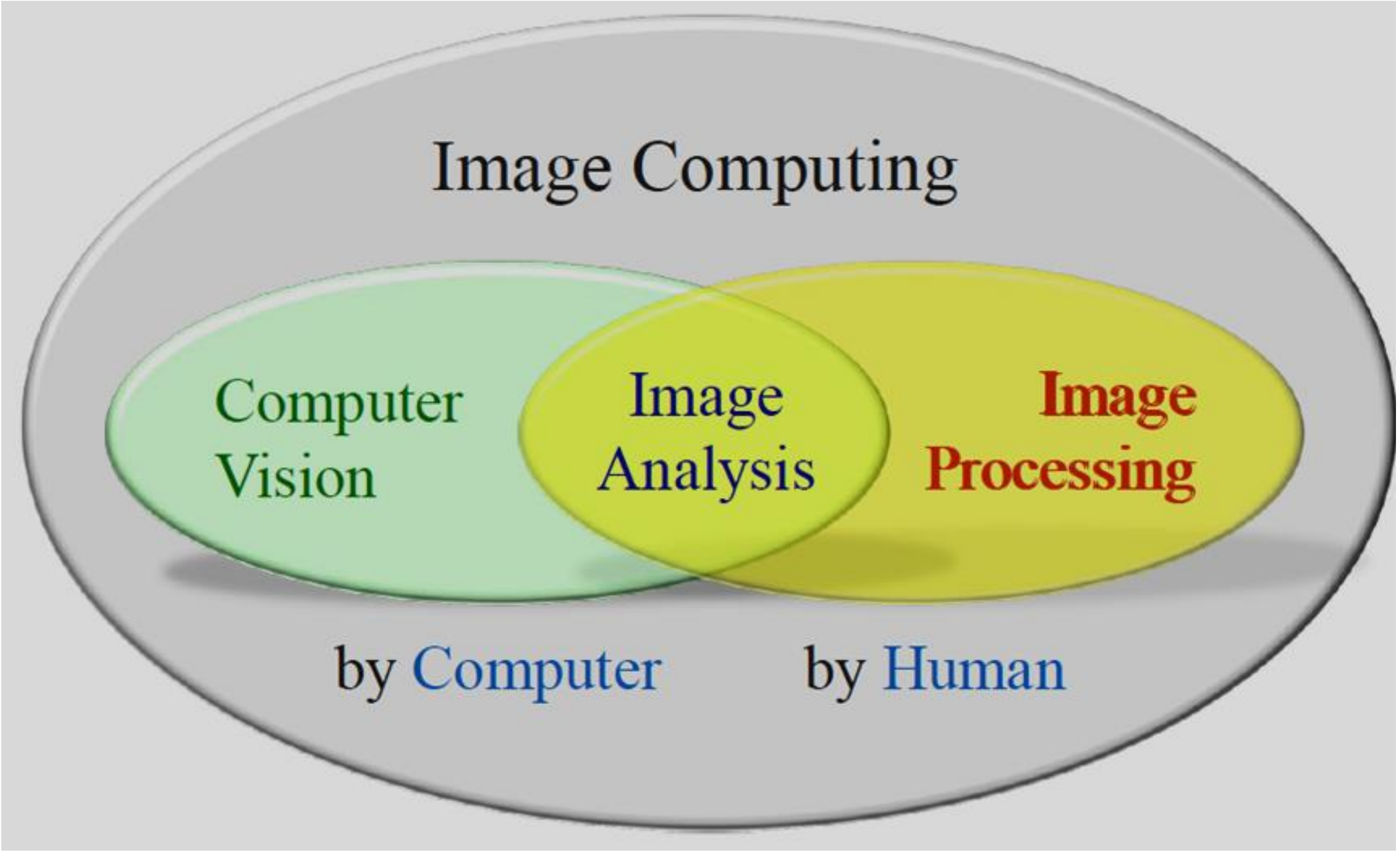
The goal of computer vision is to compute properties of the three-dimensional world from images and video. Problems in this field include identifying the 3D shape of a scene, determining how things are moving, and recognizing familiar people and objects. This course provides an introduction to computer vision, including such topics as image processing, feature extraction, object description, image segmentation, object recognition, and object tracking.

One picture is worth more than ten thousand words.

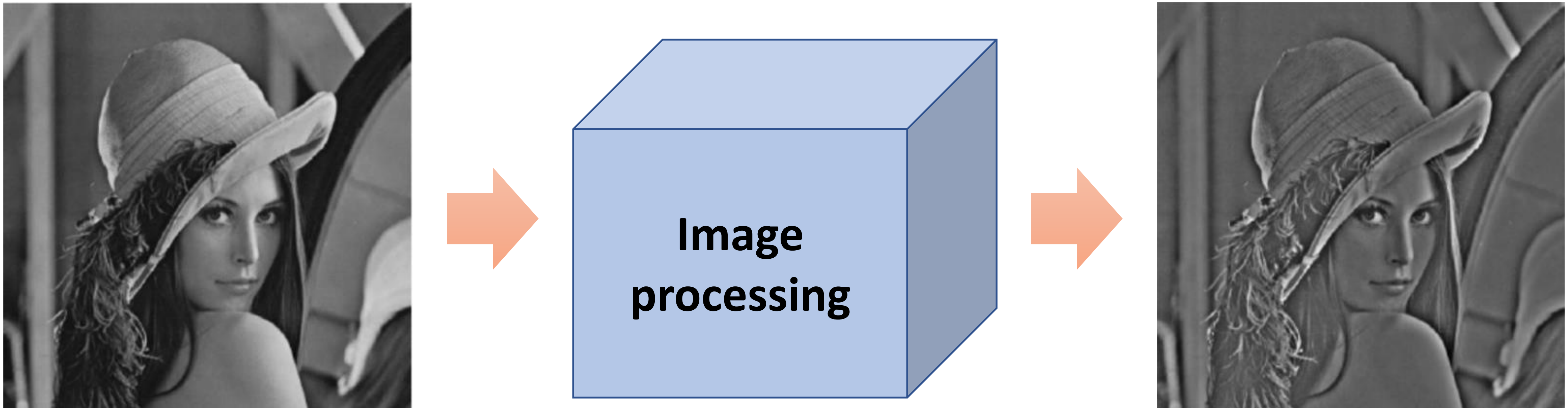
Overview of Image Processing



Overview of Image Processing



What is digital image processing and why we care?



Examples of Digital Image Processing

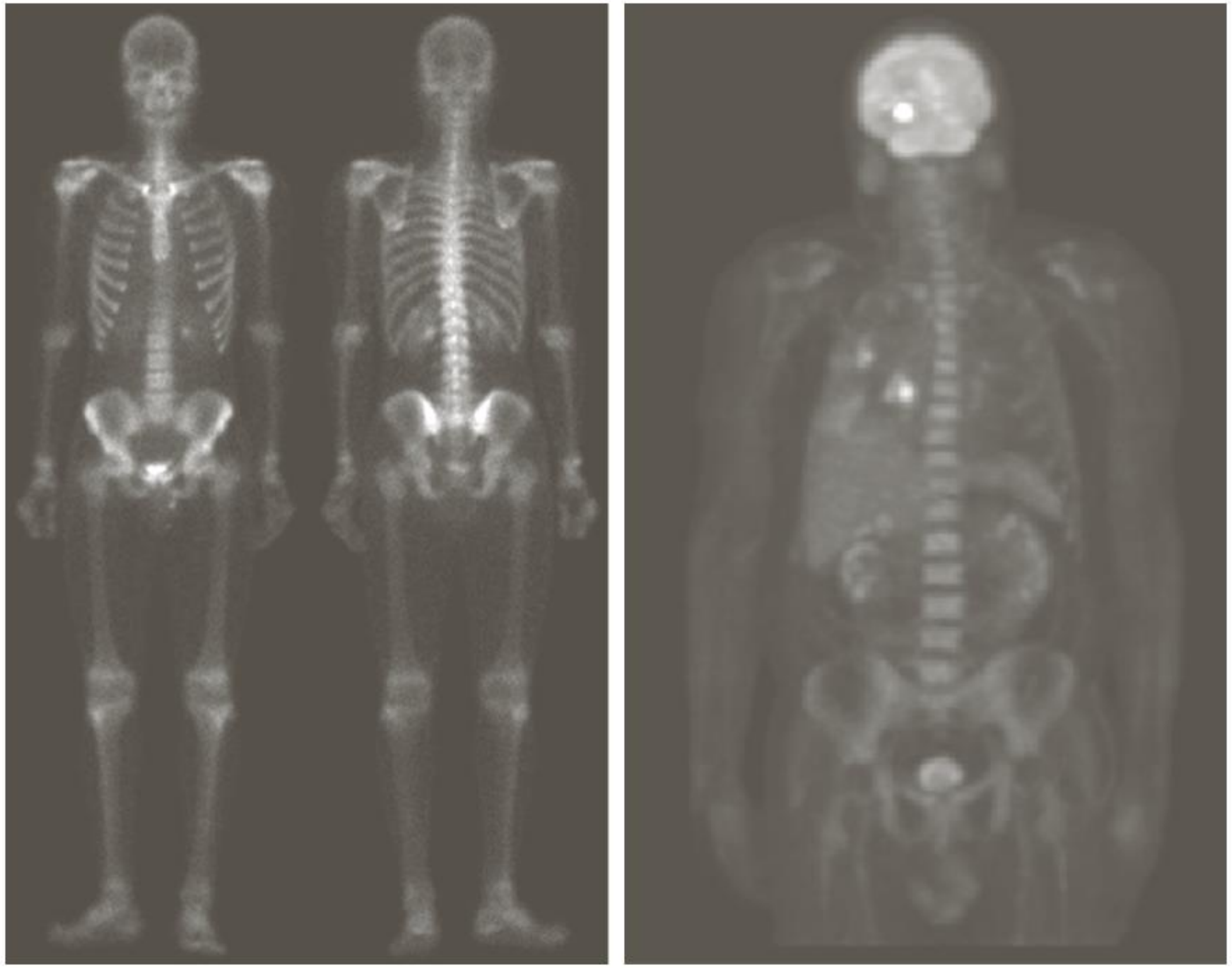


Fig 1. Gamma-ray imaging

Examples of Digital Image Processing

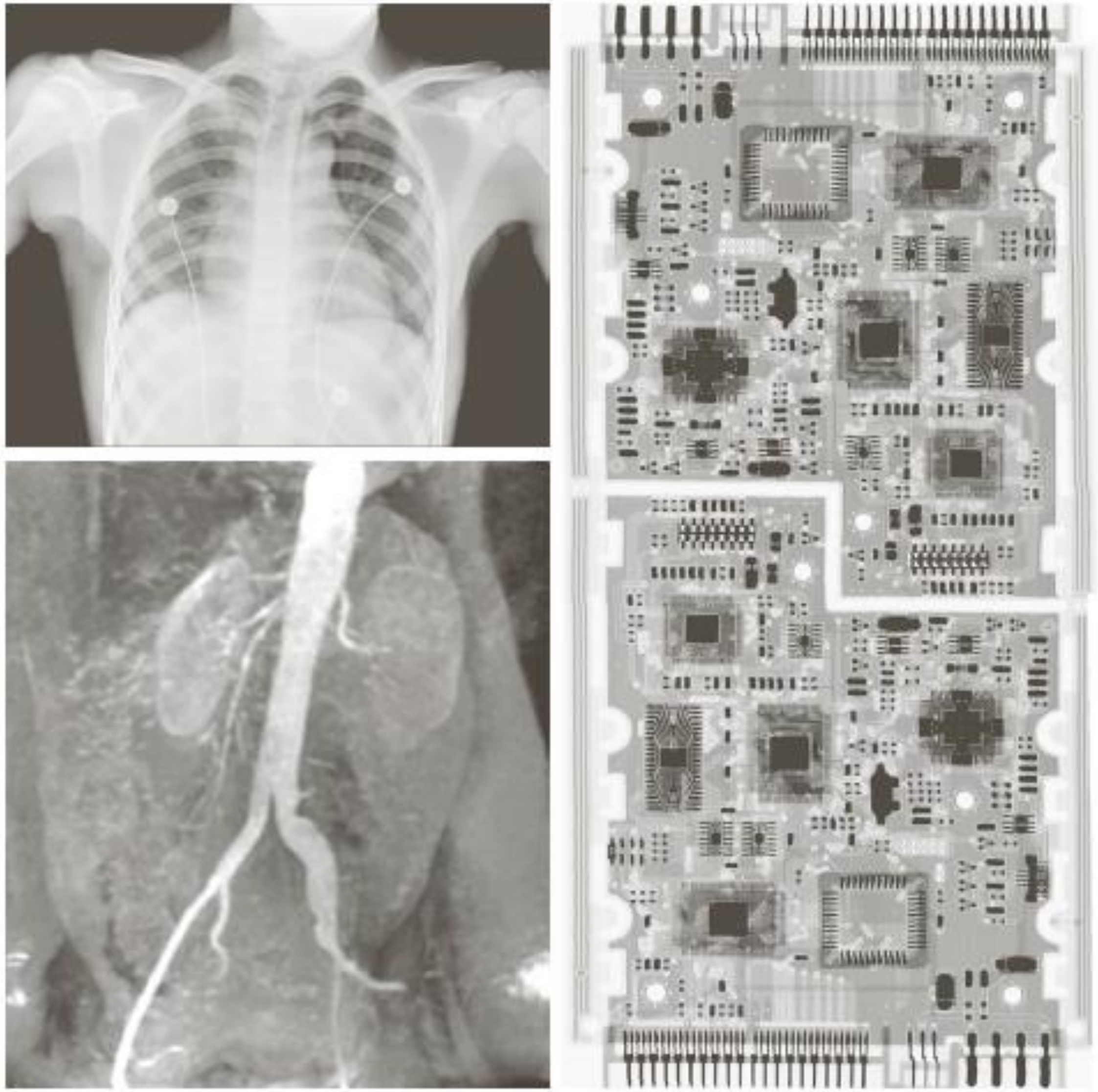


Fig 2. X-ray imaging

Examples of Digital Image Processing

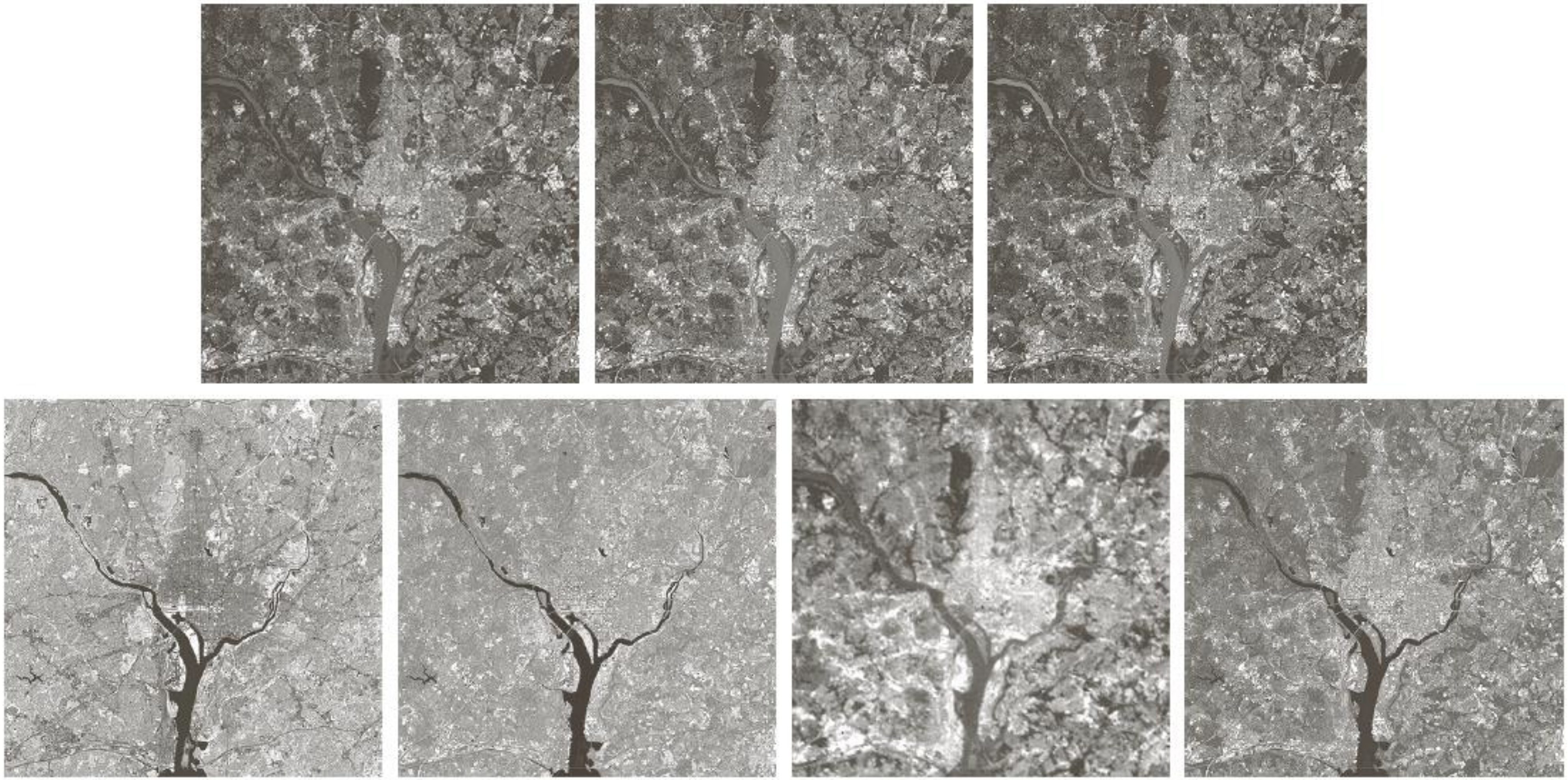
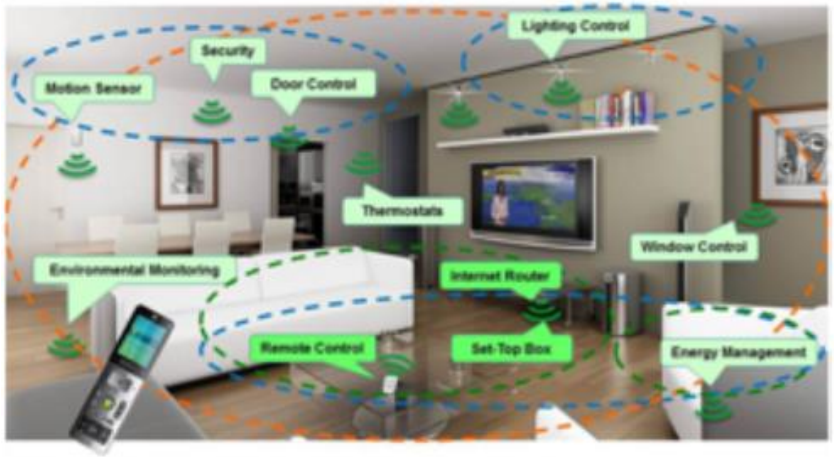


Fig 3. LANDSAT satellite images of the Washington, D.C. area.

Examples of Digital Image Processing

Autonomous driving

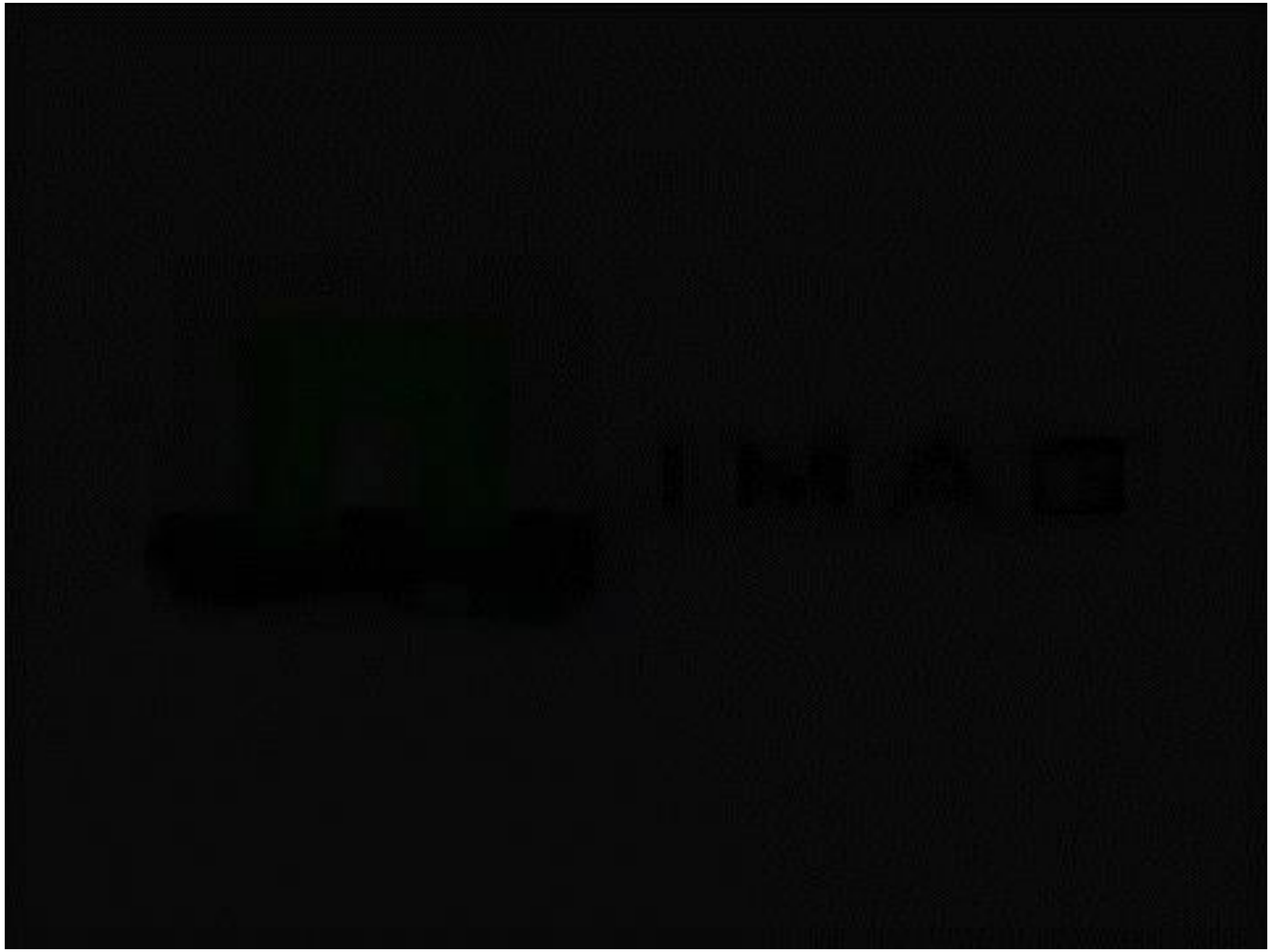
Gaming

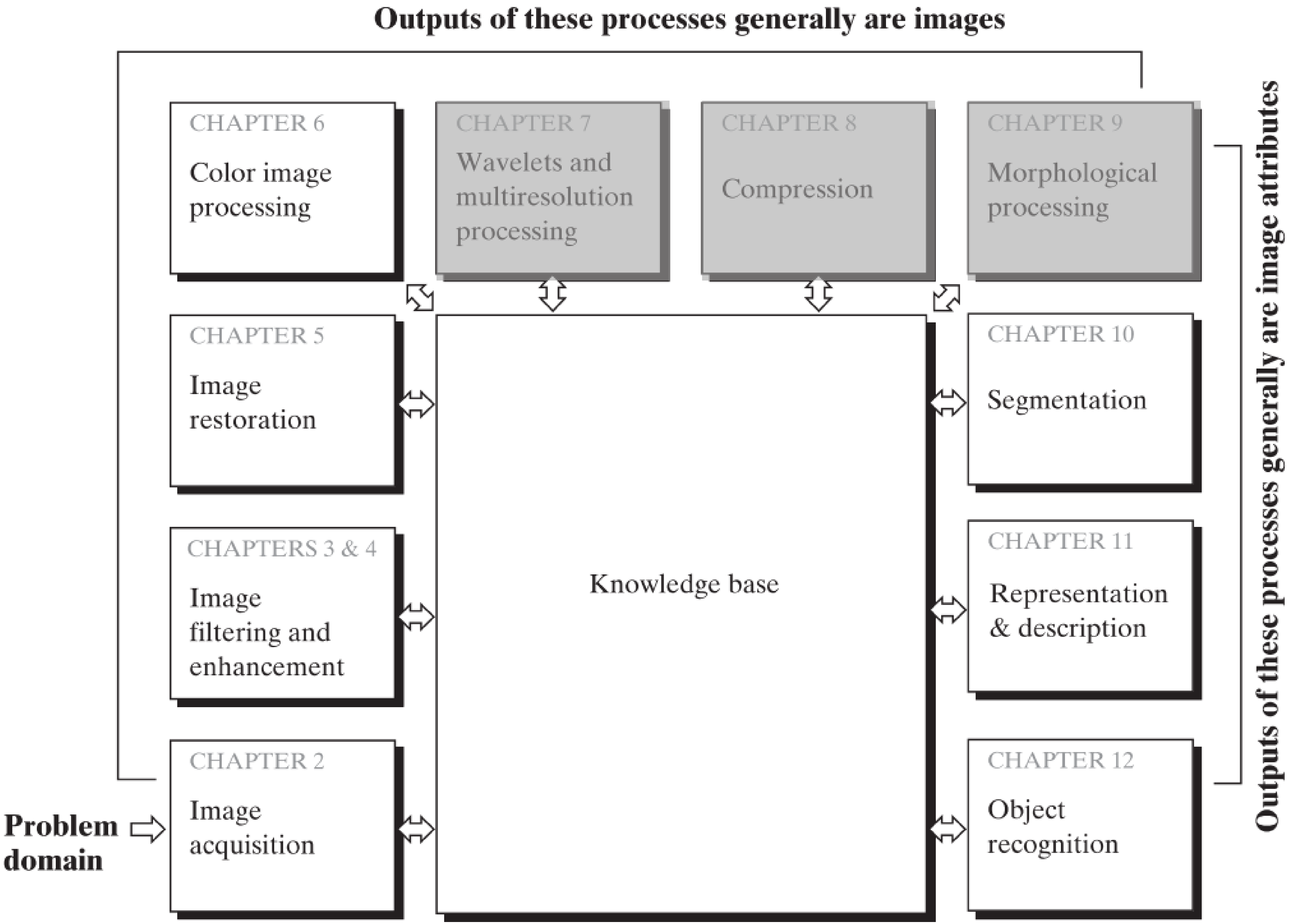


Smart homes

Factory automation

Examples of Digital Image Processing

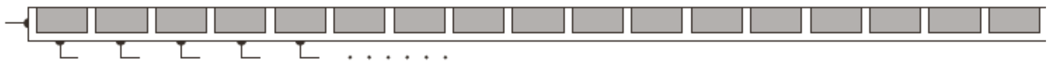


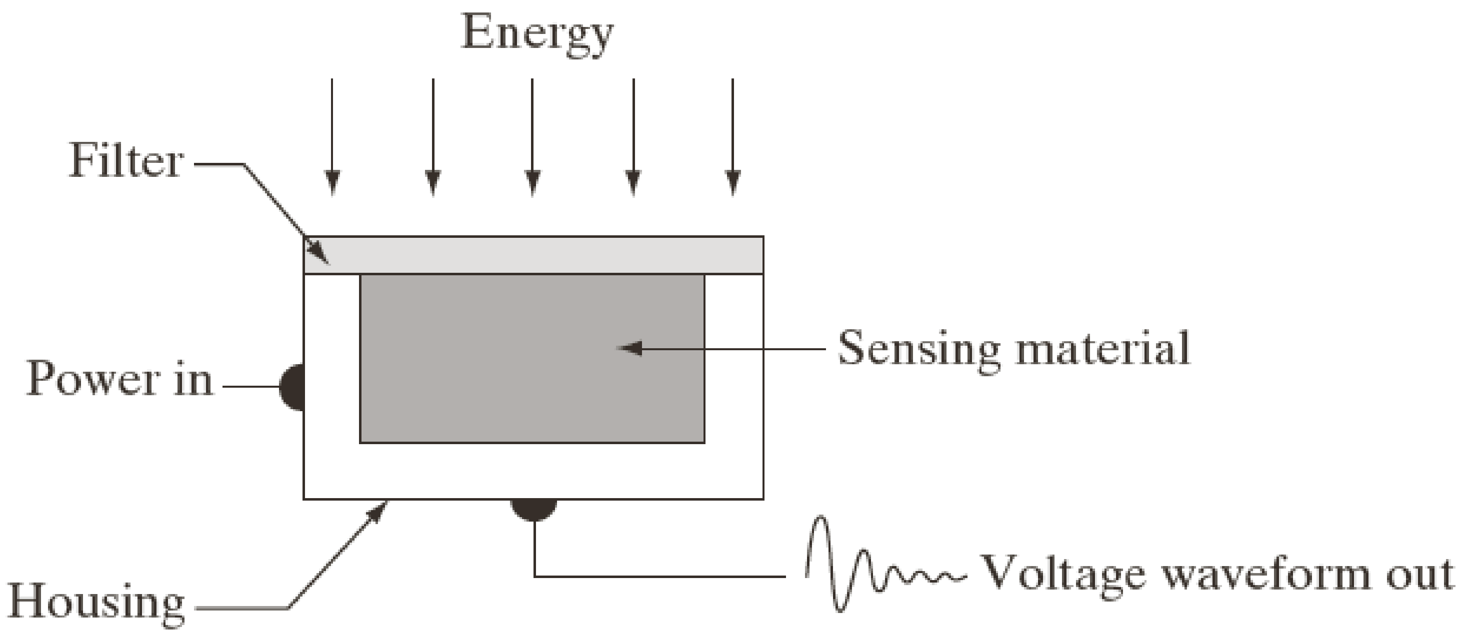

Outputs of these processes generally are images
CHAPTER 6
Color image processing
CHAPTER 7
Wavelets and multiresolution processing
CHAPTER 8
Compression
CHAPTER 9
Morphological processing
CHAPTER 5
Image restoration
CHAPTERS 3 & 4
Image filtering and enhancement
CHAPTER 2
Image acquisition
Problem domain
Knowledge base
CHAPTER 10
Segmentation
CHAPTER 11
Representation & description
CHAPTER 12
Object recognition
Outputs of these processes generally are image attributes

Digital Image Fundamentals

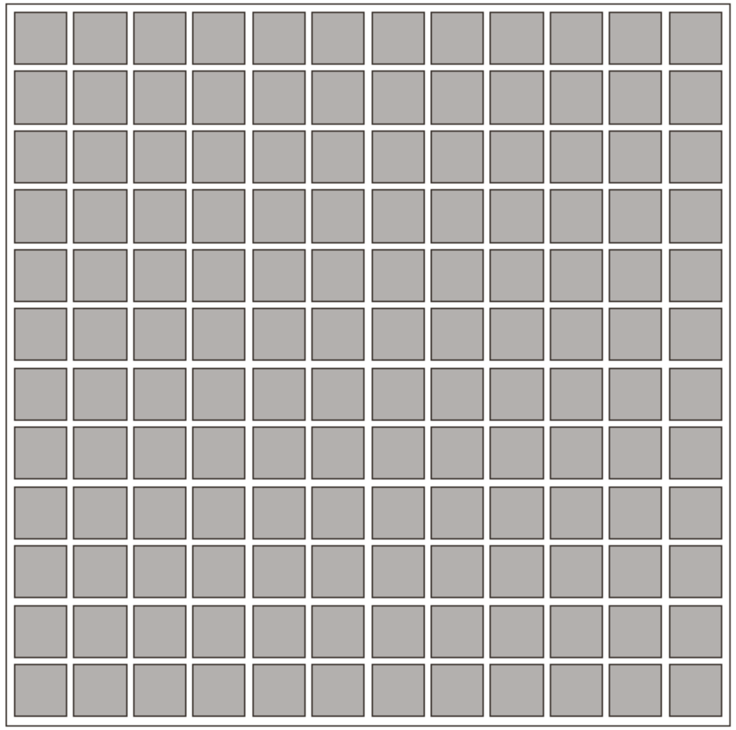
- Imaging Sensor

(b) Linear sensor





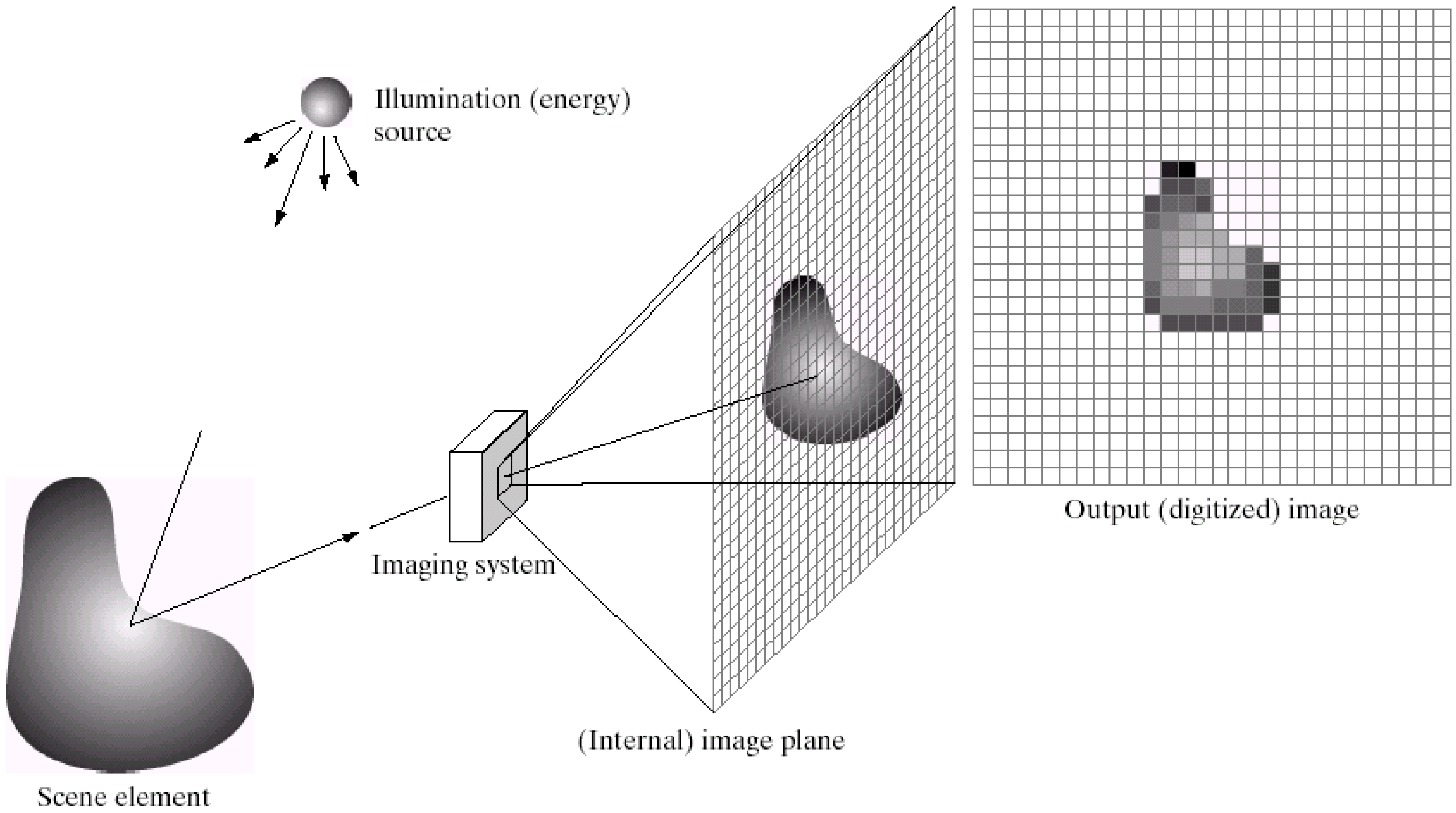
(a) Single imaging sensor



(c) Array sensor

Digital Image Fundamentals

- Imaging Formation



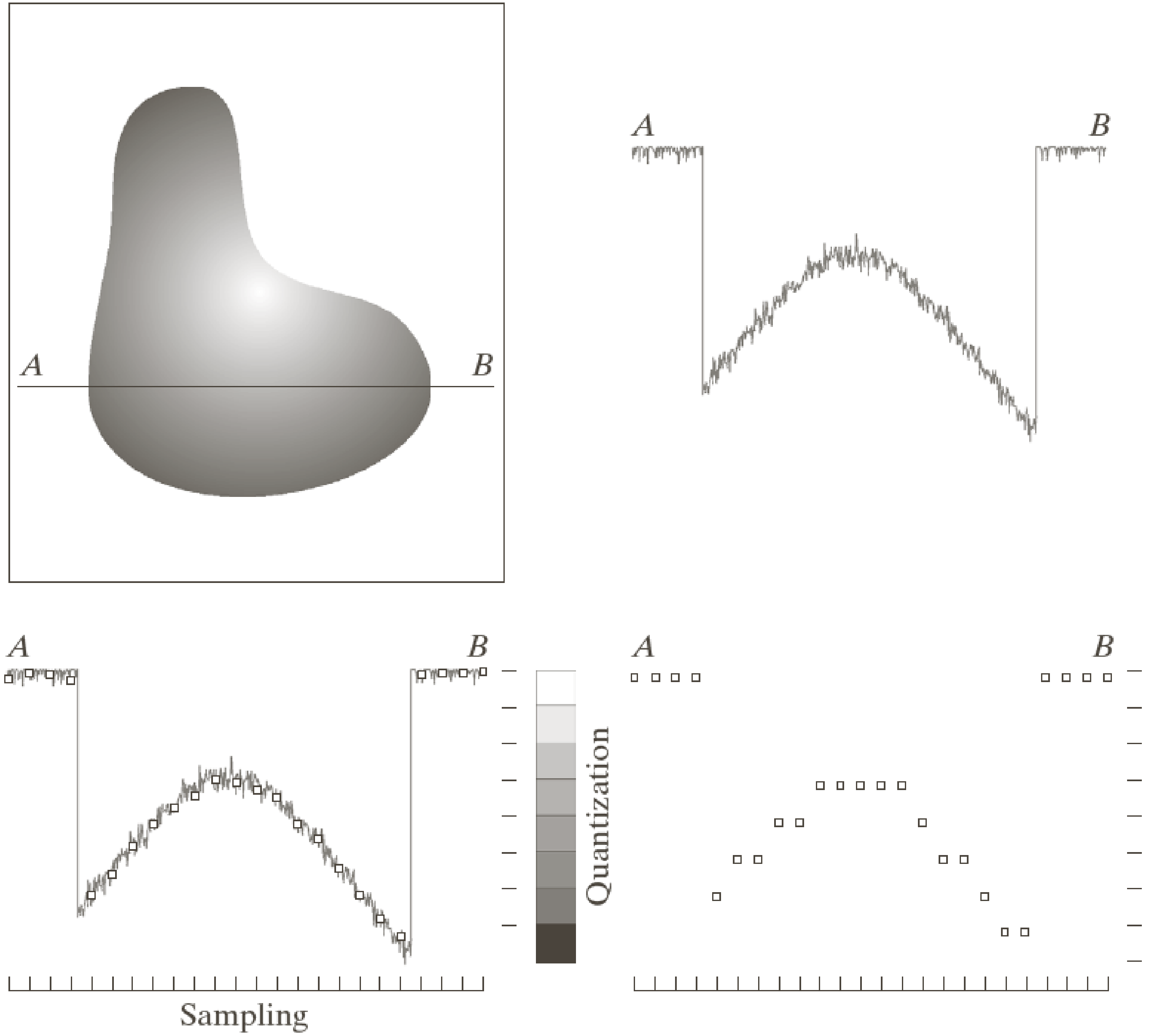
Digital Image Fundamentals

- Image could be denoted by a two-dimensional functions of the form $f(x,y)$

$$0 < f(x,y) < \infty$$

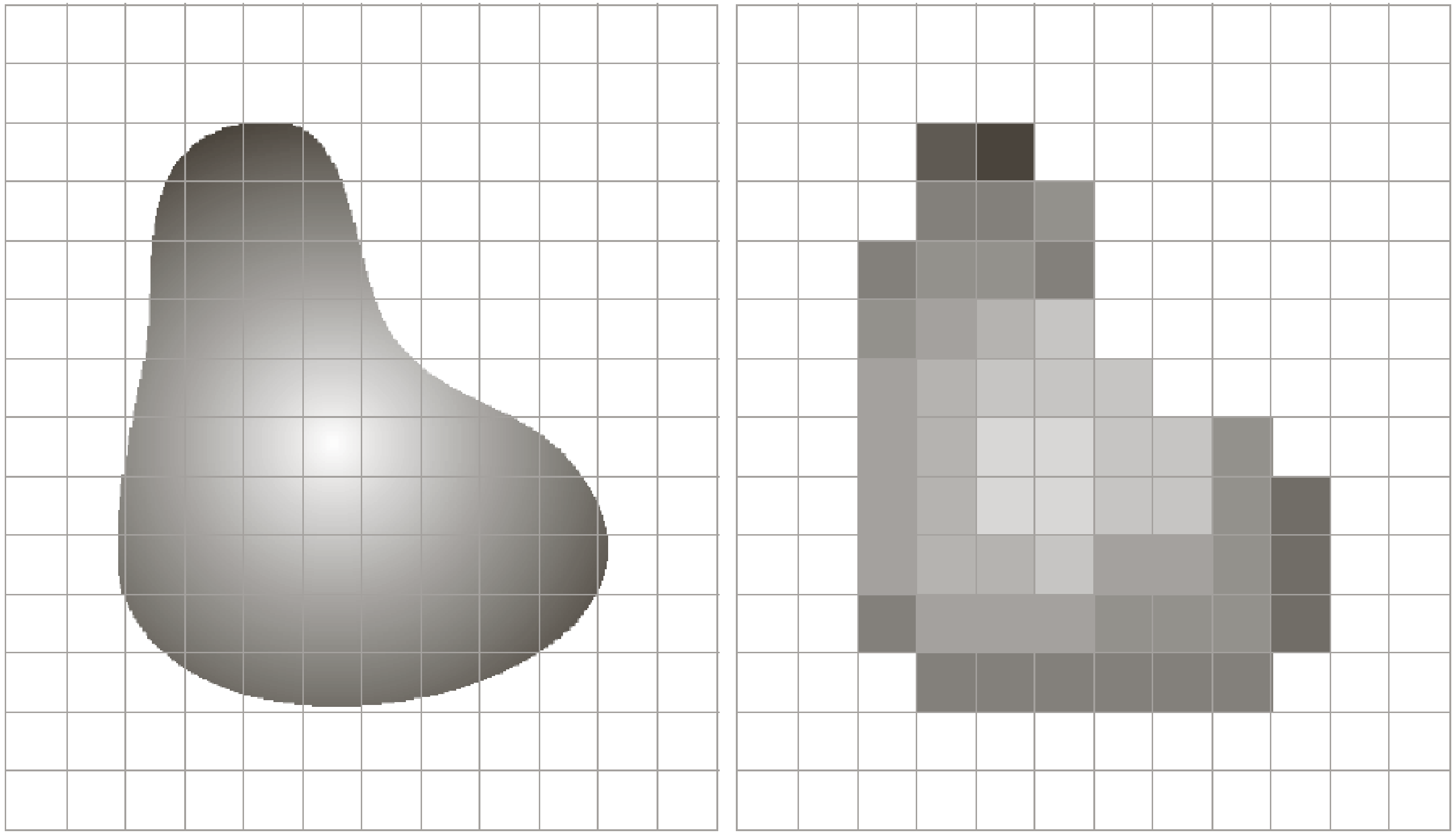
Digital Image Fundamentals

- Image Sampling and Quantization



Digital Image Fundamentals

- Image Sampling and Quantization

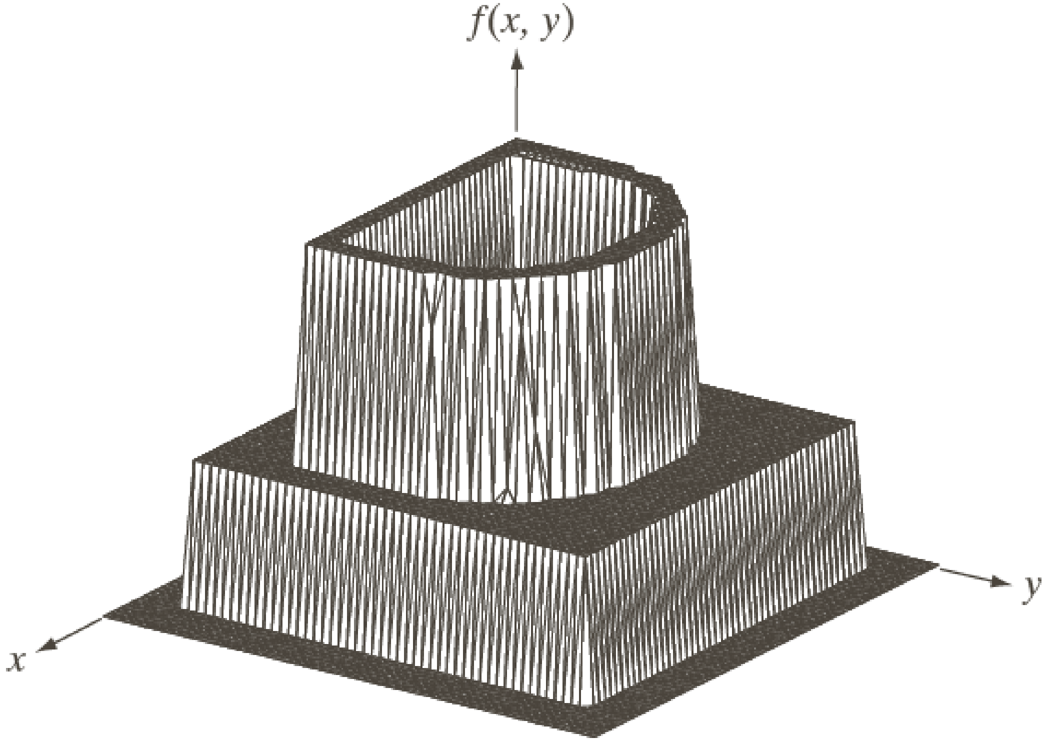


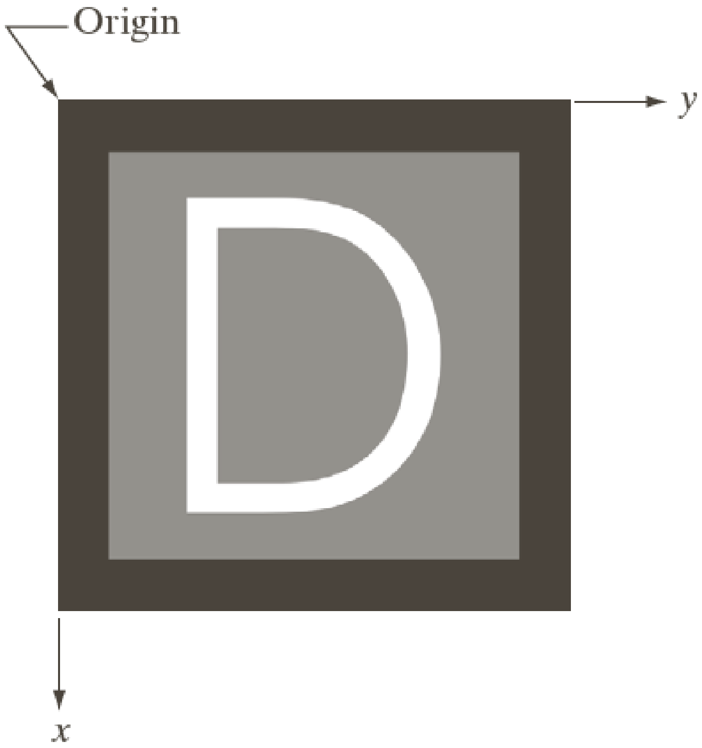
(a) Continuous image projected onto a sensor array

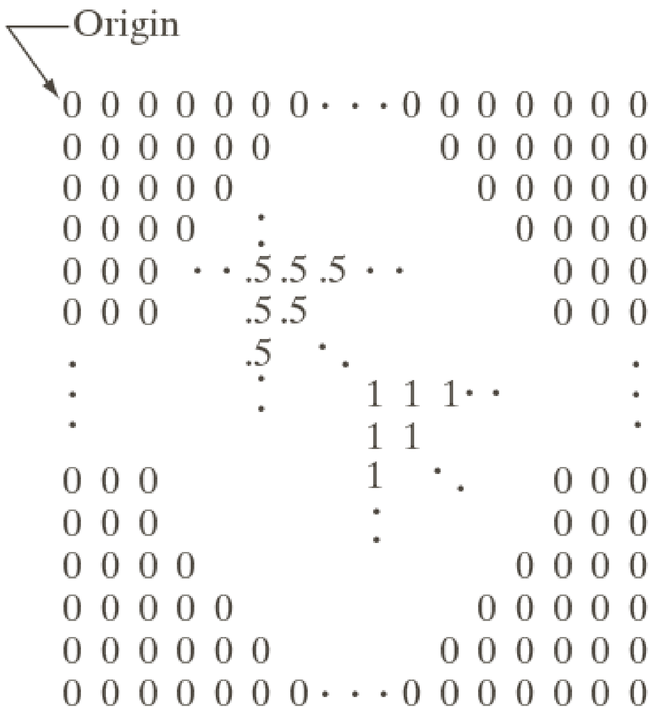
(b) Result of image sampling and quantization.

Digital Image Fundamentals

- Digital Image Representation



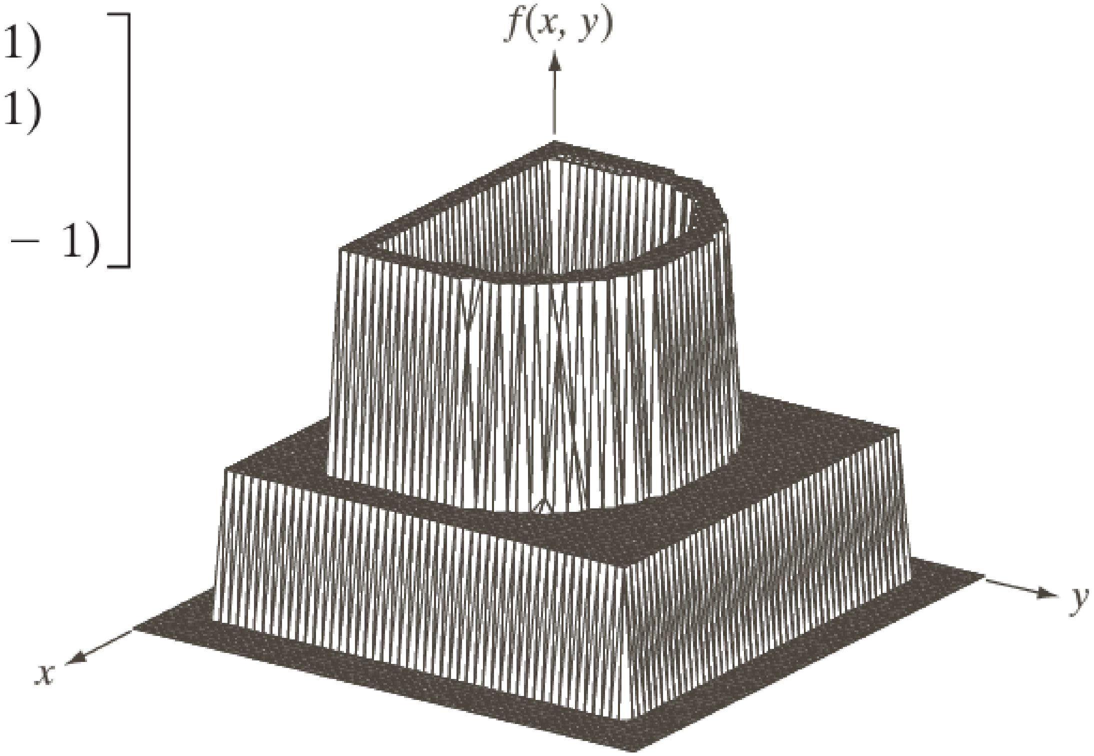




Digital Image Fundamentals

- Digital Image Representation

$$f(x, y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0, N-1) \\ f(1,0) & f(1,1) & \cdots & f(1, N-1) \\ \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1, N-1) \end{bmatrix}$$



The number of discrete intensity level: L

$$L = 2^k$$

k bits

The intensity range: $(0, L-1)$

Digital Image Fundamentals

- Digital Image Representation

- Question: If an image size is $M \times N$, each pixel is represented by k bits, how many bits are required to store this image?

Digital Image Fundamentals

- Spatial and Intensity Resolution
  - Spatial resolution – pixels per unit distance, dots per inch (dpi)

1250dpi

300dpi

150dpi

72dpi

Digital Image Fundamentals

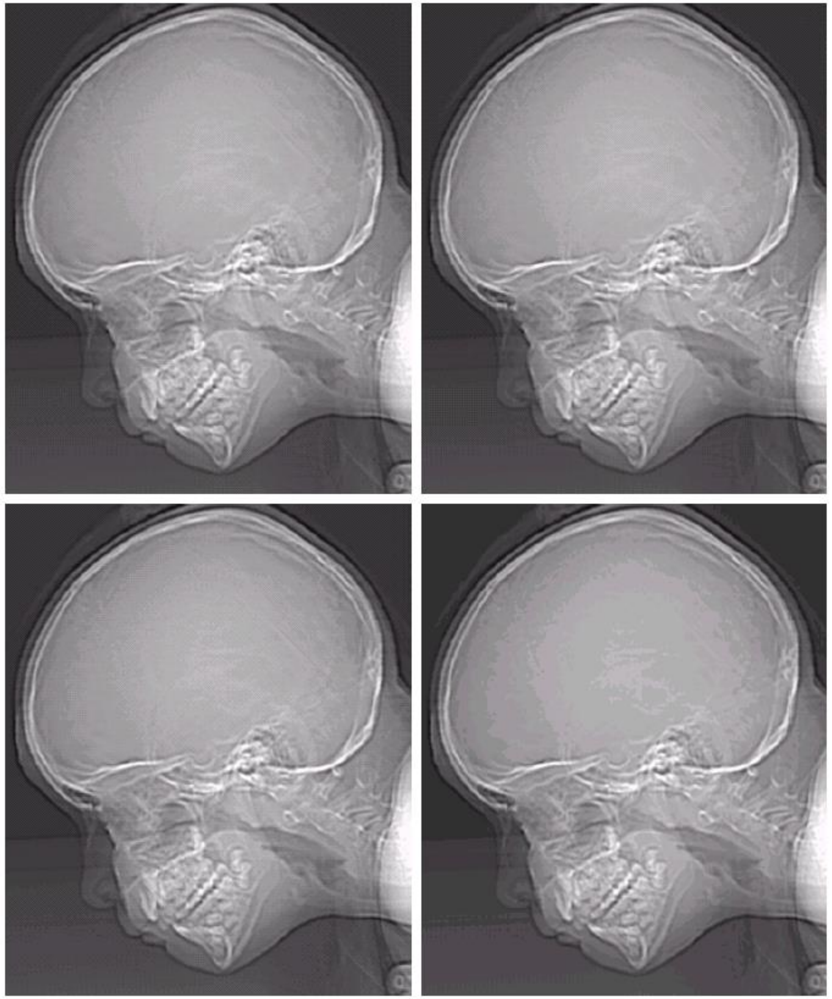
- Spatial and Intensity Resolution
  - Intensity resolution – number of bits

256 levels

128 levels

64 levels

32 levels

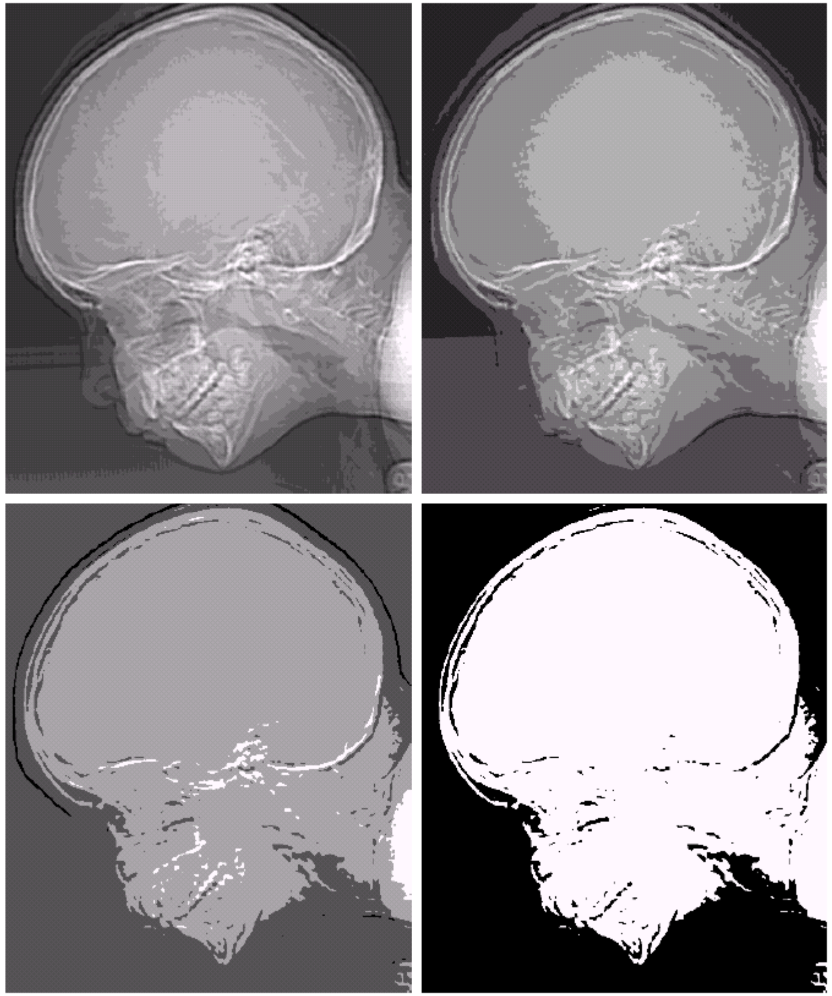


16 levels

8 levels

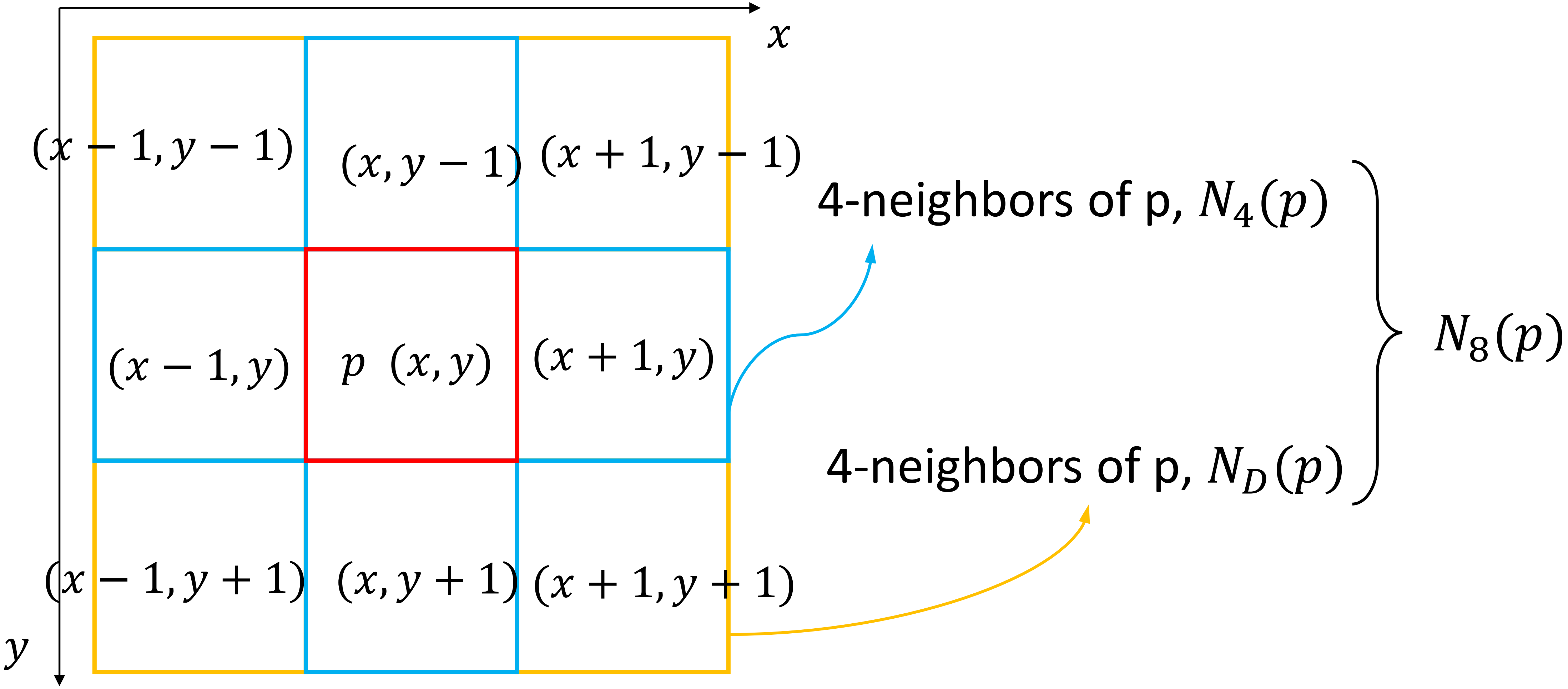
4 levels

2 levels



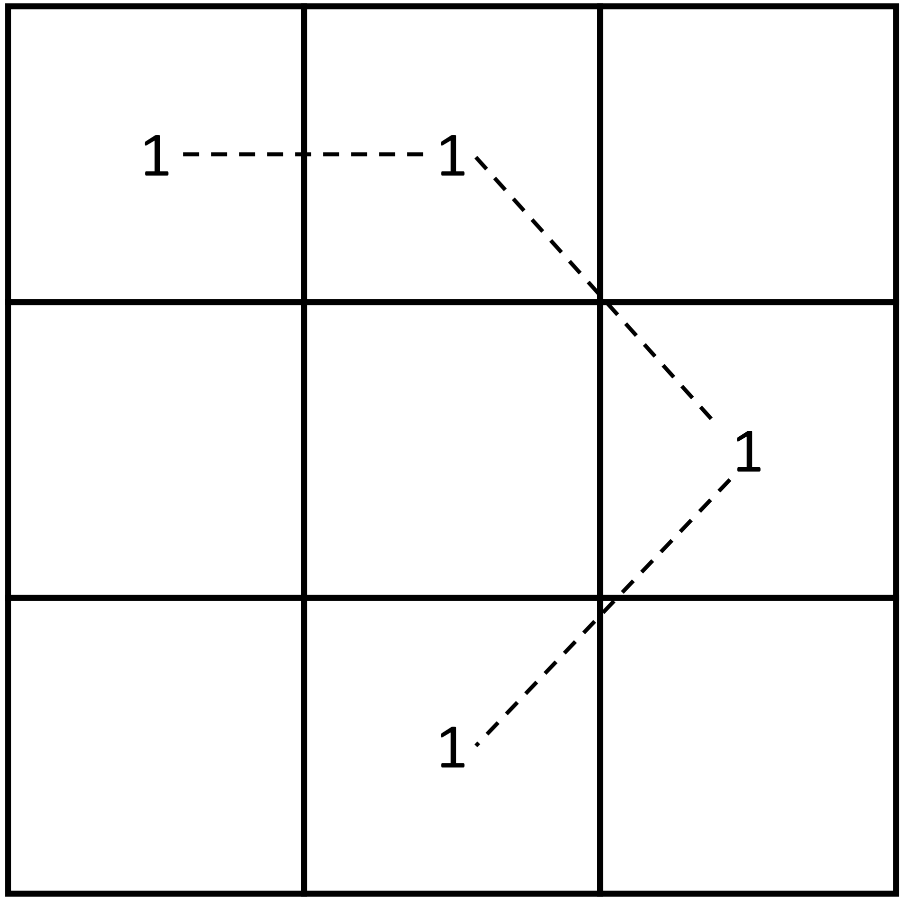
Some Basic Relationships between Pixels

- Neighbors of a pixel

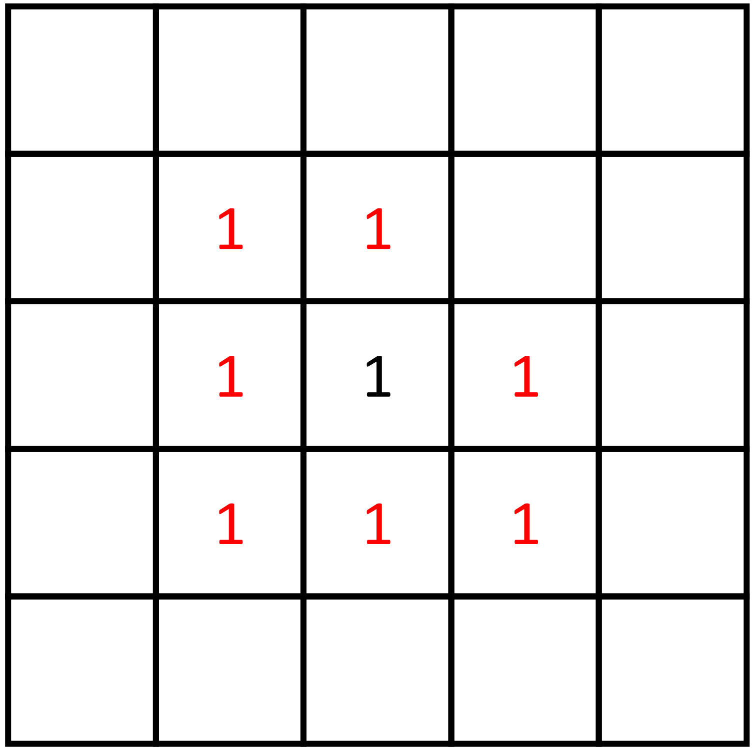


Some Basic Relationships between Pixels

- Path, Region and boundary



8-path



boundary

Some Basic Relationships between Pixels

- Distance Measures

3 pixels p, q, z, with coordinates (x, y), (s, t), and (v, w), D is a distance function if

(a) $D(p,q) \geq 0 \ \ (D(p,q) = 0 \ \ iff \ \ p = q)$

(b) $D(p,q) = D(q,p)$, and

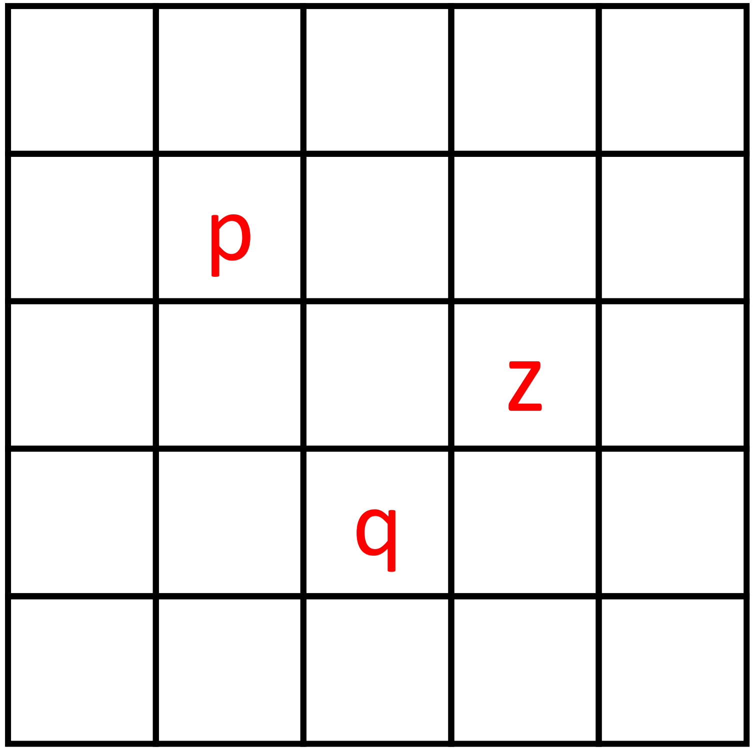
(c) $D(p,z) \leq D(p,q) + D(q,z)$

➢ Euclidean distance

$$D_e(p,q) = [(x-s)^2 + (y-t)^2]^{1/2}$$

➢ City-block distance

$$D_4(p,q) = |x-s| + |y-t|$$



Summary

- Course information
- Overview of digital image processing
- Digital image fundamentals

Next

Lecture 2: Intensity Transformations

Test of Background

Background

- Linear Algebra
- Calculus
- Probability
- Python

- For each question
  - Write down the answer
  - Self-assess your confidence: scale of 1 (lowest) to 5 (highest)

Linear Algebra

1(a) What is the rank of a matrix?

Consider the matrix $A = \begin{bmatrix} x & x^2 \\ y & y^2 \end{bmatrix}$

1(b) What is the rank of A when x=1, y=2?

1(c) What is the rank of A when x=0, y=1?

1(d) What is the null space of A when x=2, y=2?

1(e) Rate your confidence

1: Null space? Where Jedi master Yoda goes to sleep?

3: I kind of know, but not sure.

5: I can do this in my sleep!

Linear Algebra

Consider the matrix

$$A = \begin{bmatrix} 1 & 0 \\ 2 & 4 \end{bmatrix}$$

2(a) What is the transpose of A?

2(b) Define eigenvalues and eigenvectors of a matrix.

2(c) What are the eigenvalues of A?

2(d) Rate your confidence

1: Transpose? My phone autocorrects it to transport.

3: I kind of know, but not sure.

5: Transcended it!

Linear Algebra

Given two vectors, a = [1, 2, 3] and b = [-1, 0, 1]

3(a) What is the dot product $a \cdot b$?

3(b) What is the cross product $a \times b$?

3(c) Rate your confidence

- 1: Transpose? My phone autocorrects it to transport.
- 3: I kind of know, but not sure.
- 5: Transcended it!

Probability

4(a) If $P(A) = 0.5$, $P(B) = 0.4$ and $P(AB) = 0.2$, what is $P(A \cup B)$?

4(b) In the above, what is $P(A|B)$?

4(c) State the Bayes rule.

4(d) Rate your confidence

1: Probability? It's a coin toss.

3: I kind of know, but not sure.

5: Keep the dice rolling!

Calculus

5(a) What is the derivative of $f(x) = x^2$?

5(b) What is the partial derivative of $f(x, y) = x^2 y$ with respect to y?

5(c) What is the gradient of $f(x, y) = x^2 y$?

5(d) State the chain rule of differentiation.

4(e) Rate your confidence

1: Gradient? Seems a steep climb.

3: I kind of know, but not sure.

5: Top of the hill!

Python

6(a) Have you used Python in the past?

6(b) Briefly describe a program or project you wrote in Python.

6(c) Write a snippet: use a loop to print numbers from 1 to 10.

6(d) Have you used NumPy in the past?

6(e) Rate your confidence

- 1: NumPy? Does it taste like ApplePie?
- 3: I kind of know, but not sure.
- 5: I breathe and eat code!