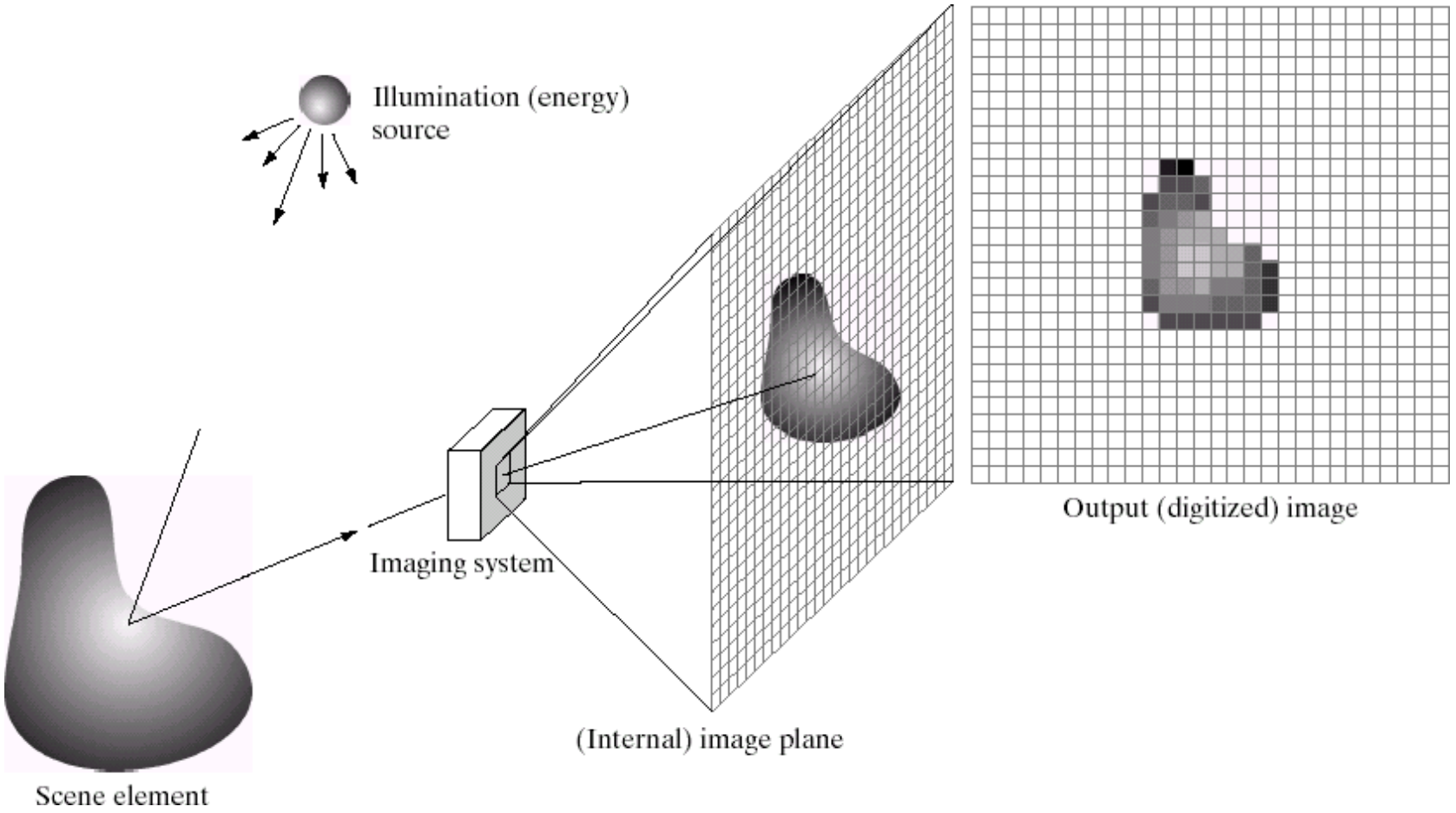
Objectives

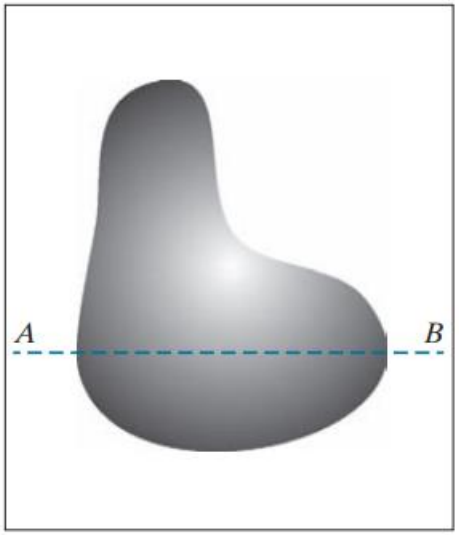
- Image acquisition
- Image sampling & quantization
- Image representation

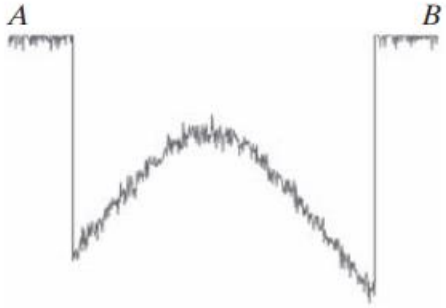
Digital Image Acquisition Process

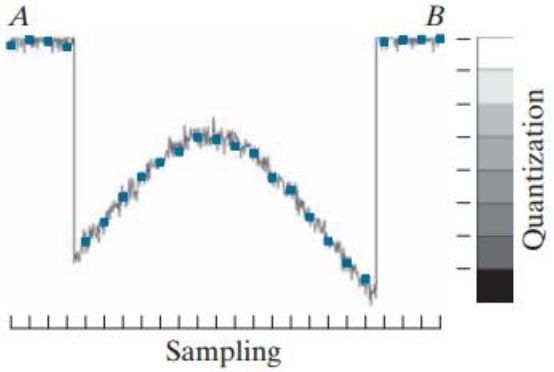


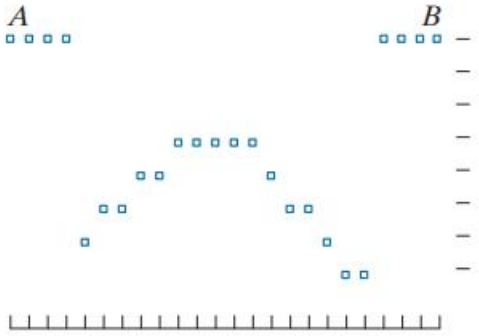
Images taken from Gonzalez & Woods, DIP book

Generating a Digital Image







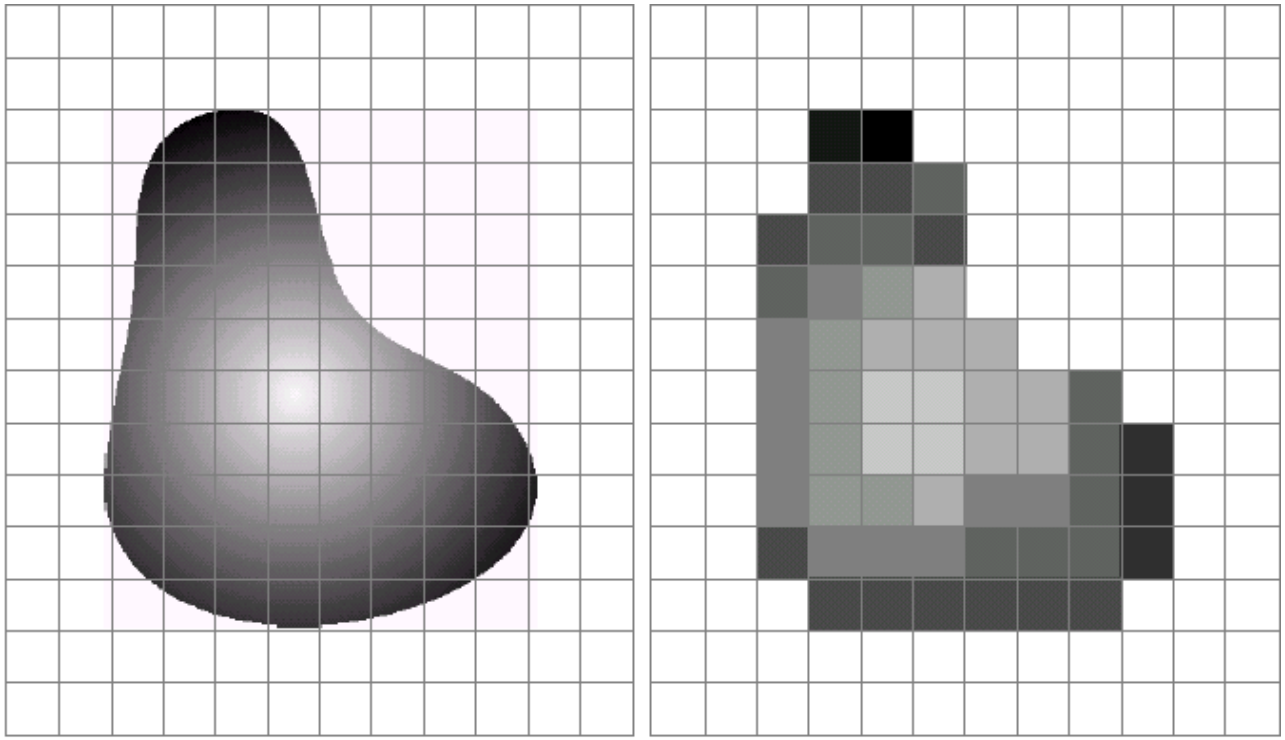


- Digitizing the coordinate values is called sampling.
- Digitizing the amplitude values is called quantization.

(a) Continuous image. (b) A scan line showing intensity variations along line AB in the continuous image. (c) Sampling and quantization. (d) Digital scan line. (The black border in (a) is included for clarity. It is not part of the image).

Images taken from Gonzalez & Woods, DIP book

Image Sampling and Quantization



a b

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

Spatial resolution: number of pixels per unit distance.

Intensity resolution: the smallest discernible change in intensity level.

Images taken from Gonzalez & Woods, DIP book

Image Formation Model

- Image is a 2-D function denoted as $f(x,y)$
- The amplitude f at spatial coordinates (x,y) is a +ve scalar quantity
- Amplitude must be nonzero and finite ($0<f(x,y)<\infty$)

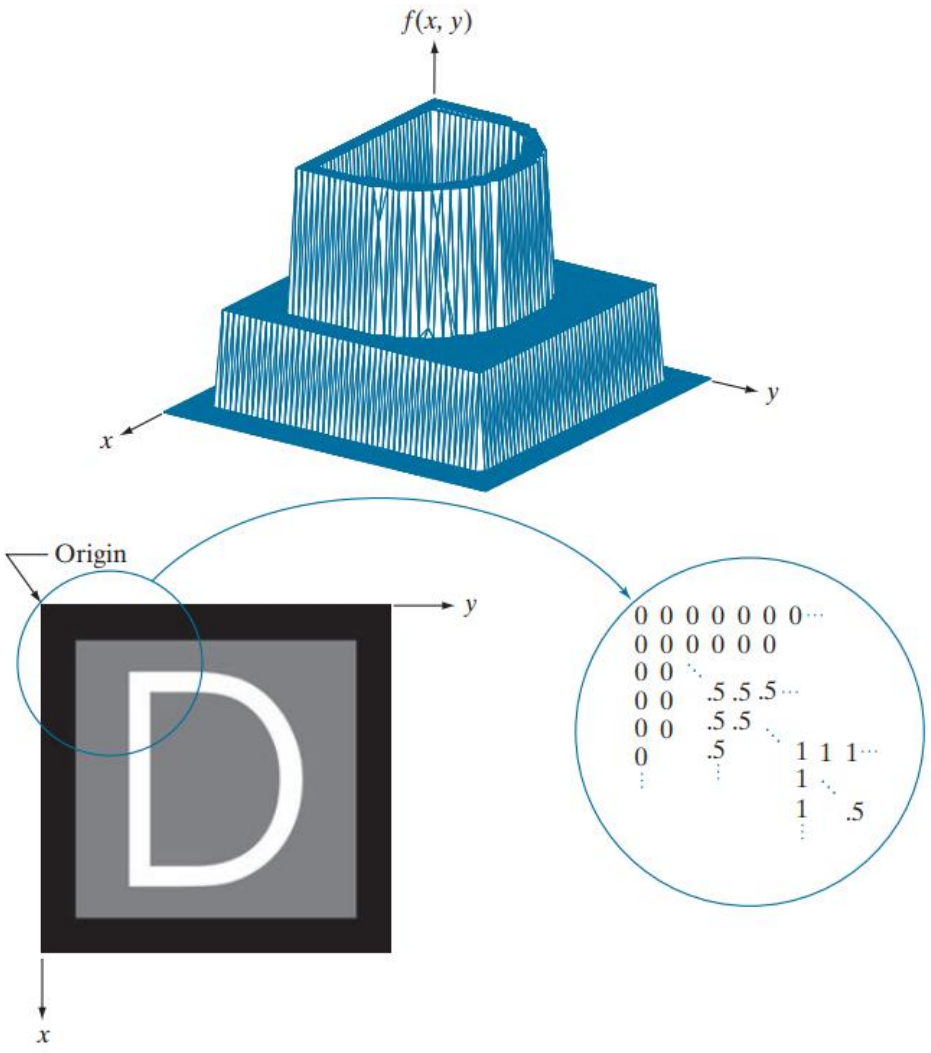
- Image, $f(x,y)$ characterized by two components:
  - the amount of source illumination incident on the scene being viewed $i(x,y)$.
  - the amount of illumination reflected by the objects in the scene $r(x,y)$.

The two components combine as a product to form $f(x,y)$

$$f(x,y)=i(x,y)r(x,y)$$

where $0<i(x,y)<\infty$; and $0<r(x,y)<1$

Representation of Digital Image



The location of a pixel is given by its 2-D coordinates, is referred to as coordinate indexing, or subscript indexing.

(a) Image plotted as a surface. (b) Image displayed as a visual intensity array. (c) Image shown as a 2-D numerical array. (The numbers 0, .5, and 1 represent black, gray, and white, respectively.

Images taken from Gonzalez & Woods, DIP book

Representation of Digital Image

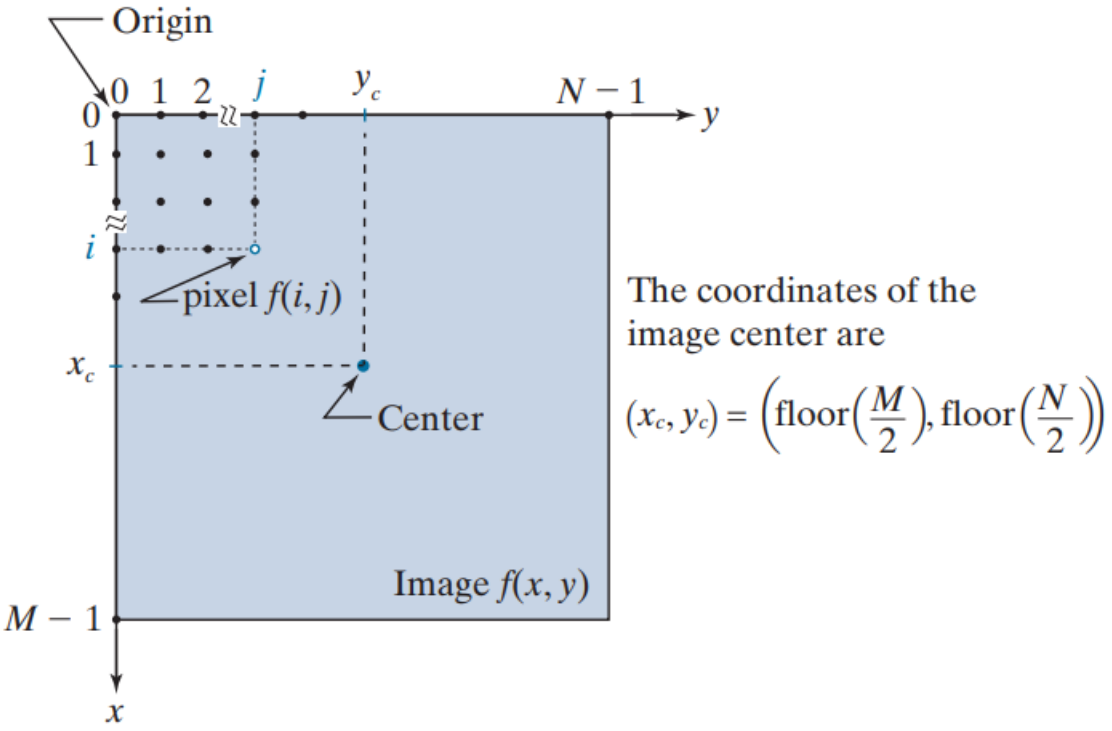
$$f(x,y)=\begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & \cdots & f(1,N-1) \\ \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1) \end{bmatrix}$$

- The right side of this equation is a digital image represented as an array of real numbers.
- Each element of this array is called an image element, picture element, pixel, or pel.

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

We can also represent a digital image in a traditional matrix form.

Representation of Digital Image



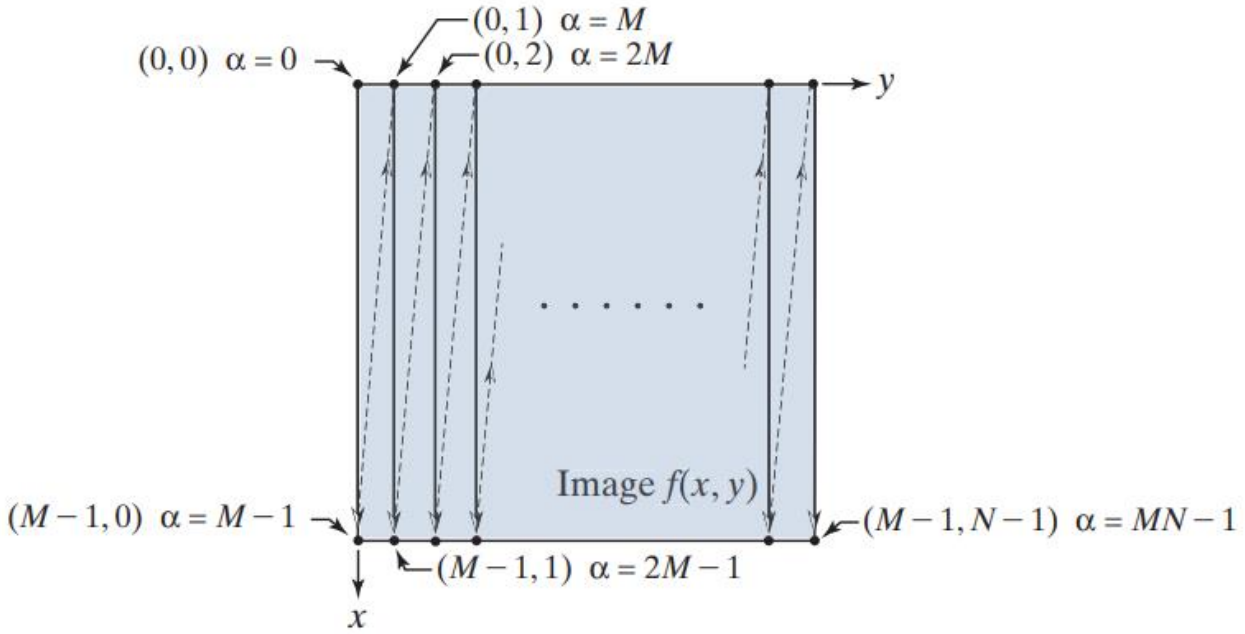
The right-handed Cartesian coordinate system

- The center of an MxN digital image with origin at (0,0) and range to (M-1, N− 1) is obtained by dividing M and N by 2.
- Rounding down to the nearest integer.
- This operation sometimes is denoted using the floor operator.

Images taken from Gonzalez & Woods, DIP book

Representation of Digital Image

Linear indexing: It consists of a 1-D string of nonnegative integers based on computing offsets from coordinates (0,0).
There are two principal types of linear indexing, one is based on a row scan of an image, and the other on a column scan.



Any pair of coordinates (x,y), the corresponding linear index value is $\alpha = My + x$

the coordinate indices for a given linear index value a are given by the equations

$$x = \alpha \bmod M$$

remainder of the division of α by **M**

$$y = (\alpha - x)/M$$

Images taken from Gonzalez & Woods, DIP book

Important points

- The range of values spanned by the gray scale is referred to as the dynamic range.
- The dynamic range of an imaging system to be the ratio of the maximum measurable intensity to the minimum detectable intensity level in the system.
- The upper limit is determined by saturation and the lower limit by noise.
- The dynamic range establishes the lowest and highest intensity levels that a system can represent.
- Image contrast: the difference in intensity between the highest and lowest intensity levels in an image.
- Contrast ratio: Ratio of highest and lowest intensity levels in an image.