Image Representation

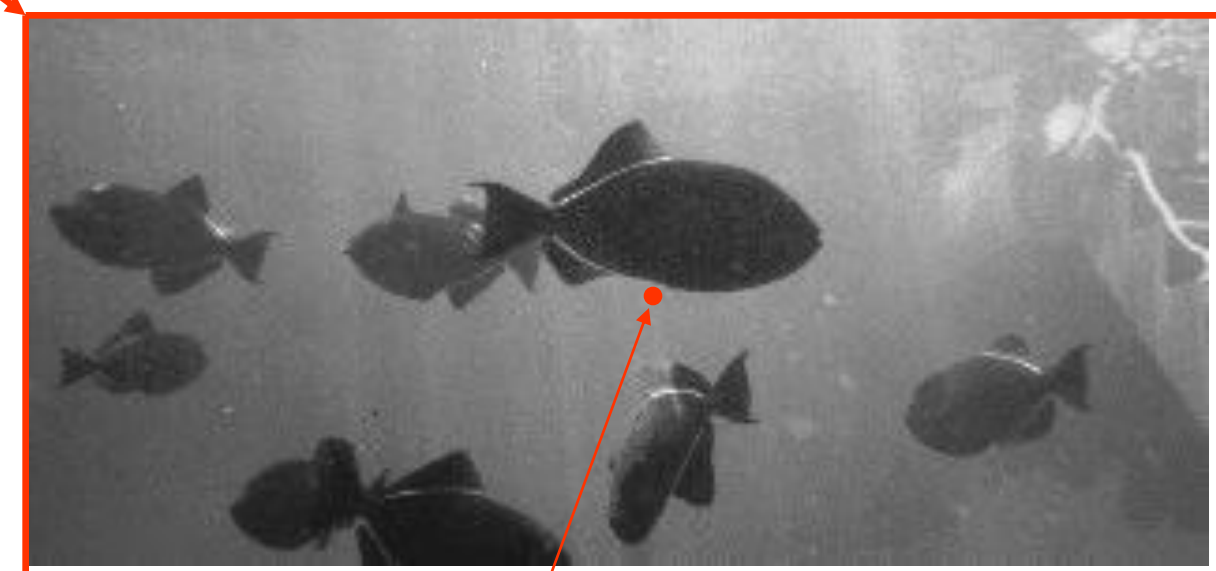
Reference:

[Gonzalez and Woods] Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Second Edition, Prentice-Hall, Inc.

http://www.imageprocessingplace.com/

Image representation

origin (0,0) in *C*, and (1,1) in *MATLAB*

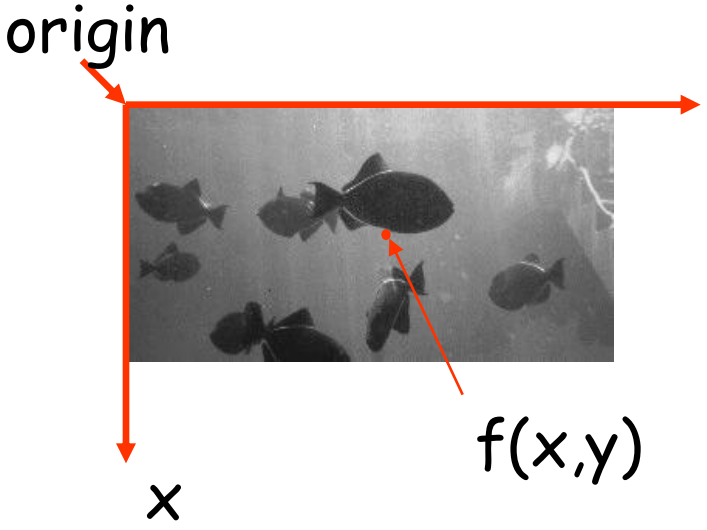


y

x

f(x,y), a 2D function representing image intensity; (x,y) represents a pair of spatial coordinates

Image representation



- **Discretized in both**
  - **Spatial coordinates**
  - **Brightness**

Similar to a matrix in Linear Algebra

Individual elements are called:
image elements, picture elements (pixels), (image points)

Image representation (MATLAB convention)

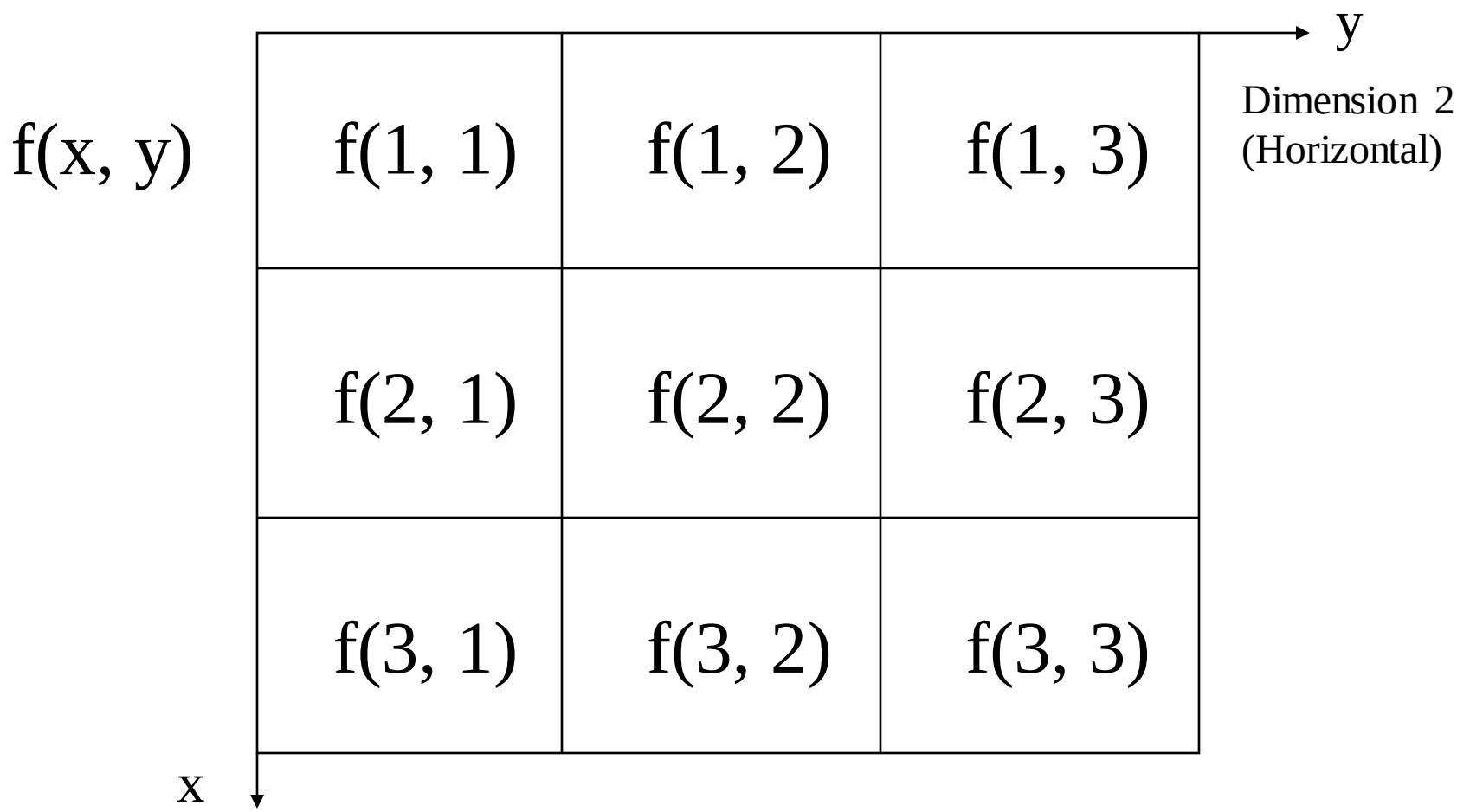
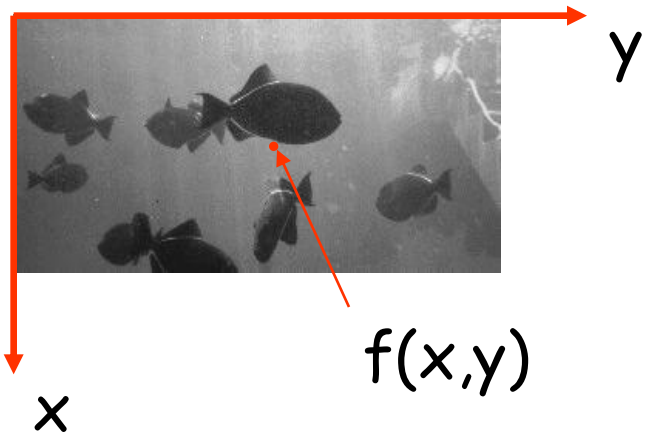


Image function, f (intensity)



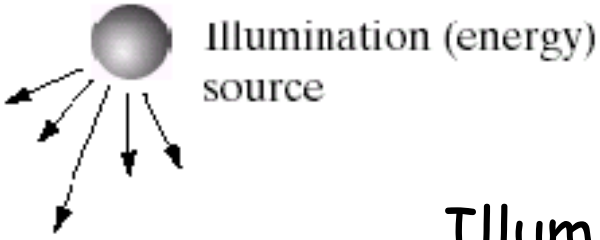
The image function (intensity/color) f can be characterized by two components:

(1) illumination (light source) and

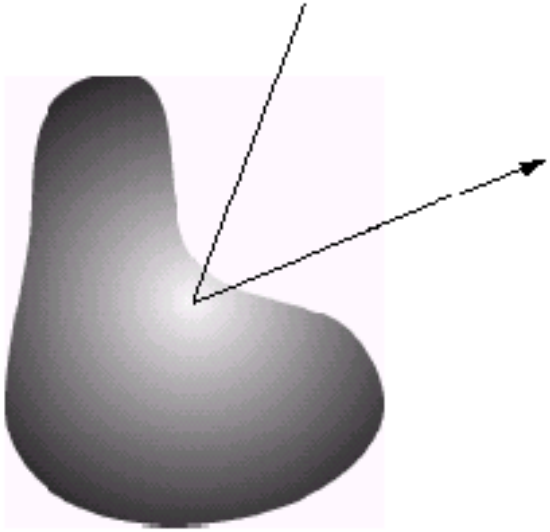
(2) reflectance (materials).

Image intensity is depending on these two factors.

Image function, f (intensity)



Illumination: the amount of source illumination (energy) incident on the scene being viewed.



Reflectance: the amount of source illumination (energy) reflected by the objects (or elements) in the scene.

[Gonzalez and Woods]

Image model

- Basic nature of f(x,y) has two components:
  $f(x,y) = i(x,y)\, r(x,y)$

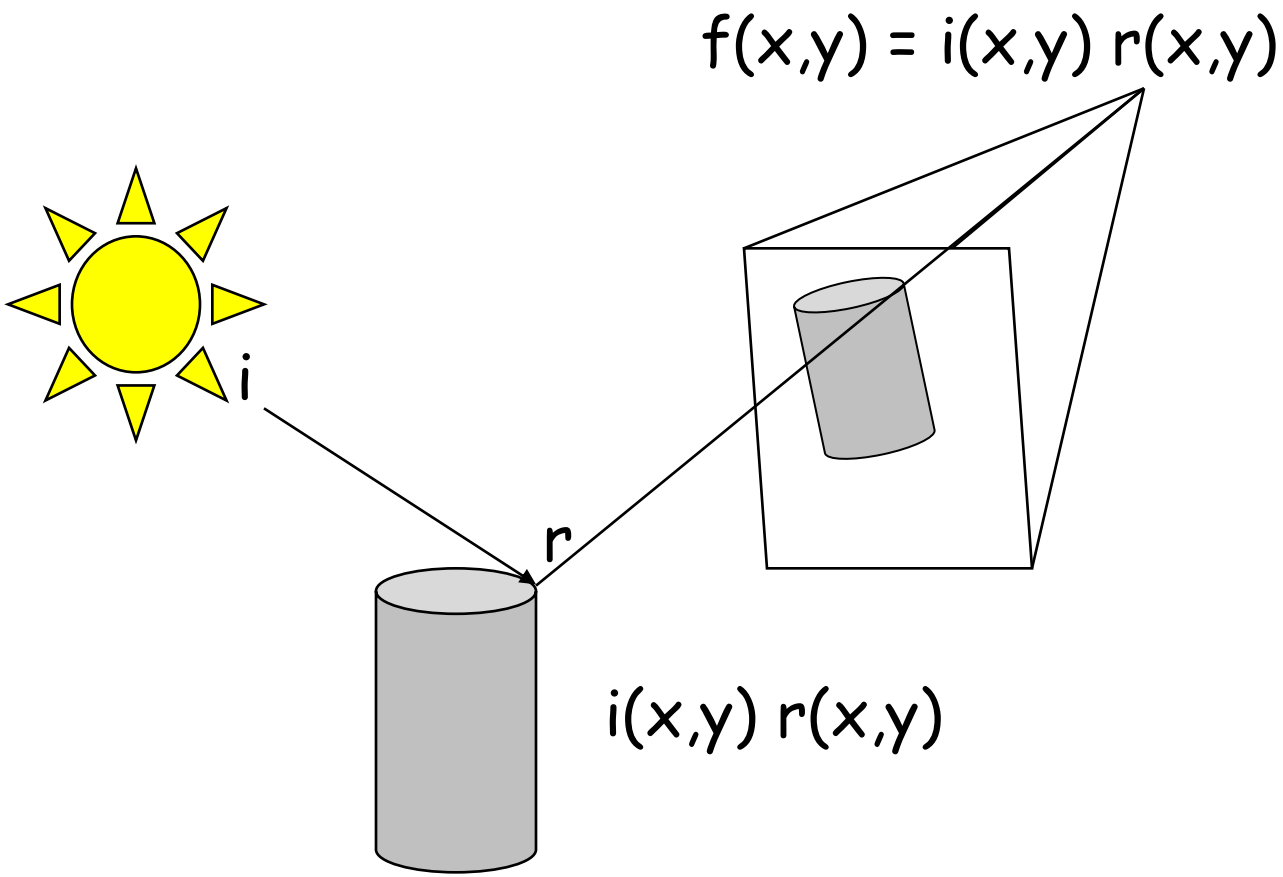
- i(x,y) is illumination component
  $0 \leq i(x,y) < +\text{infinity}$

- r(x,y) is reflectance component
  $0 \leq r(x,y) \leq 1$
  0 = total absorption, 1 = total reflectance.

- f(x,y) is intensity

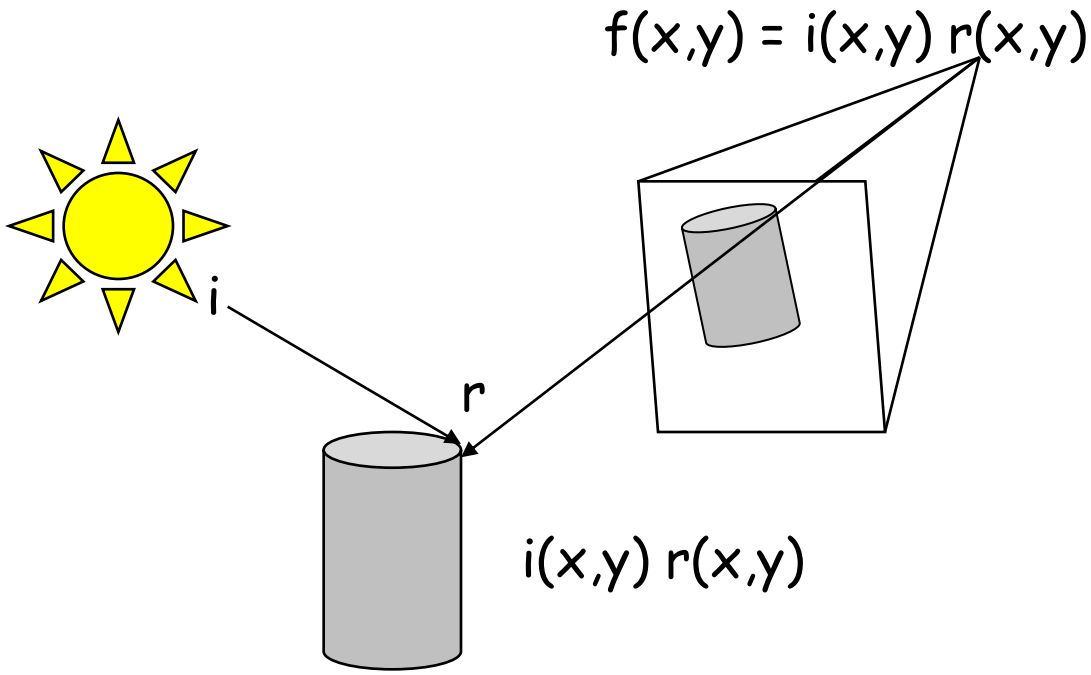
- $0 \leq f(x,y) < +\text{infinity}$

Image model



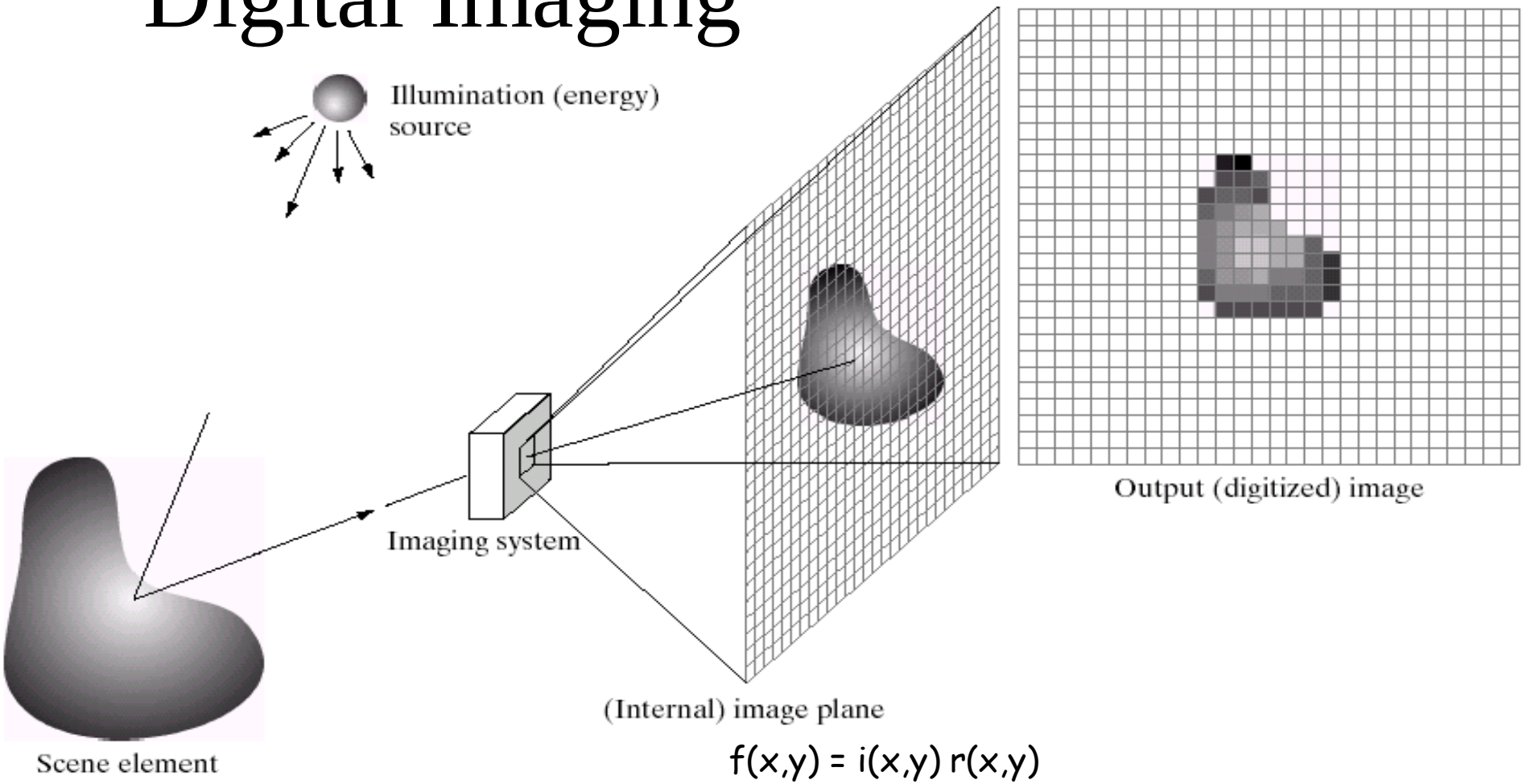
i and r are continuous functions
thus f(x,y) can be continuous

Sampling and quantization are affecting the image quality.



i and r are continuous functions
thus f(x,y) can be continuous

Digital Imaging



a b c d e

FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

[Gonzalez and Woods]

Digital Imaging

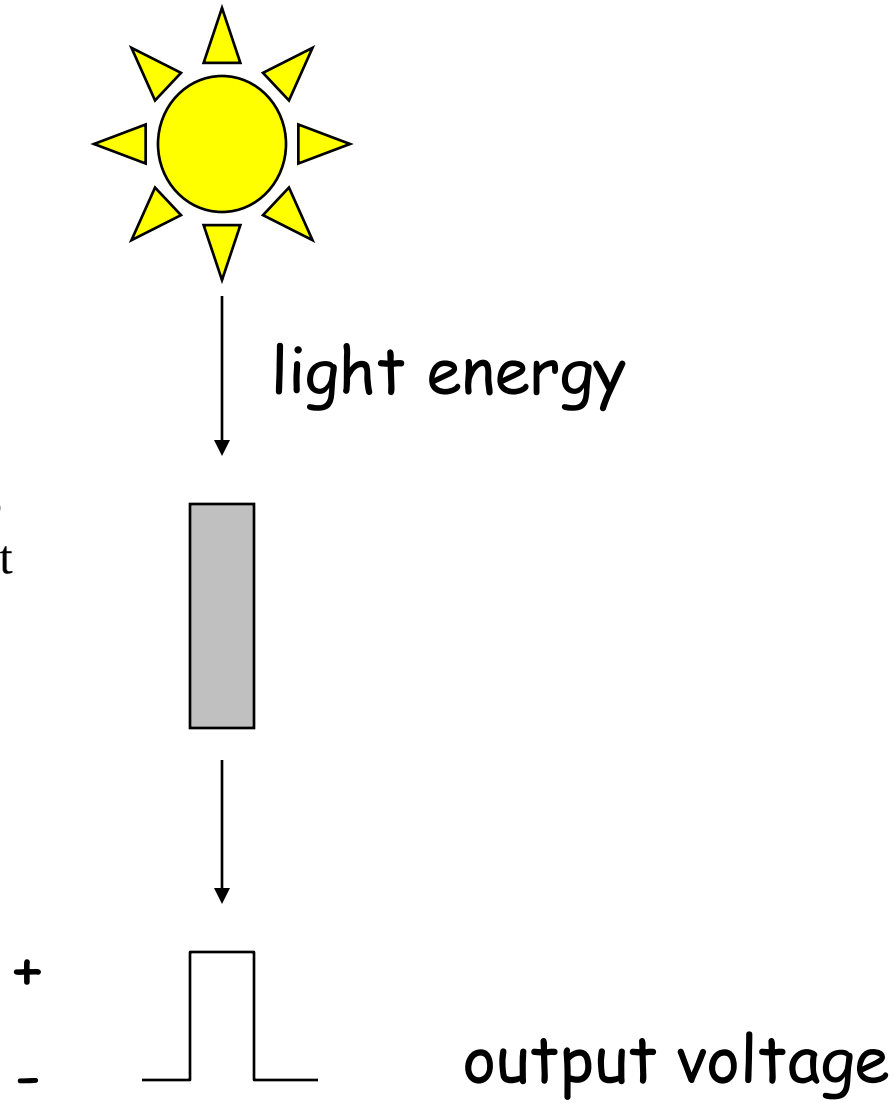
- Charged-Coupled Device (CCD)
  - consists of photosites
    - silicon imaging elements that give a voltage output proportional to the intensity of the incident light
  - linear array (scanner)
  - area array (Camera CCD)

- http://en.wikipedia.org/wiki/Charge-coupled_device

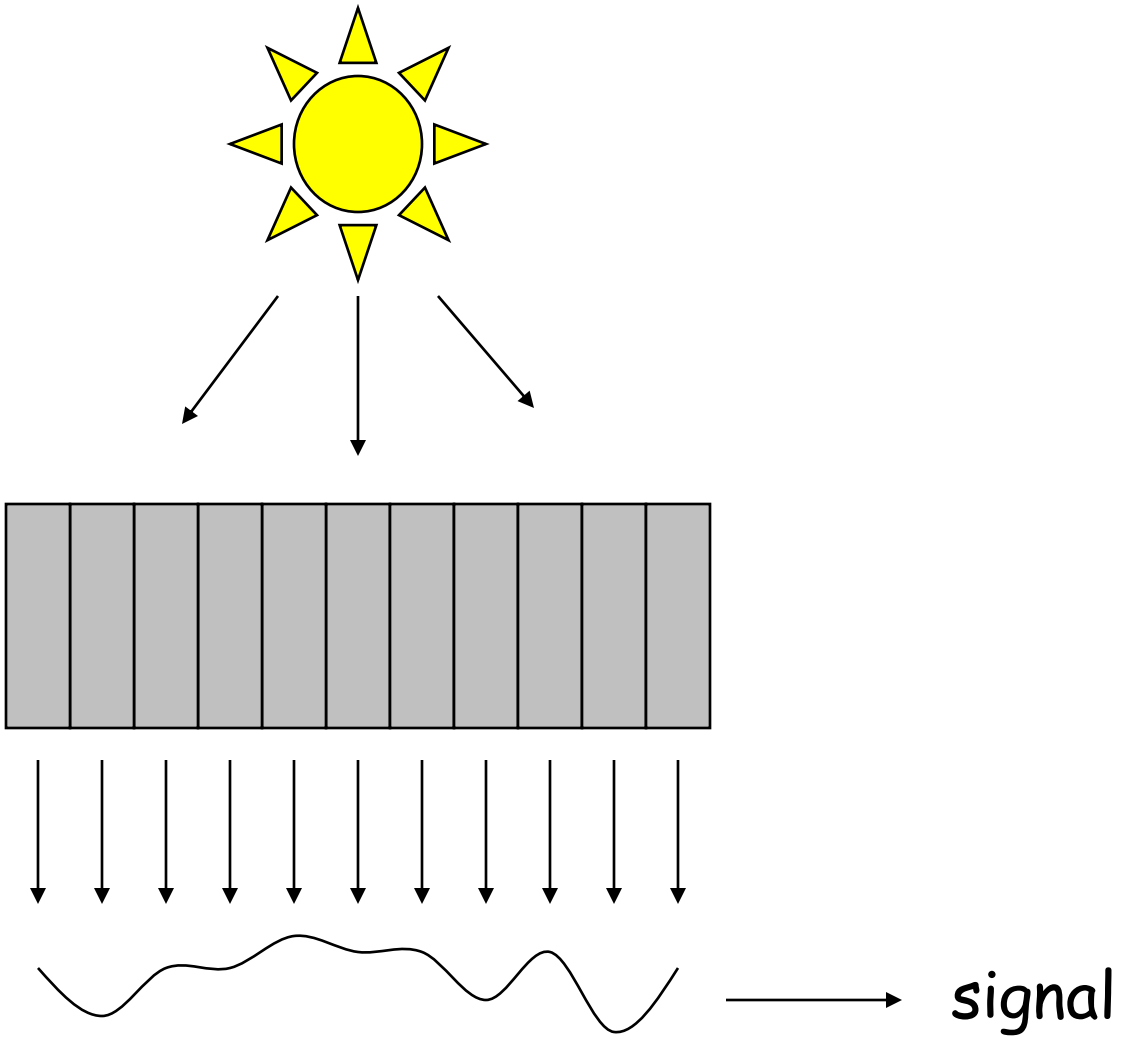
Photosites

CCD consists of photosites

- silicon imaging elements that give a voltage output proportional to the intensity of the incident light



Line scan sensor



Area scan sensor

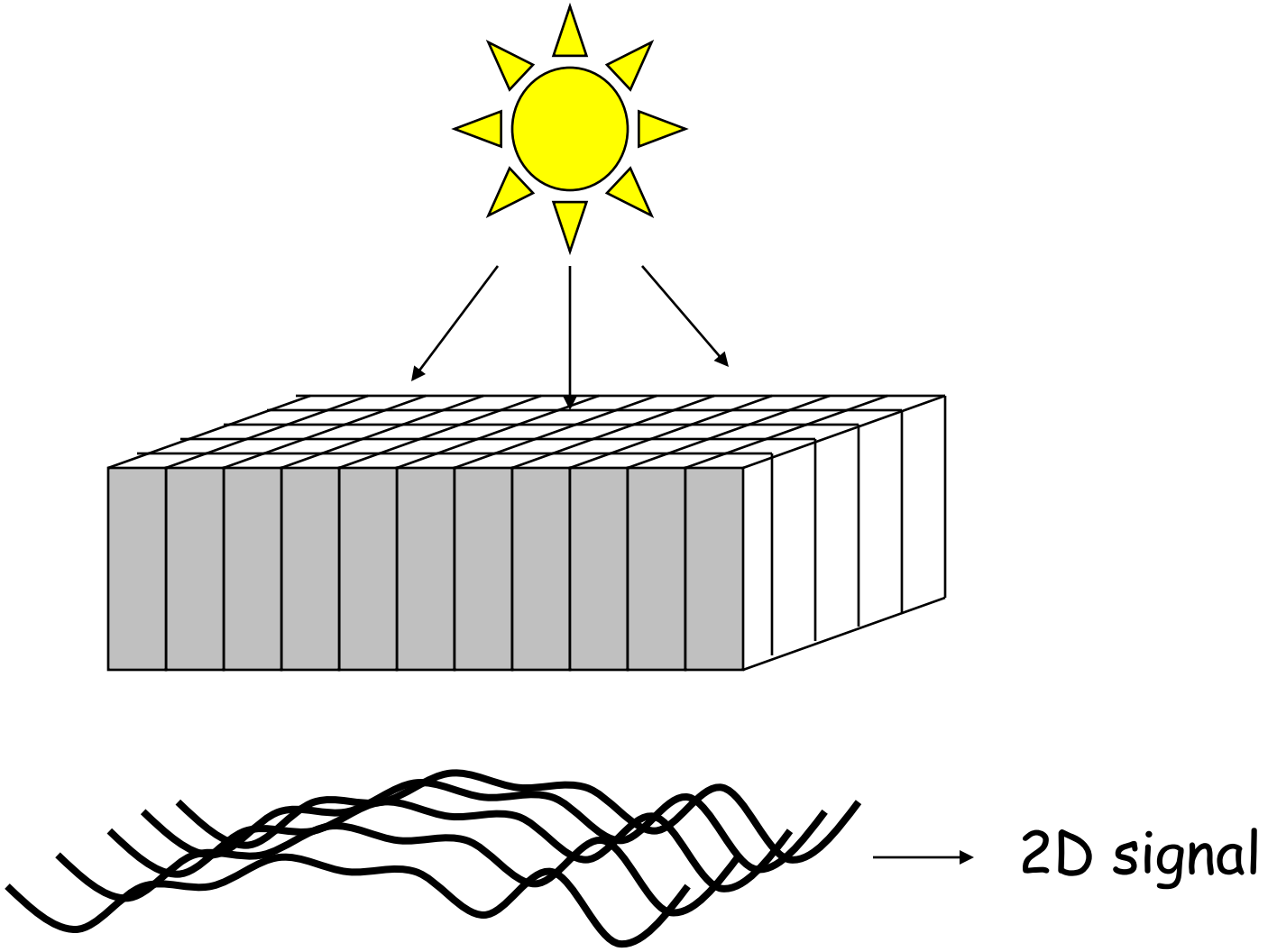
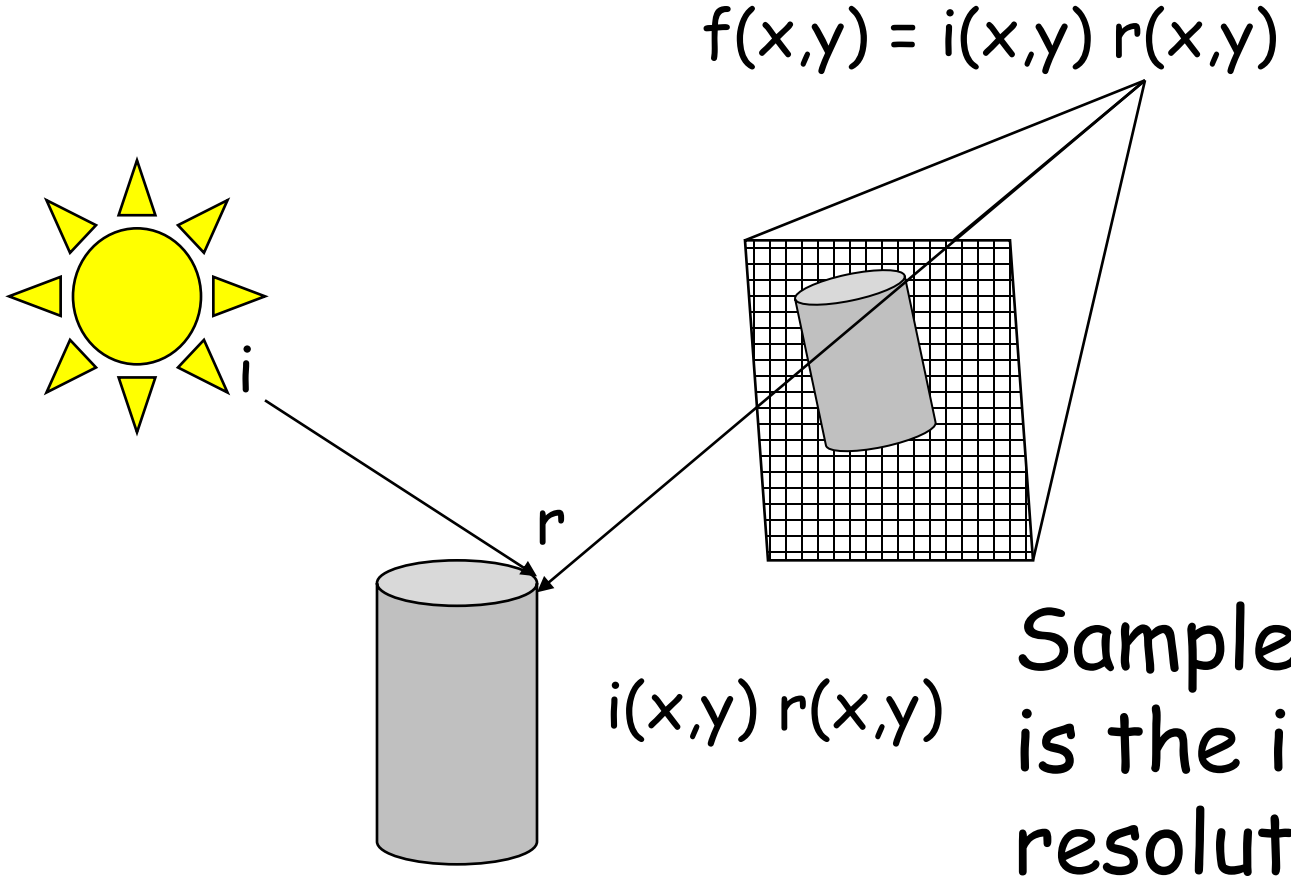
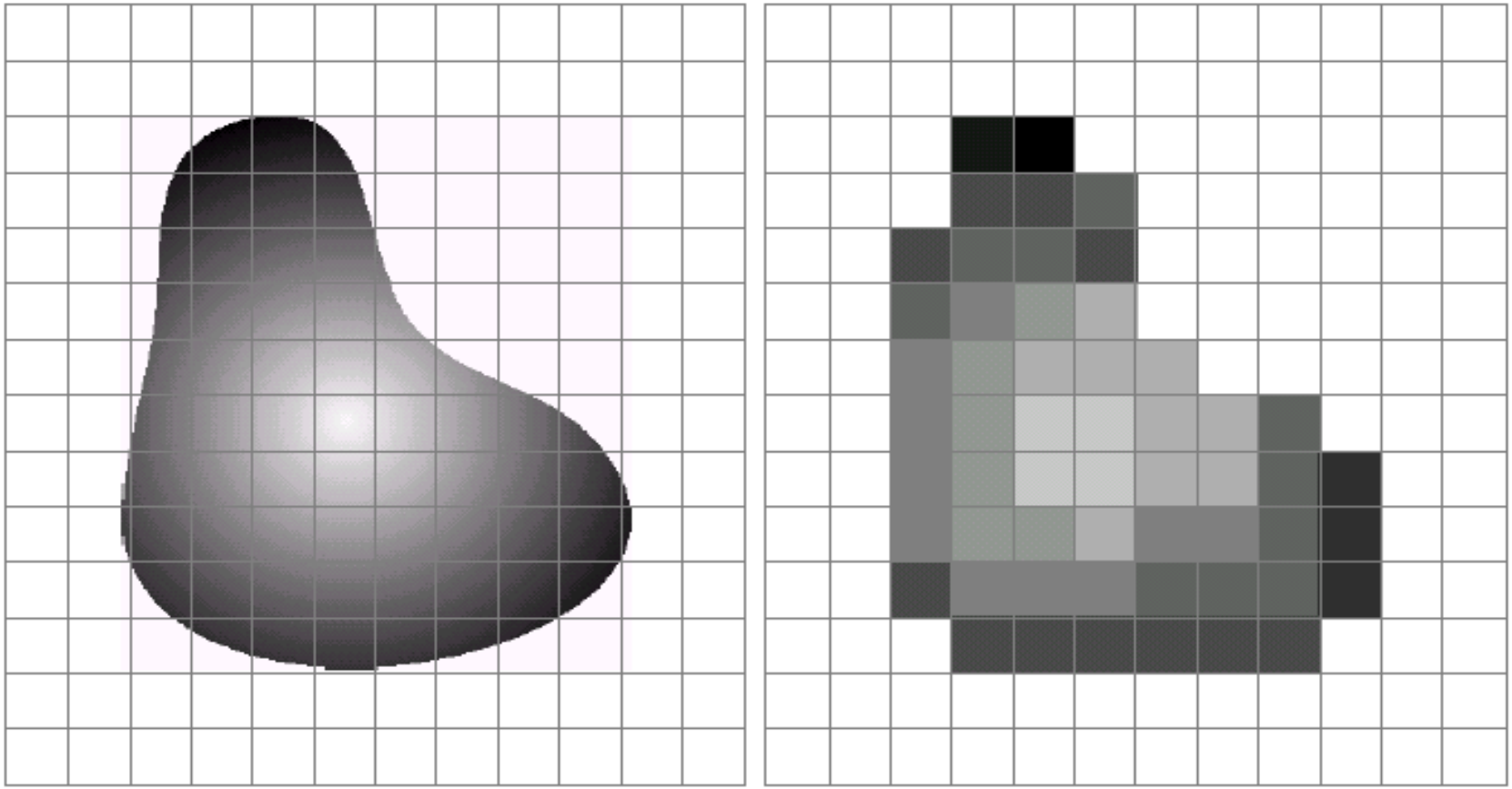


Image sampling/resolution



Sample rate is the image resolution

Spatially discretized



a b

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

[Gonzalez and Woods]

A digital image is discrete

$$f(x,y) \sim \begin{pmatrix} f(0,0) & f(0,1) & \cdots & f(0,m-1) \\ f(1,0) & f(1,1) & \cdots & f(1,m-1) \\ \vdots & & & \\ f(n-1,0) & f(n-1,1) & \cdots & f(n-1,m-1) \end{pmatrix}$$

A digital image is discrete (MATLAB convention)

$$f(x,y) \sim \begin{pmatrix} f(1,1) & f(1,2) & \cdots & f(1,m) \\ f(2,1) & f(2,2) & \cdots & f(2,m) \\ \vdots & & & \\ f(n,1) & f(n,2) & \cdots & f(n,m) \end{pmatrix}$$

Effects of spatial resolution

a b c
d e f

More pixelated!

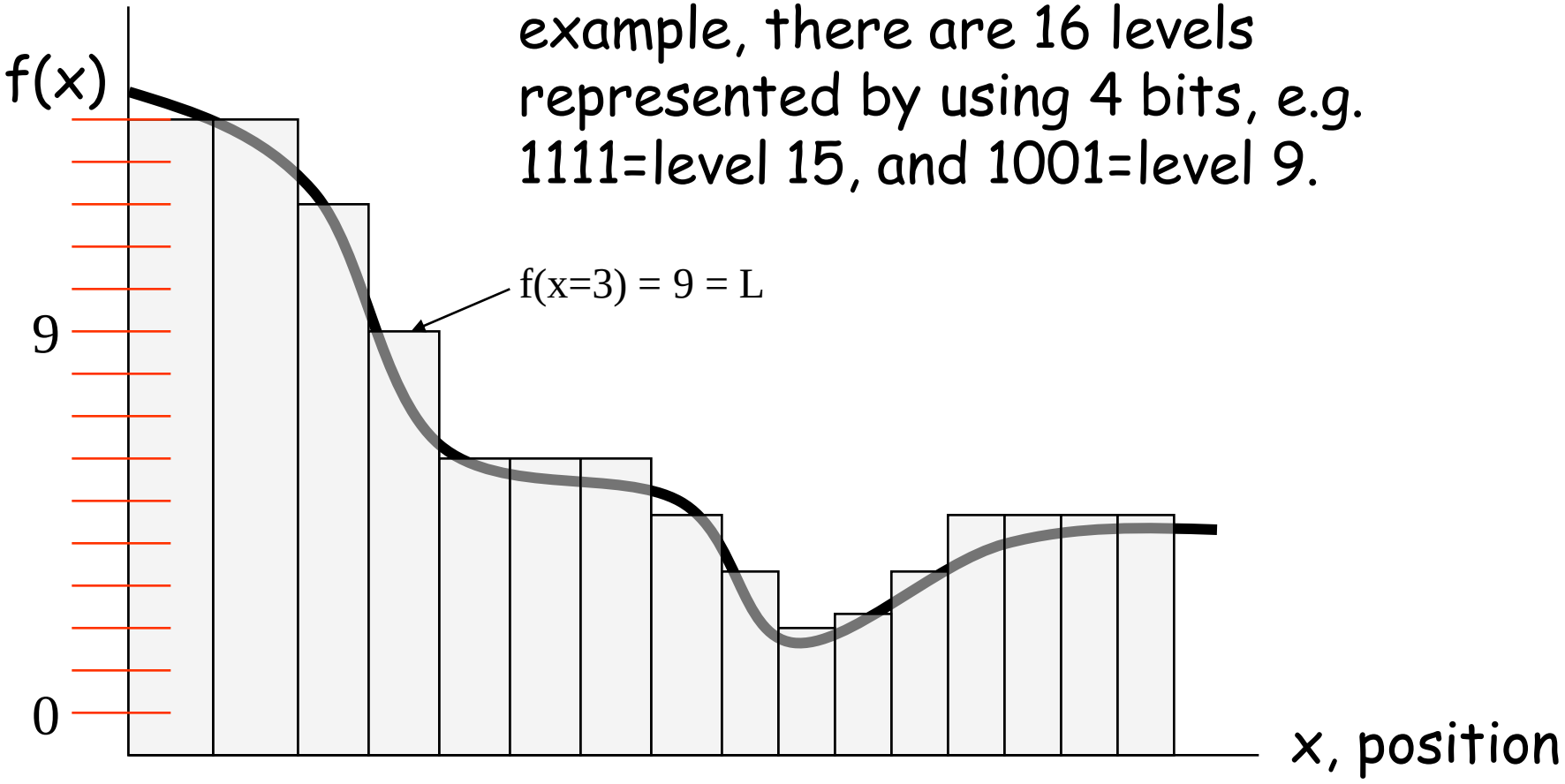
FIGURE 2.20 (a) 1024 × 1024, 8-bit image. (b) 512 × 512 image resampled into 1024 × 1024 pixels by row and column duplication. (c) through (f) 256 × 256, 128 × 128, 64 × 64, and 32 × 32 images resampled into 1024 × 1024 pixels.

[Gonzalez and Woods]

Effects of spatial resolution

Intensity quantization

We will call intensity of a monochrome image, its grey level (L). In this example, there are 16 levels represented by using 4 bits, e.g. 1111=level 15, and 1001=level 9.



Effects of intensity quantization

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.)

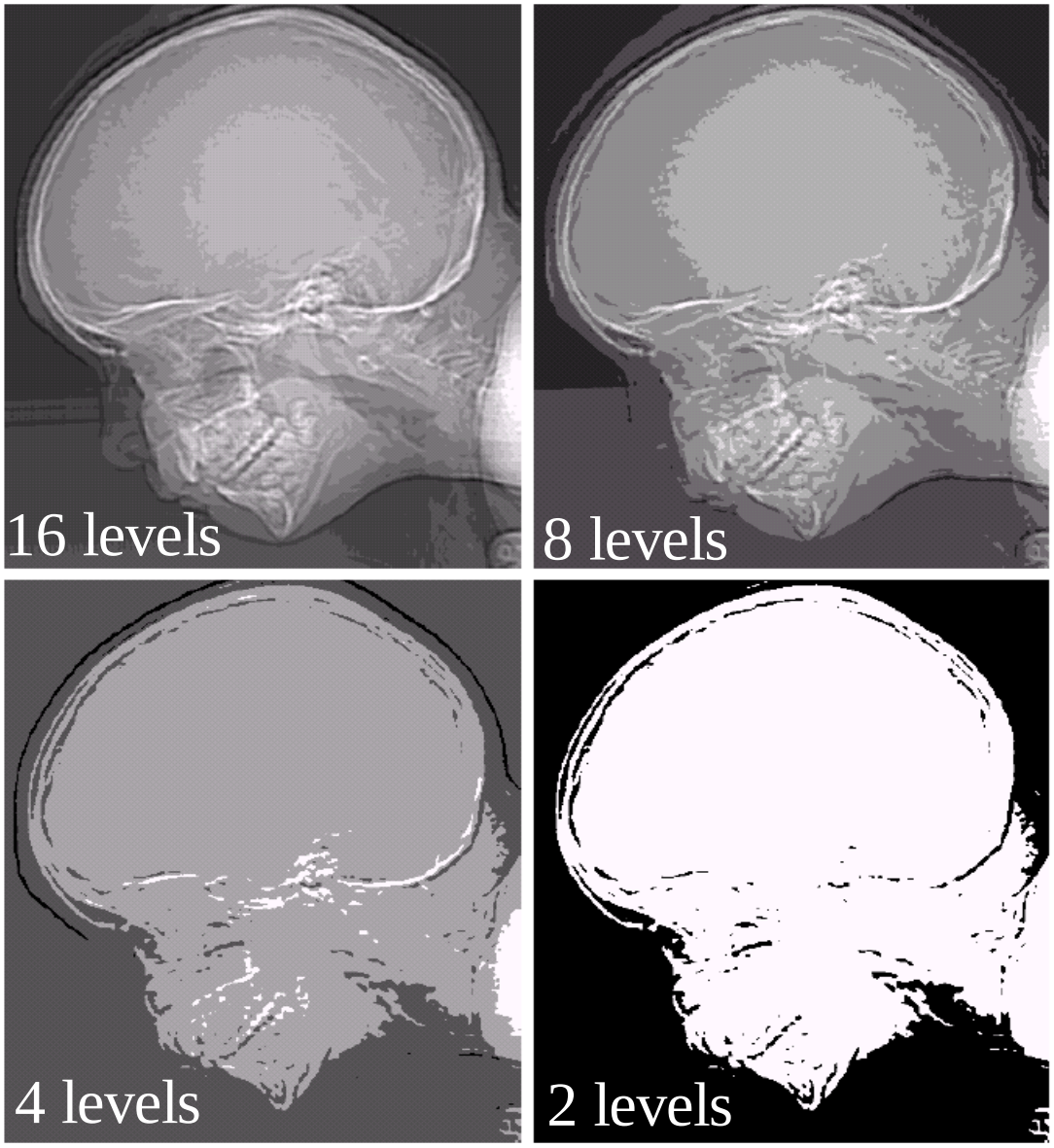


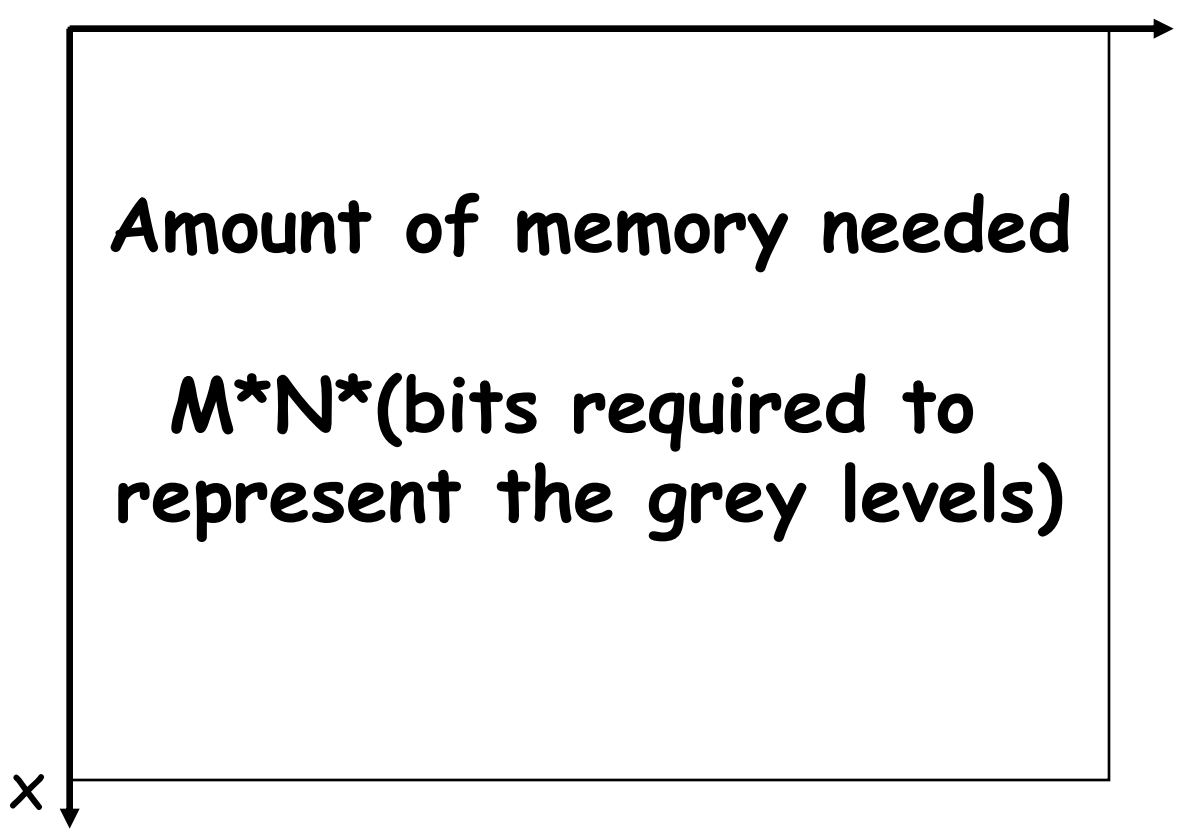
Image resolution is fixed but the number of gray levels decreases.

[Gonzalez and Woods]

Effects of intensity quantization

Storage requirements

M = number of columns,
"Width" in MATLAB



N = number of rows, "height" in MATLAB