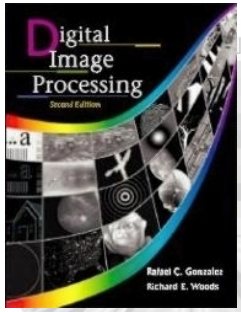

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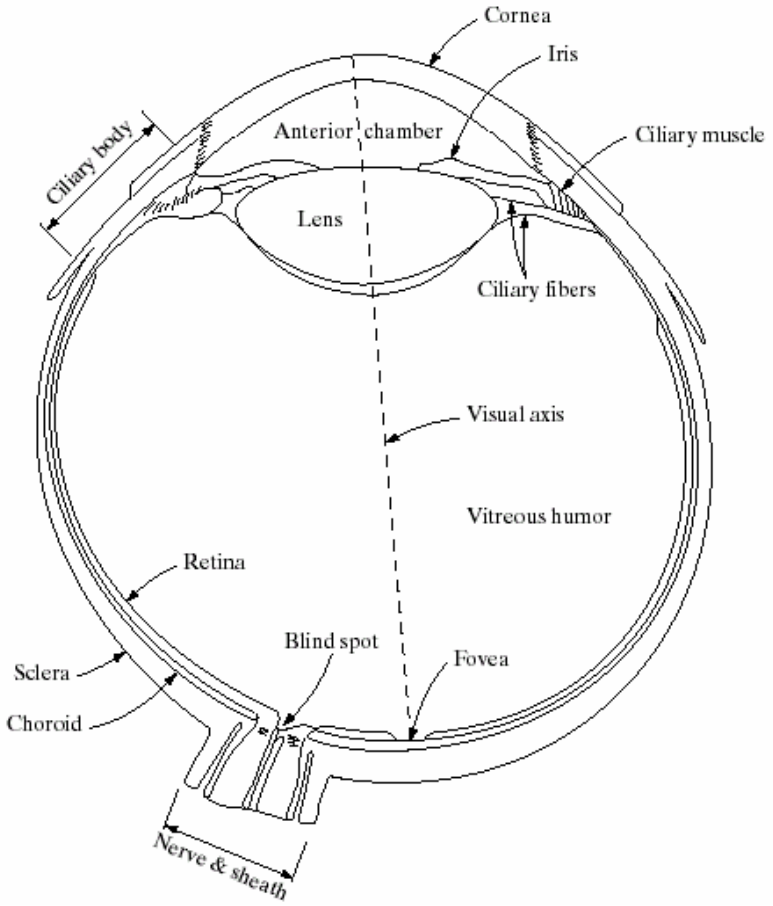
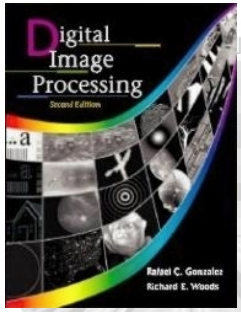


FIGURE 2.1 Simplified diagram of a cross section of the human eye.



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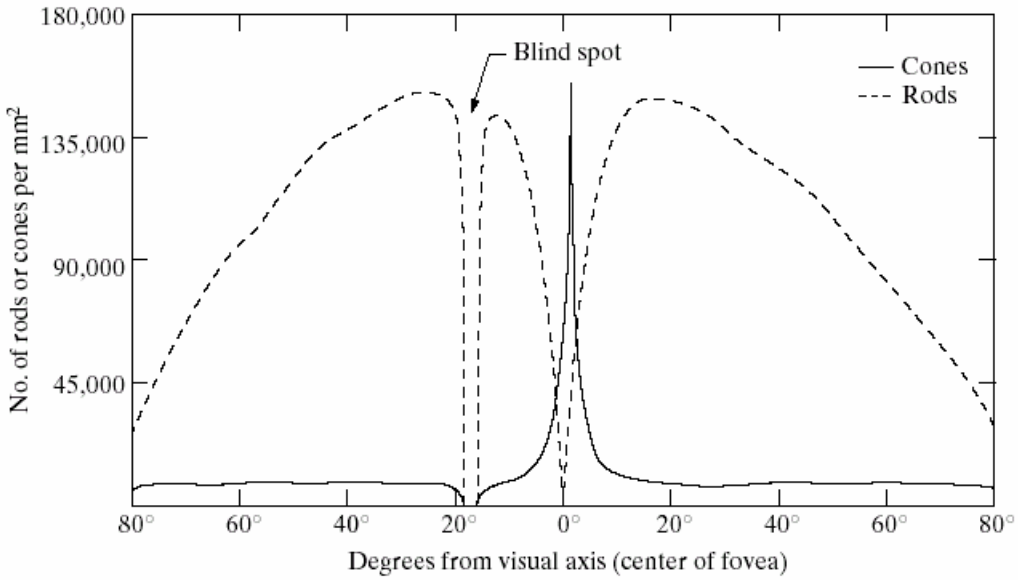

FIGURE 2.2
Distribution of rods and cones in the retina.

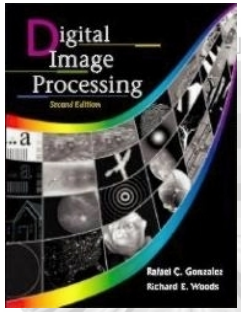

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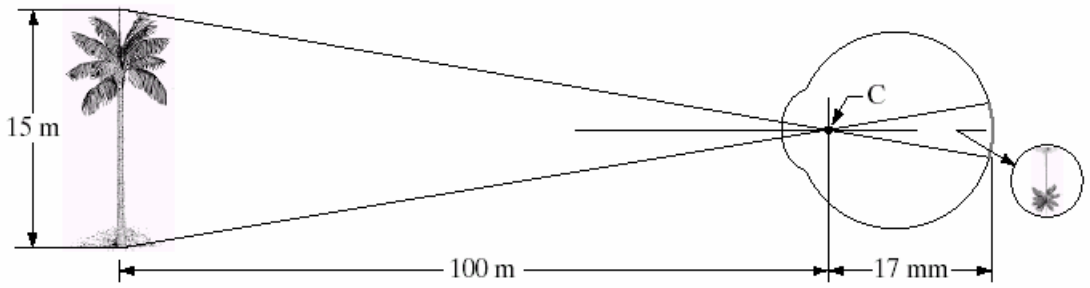
FIGURE 2.3
Graphical representation of the eye looking at a palm tree. Point *C* is the optical center of the lens.



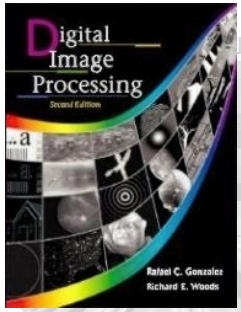


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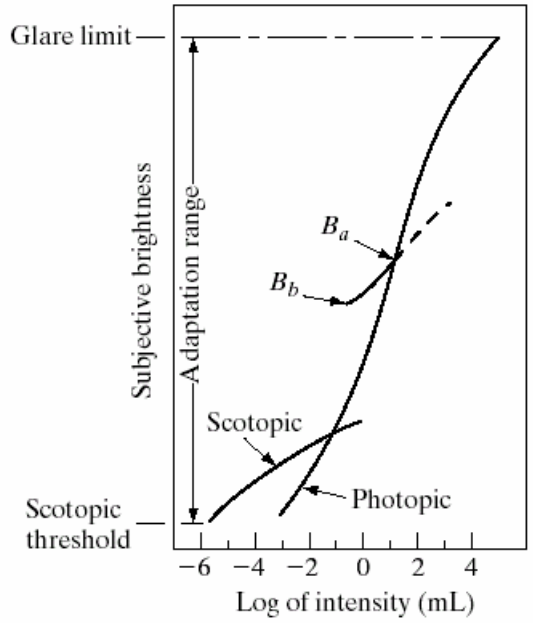
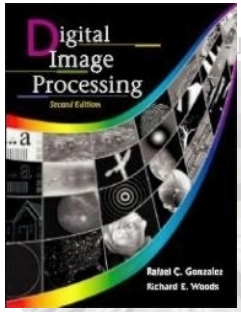
FIGURE 2.4
Range of subjective brightness sensations showing a particular adaptation level.





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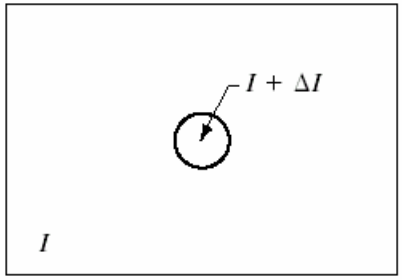

FIGURE 2.5 Basic experimental setup used to characterize brightness discrimination.

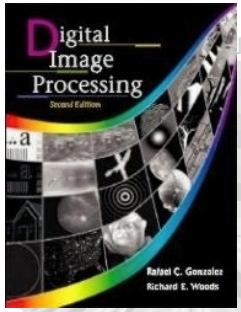

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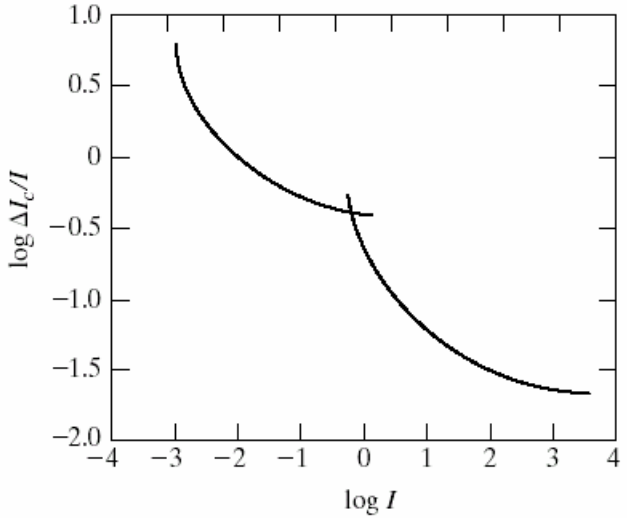
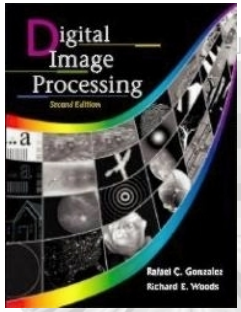
FIGURE 2.6
Typical Weber ratio as a function of intensity.





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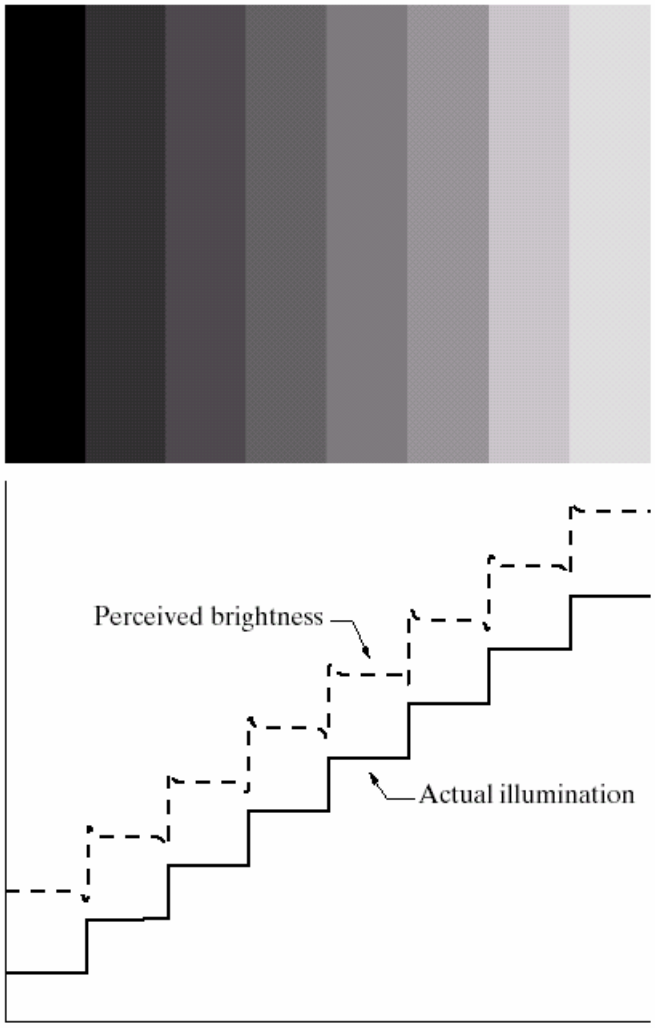
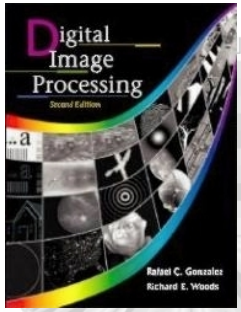


a
b

FIGURE 2.7
(a) An example showing that perceived brightness is not a simple function of intensity. The relative vertical positions between the two profiles in (b) have no special significance; they were chosen for clarity.



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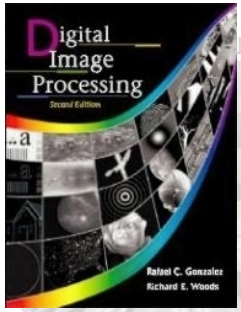
a b c

FIGURE 2.8 Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.



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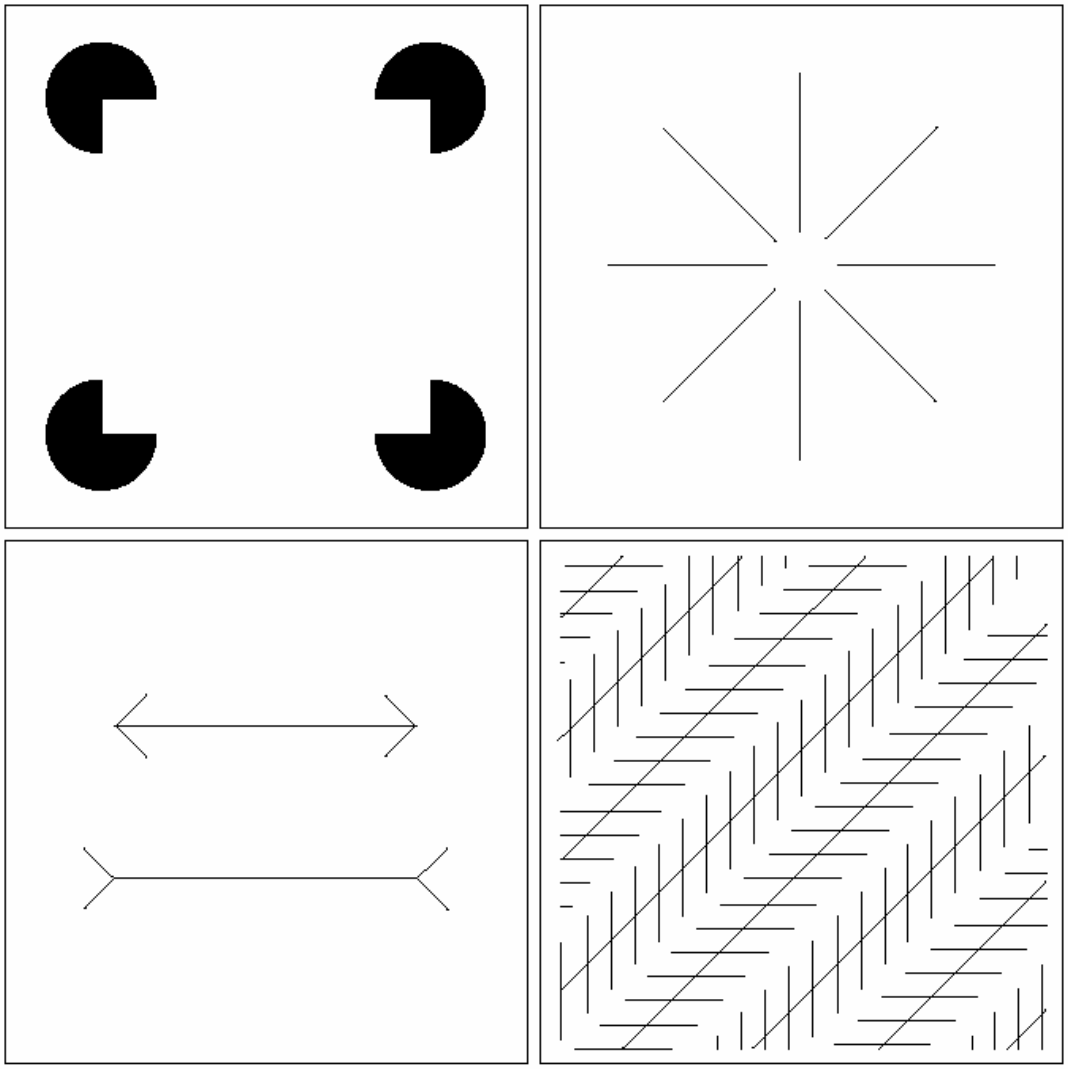
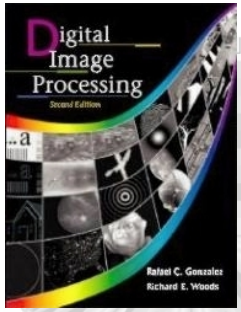
a b
c d

FIGURE 2.9 Some well-known optical illusions.





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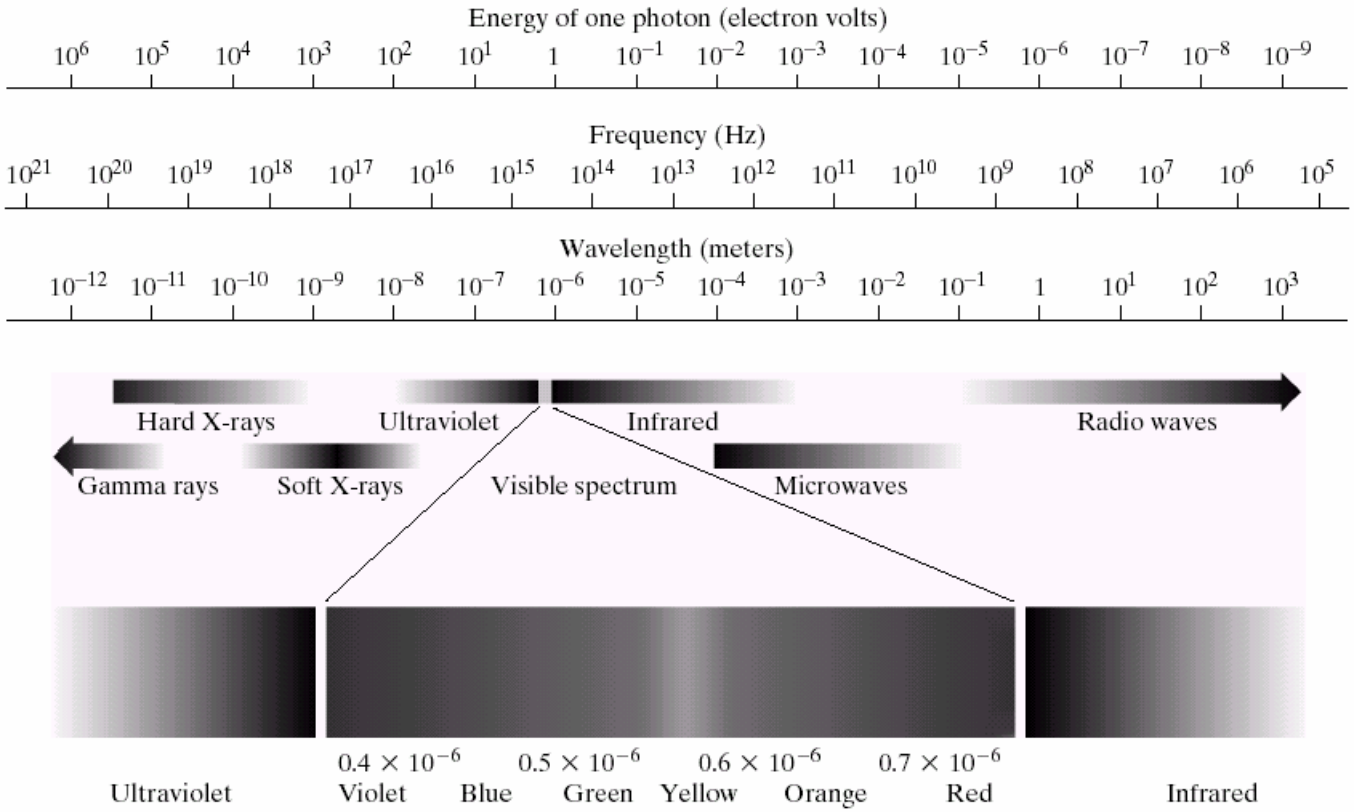

FIGURE 2.10 The electromagnetic spectrum. The visible spectrum is shown zoomed to facilitate explanation, but note that the visible spectrum is a rather narrow portion of the EM spectrum.

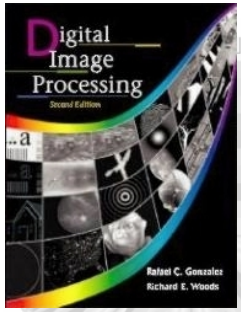

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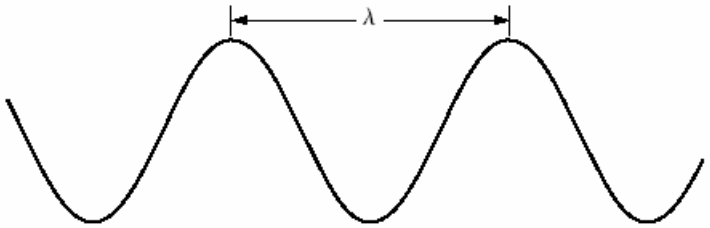
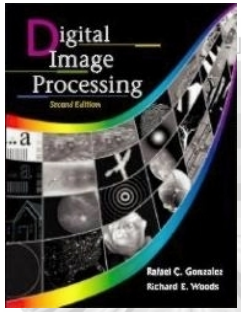
FIGURE 2.11
Graphical representation of one wavelength.





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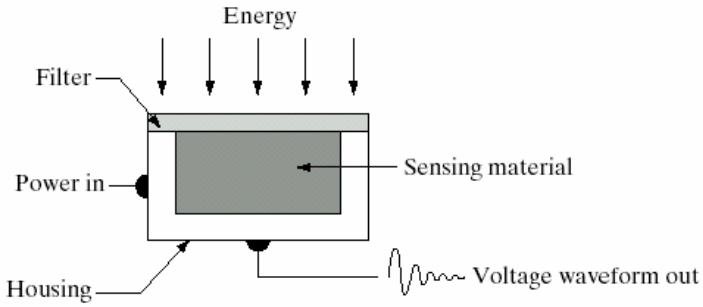
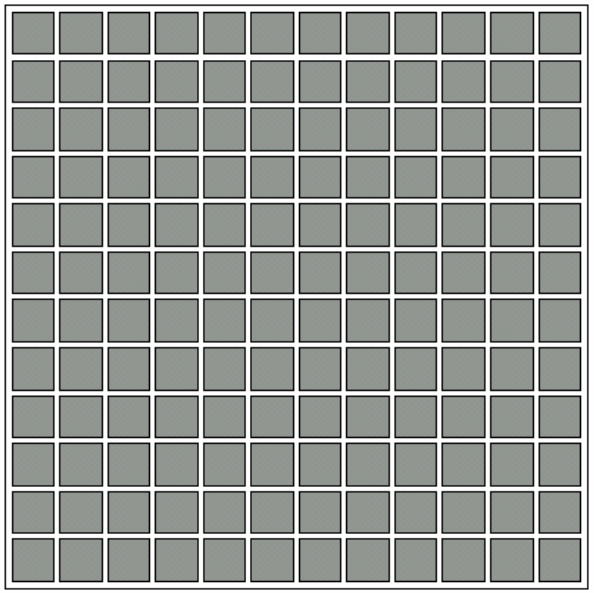
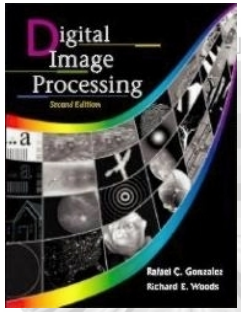
a
b
c

FIGURE 2.12
(a) Single imaging sensor.
(b) Line sensor.
(c) Array sensor.







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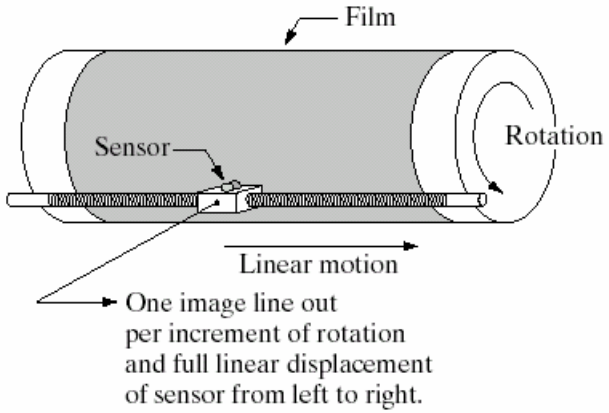
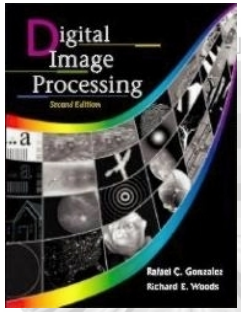


FIGURE 2.13 Combining a single sensor with motion to generate a 2-D image.



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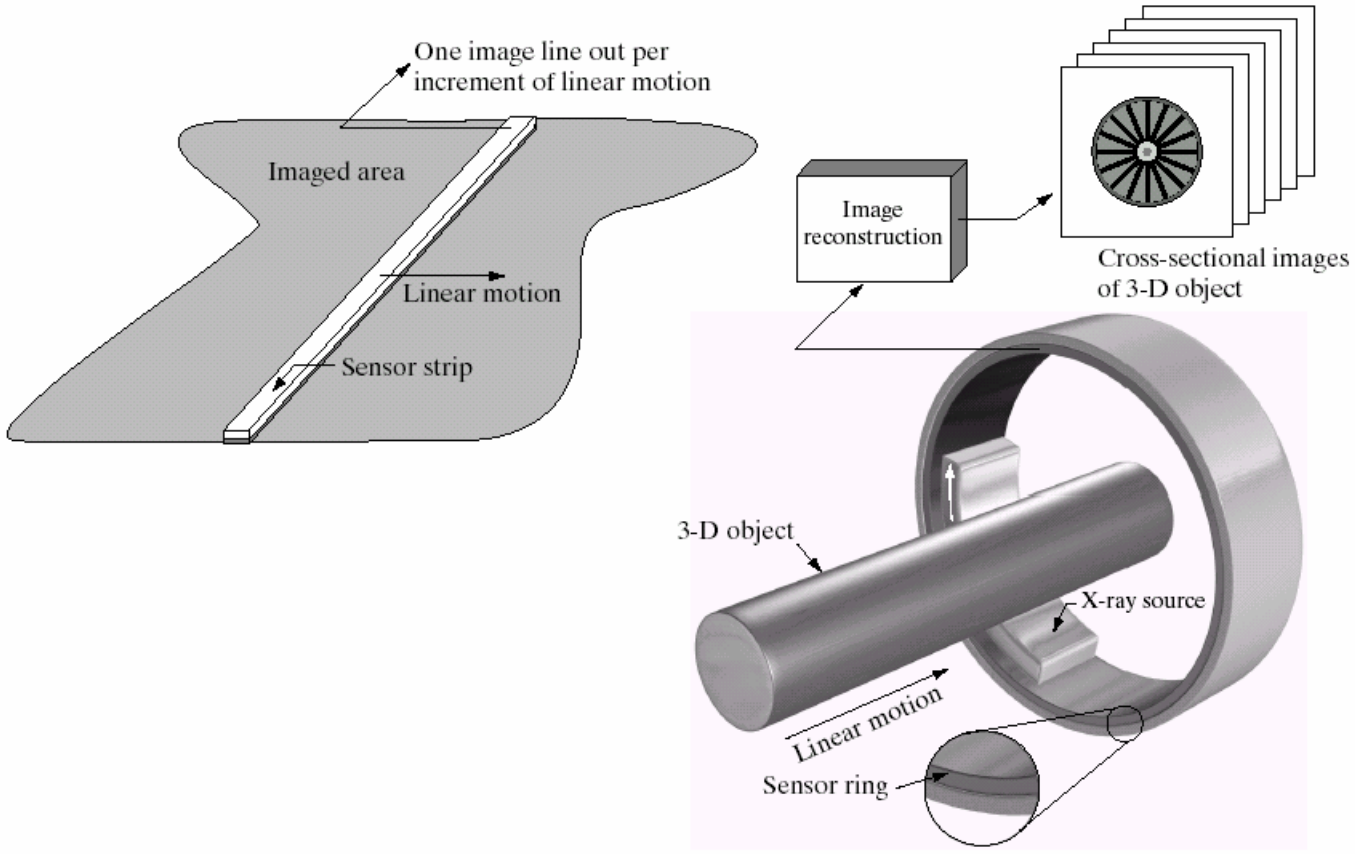
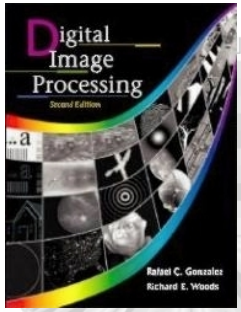


a b

FIGURE 2.14 (a) Image acquisition using a linear sensor strip. (b) Image acquisition using a circular sensor strip.



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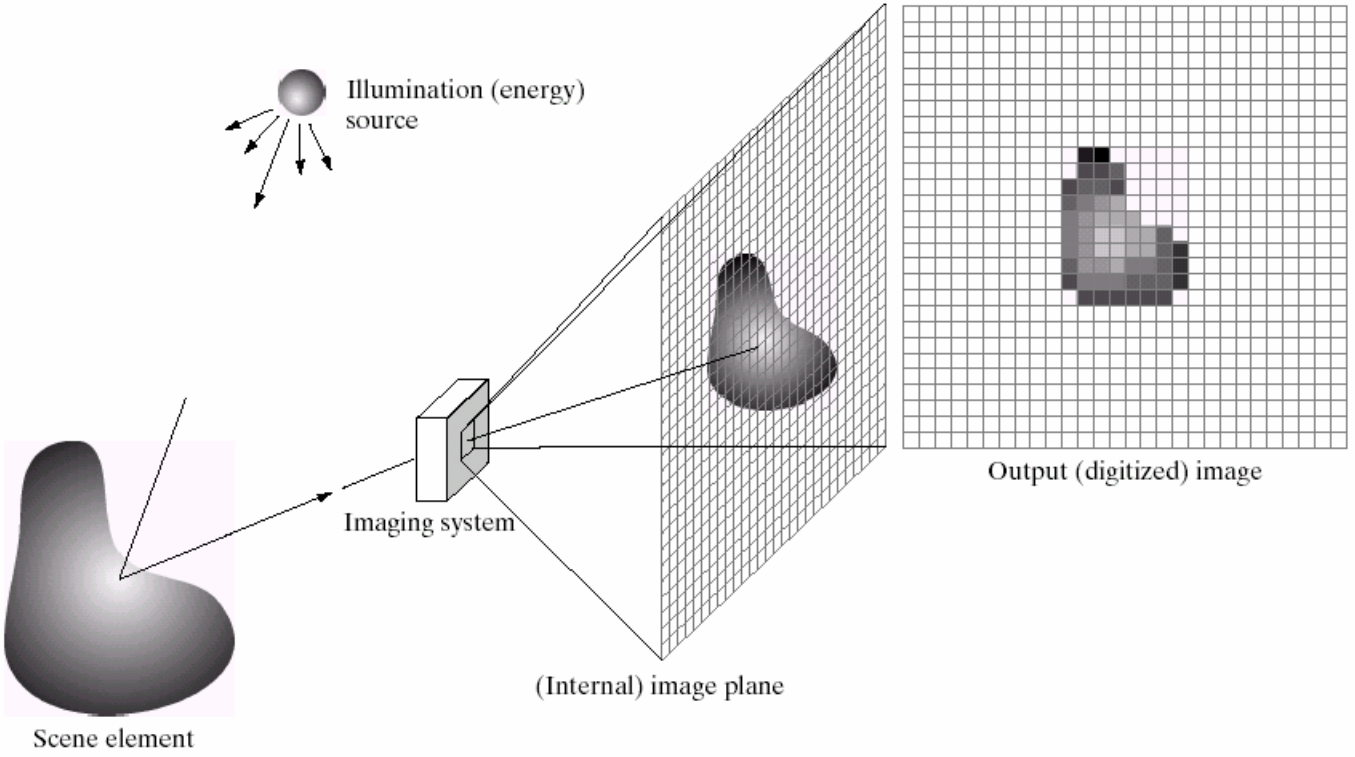
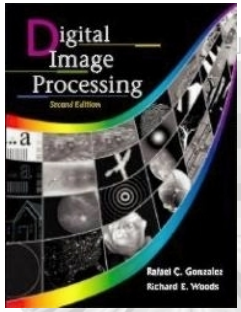


a
b c d e

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.



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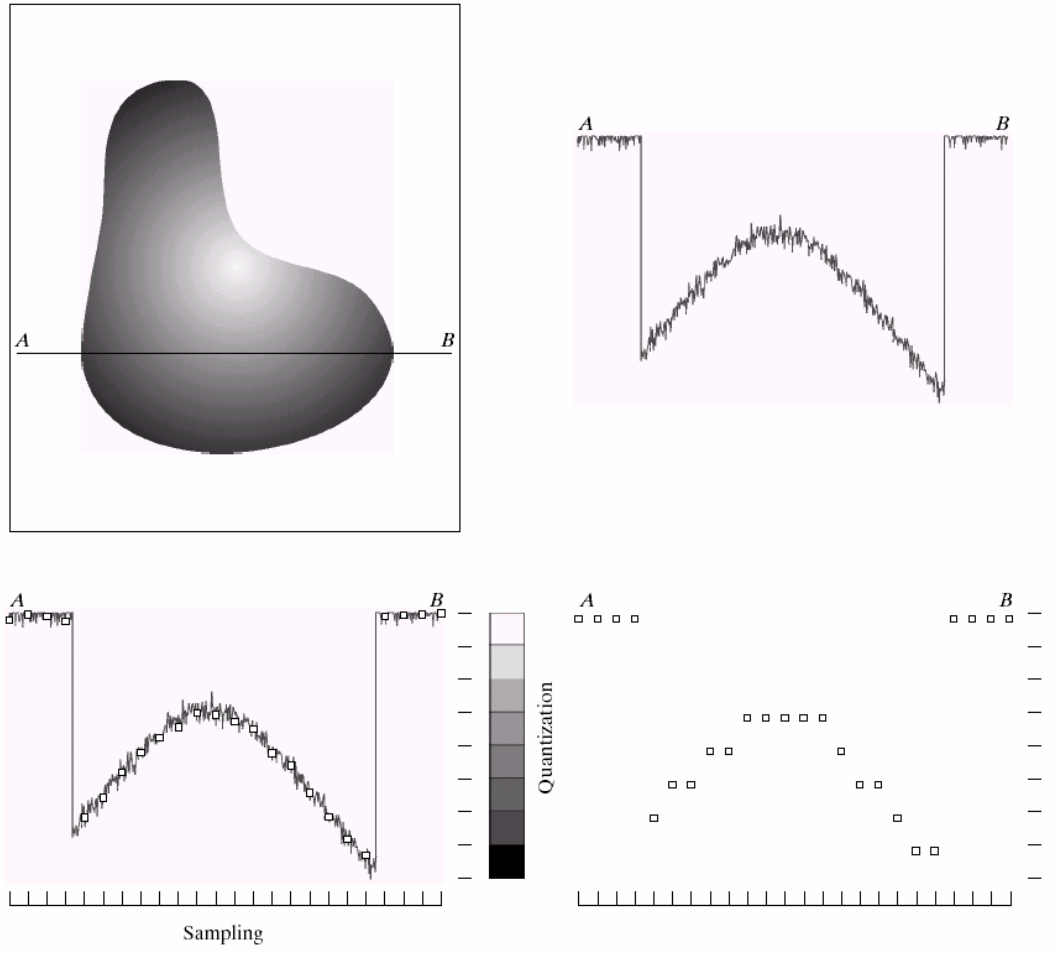
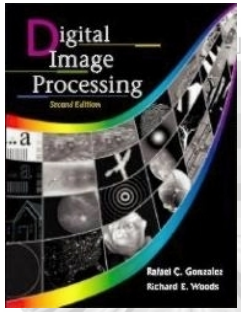


a b
c d

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.



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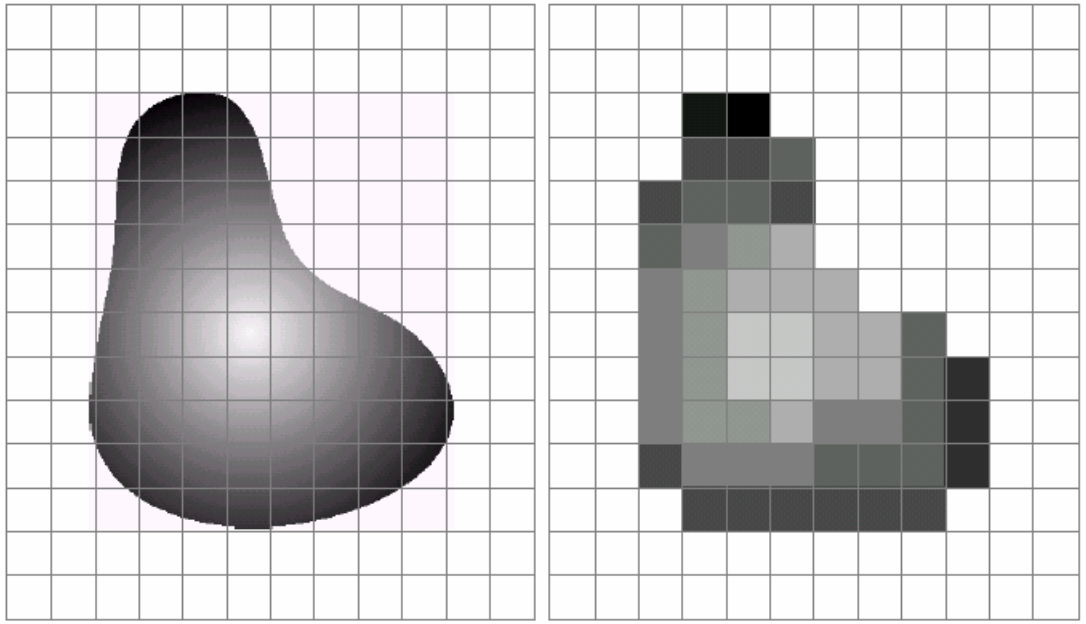

a b

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

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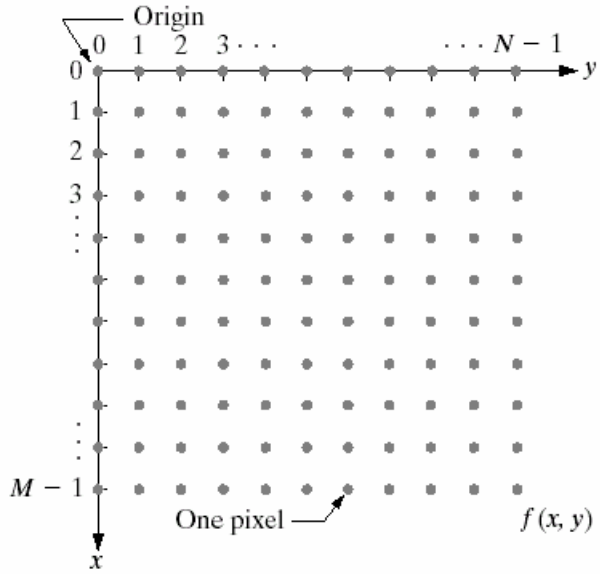
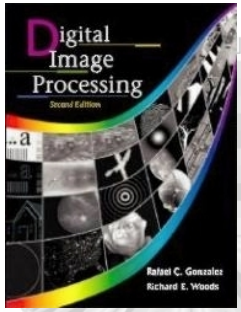


FIGURE 2.18 Coordinate convention used in this book to represent digital images.



Digital Image

- A digital image is an image f(x,y) that has been discretized both in spetial coordinate and brightness.
- F(x,y)=I(x,y)r(x,y)

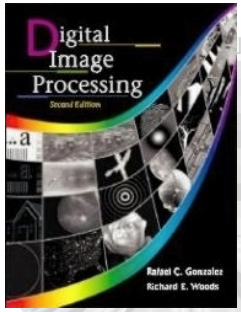


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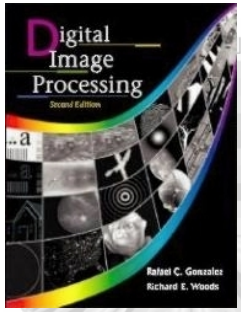
TABLE 2.1
Number of storage bits for various values of N and k.

N/k	1 ($L = 2$)	2 ($L = 4$)	3 ($L = 8$)	4 ($L = 16$)	5 ($L = 32$)	6 ($L = 64$)	7 ($L = 128$)	8 ($L = 256$)
32	1,024	2,048	3,072	4,096	5,120	6,144	7,168	8,192
64	4,096	8,192	12,288	16,384	20,480	24,576	28,672	32,768
128	16,384	32,768	49,152	65,536	81,920	98,304	114,688	131,072
256	65,536	131,072	196,608	262,144	327,680	393,216	458,752	524,288
512	262,144	524,288	786,432	1,048,576	1,310,720	1,572,864	1,835,008	2,097,152
1024	1,048,576	2,097,152	3,145,728	4,194,304	5,242,880	6,291,456	7,340,032	8,388,608
2048	4,194,304	8,388,608	12,582,912	16,777,216	20,971,520	25,165,824	29,369,128	33,554,432
4096	16,777,216	33,554,432	50,331,648	67,108,864	83,886,080	100,663,296	117,440,512	134,217,728
8192	67,108,864	134,217,728	201,326,592	268,435,456	335,544,320	402,653,184	469,762,048	536,870,912



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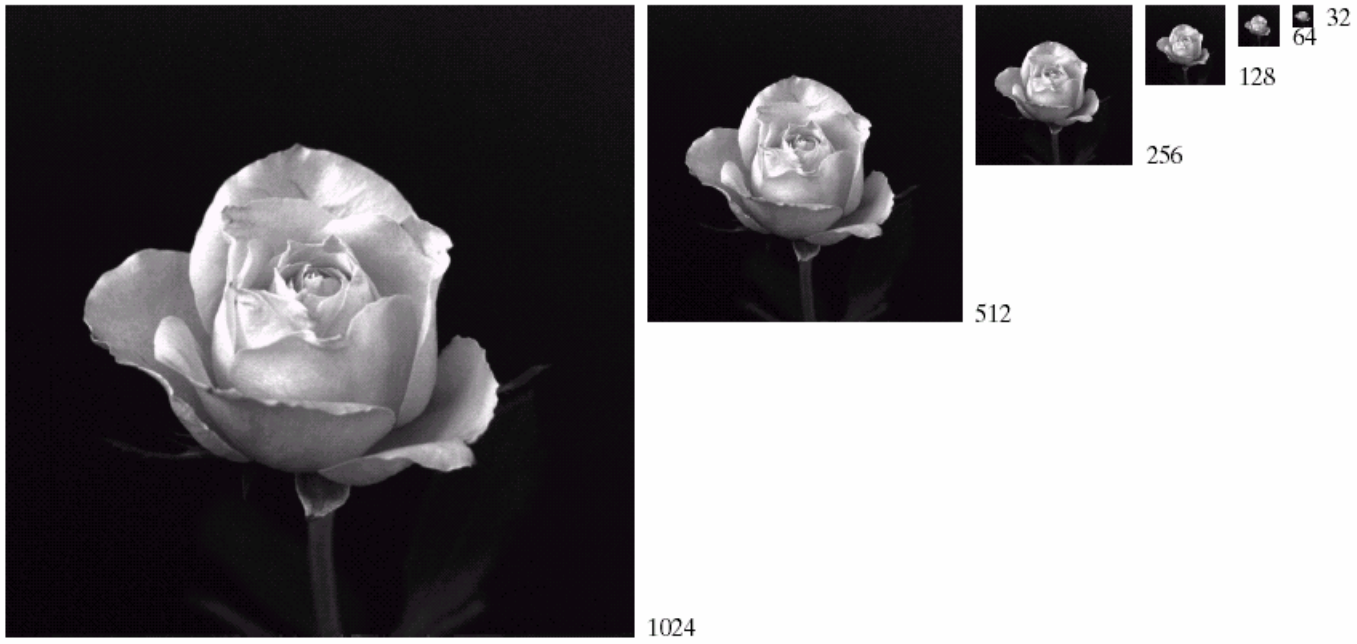
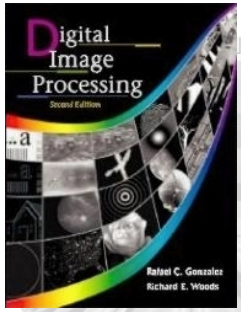


FIGURE 2.19 A 1024 × 1024, 8-bit image subsampled down to size 32 × 32 pixels. The number of allowable gray levels was kept at 256.



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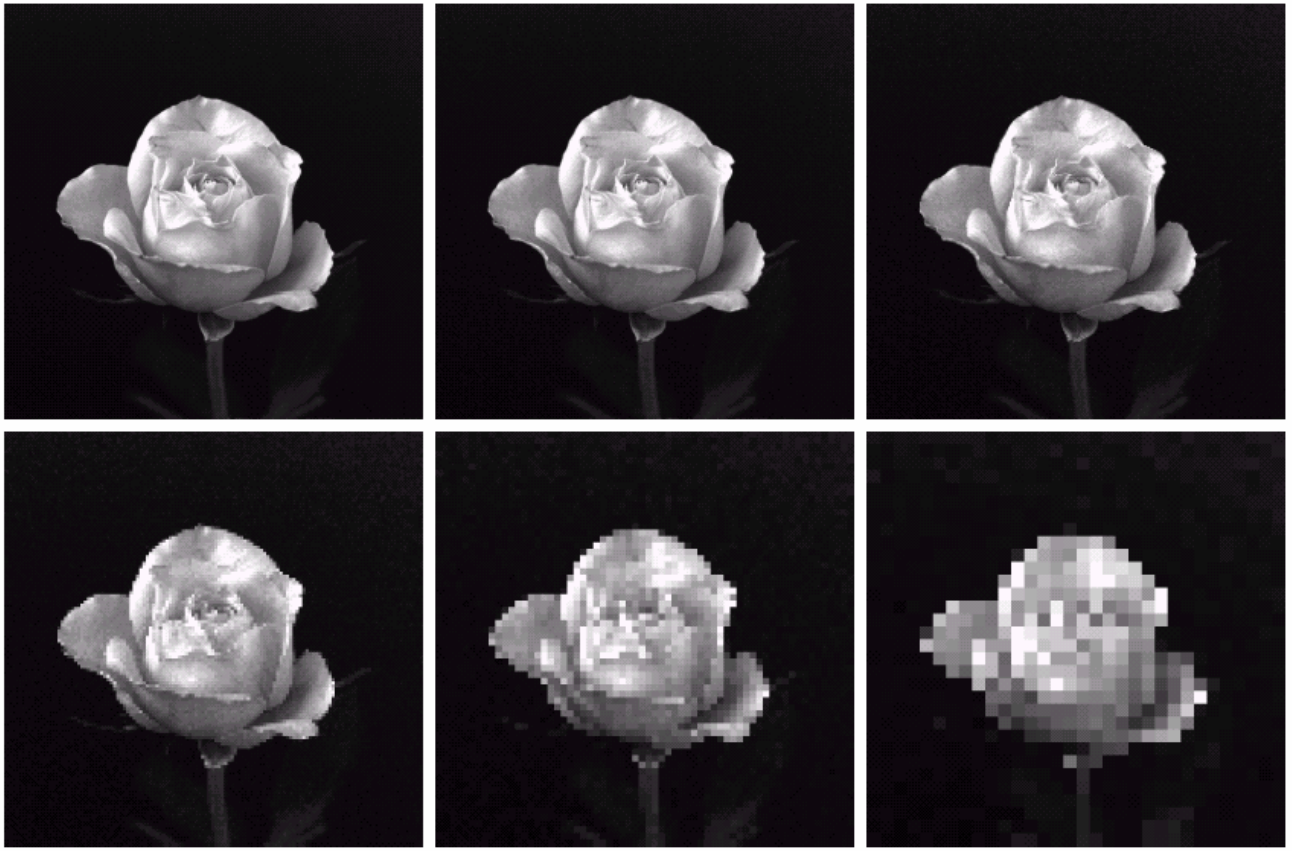
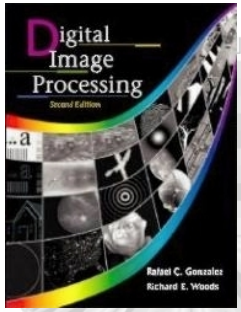


a b c
d e f

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.



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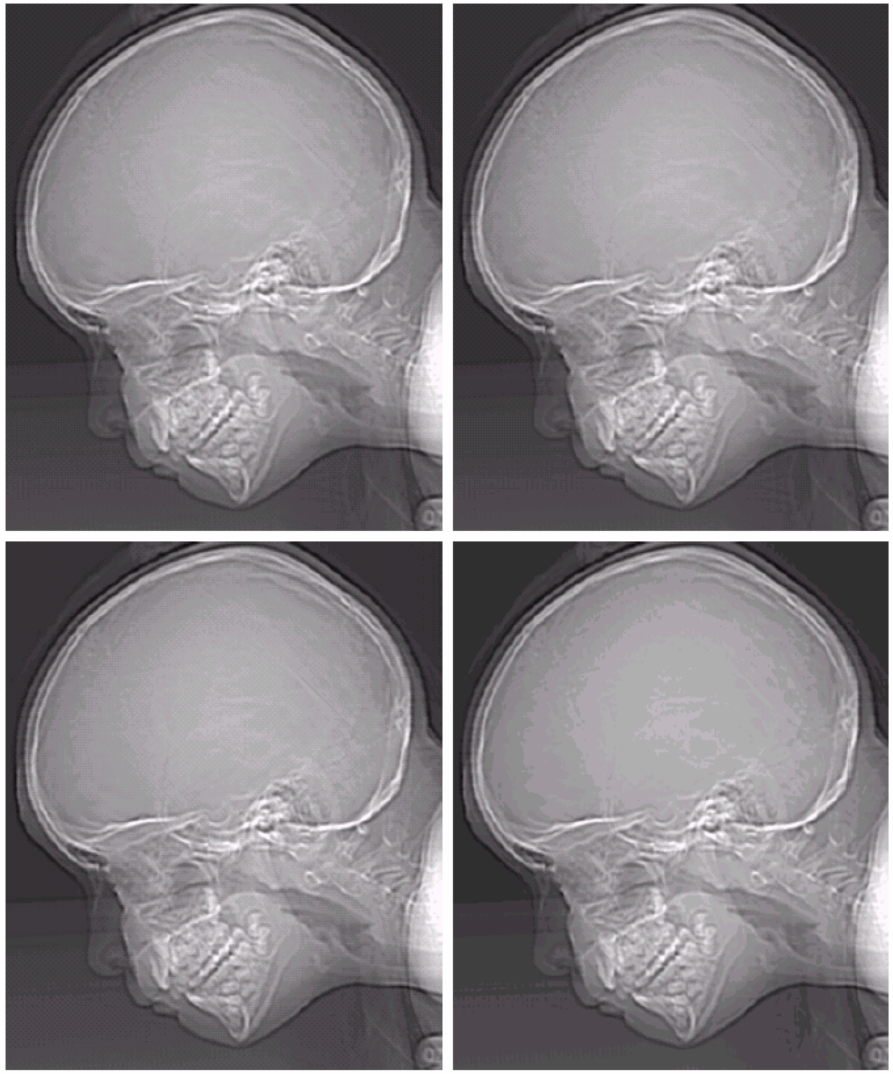
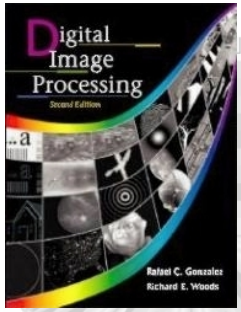


a b
c d

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.



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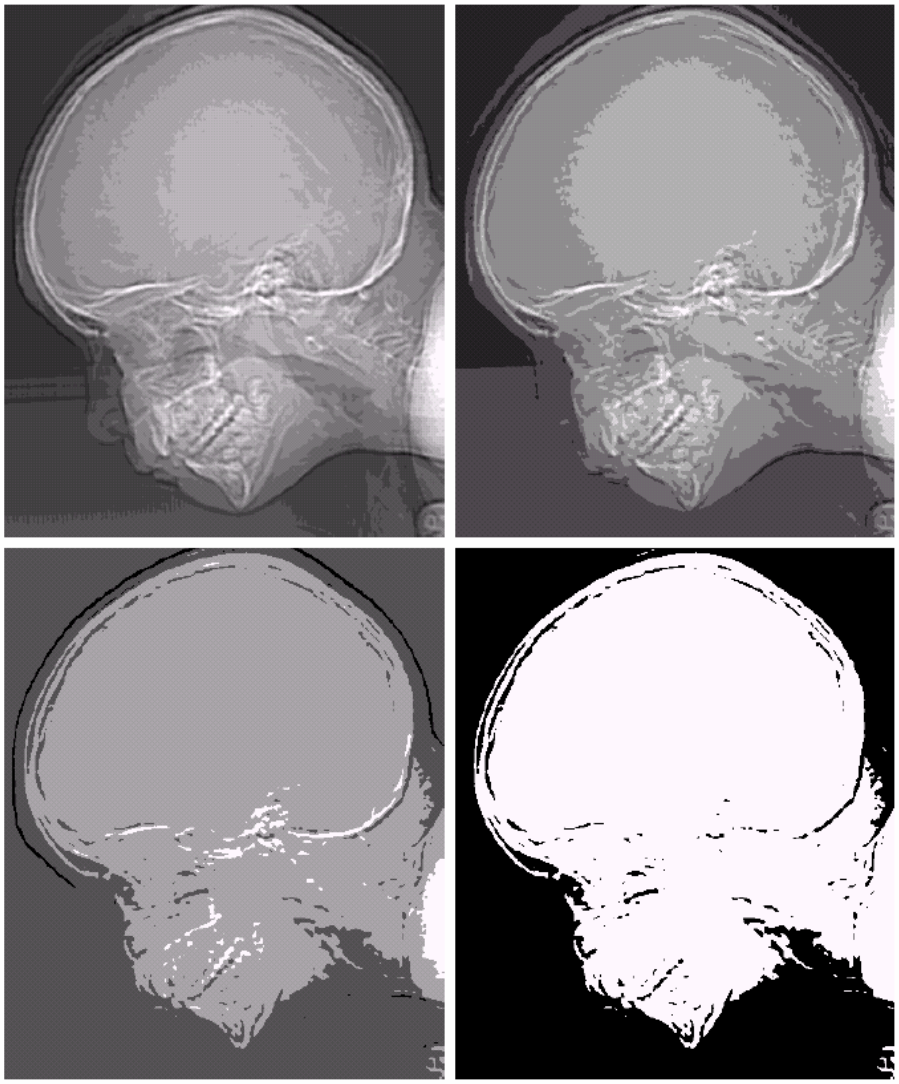
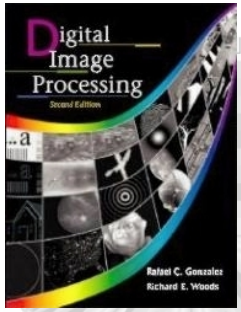
e f
g h

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.)





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a b c

FIGURE 2.22 (a) Image with a low level of detail. (b) Image with a medium level of detail. (c) Image with a relatively large amount of detail. (Image (b) courtesy of the Massachusetts Institute of Technology.)

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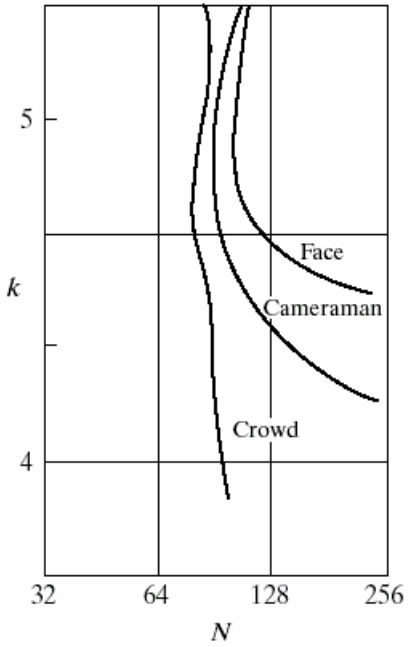
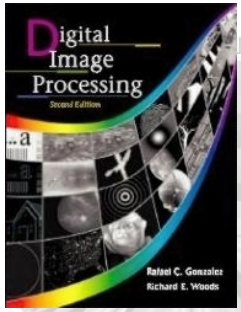
FIGURE 2.23 Representative isopreference curves for the three types of images in Fig. 2.22.





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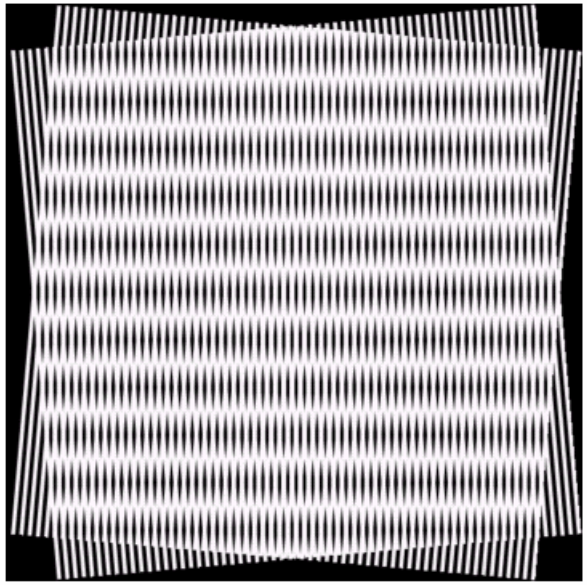
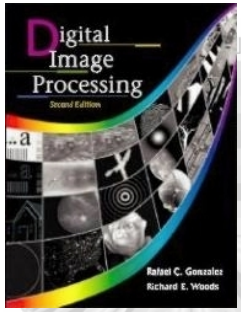
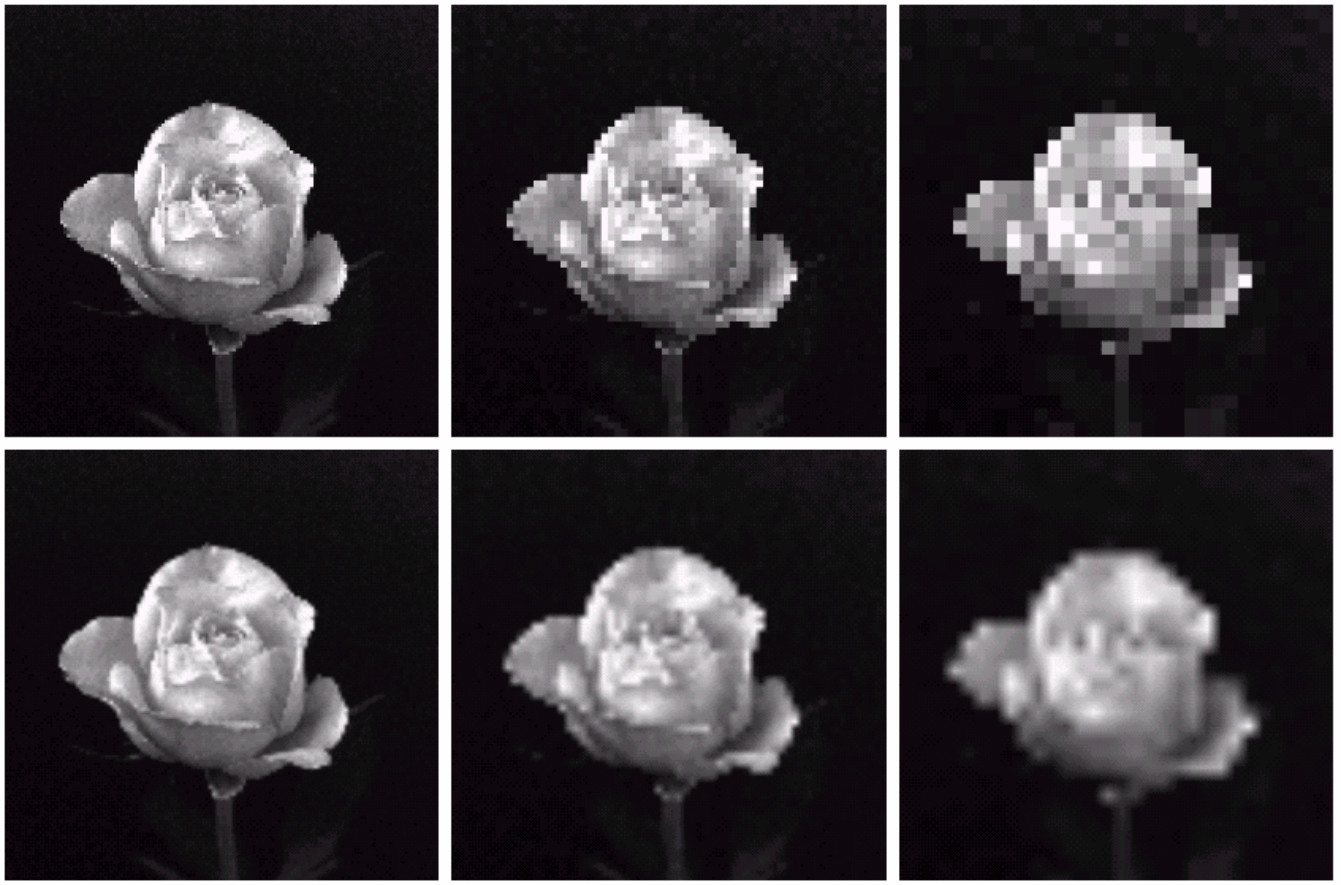


FIGURE 2.24 Illustration of the Moiré pattern effect.



Chapter 2: Digital Image Fundamentals

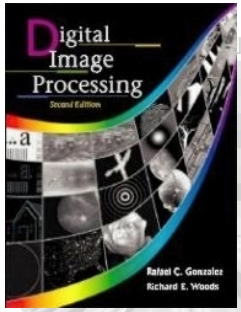


a b c
d e f

FIGURE 2.25 Top row: images zoomed from 128 × 128, 64 × 64, and 32 × 32 pixels to 1024 × 1024 pixels, using nearest neighbor gray-level interpolation. Bottom row: same sequence, but using bilinear interpolation.

1. Neighbor of a pixel

2. Connectivity



2.5 Basic Relation

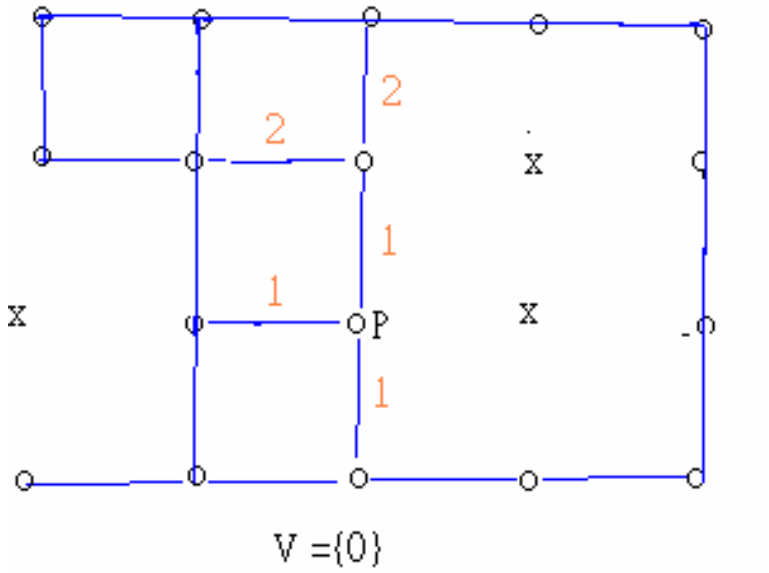
Neighbor of a pixel

1. A pixel p at coordinates (x,y) has four neighbors $N_4(p)$
2. Four diagonal neighbors $N_D(p)$
3. 8 neighbors $N_8(p)$

Connectivity

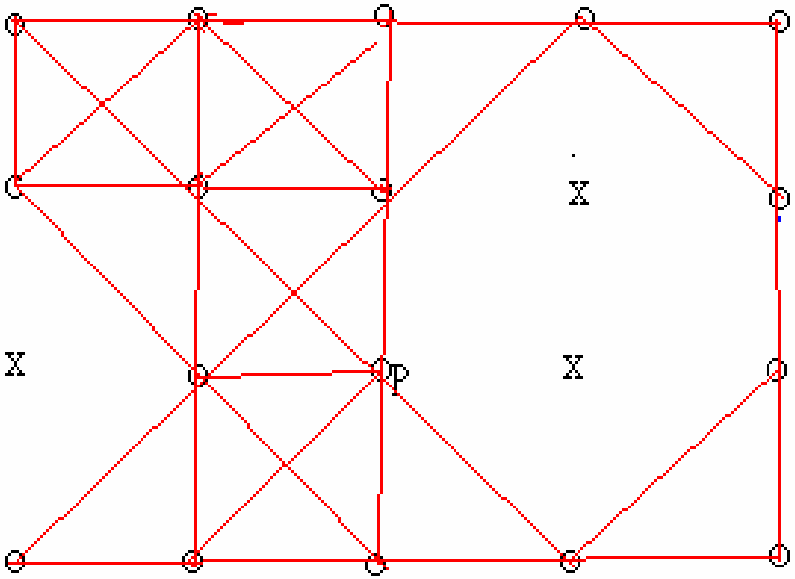
- 4-connectivity

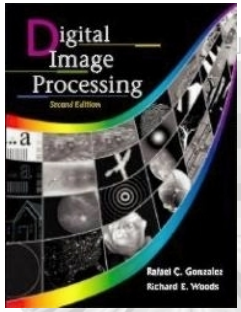
$\forall$ p, q $\in$ V if q $\in N_4(p)$ then q is connected with p,
V is the set of points to be connected.



- 8 – connectivity

$\forall p, q \in v$, if $g \in N_8(P)$ then q is connected with p

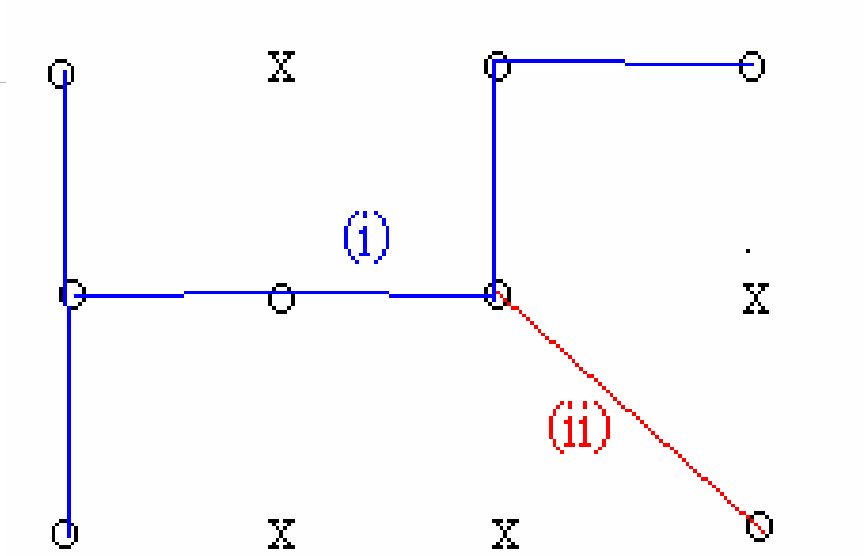




- m – connectivity

  ↑

  mixed

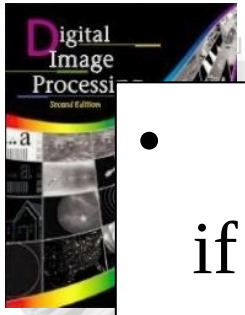


(i) q in $N_4(p)$

(ii) q in $N_D(P)$ & $(N_4(P) \cap N_4(Q)) = \varphi$

- Adjacent: p is adjancent to q if they are connected

- Path: a path from (X, Y) to (X_n, Y_n) where (X_i, Y_i) is adjancent to (X_{i-1}, Y_{i-1})



- ***Connected component***

  if $p,q \in s$, p is connected to q in s ; if there is a path from p to q consisting entirely of pixels in s

- ***Labeling of connected component***

  - scanning sequence

  "from left to right , from top to button "

  - procedure (eg. For 4-connected component)

  1.if $p,q \notin s$ **,** move on

  2.if $p \in v$,examine r and t

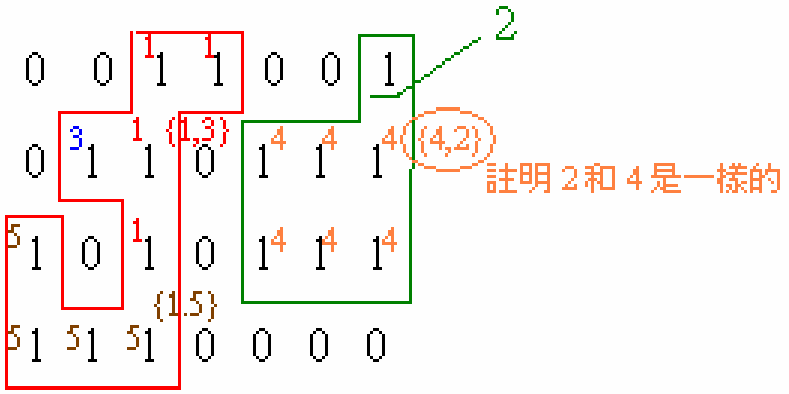
  (1) if both $\notin v$, assign a new label to p

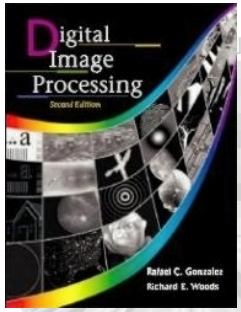
(2) if only one of the two neighbors $\in V$, assign its label to p

(3) if both $\in V$ and have same label , assign that to p

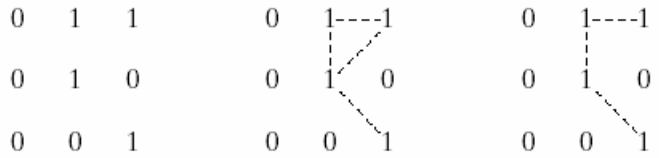
(4) if both $\in V$, but have different lable , assign either one to p and make note that these two labels one equivelent

EX. $V = \{1\}$





Chapter 2: Digital Image Fundamentals



a b c

FIGURE 2.26 (a) Arrangement of pixels; (b) pixels that are 8-adjacent (shown dashed) to the center pixel; (c) *m*-adjacency.

- ***Distance Measure*** (p(x,y) , q(s,t))

  - **Euclidean distance**

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

  - **City-block distance**

$$D4(p,q) = |x-s| + |y-t|$$

  - **Chessboard distance**

$$D8(p,q) = \max(|x-s|, |y-t|)$$