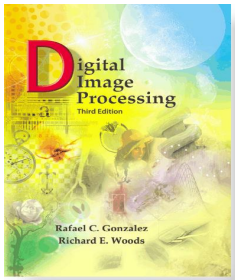


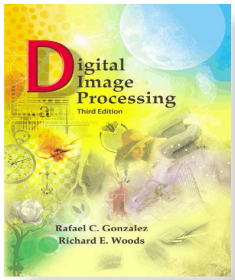



Chapter 9

# Morphological Image Processing

A tool for extracting image components that are useful for in the representation and description of region shape .

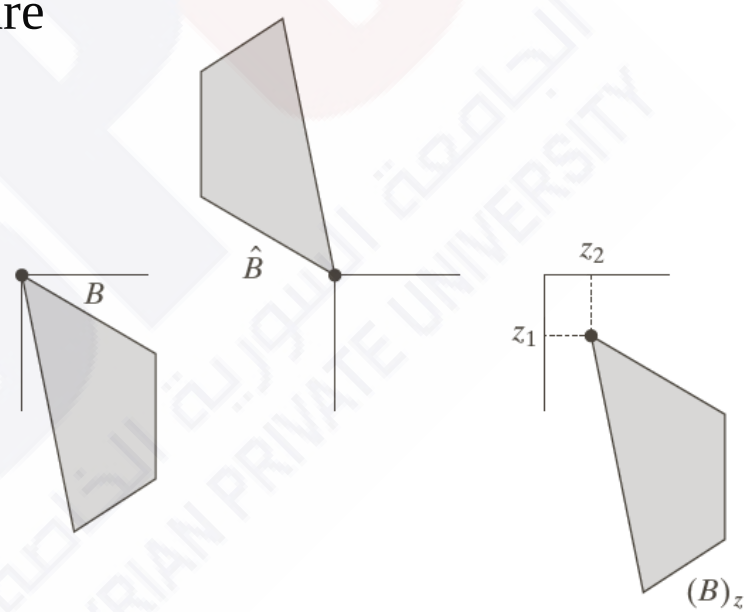
Sets are Objects in an image. White or black pixels in binary images

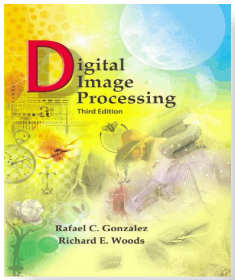



Chapter 9
# Morphological Image Processing

**Reflection** : B a set of points in B whose (x,y) coordinates have been replaced by *(-x,-y)*

**Translation** : (x,y) coordinates are replaced by *(x+z1,y+z2)*

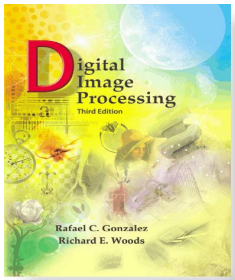







Chapter 9
# Morphological Image Processing

Reflection and translation are used to formulate operations on image are based on *structuring elements (SE )* which are small sets of image that are used to **probe** an image for properties of interest.
SE are rectangular arrays.






# Chapter 9
# Morphological Image Processing

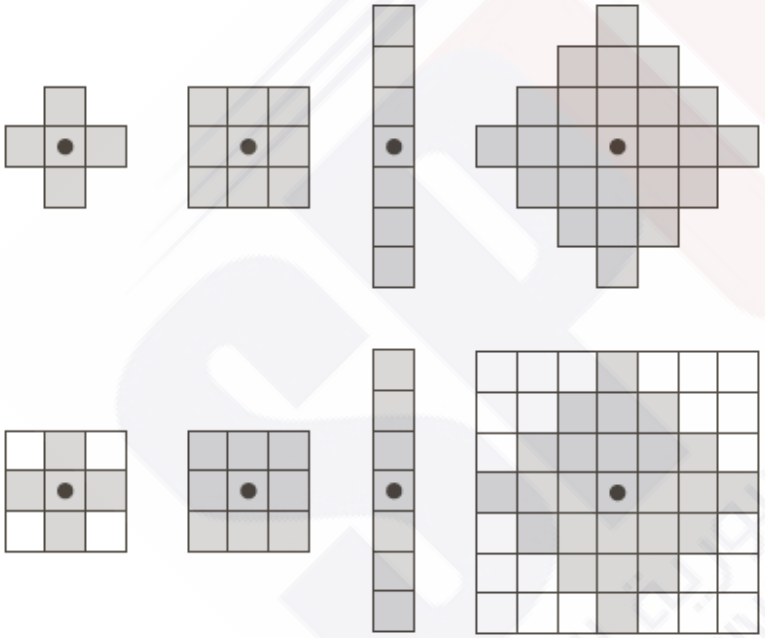
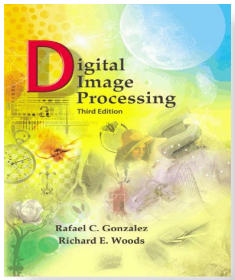


**FIGURE 9.2** First row: Examples of structuring elements. Second row: Structuring elements converted to rectangular arrays. The dots denote the centers of the SEs.




# Chapter 9
# Morphological Image Processing

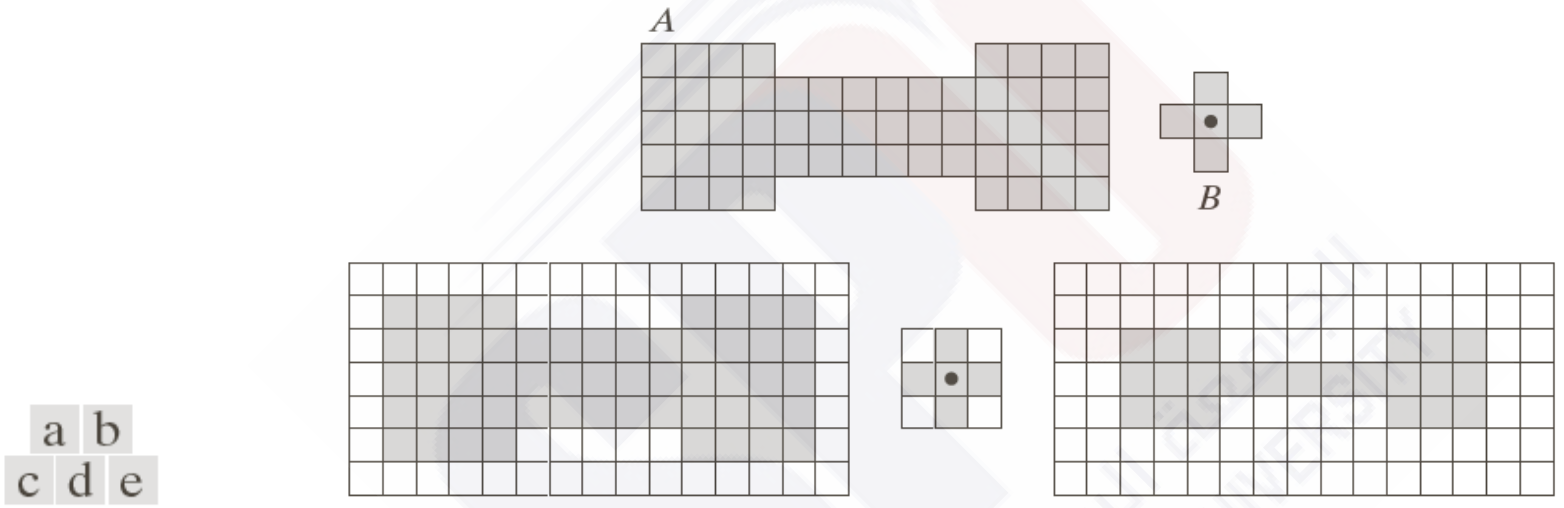
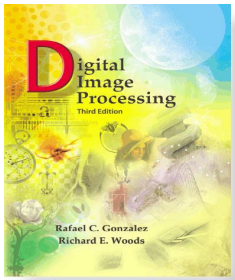



**FIGURE 9.3** (a) A set (each shaded square is a member of the set). (b) A structuring element. (c) The set padded with background elements to form a rectangular array and provide a background border. (d) Structuring element as a rectangular array. (e) Set processed by the structuring element.

At each location of the origin of B When B is completely contained in A this location is a member of the new set.

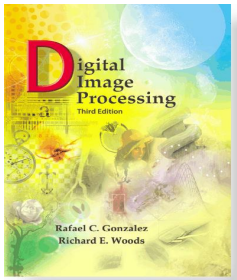





Chapter 9
Morphological Image Processing

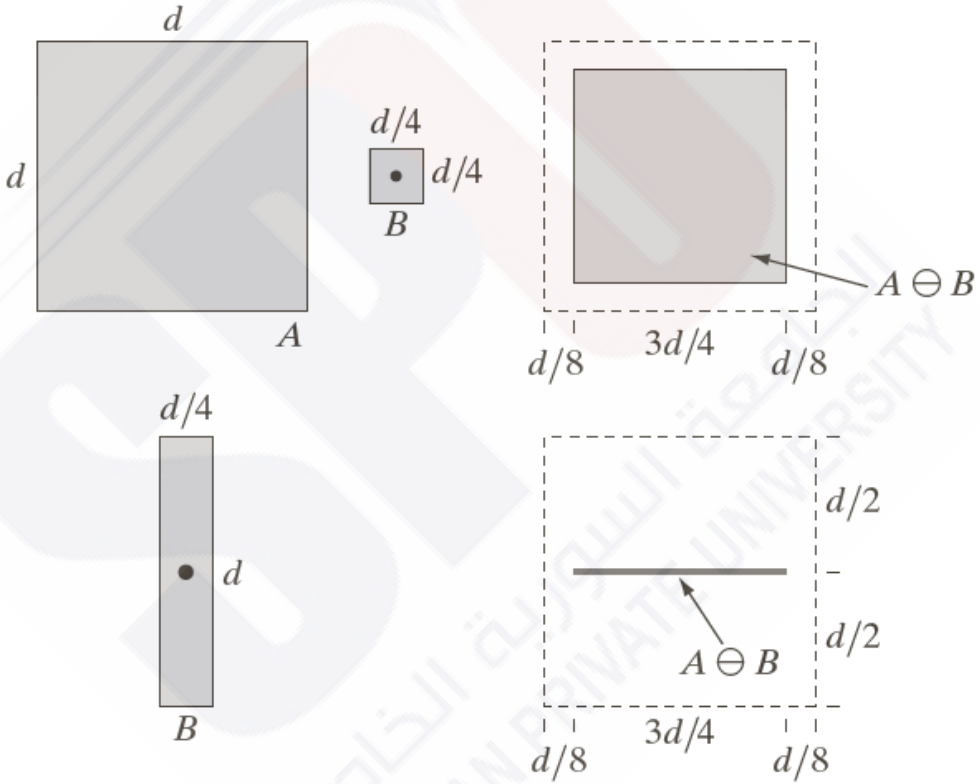
# Basic Operations

**Erosion** of A by B (AθB) is a set of all points z such that B , translated by z is contained in A.
The erosion of A by B is a set of all elements of B that has no sharing of any element from the background,
Erosion is a shrinking or thinning operation



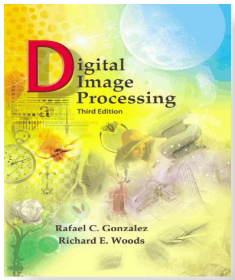



Chapter 9
# Morphological Image Processing



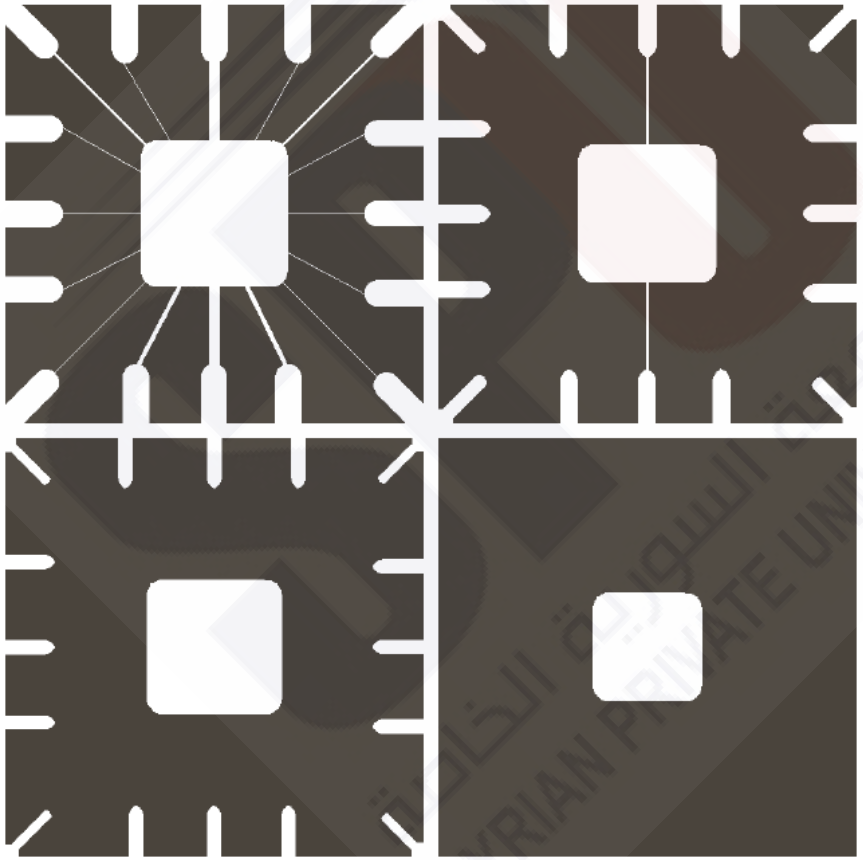

a b c
d e

**FIGURE 9.4** (a) Set $A$. (b) Square structuring element, $B$. (c) Erosion of $A$ by $B$, shown shaded. (d) Elongated structuring element. (e) Erosion of $A$ by $B$ using this element. The dotted border in (c) and (e) is the boundary of set $A$, shown only for reference.



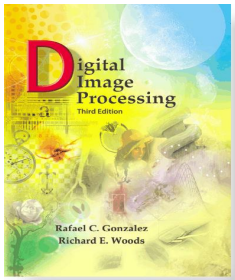



# Chapter 9
# Morphological Image Processing



a b
c d

**FIGURE 9.5** Using erosion to remove image components. (a) A 486 × 486 binary image of a wire-bond mask. (b)–(d) Image eroded using square structuring elements of sizes 11 × 11, 15 × 15, and 45 × 45, respectively. The elements of the SEs were all 1s.



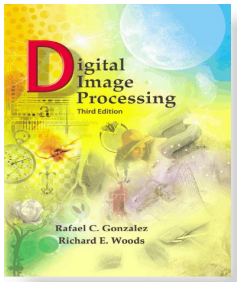



Chapter 9
Morphological Image Processing

# Dilation

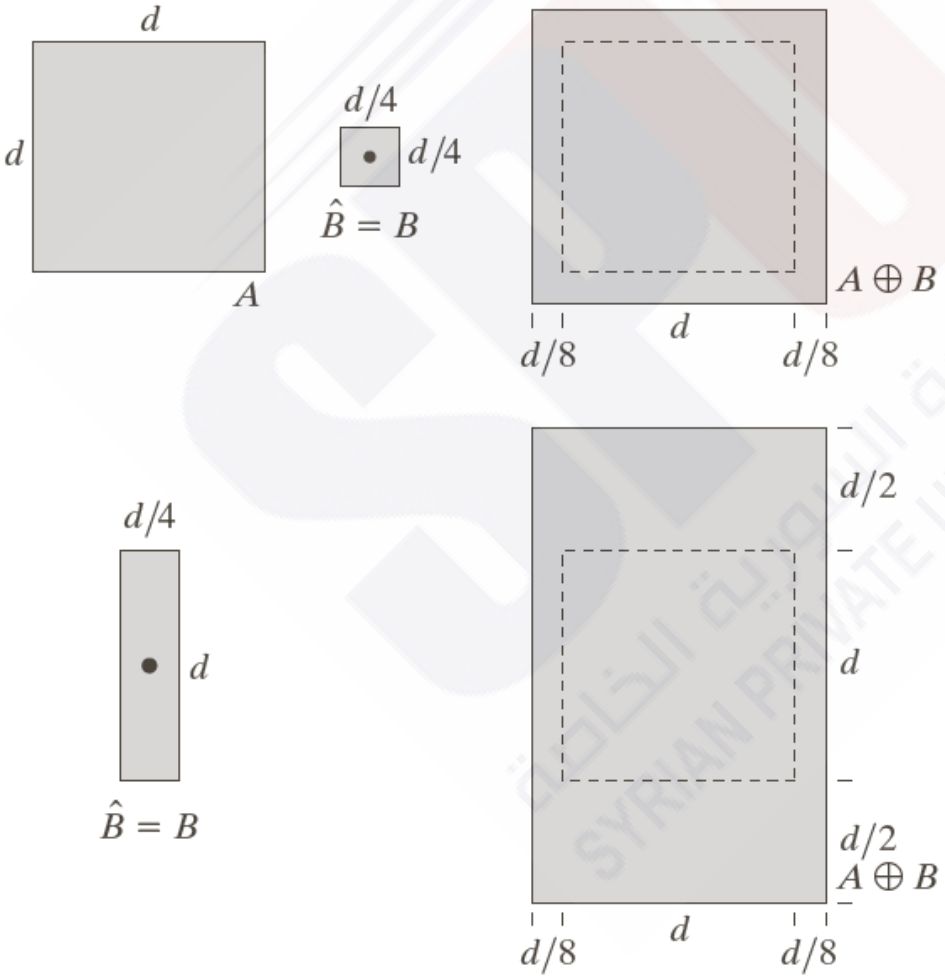
The dilation of A by B ($A \oplus B$) is the set of all displacements such that B reflection and A overlap by at least one element.

Dilation grows or thickens objects



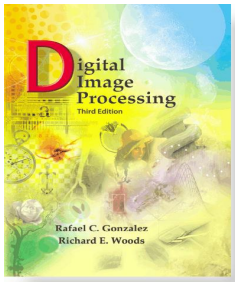



# Chapter 9
# Morphological Image Processing




a b c
d e

**FIGURE 9.6** (a) Set $A$. (b) Square structuring element (the dot denotes the origin). (c) Dilation of $A$ by $B$, shown shaded. (d) Elongated structuring element. (e) Dilation of $A$ using this element. The dotted border in (c) and (e) is the boundary of set $A$, shown only for reference

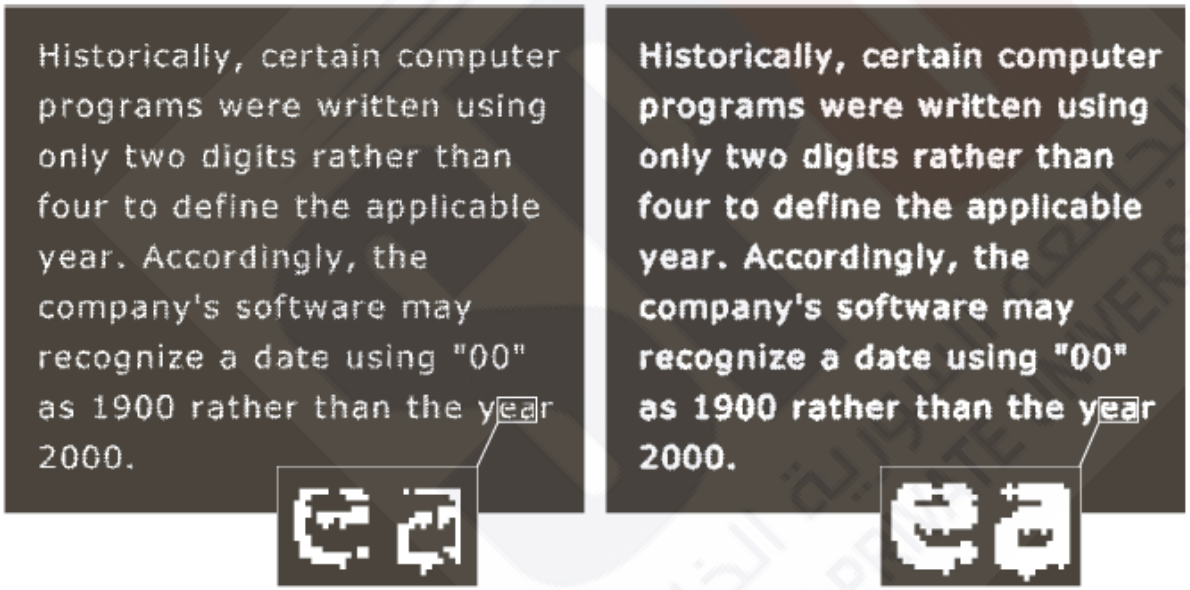





Chapter 9

# Morphological Image Processing

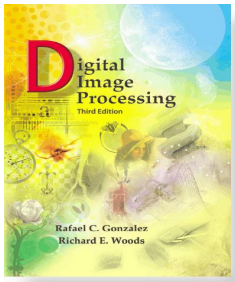
## Bridging gaps




| | | |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 1 | 1 |
| 0 | 1 | 0 |

a c
b

**FIGURE 9.7**
(a) Sample text of poor resolution with broken characters (see magnified view). (b) Structuring element. (c) Dilation of (a) by (b). Broken segments were joined.






Chapter 9
Morphological Image Processing

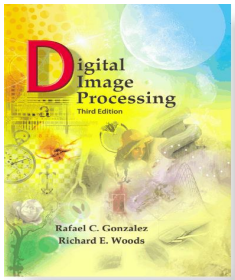
# Opening and closing

$A \circ B = (A \ominus B) \oplus B$

Opening smoothes the contour of an object.

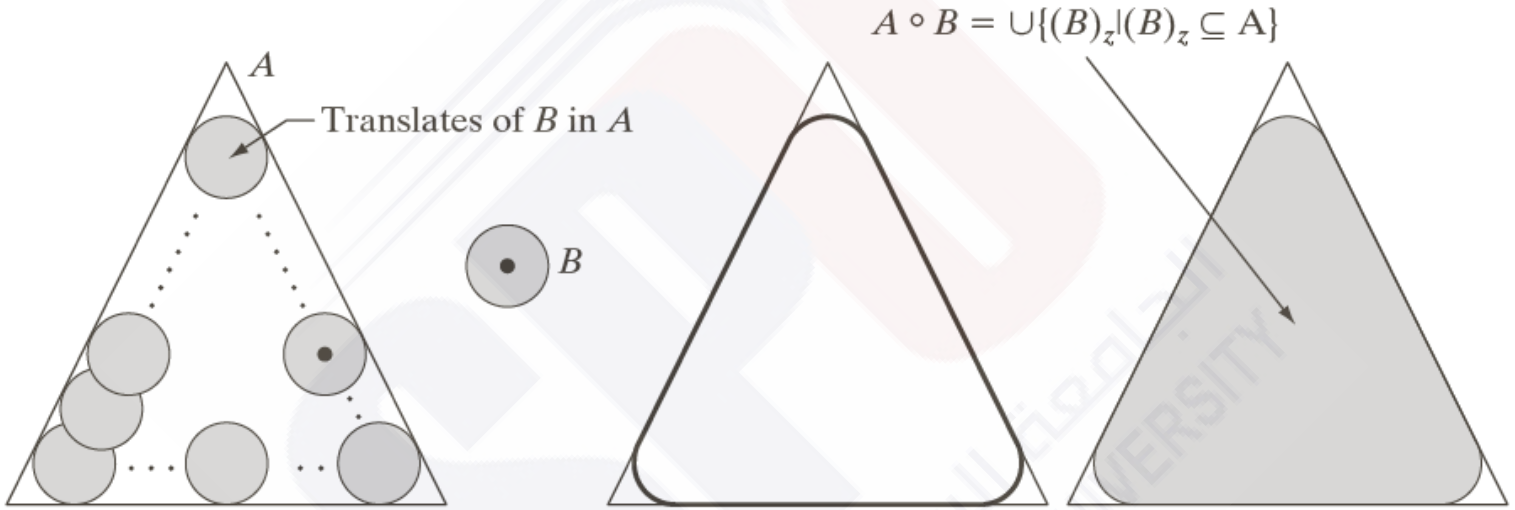
$A \bullet B = (A \oplus B) \ominus A$

Closing eliminate small halls, fuses narrow breaks and fills gaps in contours



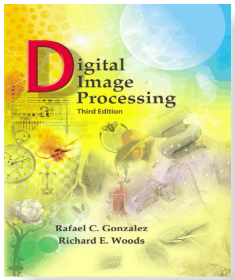



# Chapter 9
# Morphological Image Processing



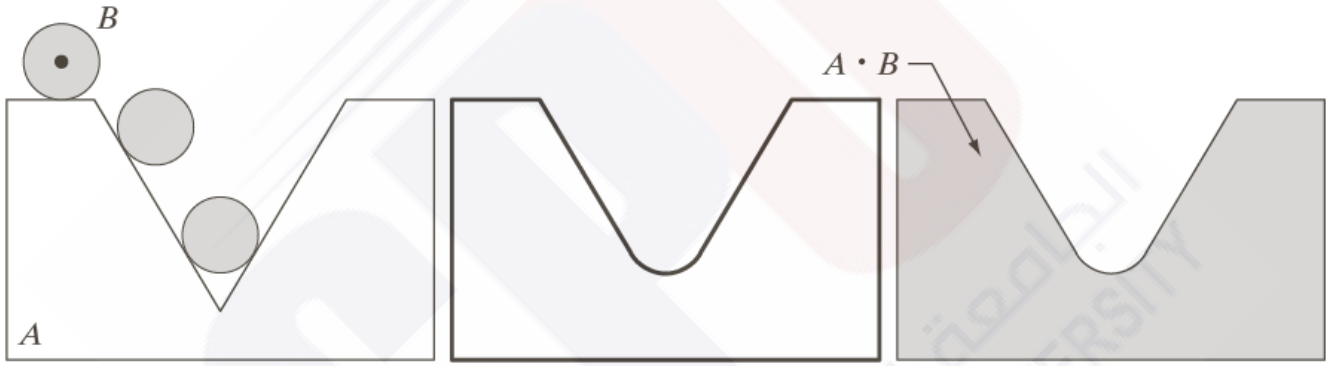

a b c d

**FIGURE 9.8** (a) Structuring element $B$ "rolling" along the inner boundary of $A$ (the dot indicates the origin of $B$). (b) Structuring element. (c) The heavy line is the outer boundary of the opening. (d) Complete opening (shaded). We did not shade $A$ in (a) for clarity.



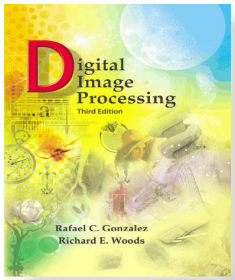



# Chapter 9
# Morphological Image Processing



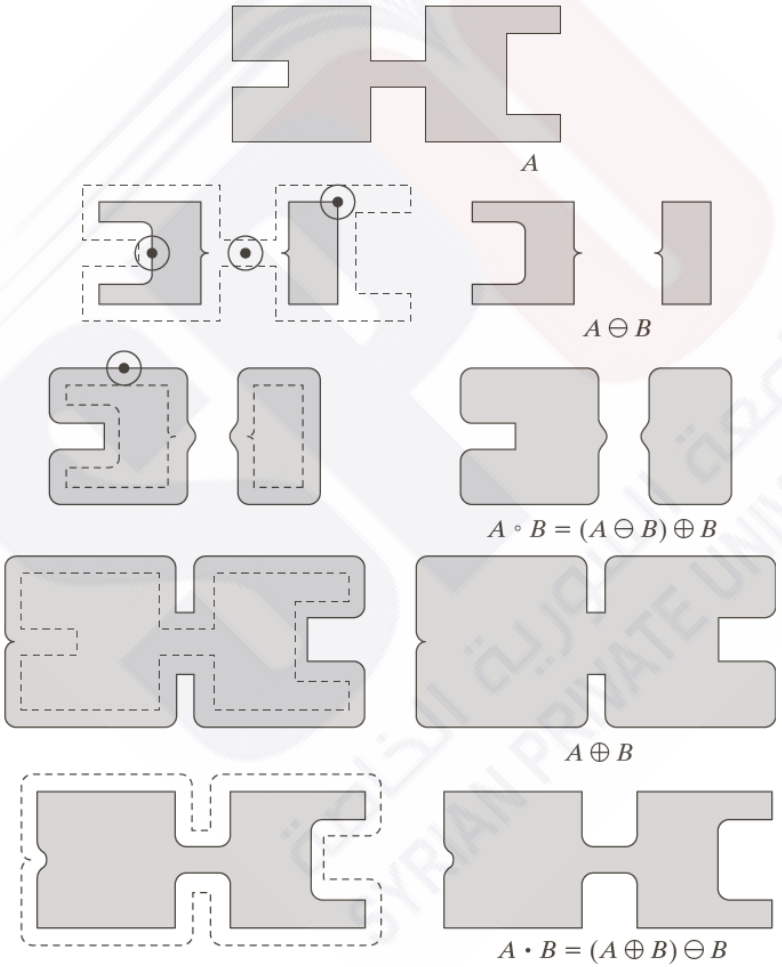

a b c

**FIGURE 9.9** (a) Structuring element $B$ "rolling" on the outer boundary of set $A$. (b) The heavy line is the outer boundary of the closing. (c) Complete closing (shaded). We did not shade $A$ in (a) for clarity.



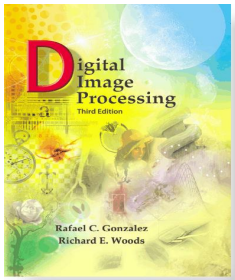



# Chapter 9
# Morphological Image Processing




a
b c
d e
f g
h i

**FIGURE 9.10** Morphological opening and closing. The structuring element is the small circle shown in various positions in (b). The SE was not shaded here for clarity. The dark dot is the center of the structuring element.

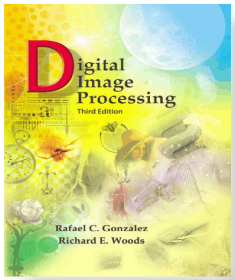





# Chapter 9
# Morphological Image Processing


a b
d c
e f

**FIGURE 9.11**
(a) Noisy image. (b) Structuring element. (c) Eroded image. (d) Opening of $A$. (e) Dilation of the opening. (f) Closing of the opening. (Original image courtesy of the National Institute of Standards and Technology.)



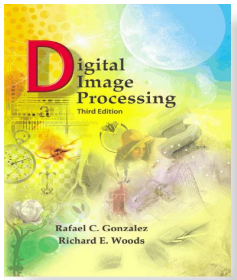



Chapter 9

Morphological Image Processing

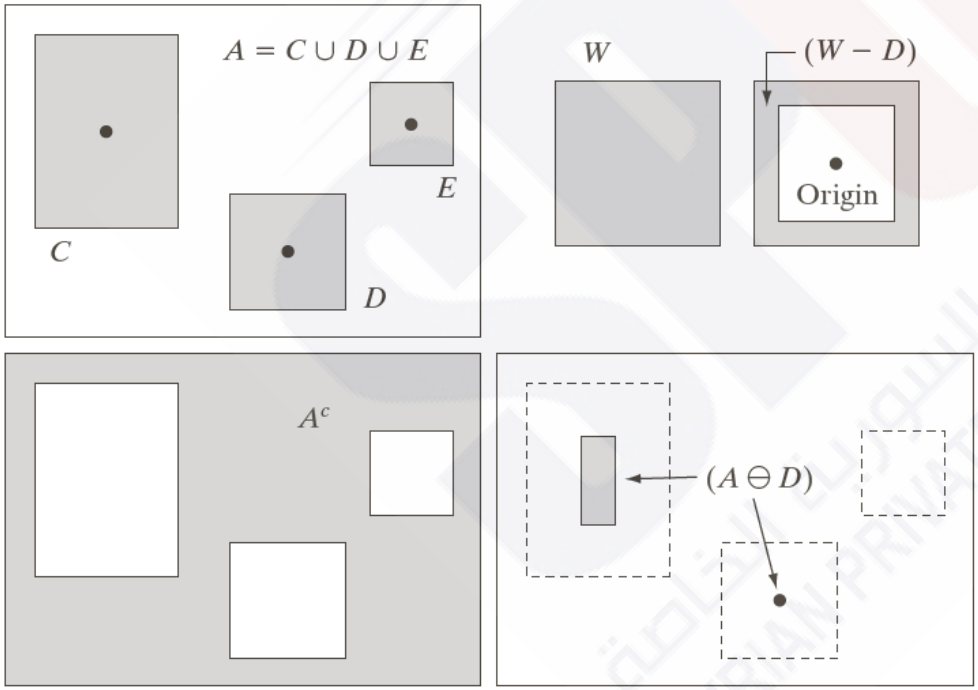
# The Hit-or-Miss Transformation

## A basic tool for shape detection



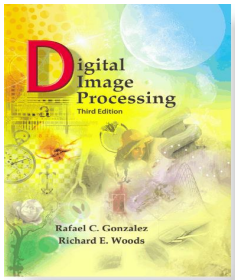



# Chapter 9
# Morphological Image Processing




a b
c d
e
f

**FIGURE 9.12** (a) Set $A$. (b) A window, $W$, and the local background of $D$ with respect to $W$, $(W - D)$. (c) Complement of $A$. (d) Erosion of $A$ by $D$. (e) Erosion of $A^c$ by $(W - D)$. (f) Intersection of (d) and (e), showing the location of the origin of $D$, as desired. The dots indicate the origins of $C$, $D$, and $E$.

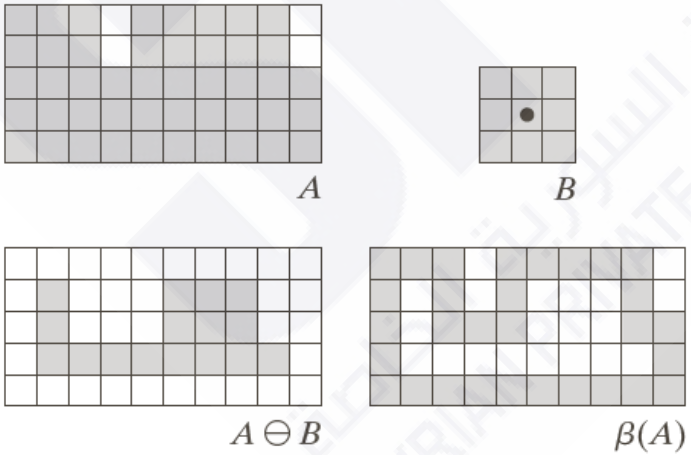



Chapter 9
Morphological Image Processing

# Some basic morphological algorithms

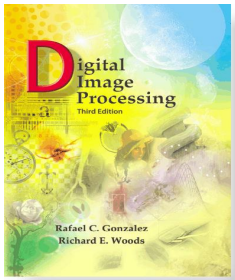
- Boundary extraction :

  ß(A) = A – ( A erosion by B)




a b
c d

**FIGURE 9.13** (a) Set $A$. (b) Structuring element $B$. (c) $A$ eroded by $B$. (d) Boundary, given by the set difference between $A$ and its erosion.

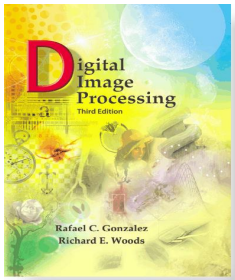





# Chapter 9
# Morphological Image Processing

a b

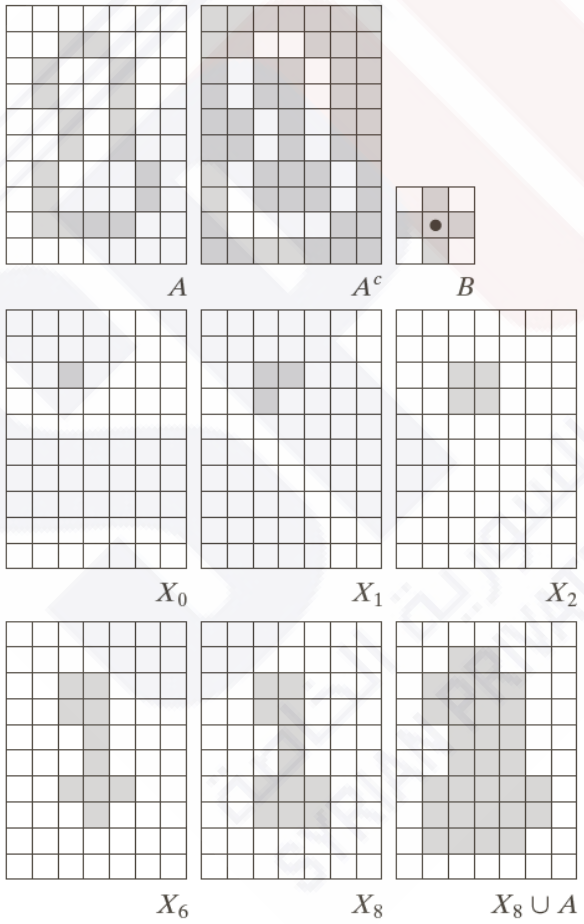
**FIGURE 9.14**
(a) A simple binary image, with 1s represented in white. (b) Result of using Eq. (9.5-1) with the structuring element in Fig. 9.13(b).





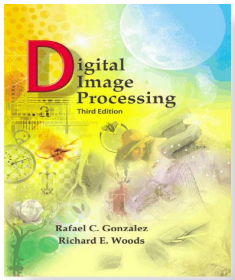

# Chapter 9
# Morphological Image Processing

Hole filling :
(equation)
Conditional
dilation




a b c
d e f
g h i

**FIGURE 9.15** Hole filling. (a) Set $A$ (shown shaded). (b) Complement of $A$. (c) Structuring element $B$. (d) Initial point inside the boundary. (e)–(h) Various steps of Eq. (9.5-2). (i) Final result [union of (a) and (h)].

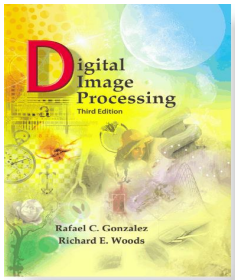





# Chapter 9
# Morphological Image Processing

a b c

**FIGURE 9.16** (a) Binary image (the white dot inside one of the regions is the starting point for the hole-filling algorithm). (b) Result of filling that region. (c) Result of filling all holes.





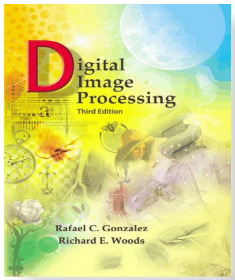

Chapter 9
Morphological Image Processing

# Extraction of connected components

:

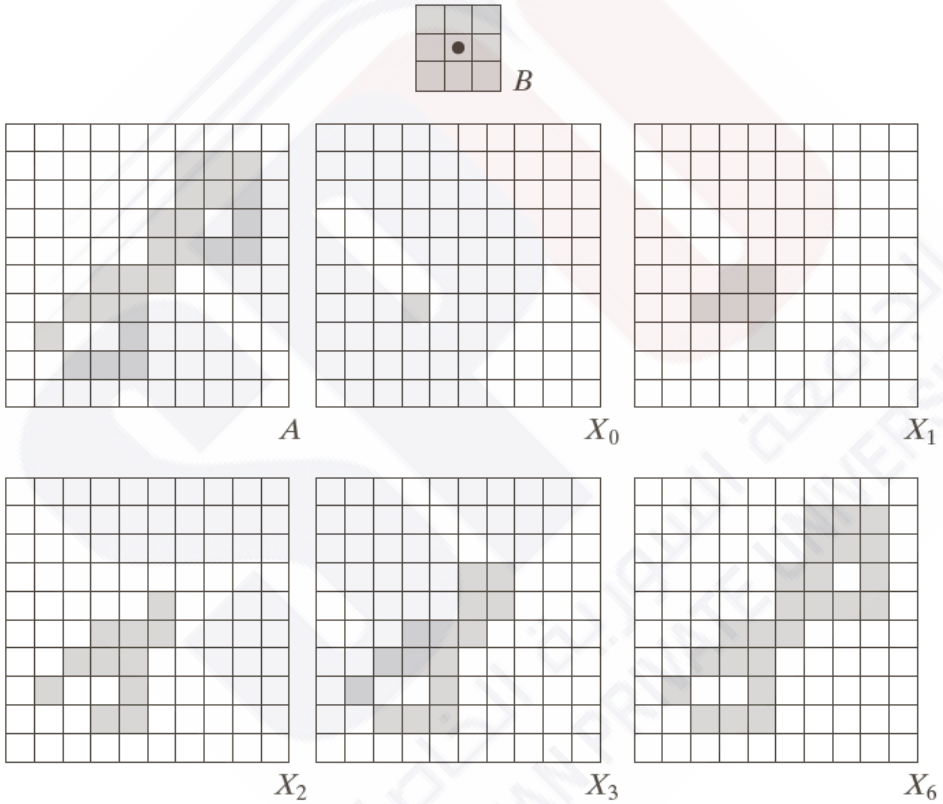
It is central to many automated image analysis application

Equation 9.5.3



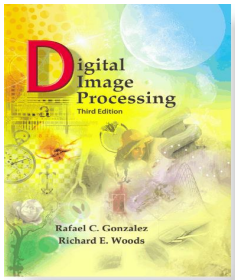



# Chapter 9
# Morphological Image Processing




a
b c d
e f g

**FIGURE 9.17** Extracting connected components. (a) Structuring element. (b) Array containing a set with one connected component. (c) Initial array containing a 1 in the region of the connected component. (d)–(g) Various steps in the iteration of Eq. (9.5-3).

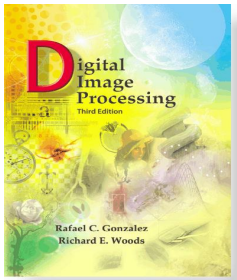


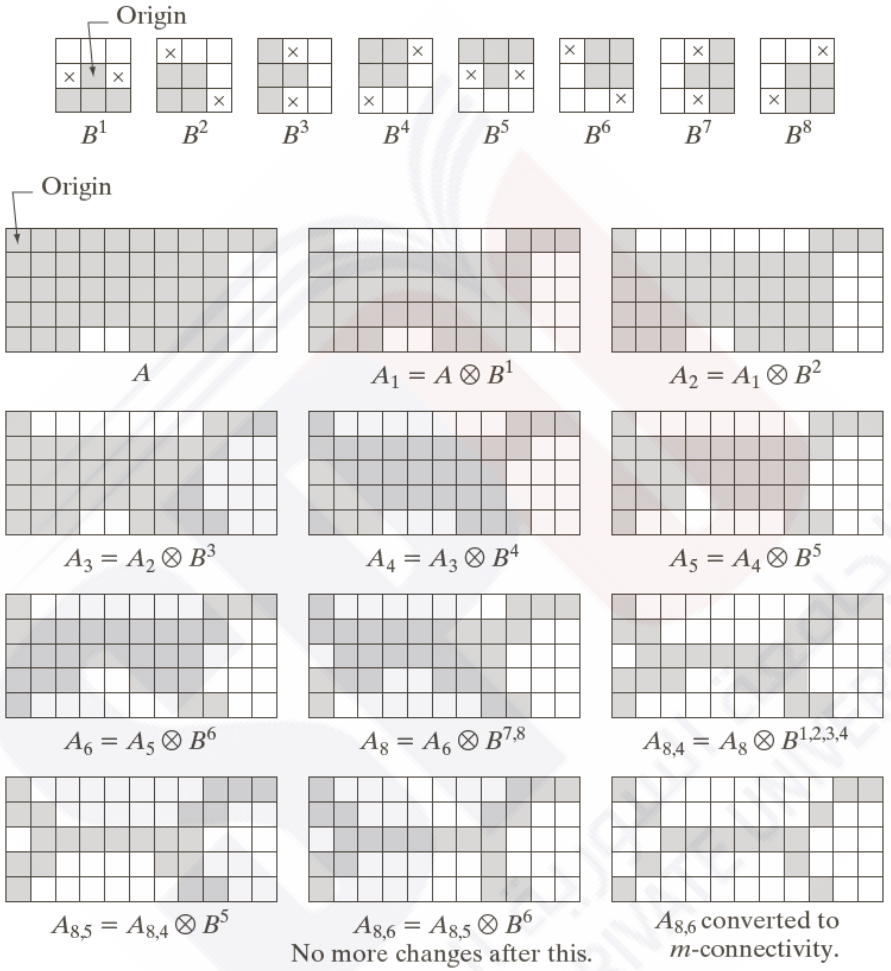



Chapter 9

# Morphological Image Processing

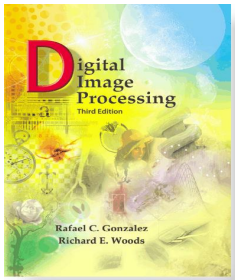
## Thinning




a
b c d
e f g
h i j
k l m

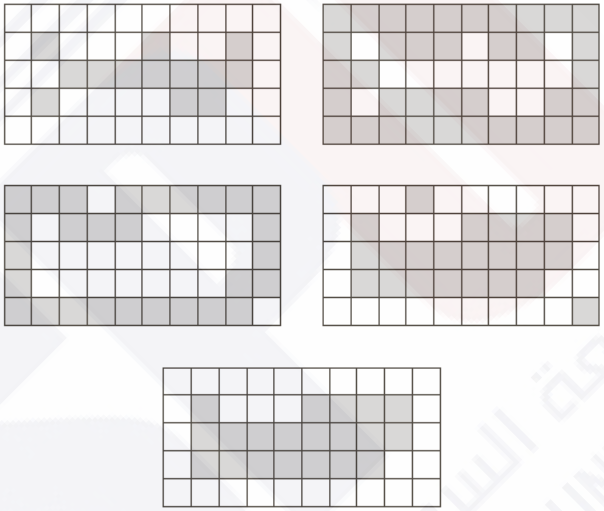
**FIGURE 9.21** (a) Sequence of rotated structuring elements used for thinning. (b) Set $A$. (c) Result of thinning with the first element. (d)–(i) Results of thinning with the next seven elements (there was no change between the seventh and eighth elements). (j) Result of using the first four elements again. (l) Result after convergence. (m) Conversion to $m$-connectivity.





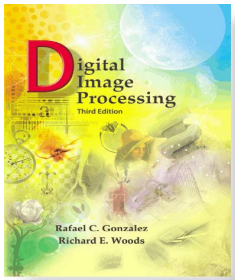

Chapter 9
# Morphological Image Processing

## Thickening



a b
c d
e

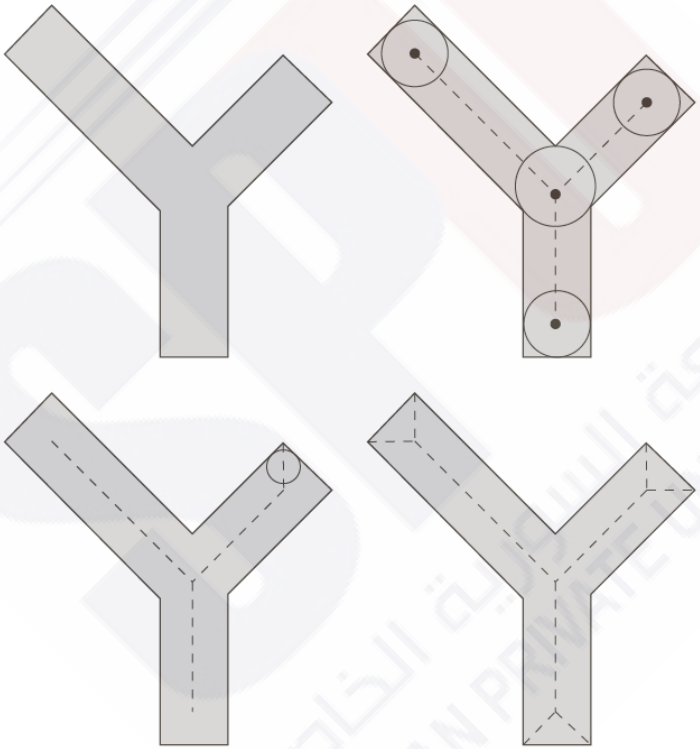
**FIGURE 9.22** (a) Set $A$. (b) Complement of $A$. (c) Result of thinning the complement of $A$. (d) Thickened set obtained by complementing (c). (e) Final result, with no disconnected points.





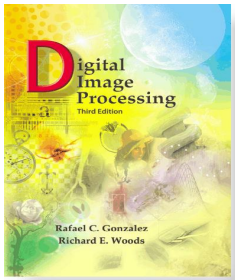

Chapter 9
Morphological Image Processing

# Skeletons



a b
c d

**FIGURE 9.23**
(a) Set $A$.
(b) Various positions of maximum disks with centers on the skeleton of $A$.
(c) Another maximum disk on a different segment of the skeleton of $A$.
(d) Complete skeleton.

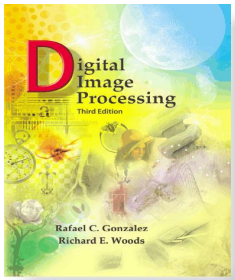





Chapter 9

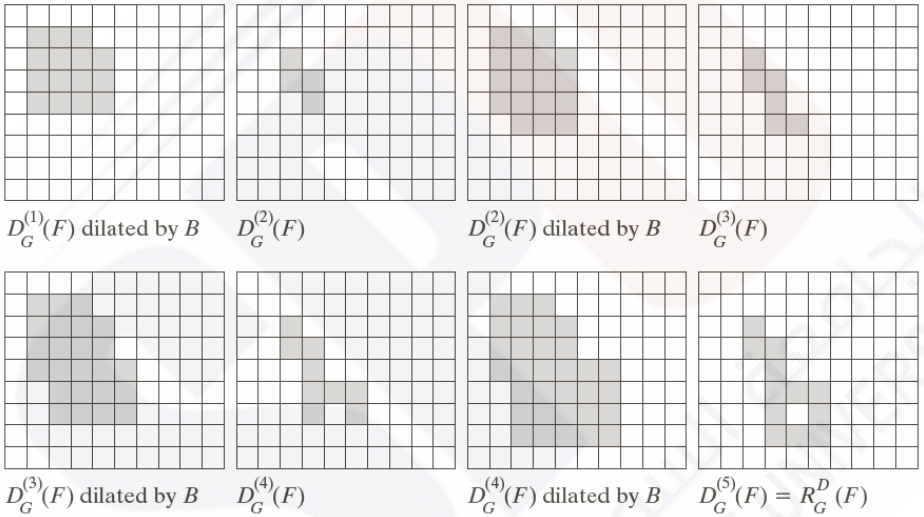
# Morphological Image Processing

END



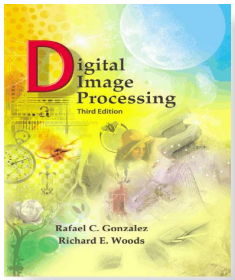



# Chapter 9
# Morphological Image Processing



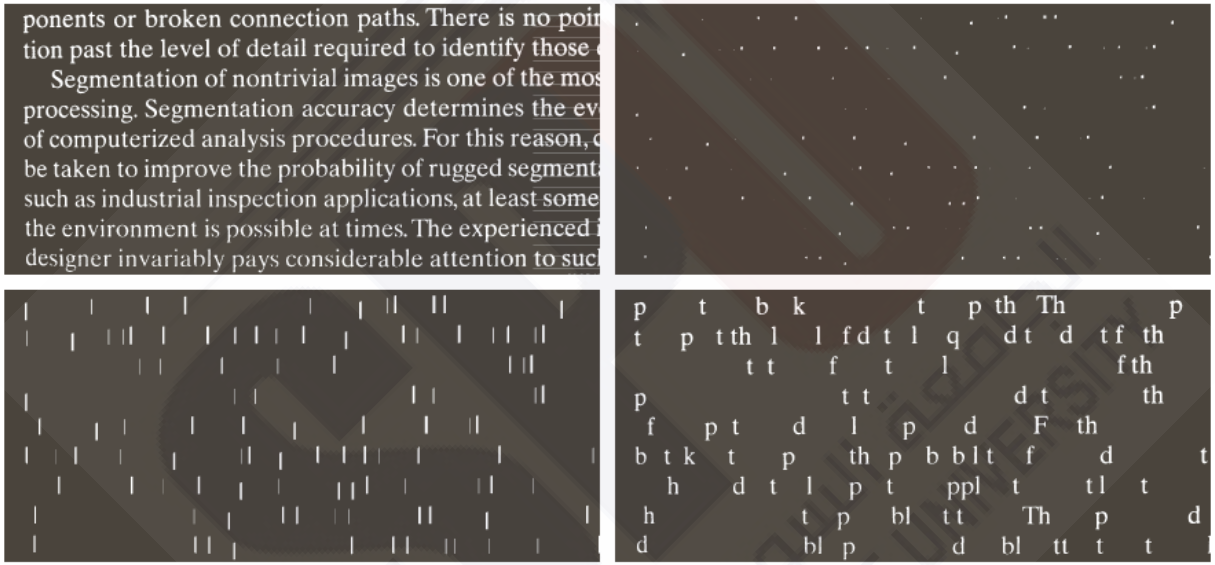

a b c d
e f g h

**FIGURE 9.28** Illustration of morphological reconstruction by dilation. $F$, $G$, $B$ and $D_G^{(1)}(F)$ are from Fig. 9.26.



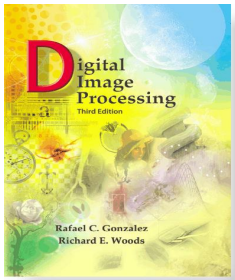



# Chapter 9
# Morphological Image Processing



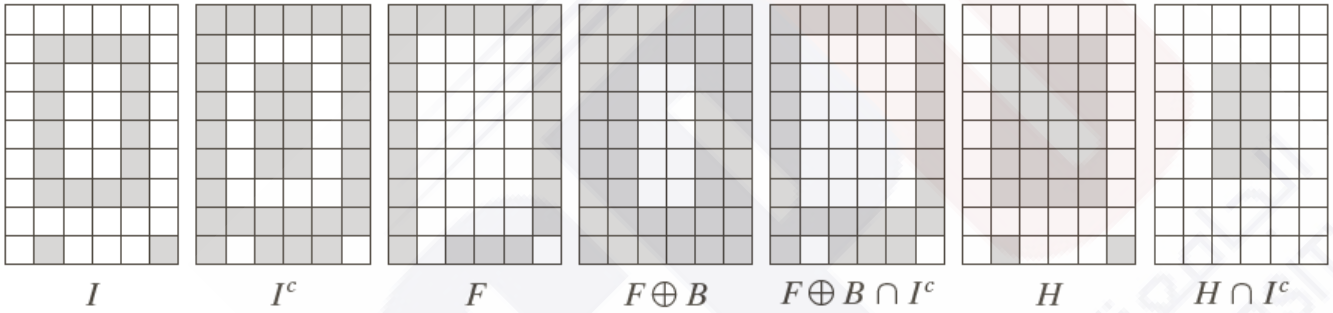

a b
c d

**FIGURE 9.29** (a) Text image of size 918 × 2018 pixels. The approximate average height of the tall characters is 50 pixels. (b) Erosion of (a) with a structuring element of size 51 × 1 pixels. (c) Opening of (a) with the same structuring element, shown for reference. (d) Result of opening by reconstruction.



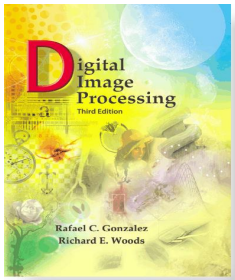



# Chapter 9
# Morphological Image Processing




a b c d e f g

**FIGURE 9.30** Illustration of hole filling on a simple image.






# Chapter 9
# Morphological Image Processing

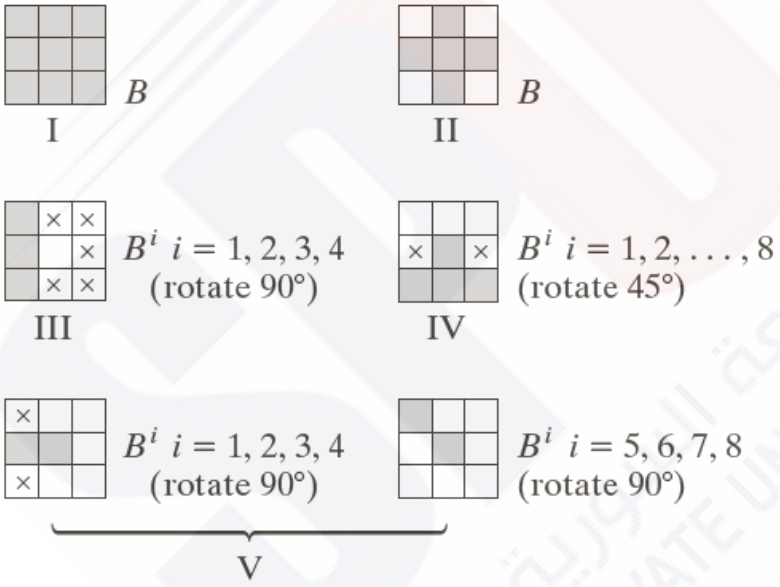
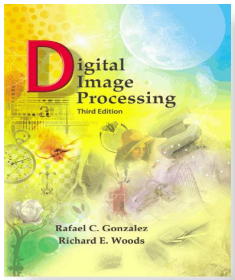



**FIGURE 9.33** Five basic types of structuring elements used for binary morphology. The origin of each element is at its center and the ×'s indicate "don't care" values.




# Chapter 9
# Morphological Image Processing

**TABLE 9.1**
Summary of morphological operations and their properties.

| Operation | Equation | Comments (The Roman numerals refer to the structuring elements in Fig. 9.33.) |
|---|---|---|
| Translation | $(B)_z = \{w \mid w = b + z, \text{ for } b \in B\}$ | Translates the origin of $B$ to point $z$. |
| Reflection | $\hat{B} = \{w \mid w = -b, \text{ for } b \in B\}$ | Reflects all elements of $B$ about the origin of this set. |
| Complement | $A^c = \{w \mid w \notin A\}$ | Set of points not in $A$. |
| Difference | $A - B = \{w \mid w \in A, w \notin B\} = A \cap B^c$ | Set of points that belong to $A$ but not to $B$. |
| Dilation | $A \oplus B = \left\{z \mid (\hat{B}_z) \cap A \neq \varnothing\right\}$ | "Expands" the boundary of $A$. (I) |
| Erosion | $A \ominus B = \left\{z \mid (B)_z \subseteq A\right\}$ | "Contracts" the boundary of $A$. (I) |
| Opening | $A \circ B = (A \ominus B) \oplus B$ | Smoothes contours, breaks narrow isthmuses, and eliminates small islands and sharp peaks. (I) |

(*Continued*)