SNS COLLEGE OF TECHNOLOGY
(AN AUTONOMOUS INSTITUTION)
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Recognized by UGC saravanampatti (post), Coimbatore-641035.

Department of Biomedical Engineering

Course Name: 19BMB304 & Biomedical Image Processing

III Year : VI Semester

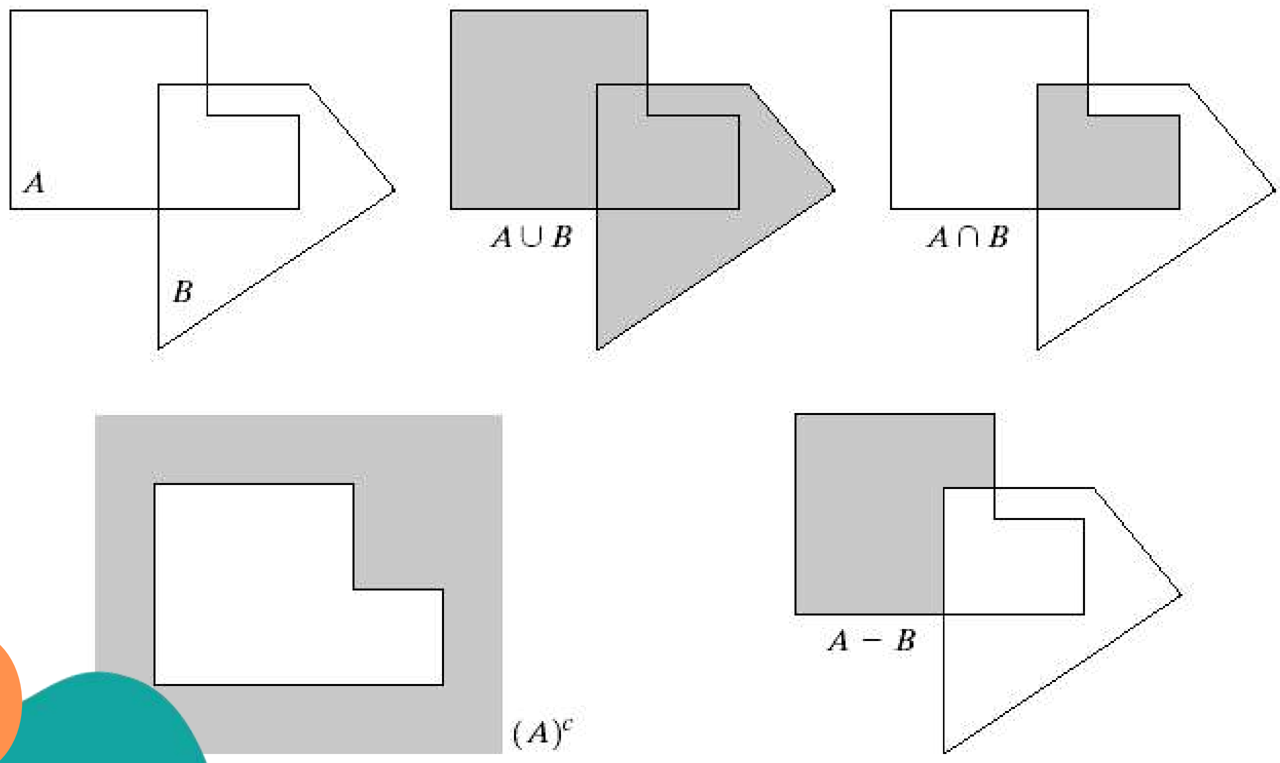
Unit III –IMAGE RESTORATION AND SEGMENTATION

Topic : Morphological Processing-Erosion & Dilation

Mathematic Morphology

- used to extract image components that are useful in the representation and description of region shape, such as
  - boundaries extraction
  - skeletons
  - convex hull
  - morphological filtering
  - thinning
  - pruning

Basic Set Theory



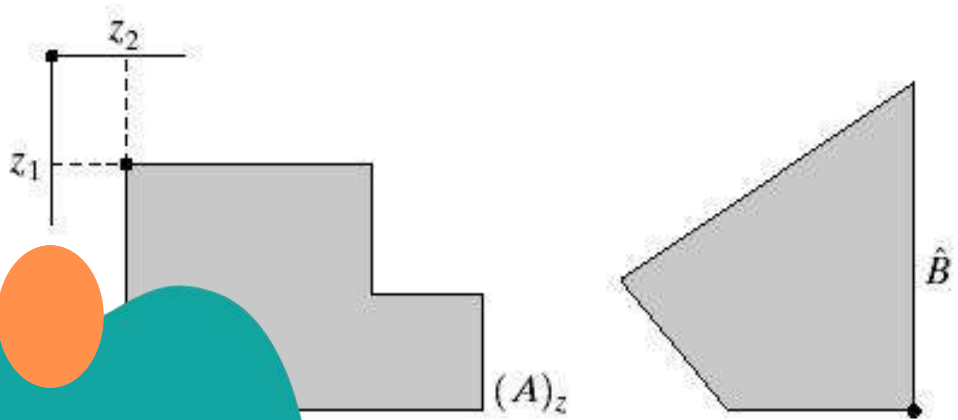
a b c
d e

FIGURE 9.1
(a) Two sets A and B. (b) The union of A and B. (c) The intersection of A and B. (d) The complement of A. (e) The difference between A and B.

Reflection and Translation

$$\hat{B} = \{ w \mid w \in -b, \quad for\ b \in B \}$$

$$(A)_z = \{ c \mid c \in a + z, \quad for\ a \in A \}$$



a b

FIGURE 9.2
(a) Translation of A by z.
(b) Reflection of B. The sets A an B are from Fig. 9.1.

Example

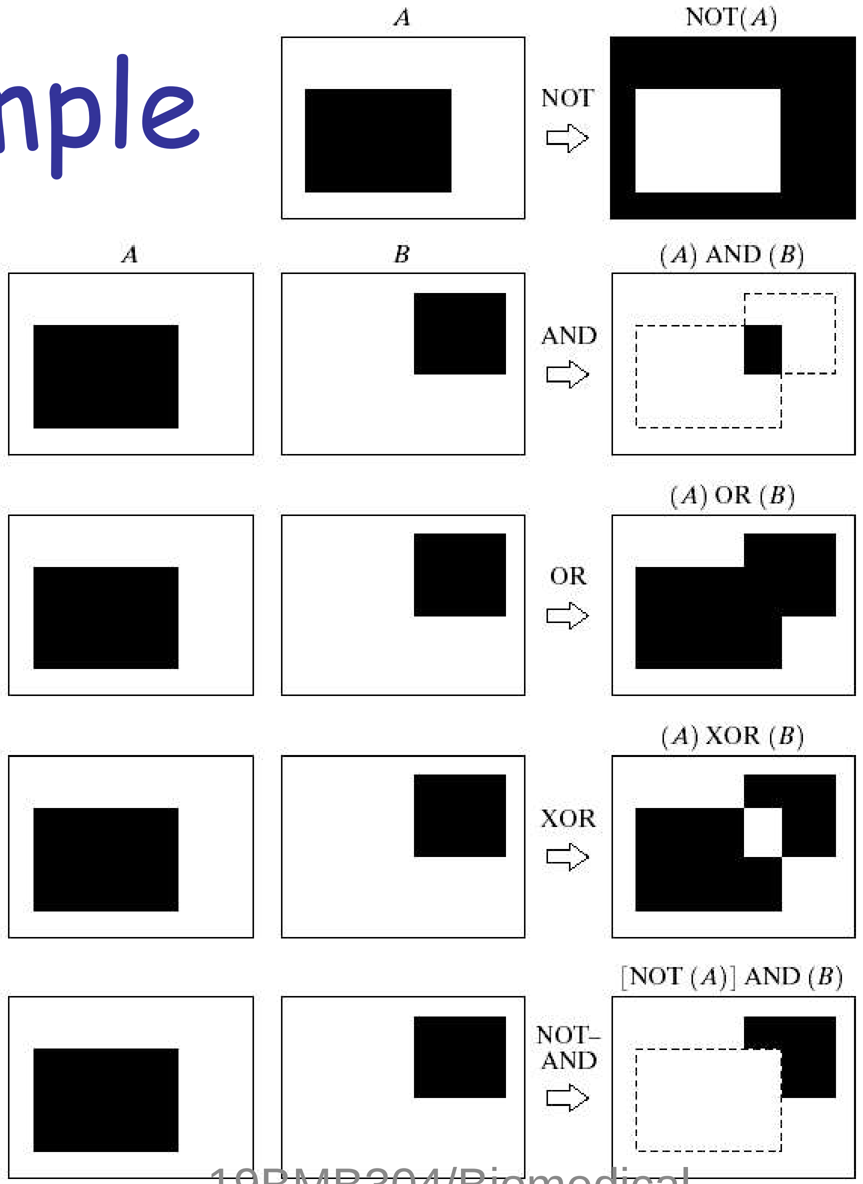
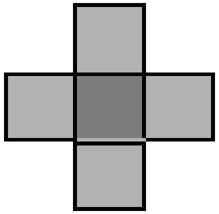
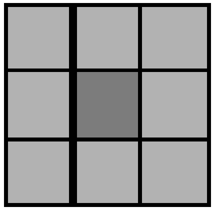


FIGURE 9.3 Some logic operations between binary images. Black represents binary 1s and white binary 0s in this example.

Structuring element (SE)

- small set to probe the image under study
- for each SE, define origo
- shape and size must be adapted to geometric properties for the objects





Basic morphological operations

- Erosion 

- Dilation 

- combine to
  - Opening
  - Closening

keep general shape but smooth with respect to

object

background

Erosion

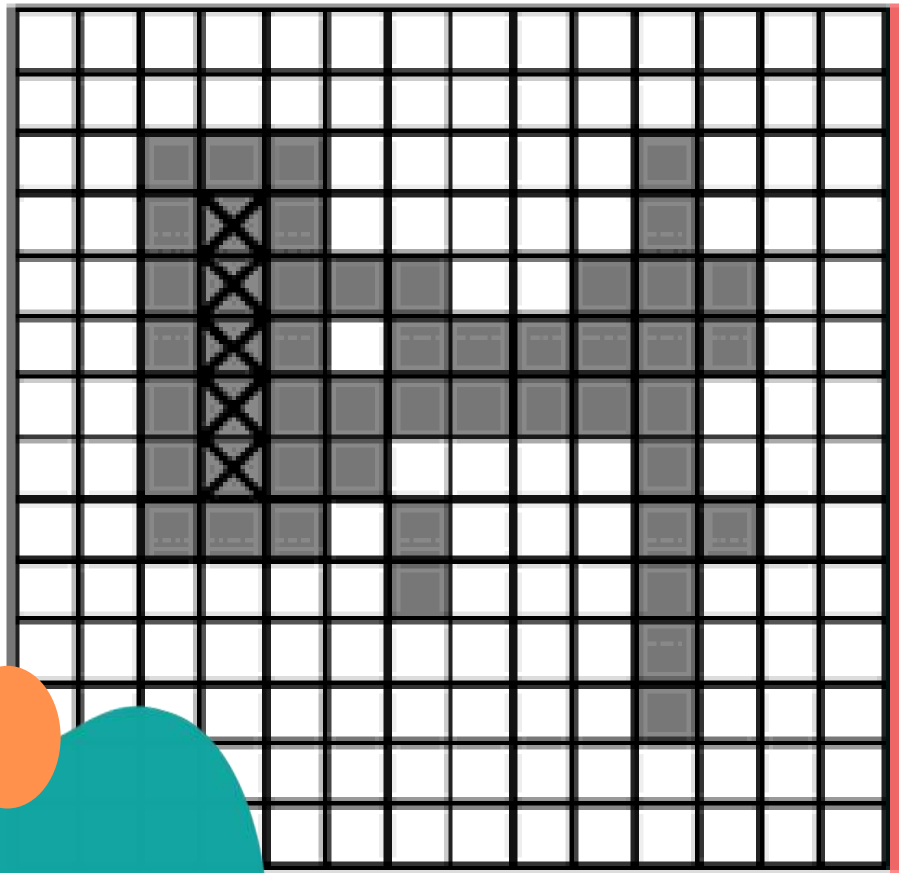
- Does the structuring element **fit the set?**

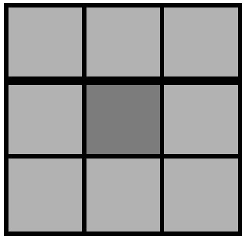
erosion of a set A by structuring element B: all z in A such that B is in A when origin of B=z

$$A \ominus B = \{z \mid (B)_z \subseteq A\}$$

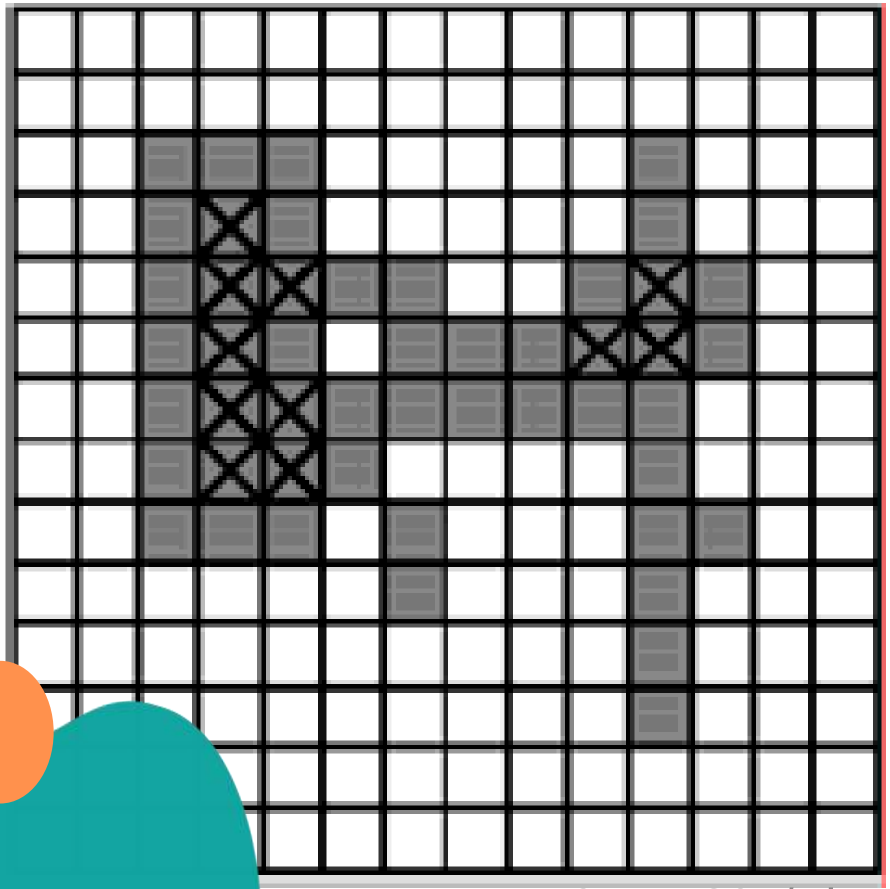
shrink the object

Erosion

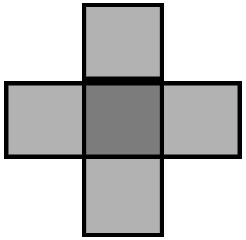


SE= 

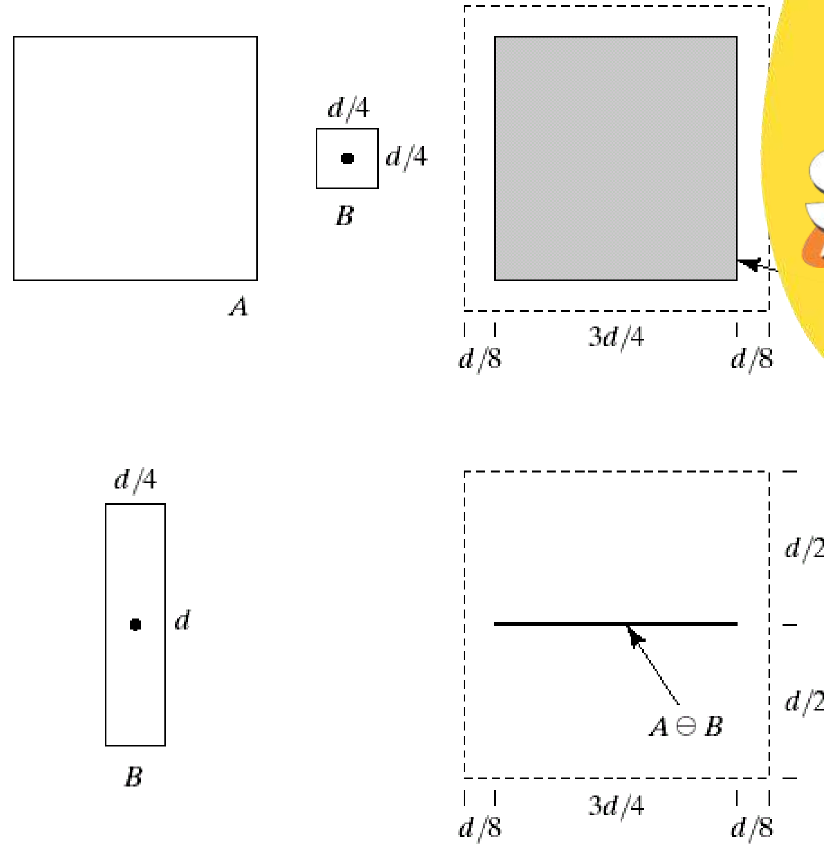
Erosion



SE=



Erosion



a b c
d e

FIGURE 9.6 (a) Set A. (b) Square structuring element. (c) Erosion of A by B shown shaded. (d) Elongated structuring element. (e) Erosion of A using this elem

$$A \ominus B = \{ z \mid (B)_z \subseteq A \}$$

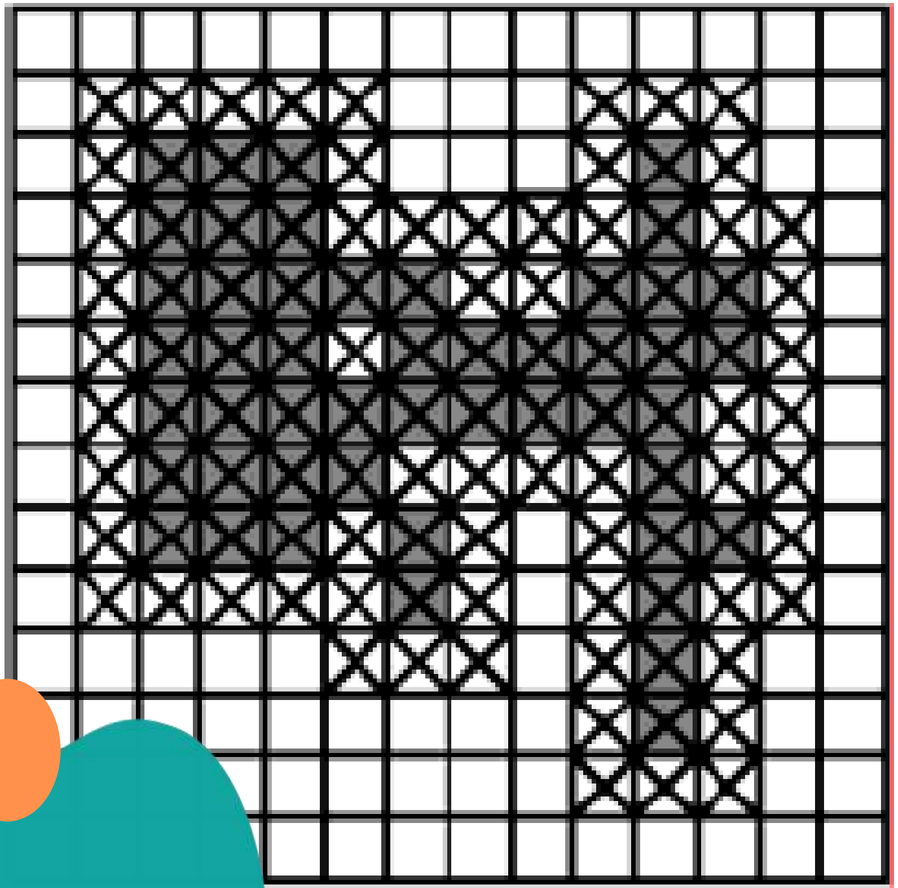
Dilation

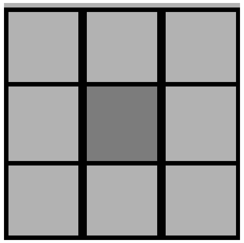
- Does the structuring element **hit the set?**
- dilation of a set *A* by structuring element B: all z in *A* such that B hits *A* when origin of B=z

$$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \Phi\}$$

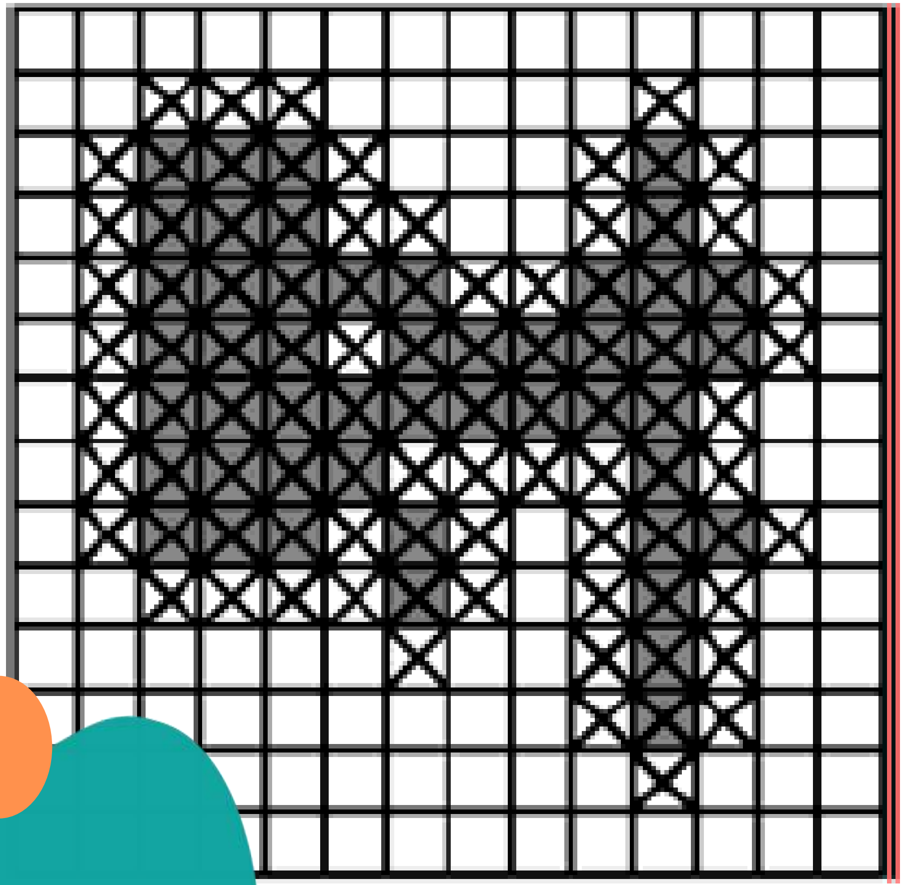
grow the object

Dilation

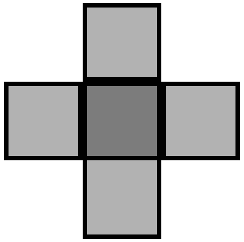


SE= 

Dilation



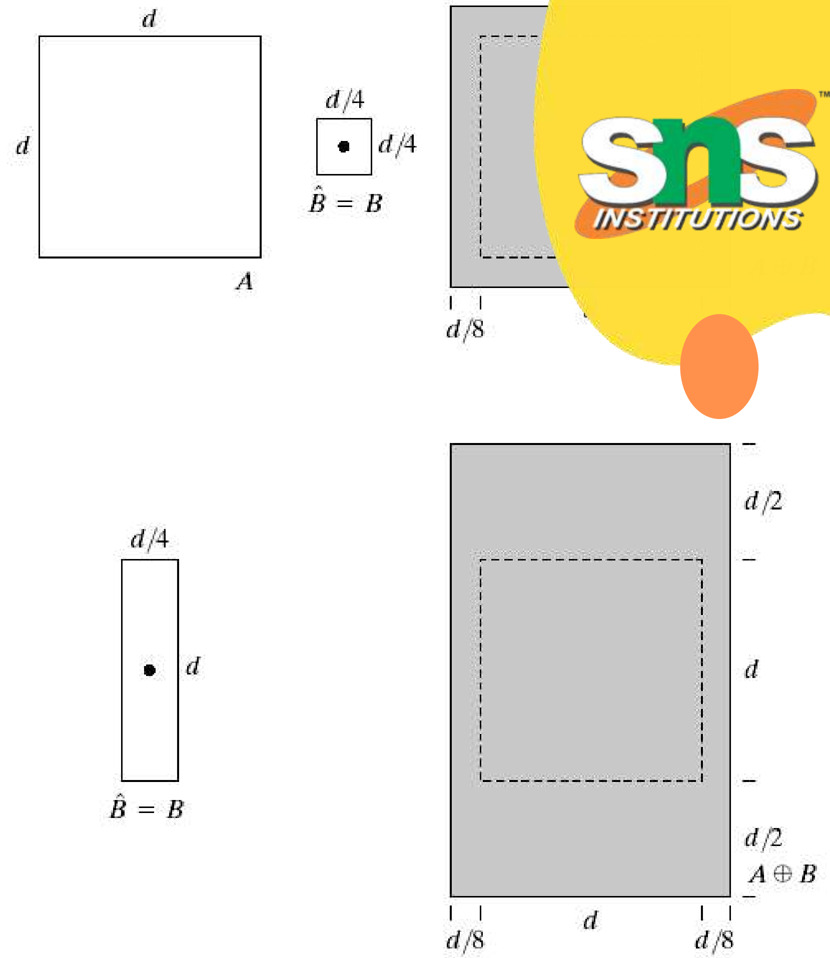
SE=



Dilation

a b c
d e

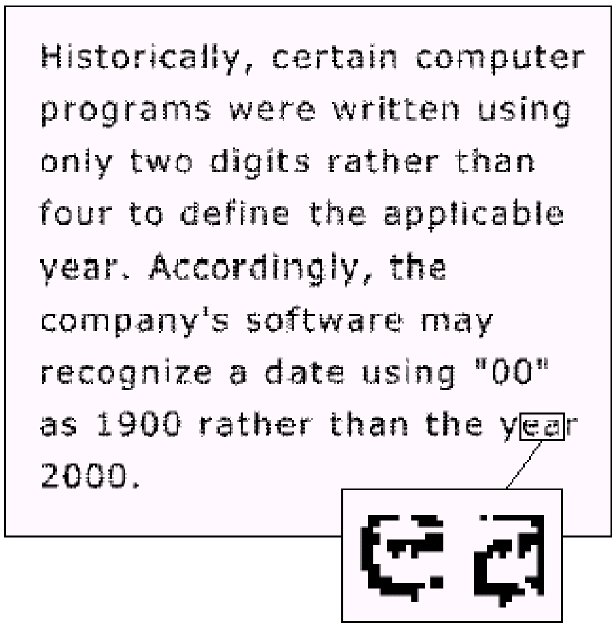
FIGURE 9.4
(a) Set A.
(b) Square structuring element (dot is the center).
(c) Dilation of A by B, shown shaded.
(d) Elongated structuring element.
(e) Dilation of A using this element.



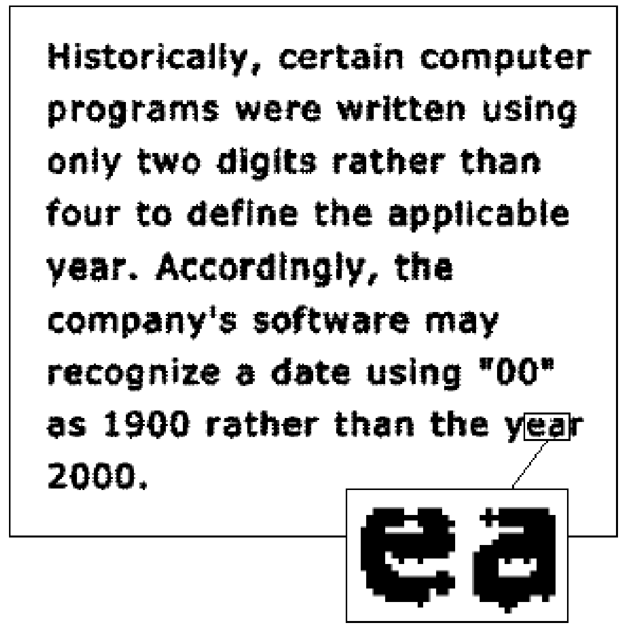
B = structuring element

$$A \square B = \{z|(\hat{B})_z \;\; \Omega\, A \neq \Phi\}$$

Dilation : Bridging gaps



Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.



Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.

0	1	0
1	1	1
0	1	0

a c
b

FIGURE 9.5 (a) Sample text of poor resolution with broken characters (magnified view). (b) Structuring element. (c) Dilation of (a) by (b). Broken segments were joined.

useful

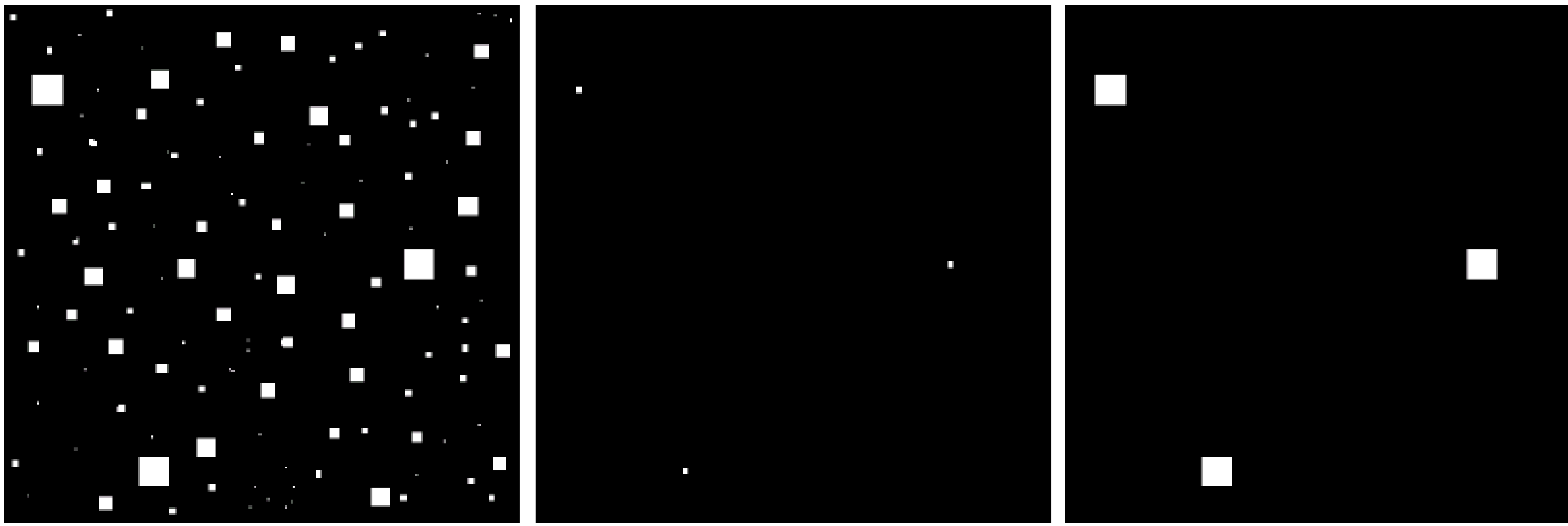
- erosion
  - removal of structures of certain shape and size, given by SE
- Dilation
  - filling of holes of certain shape and size, given by SE

Combining erosion and dilation

- WANTED:
  - remove structures / fill holes
  - without affecting remaining parts

- SOLUTION:
- combine erosion and dilation (using same SE)

Erosion : eliminating irrelevant detail



a b c

FIGURE 9.7 (a) Image of squares of size 1, 3, 5, 7, 9, and 15 pixels on the side. (b) Erosion of (a) with a squa ructuring element of 1's, 13 pixels on the side. (c) Dilation of (b) with the same structuring element.

structuring element B = 13x13 pixels of gray level 1

Opening

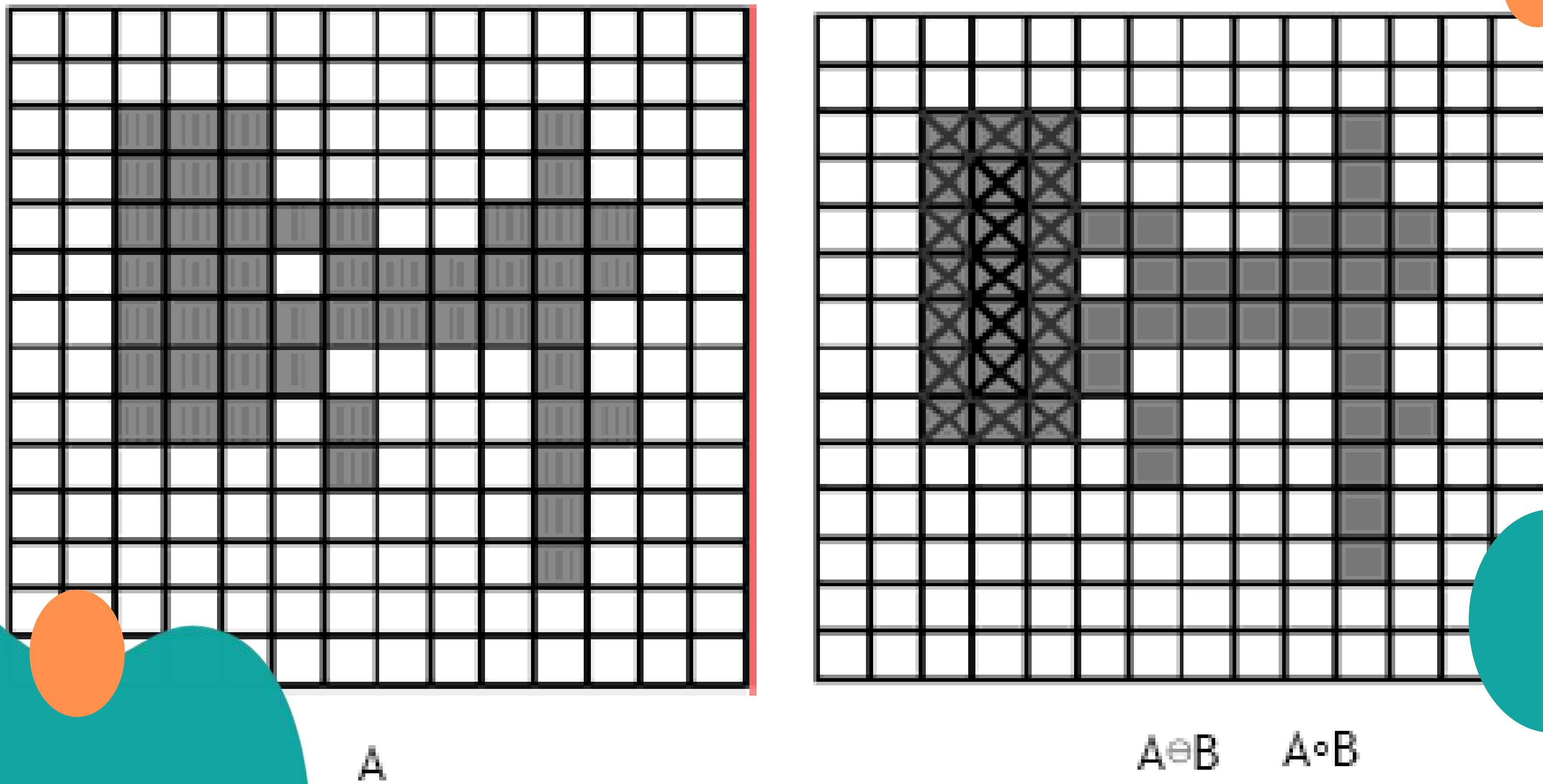
erosion followed by dilation, denoted ∘

$$A \circ B = (A \ominus B) \textcircled{1} B$$

- eliminates protrusions
- breaks necks
- smoothes contour

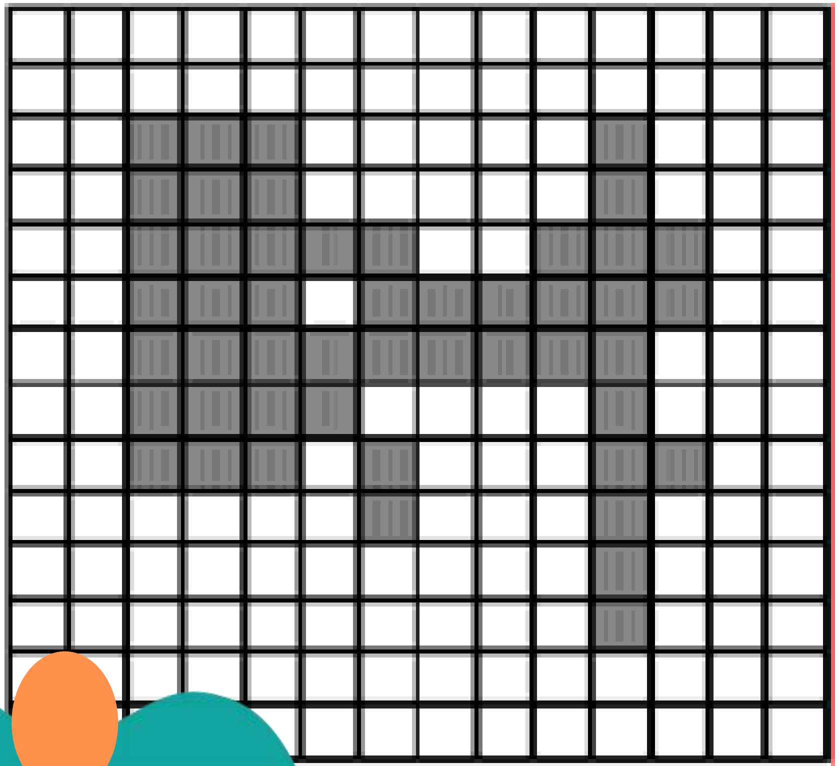
Opening

B=

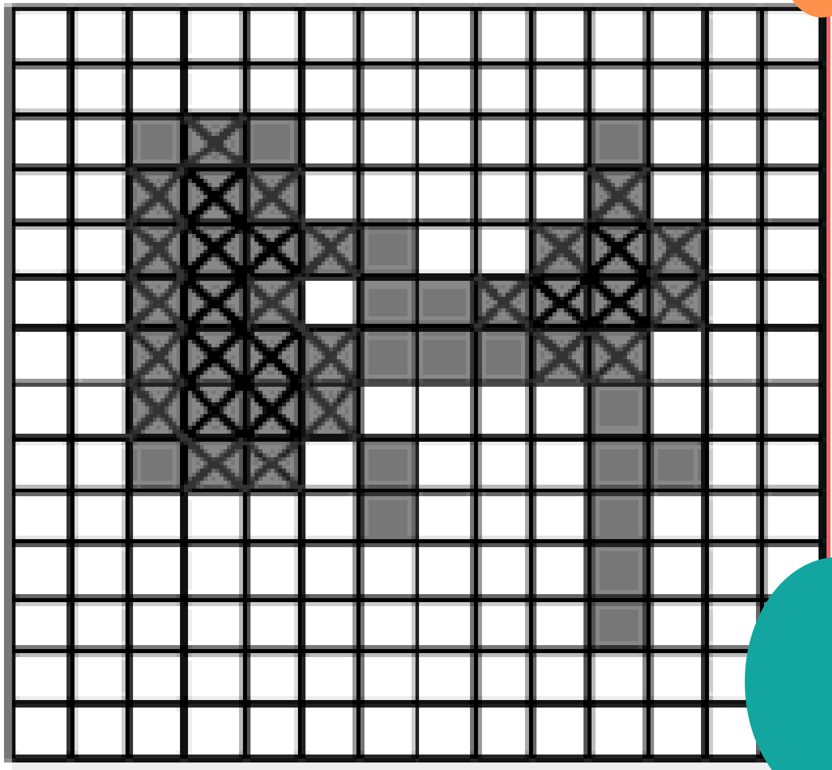


Opening

B=

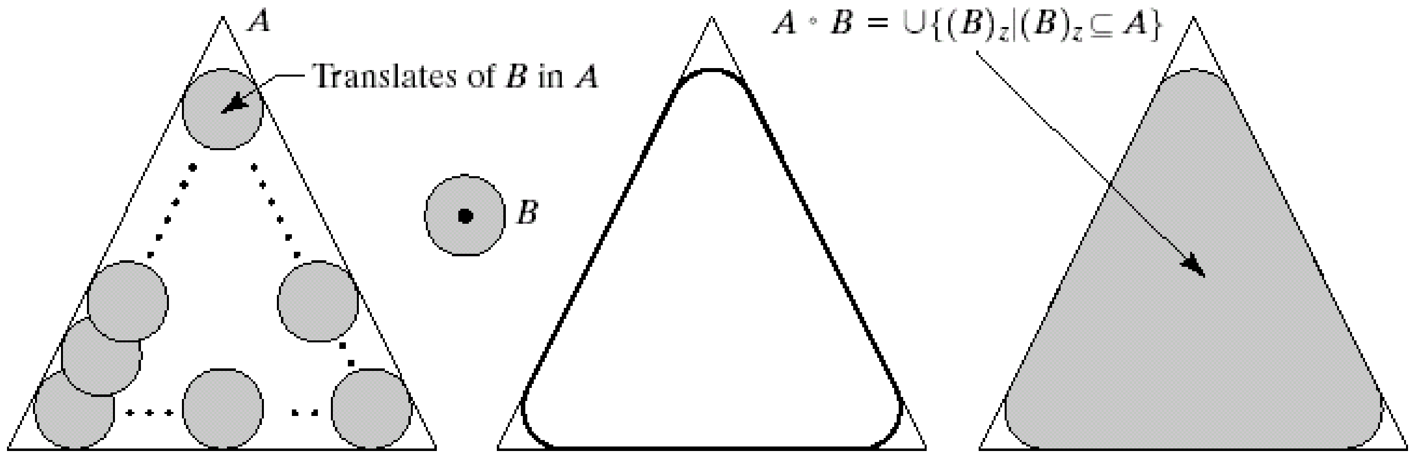


A



A⊖B A∘B

Opening



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). (c) The heavy line is the outer boundary of the opening. (d) Complete opening (shaded).

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

$$A \circ B = \cup \{(B)_z \mid (B)_z \subseteq A\}$$

Closing

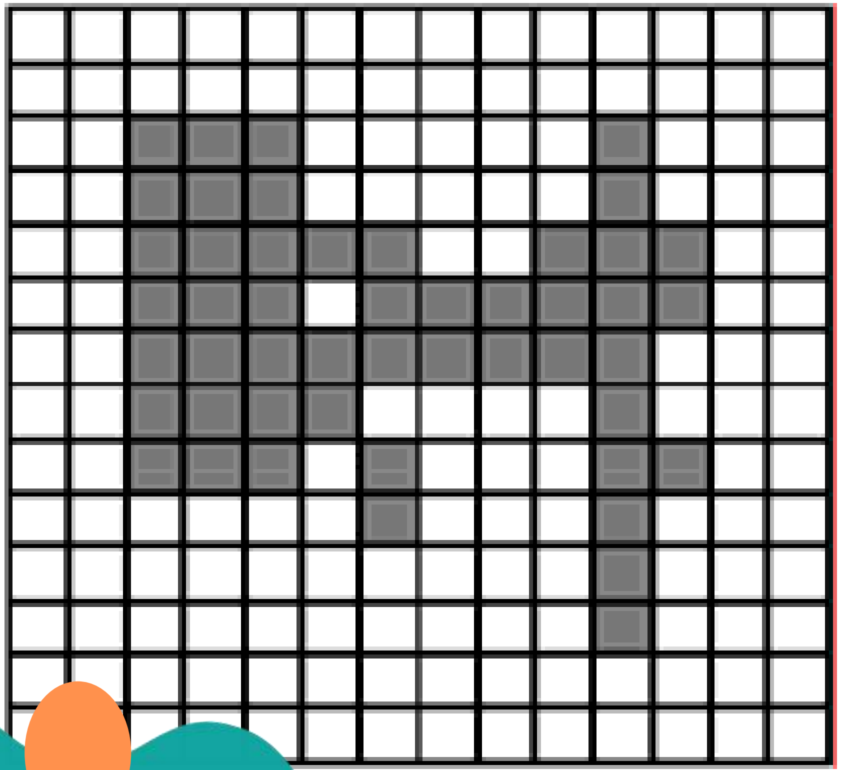
dilation followed by erosion, denoted •

$$A \bullet B = (A \textcircled{1} B) \ominus B$$

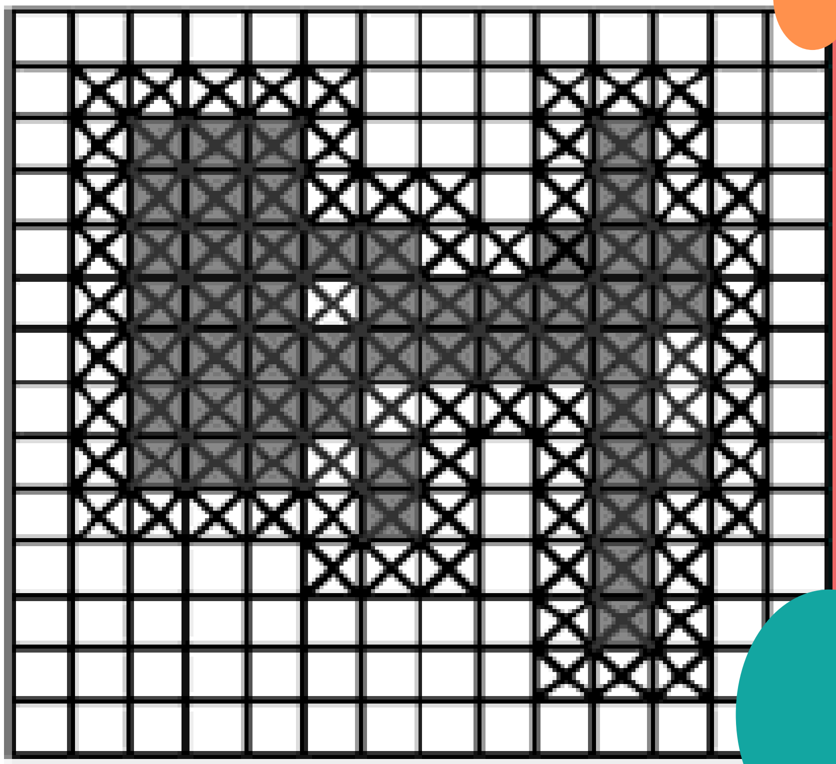
- smooth contour
- fuse narrow breaks and long thin gulfs
- eliminate small holes
- fill gaps in the contour

Closing

B=



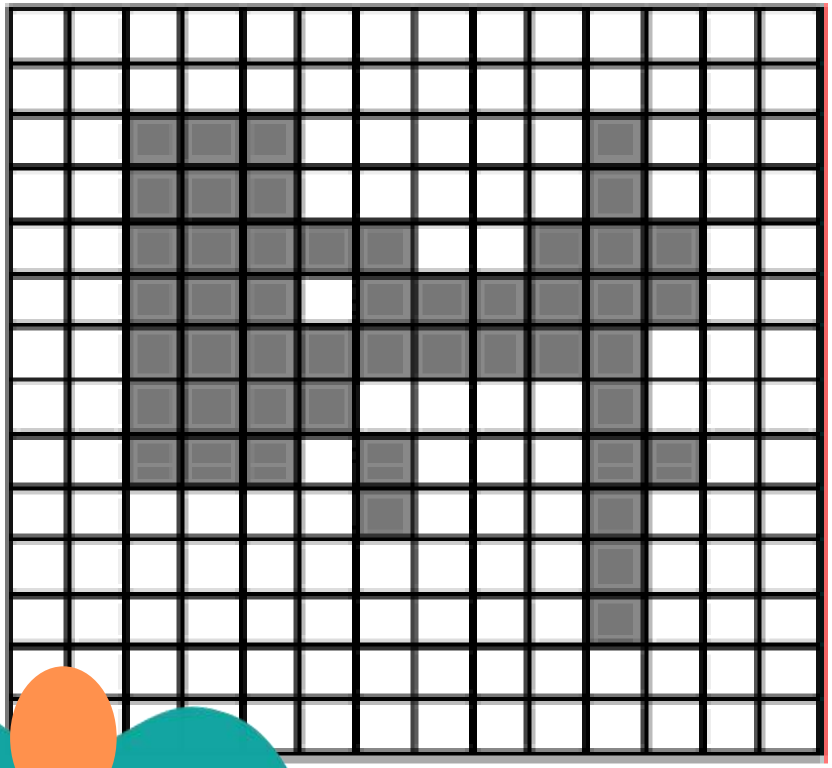
A



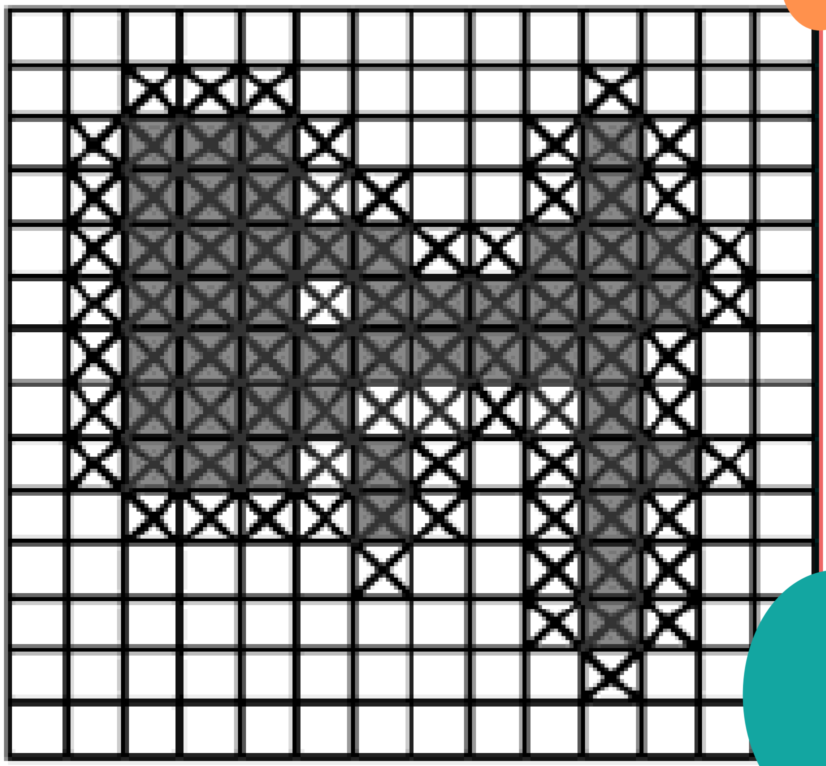
$A \oplus B$ $\quad A \bullet B$

Closing

B=

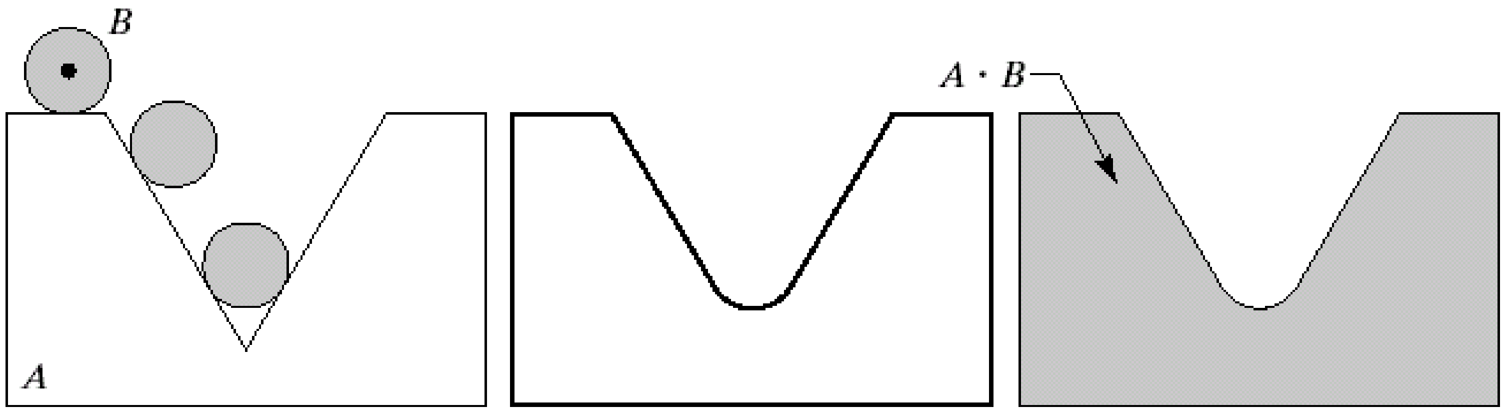


A



A⊕B A • B

Closing



a b c

FIGURE 9.9 (a) Structuring element B "rolling" on the outer boundary of set A. (b) Heavy line is the outer boundary of the closing. (c) Complete closing (shaded).

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

Properties

Opening

(i) A∘B is a subset (subimage) of A

(ii) If C is a subset of D, then C ∘B is a subset of D ∘B

(iii) (A ∘B) ∘B = A ∘B

Closing

(i) A is a subset (subimage) of A•B

(ii) If C is a subset of D, then C •B is a subset of D •B

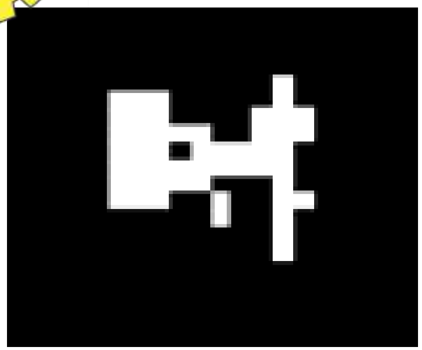
(iii) (A •B) •B = A •B

Note: repeated openings/closings has no effect!

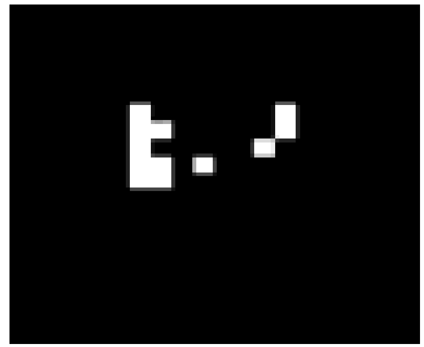
Duality

- Opening and closing are dual with respect to complementation and reflection

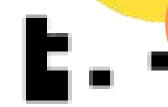
$$(A \bullet B)^c = (A^c \circ \hat{B})$$



A

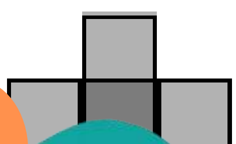


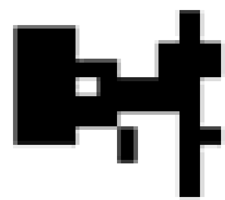
$A \ominus B$



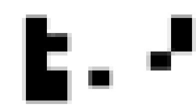
$(A \ominus B)^C$

$$B = \hat{B}$$





A^C



$A^C \oplus B$

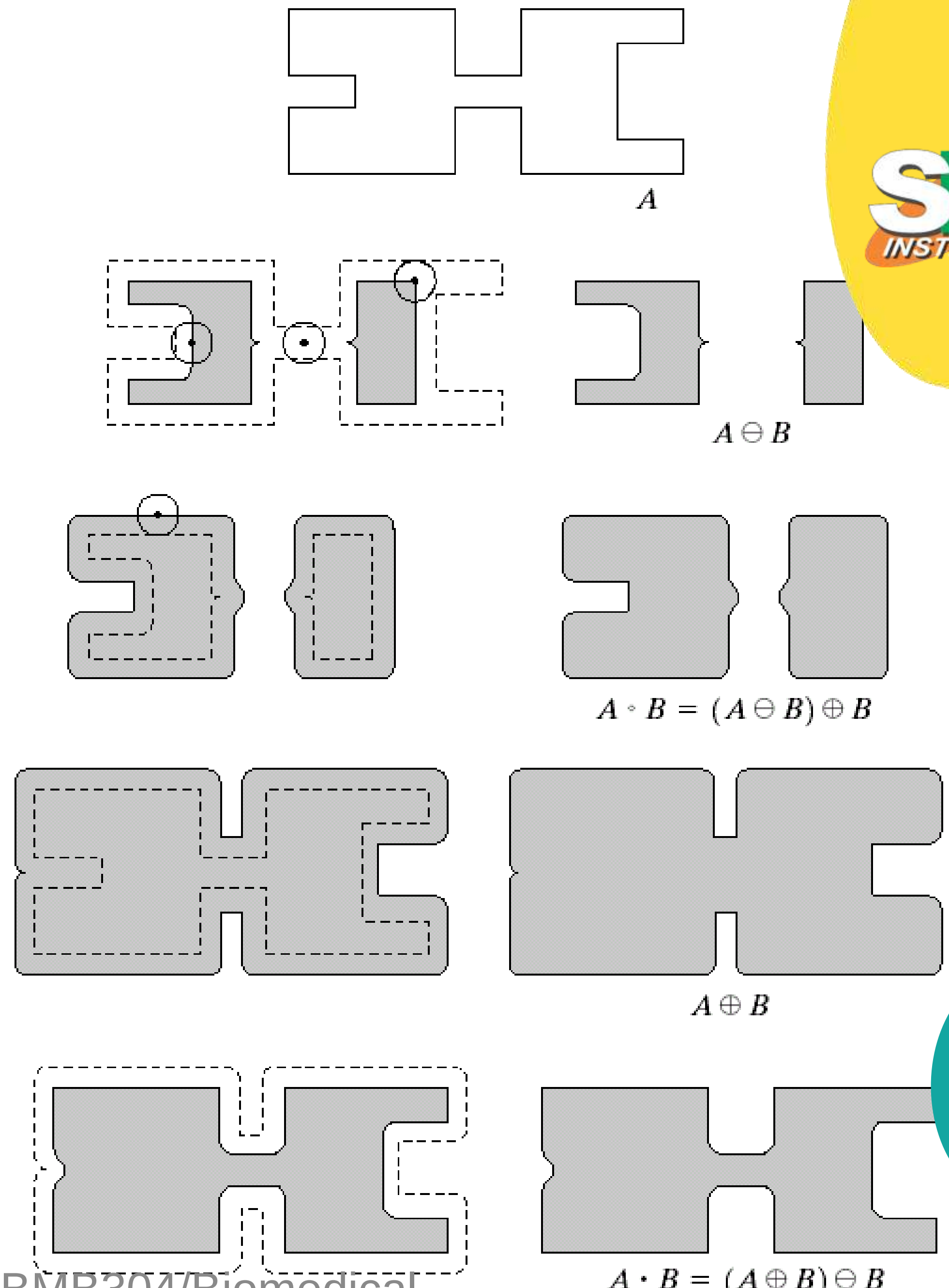
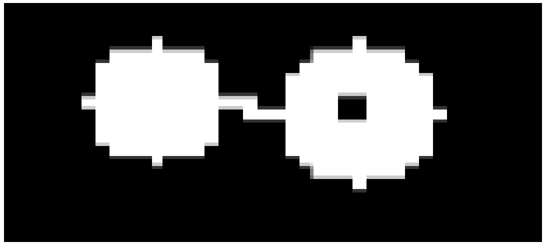
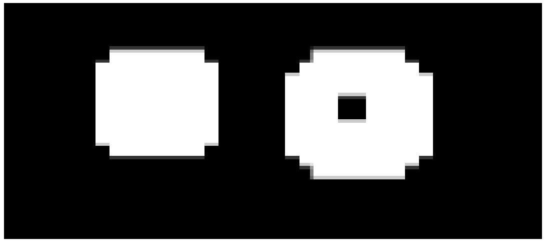


FIGURE 9.10 Morphological opening and closing. The structuring element is the small circle shown in various positions in (b). The dark dot is the center of the structuring element.

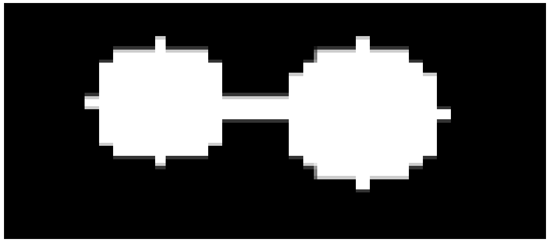
Useful: open & close



A

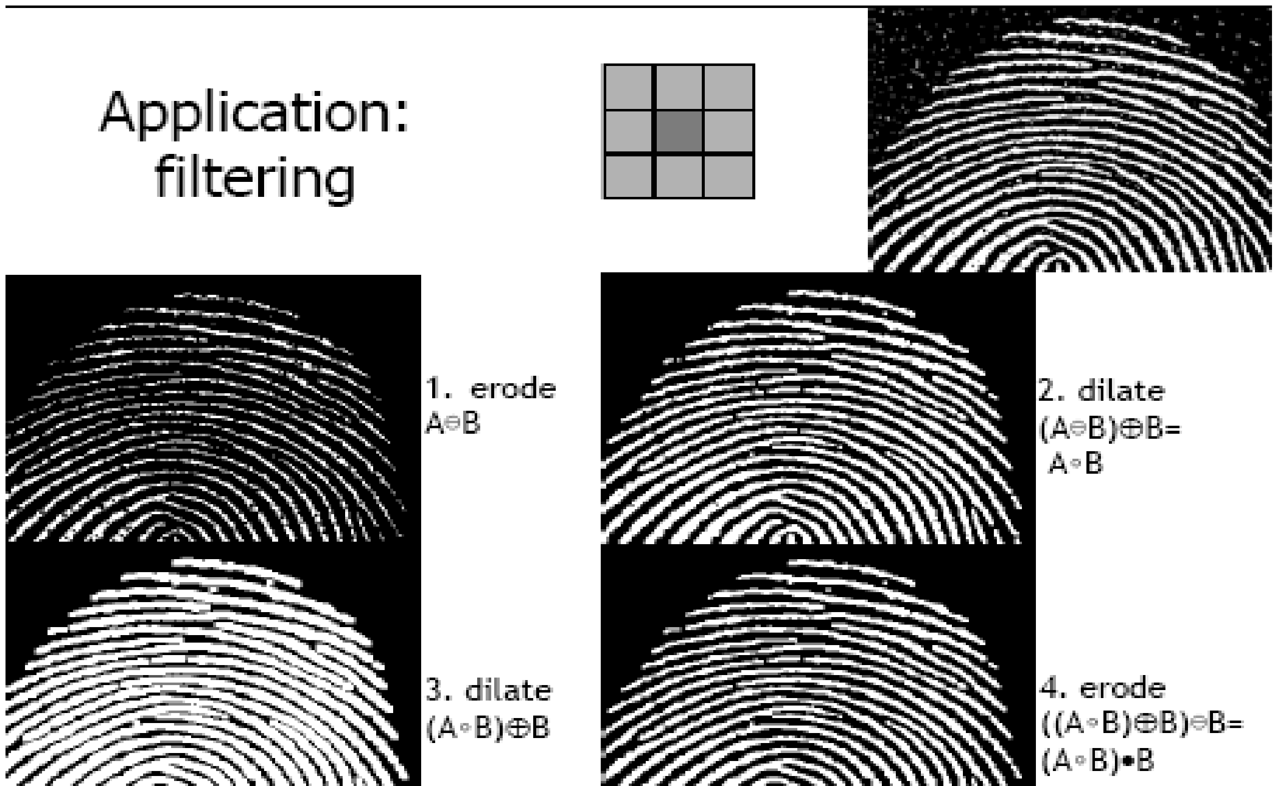


opening of A
→removal of small protrusions, thin connections, ...



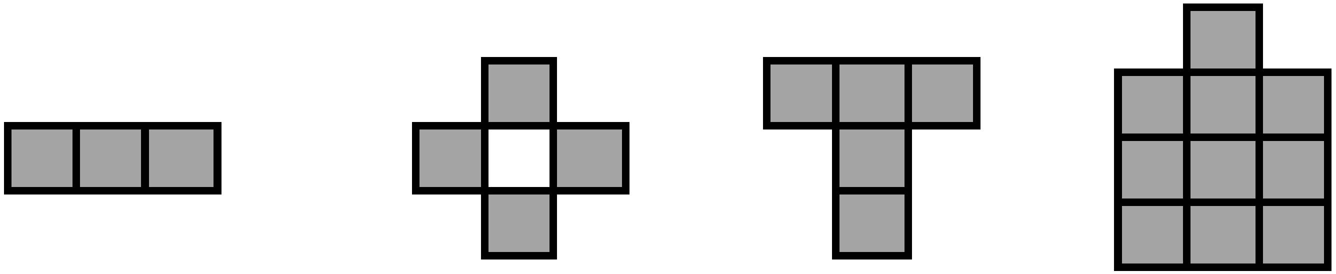
closing of A
→ removal of holes

Application: filtering



Hit-or-Miss Transformation ⊛ (HMT)

- find location of one shape among a set of shapes ”template matching



- composite SE: object part (B1) and background pa (B2)
- does B1 ***fits the object while, simultaneously,*** B2 misses the object, i.e., ***fits the background?***

Hit-or-Miss Transformation

a b
c d
e
f

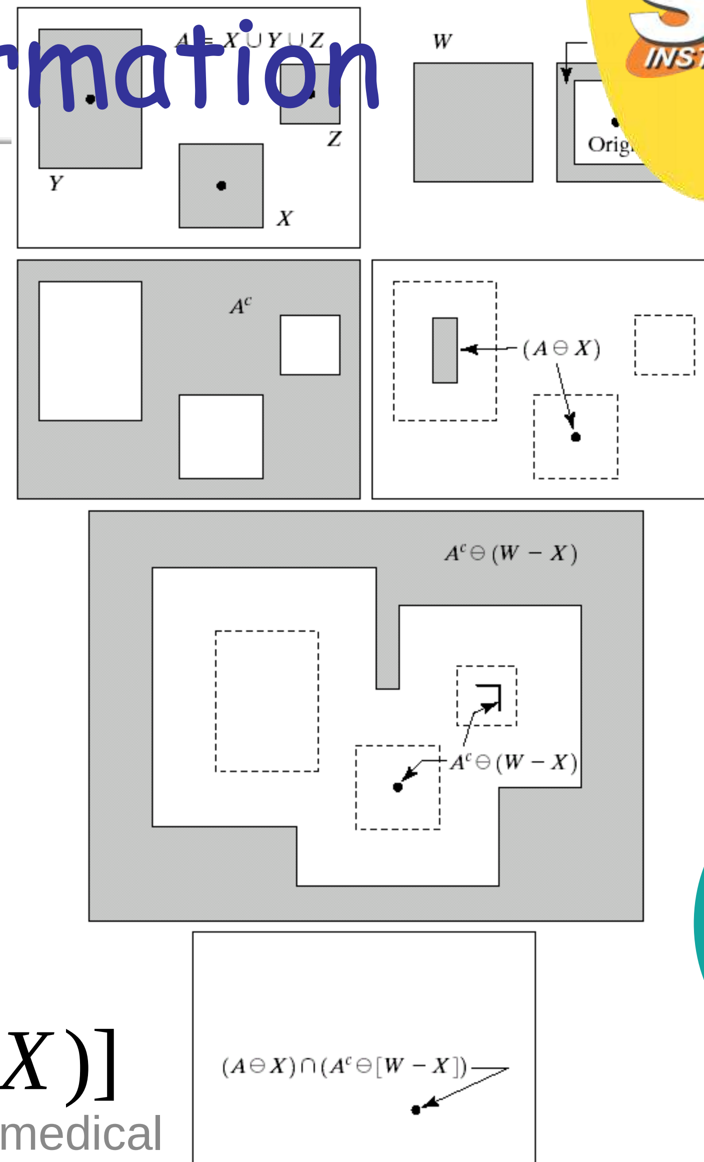


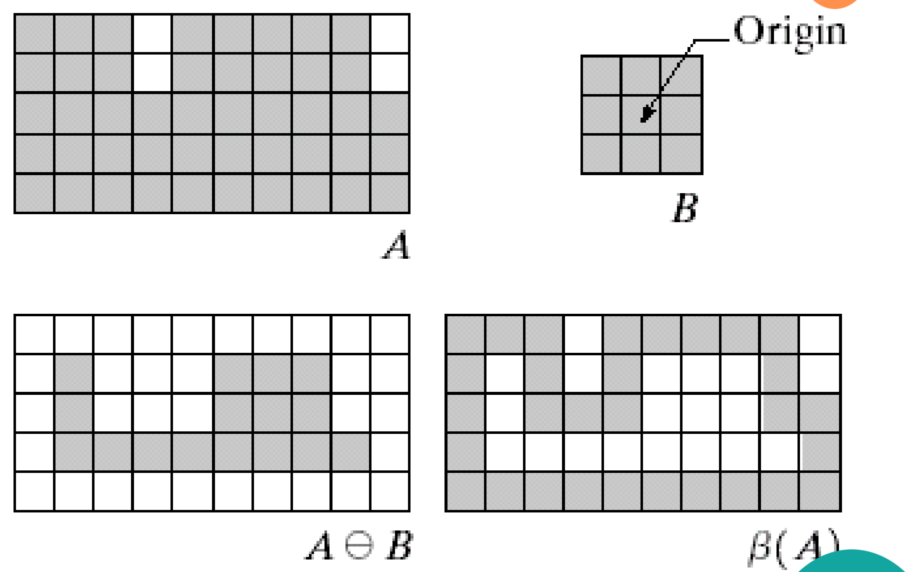
FIGURE 9.12
(a) Set A. (b) A window, W, and the local background of X with respect to W, $(W - X)$. (c) Complement of A. (d) Erosion of A by X. (e) Erosion of A^c by $(W - X)$. (f) Intersection of (d) and (e), showing the location of the origin of X, as desired.

$$A \circledast B = (A \ominus X)\, \Omega\, [A^c \ominus (W - X)]$$

Boundary Extraction

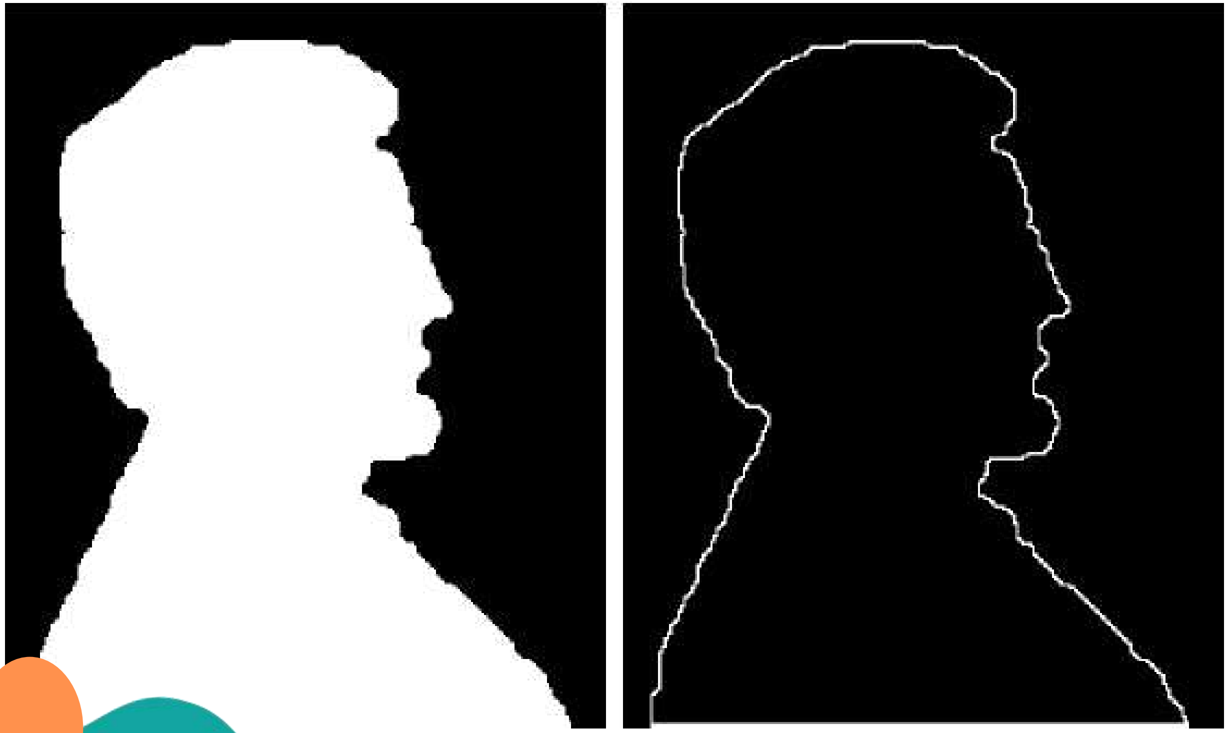
a b
c d

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.



$$\beta(A) = A - (A \ominus B)$$

Example



a b

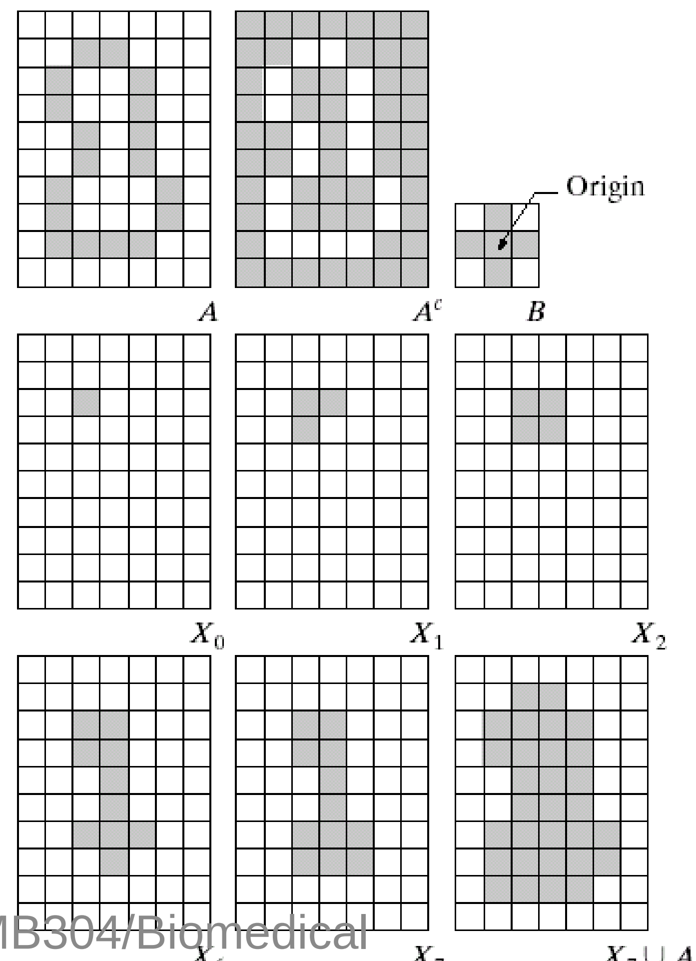
FIGURE 9.14
(a) A simple binary image, with 1's represented in white. (b) Result of using Eq. (9.5-1) with the structuring element in Fig. 9.13(b).

Region Filling

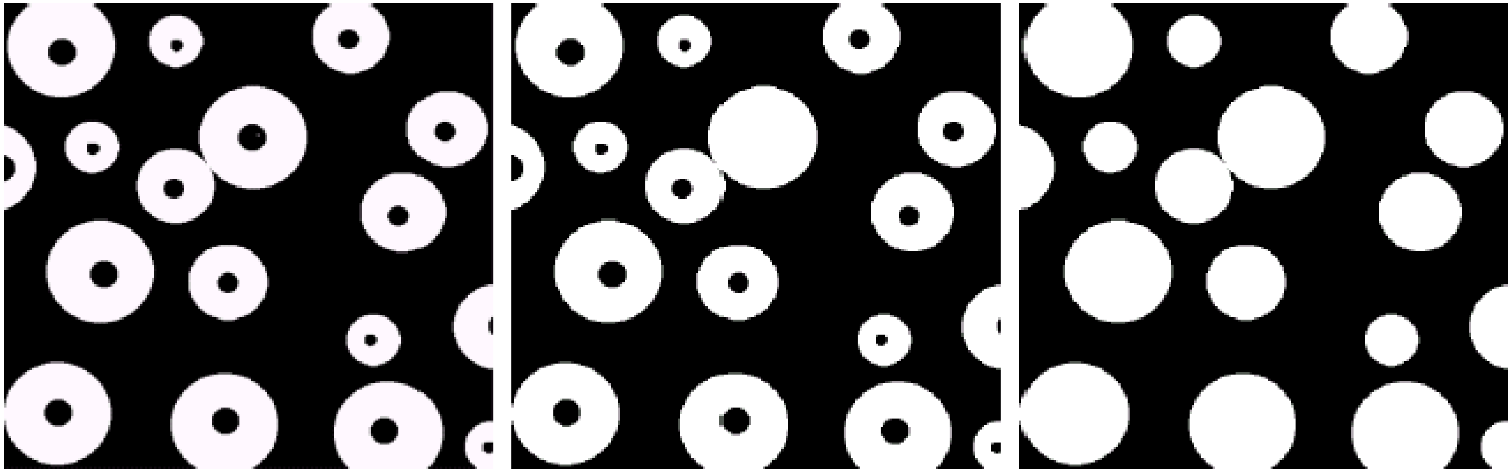
$$X_k = (X_{k-1} \text{①} B)\,\Omega\, A^c \quad k = 1,2,3,\ldots$$

a	b	c
d	e	f
g	h	i

FIGURE 9.15 Region filling. (a) Set A. (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)].



Example



a b c

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

Thank You