IMAGE PROCESSING

Chapter 6: morphological IP

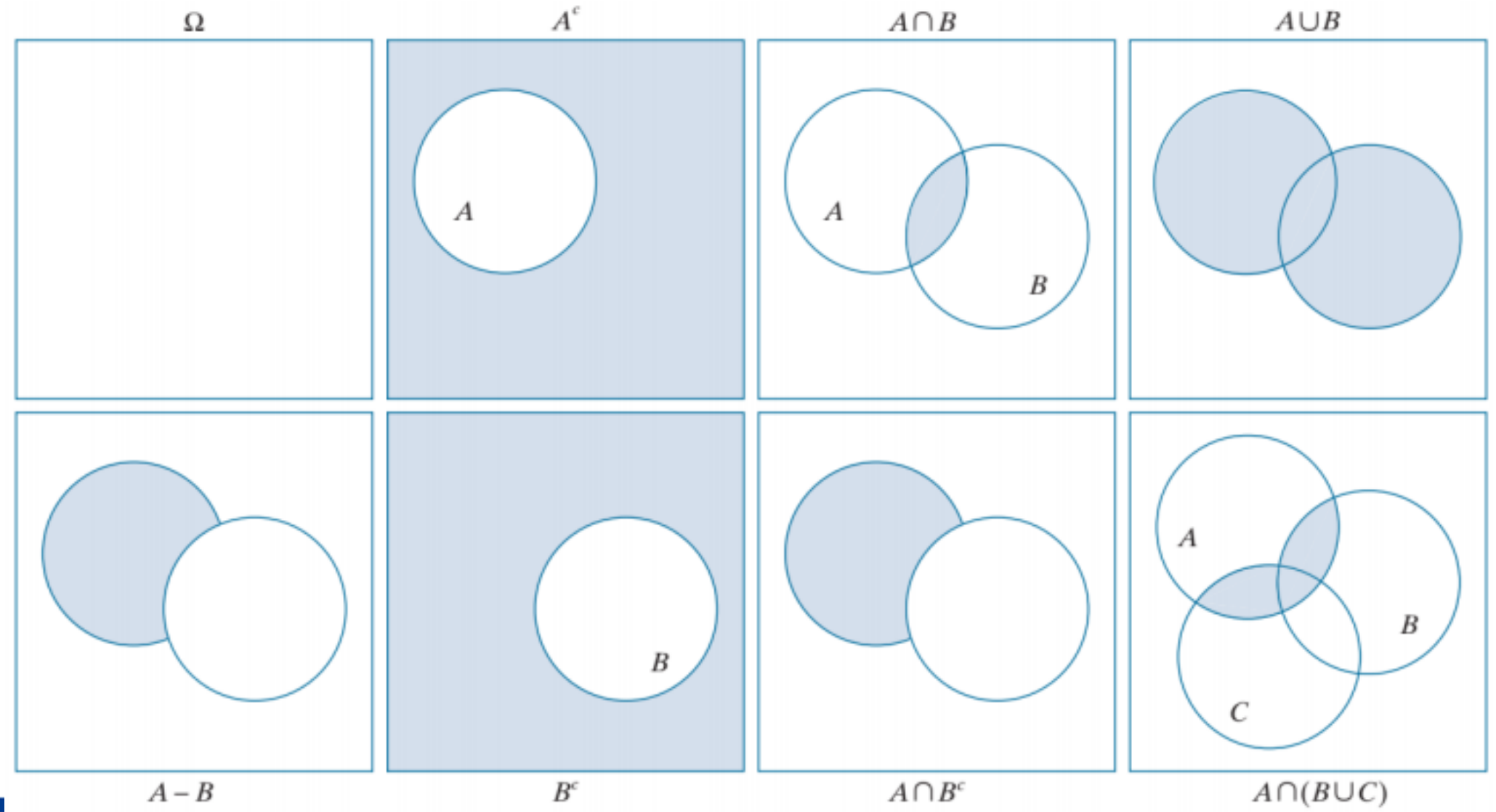
Dr. Cao Thi Luyen
Email: luyenct@utc.edu.vn
Tel: 0912403345

Application

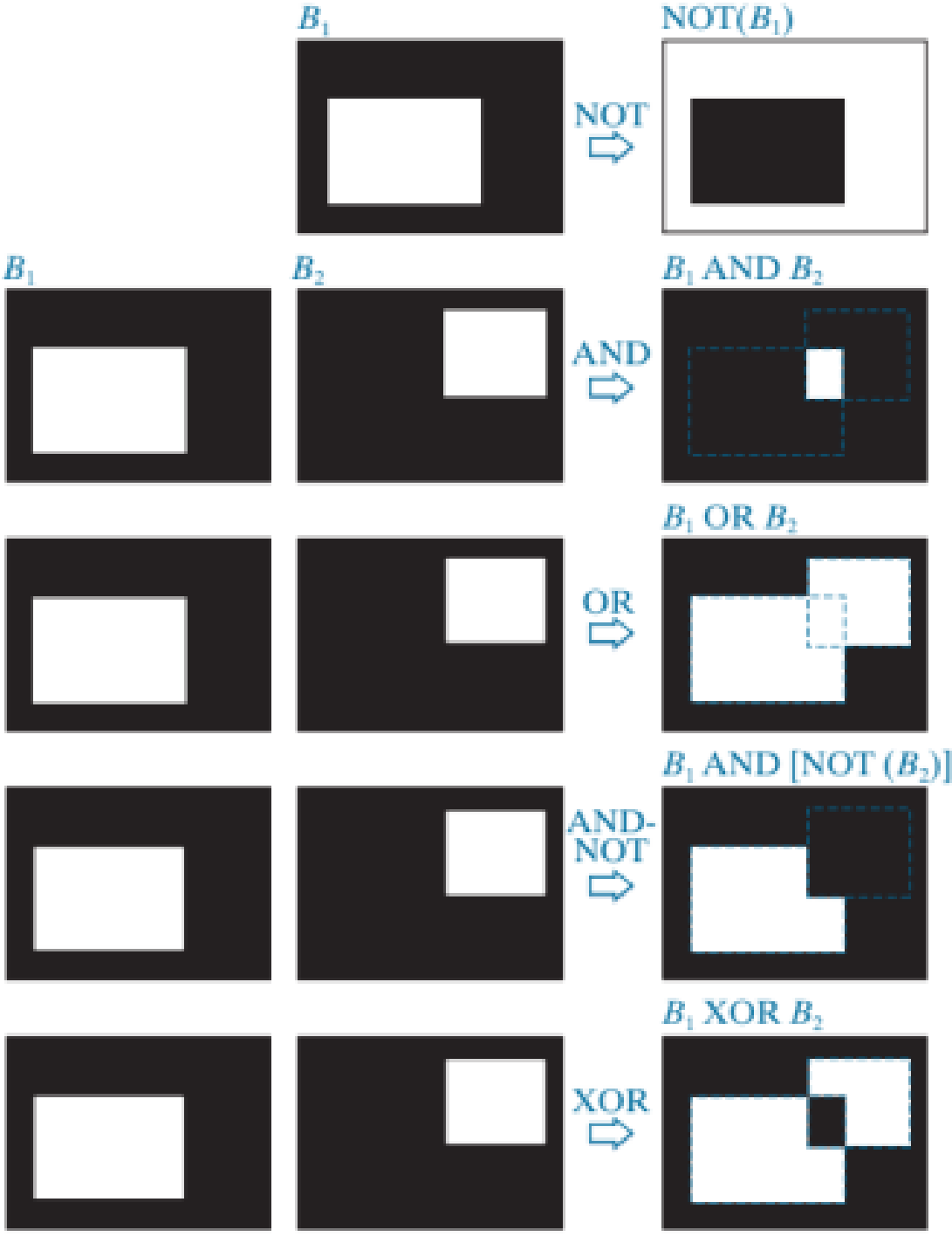
Image after segmentation

Image after segmentation and morphological processing

Set theory

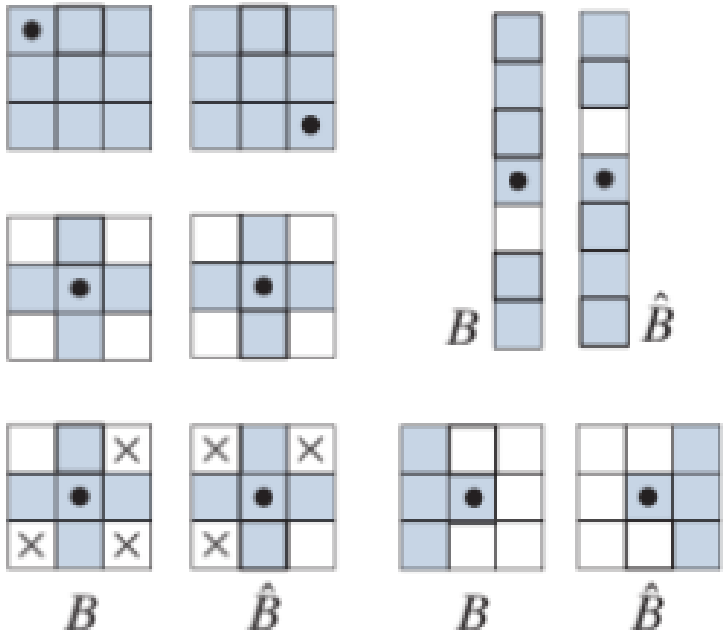


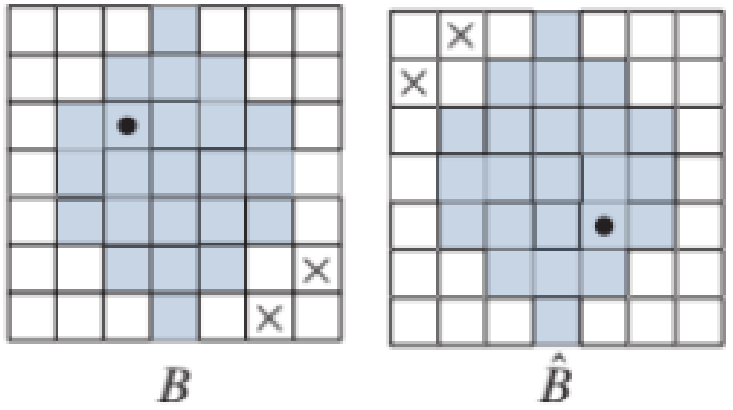
Logic operators



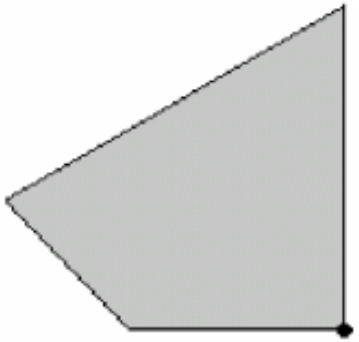
Reflection Of Structural Element

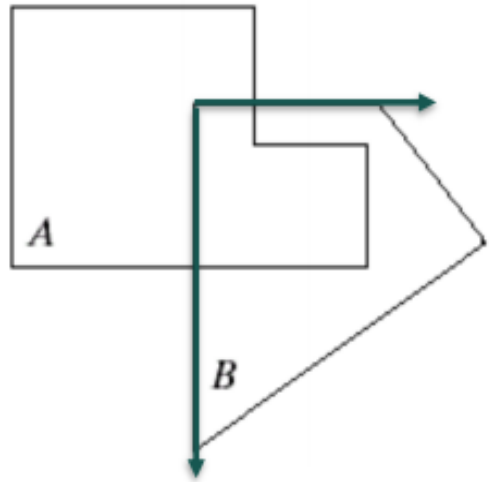
- **Structural element and its reflection through the center** (.) is the center). Reflection is a 180-degree rotation of the SE around the center.





$$\hat{B} = \{w | w = -b, b \in B\}$$





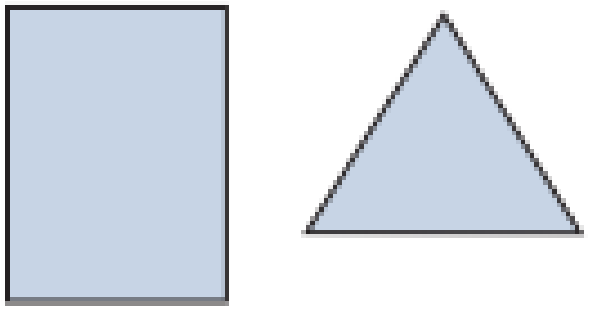
Structuring element

- **Structural Elements (SEs)** are matrices with structures created using two gray levels, 0 and 1.
- **Typically**, SEs are symmetric in shape with the centroid at the center.
- **Sometimes**, SEs contain “don’t care” elements, denoted by ×.

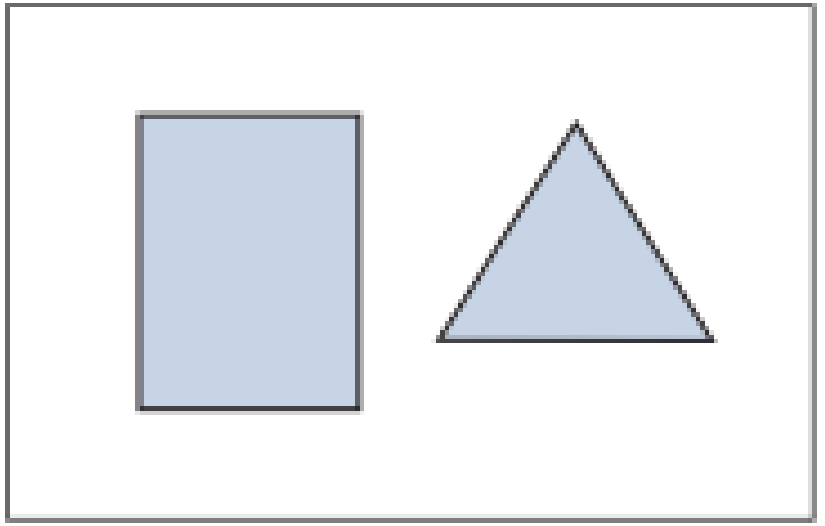
0	0	1	0	0
0	1	1	1	0
1	1	1	1	1
0	1	1	1	0
0	0	1	0	0

0	1	0
1	1	1
0	1	0

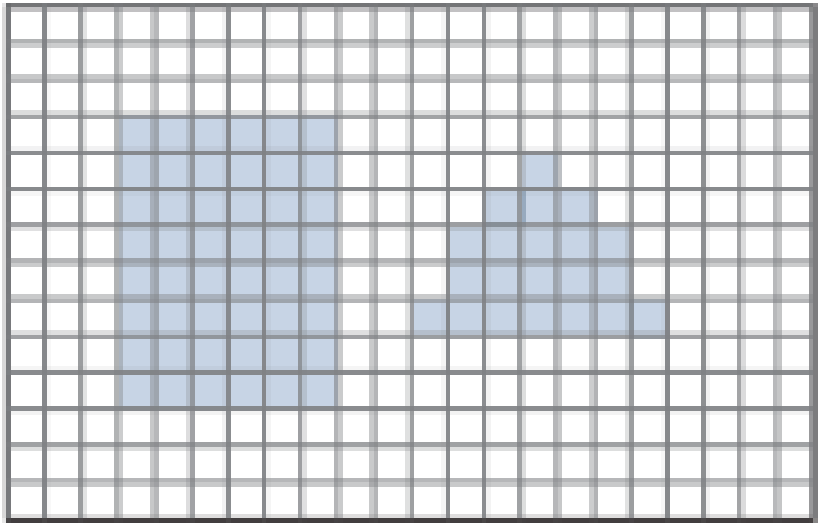
1	1	1
1	1	1
1	1	1



Objects represenced
as sets



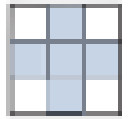
Objects represented as
a graphical image



Digital image

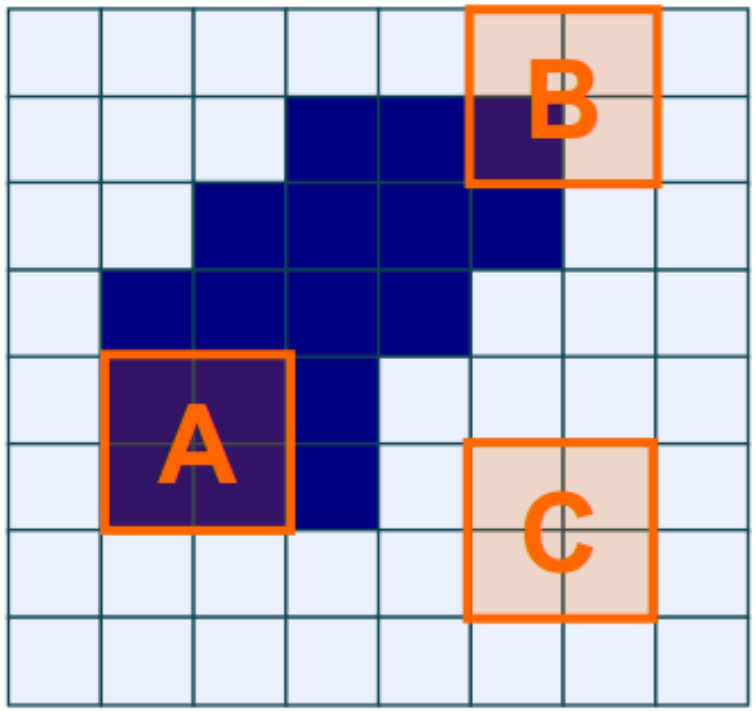
Structuring element
represented as a set

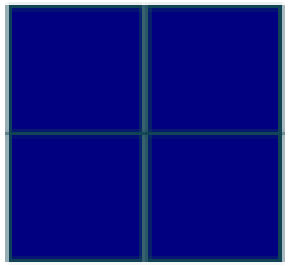
Structuring element
represented as a graphical image



Digital
structuring element

Hit, Fit, Miss



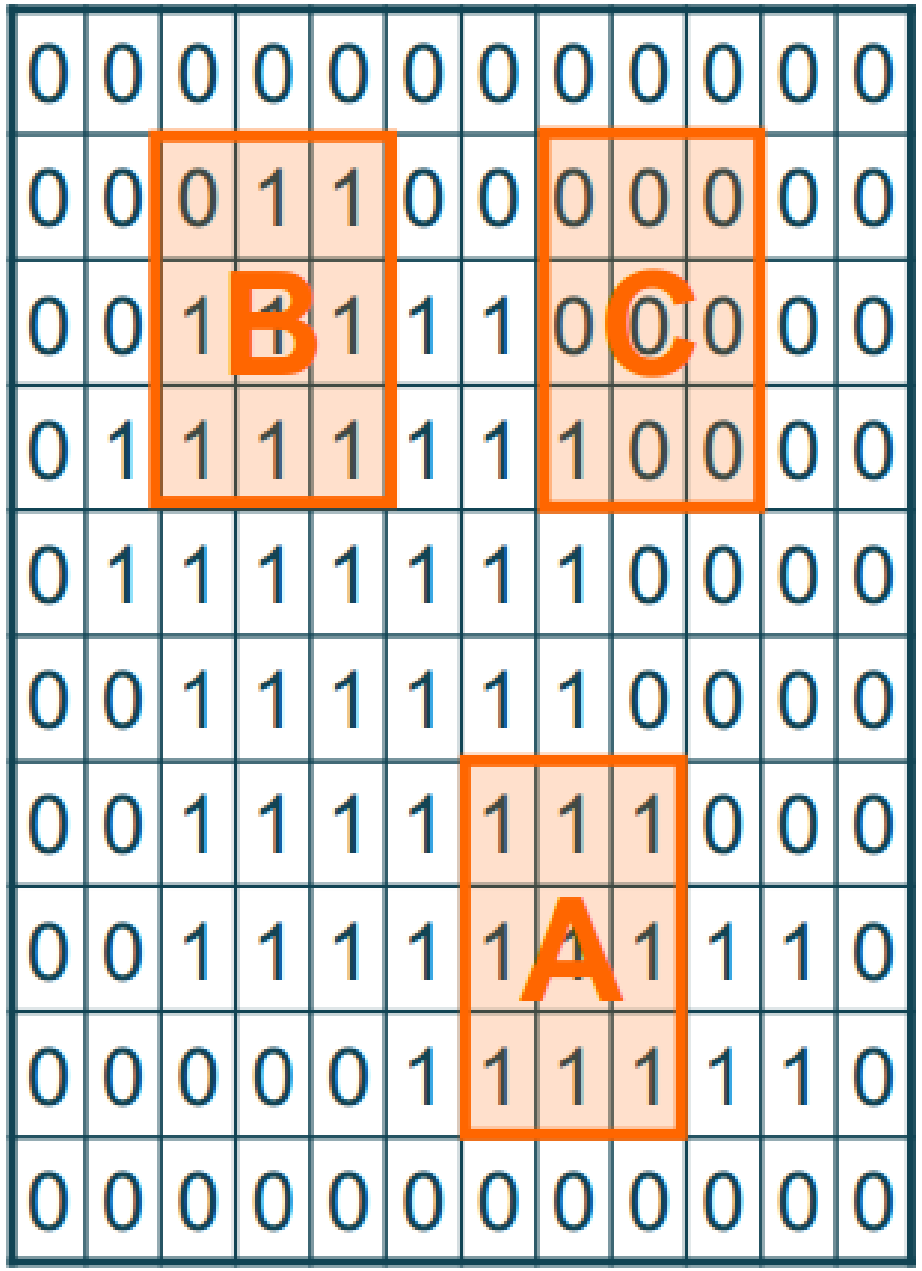


structural element

Fit: Fit occurs when all the pixels of the SE match the pixels of the image.

Hit: Hit occurs when any pixel of the SE matches a pixel of the image.

Miss: otherwise



1	1	1
1	1	1
1	1	1

Structuring Element 1

0	1	0
1	1	1
0	1	0

Structuring Element 2

Basic Morphological Operations

- **Morphological image processing** is fundamentally similar to spatial filtering.
- The SE is moved across all pixels of the original image to create a new image.
- The value of the new pixels depends on the morphological operation.
- The two basic morphological operations are: erosion (shrink, reduce) and dilation (grow, expand).

Erosion

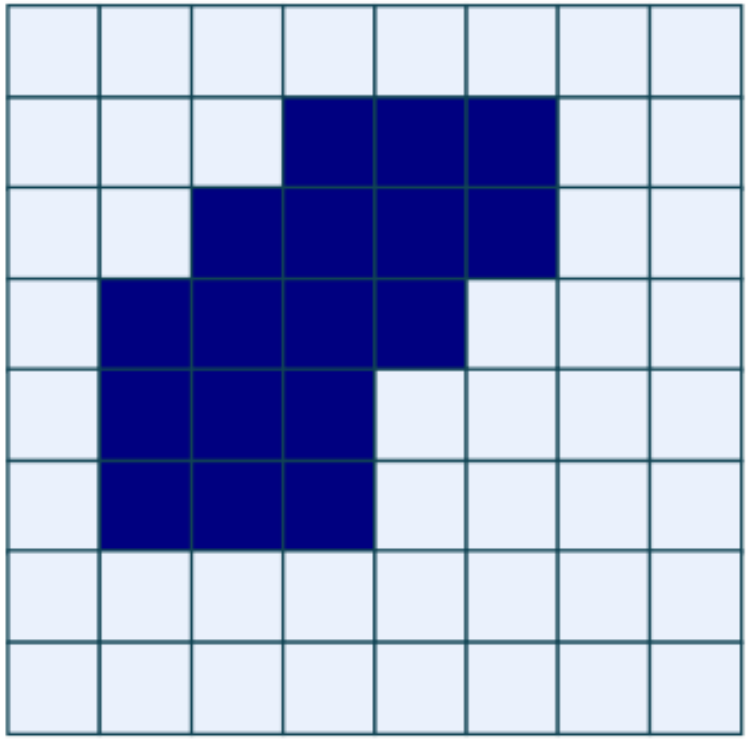
- erosion equivalently as:

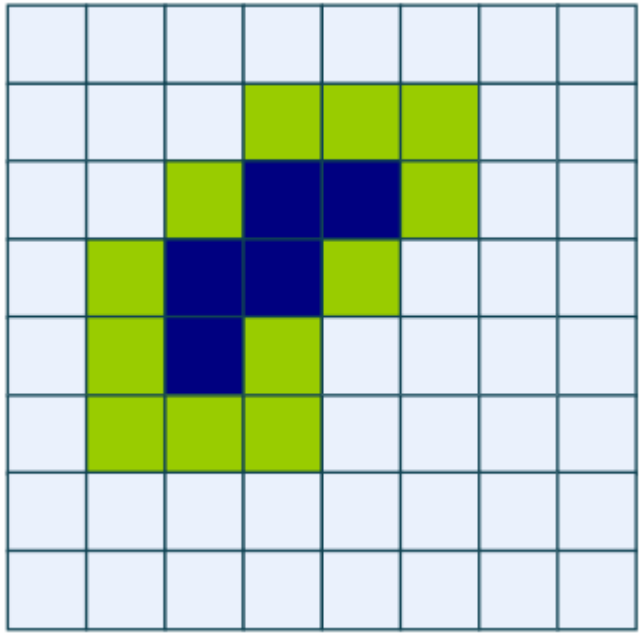
$$A \ominus B = \left\{ z \middle| (B)_z \cap A^c = \varnothing \right\}$$

Assume SE B is at position (x,y). The new pixel value after performing the operation is as follows:

$$g(x,y) = \begin{cases} 1 & B\ fit\ A \\ 0 & otherwise \end{cases}$$

Example





Example

Original image

Erosion by 3*3 square structuring element

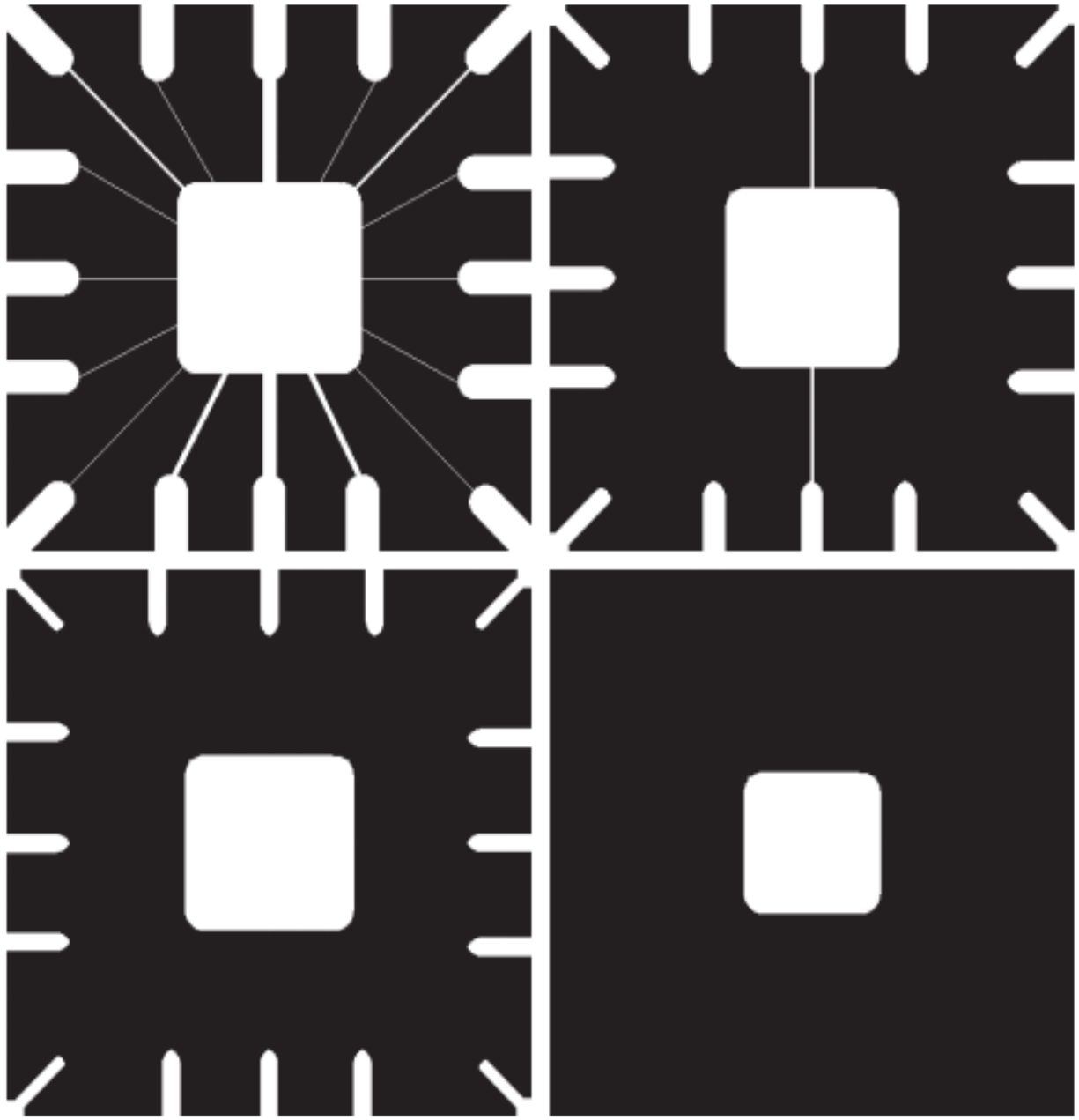
Erosion by 5*5 square structuring element

Application

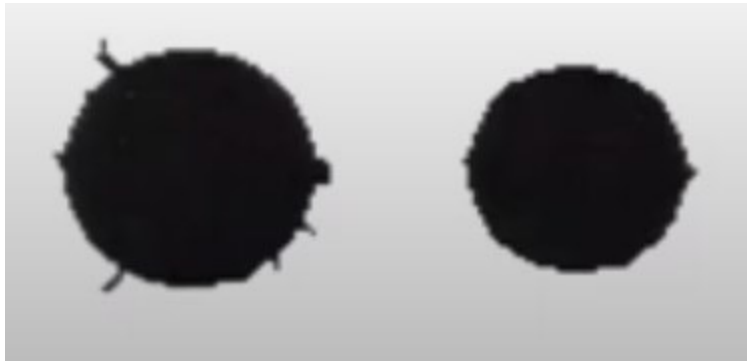
a b
c d

FIGURE 9.5
Using erosion to remove image components. (a) A 486 × 486 binary image of a wire-bond mask in which foreground pixels are shown in white. (b)–(d) Image eroded using square structuring elements of sizes 11 × 11, 15 × 15, and 45 × 45 elements, respectively, all valued 1.

- Reduce the size of the object.
- Remove irrelevant details, trim the excess parts.
- Separate adjacent objects.



Application of Erosion



- Reduce the size of the object.
- Remove irrelevant details, trim the excess parts.
- Separate adjacent objects.

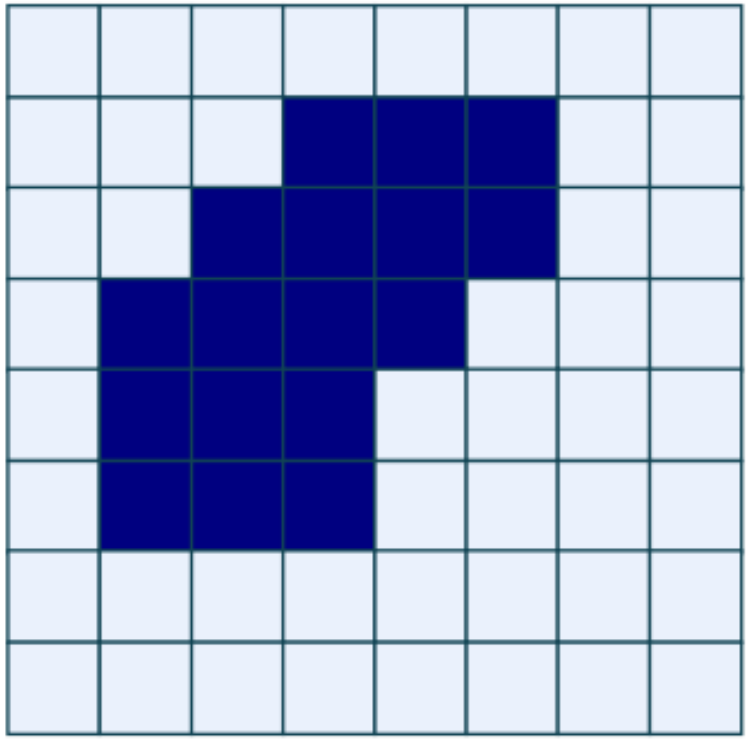
Dilation

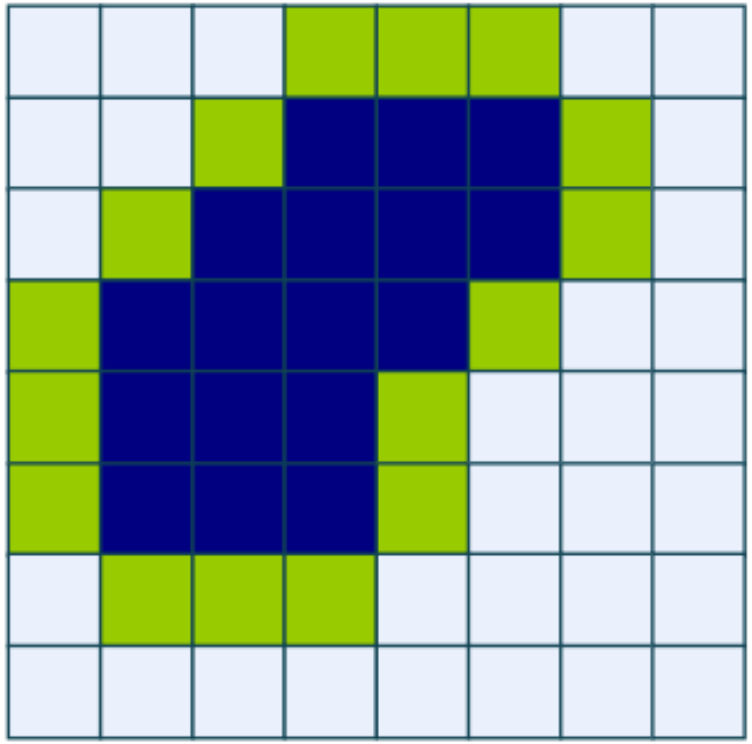
$$A \oplus B = \left\{ z \middle| (\hat{B})_z \cap A \neq \varnothing \right\}$$

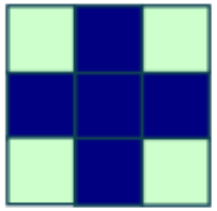
Assume SE B is at position (x,y). The new pixel value after performing the operation is as follows:

$$g(x,y) = \begin{cases} 1 \text{ if } s \text{ hits } f \\ 0 \text{ otherwise} \end{cases}$$

Example







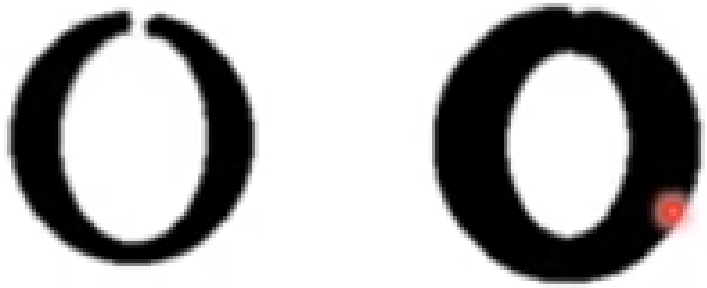
SE

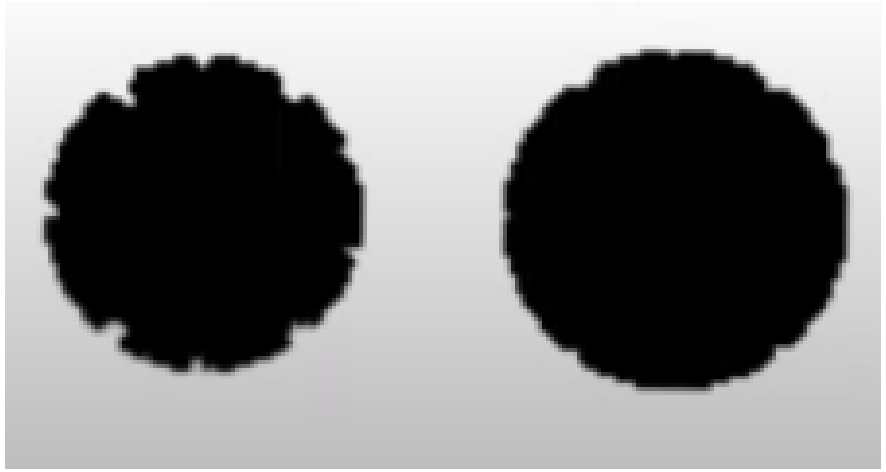
Original image

Dilation by 3*3 square structuring element

Dilation by 5*5 square structuring element

Application of Dilation

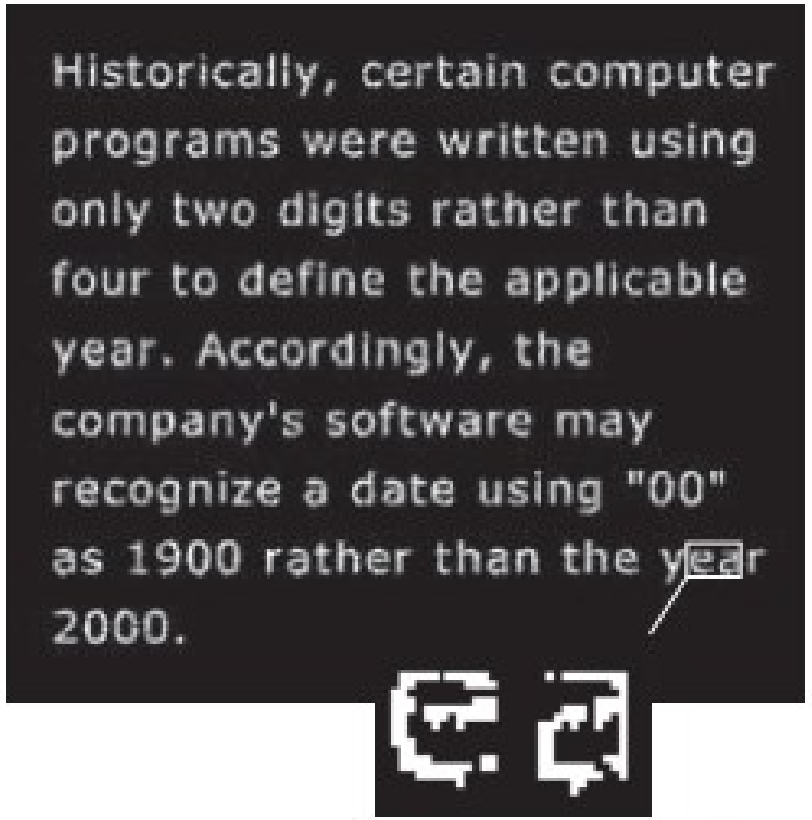




- Increase the size of the object.
- Fill in the missing parts of the object.
- Fix broken objects.

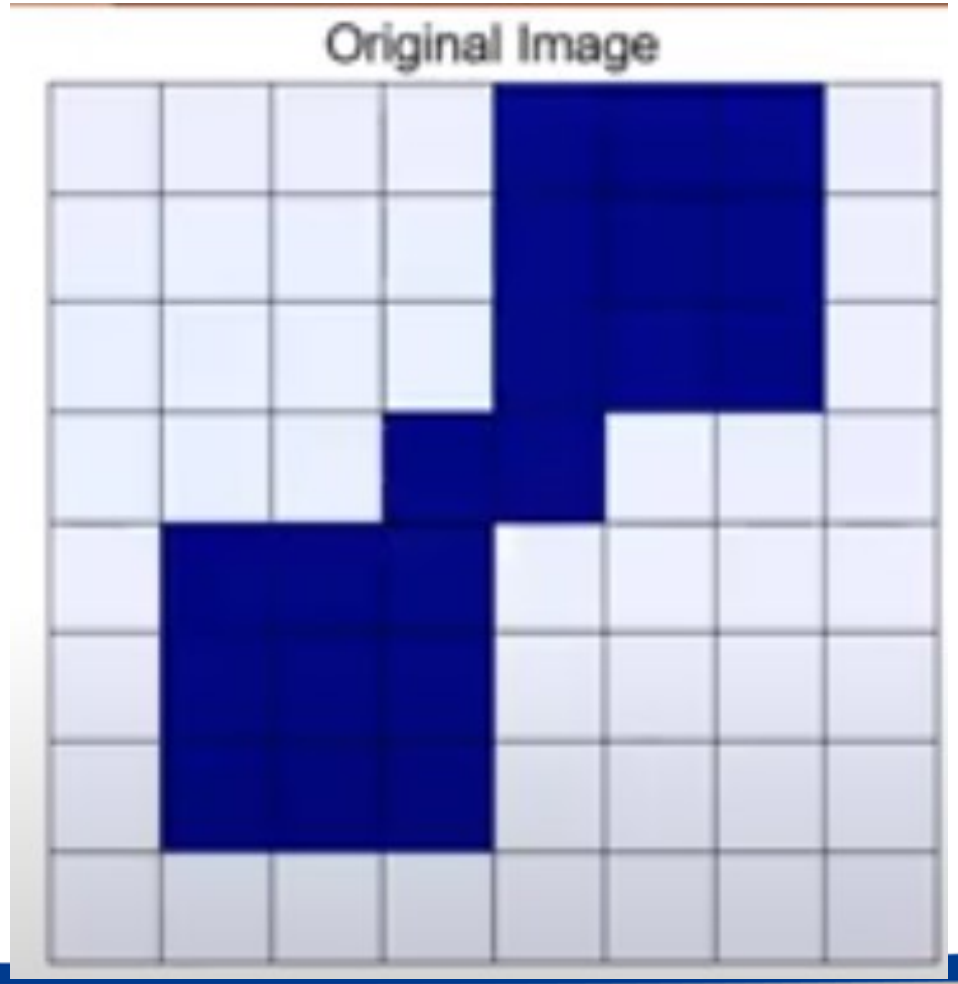
a c
b

FIGURE 9.7
(a) Low-resolution text showing broken characters (see magnified view).
(b) Structuring element.
(c) Dilation of (a) by (b). Broken segments were joined.



1	1	1
1	1	1
1	1	1

Practic with Erosion and dilation



Practic with Erosion and dilation

$$X = \begin{bmatrix} 0 & 1 & 1 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix} \text{ với } B = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

Combining erosion and dilation

- **Erosion**: Shrinking the object.
- **Dilation**: Expanding the object with a structural element.
- **Desire**:
  - Remove structures or fill gaps.
  - Do not alter the remaining parts.
- **Solution**:
  - Combine erosion and dilation.
- Does erosion + dilation = the original image???

Closing and opening

- The *opening* of set *A* by structuring element *B*

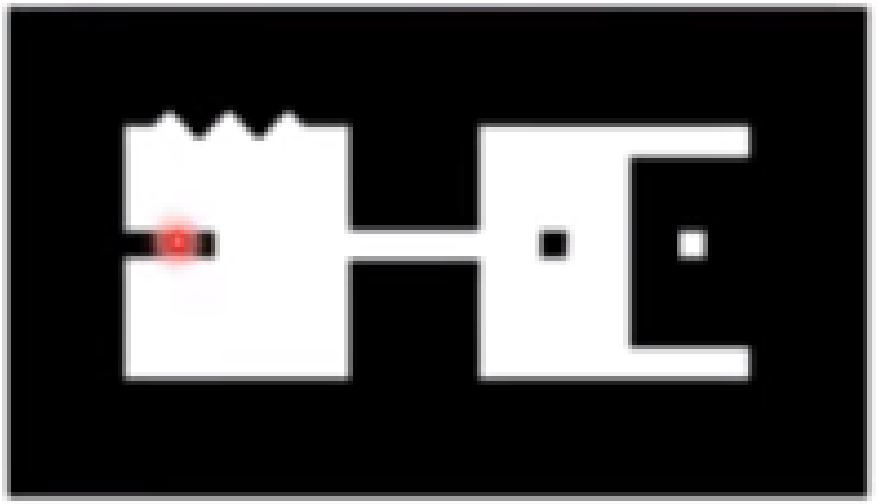
$$A \circ B = (A \ominus B) \oplus B$$

- the *closing* of set *A* by structuring element *B*

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

Closing


A
A ⊕ B
A • B = (A ⊕ B) ⊖ B
Original shape
After dilation
After erosion
(closing)



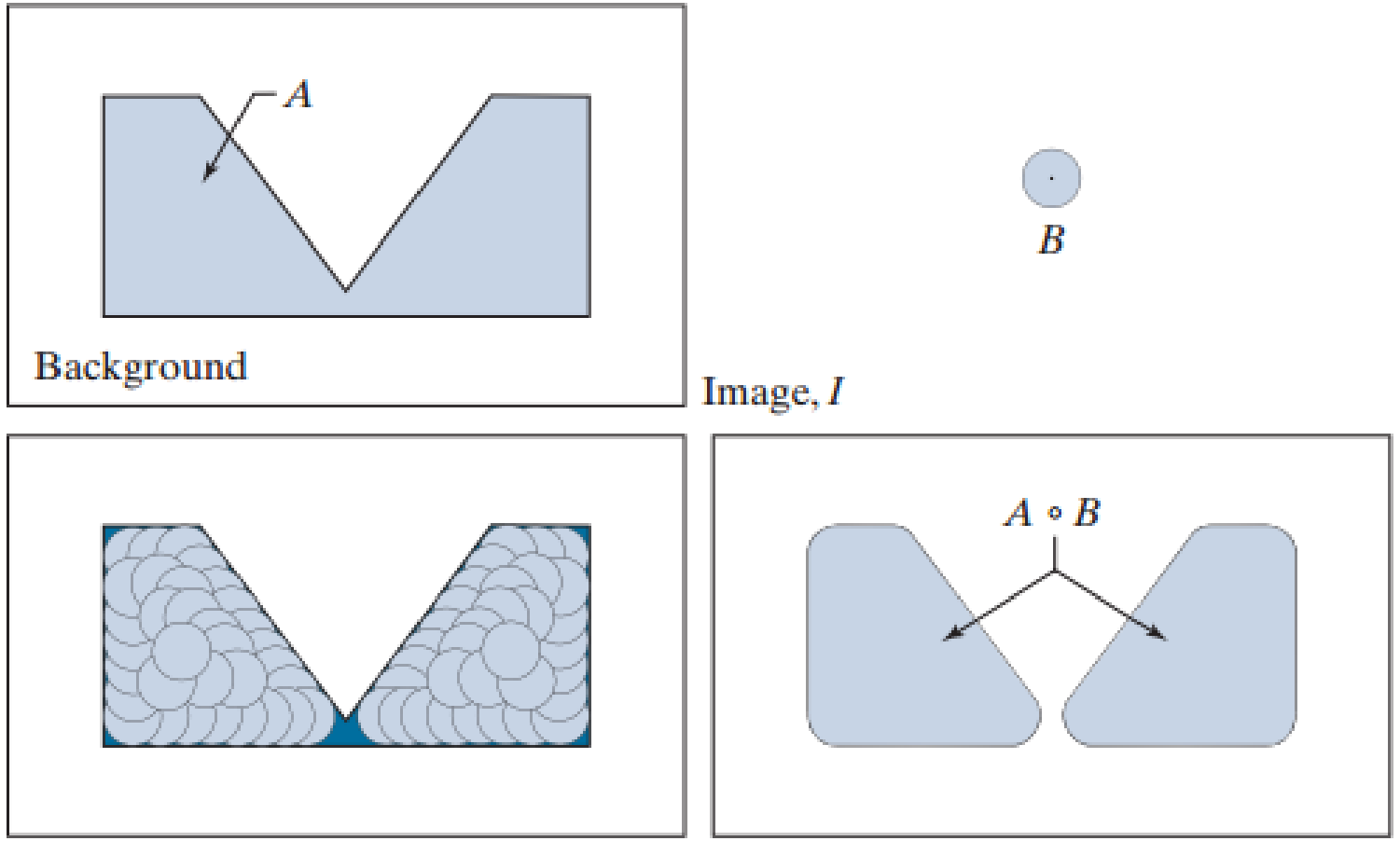
Original Image

Image After Closing

Opening

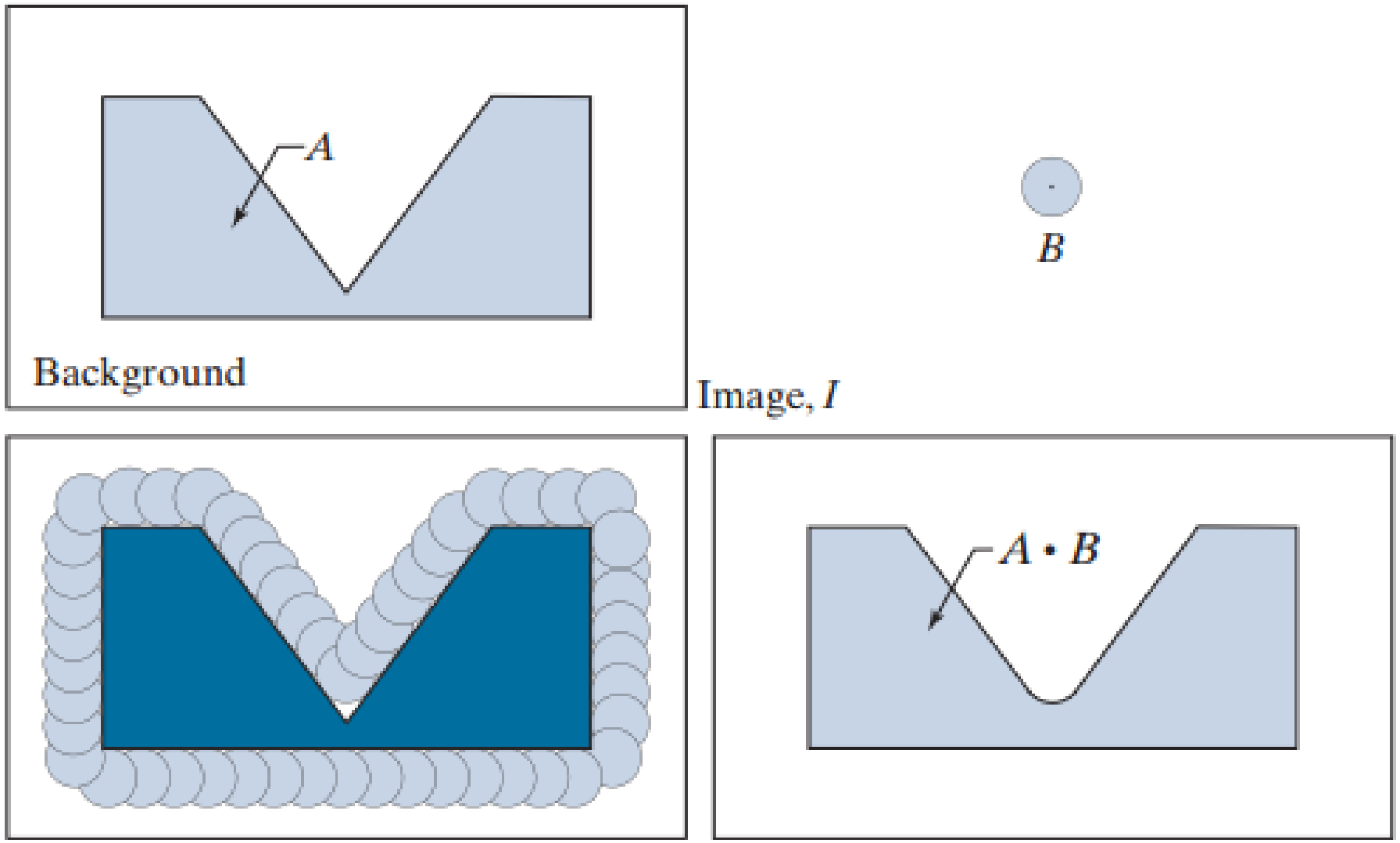
a b
c d

FIGURE 9.8
(a) Image I, composed of set (object) A and background.
(b) Structuring element, B.
(c) Translations of B while being contained in A. (A is shown dark for clarity.)
(d) Opening of A by B.

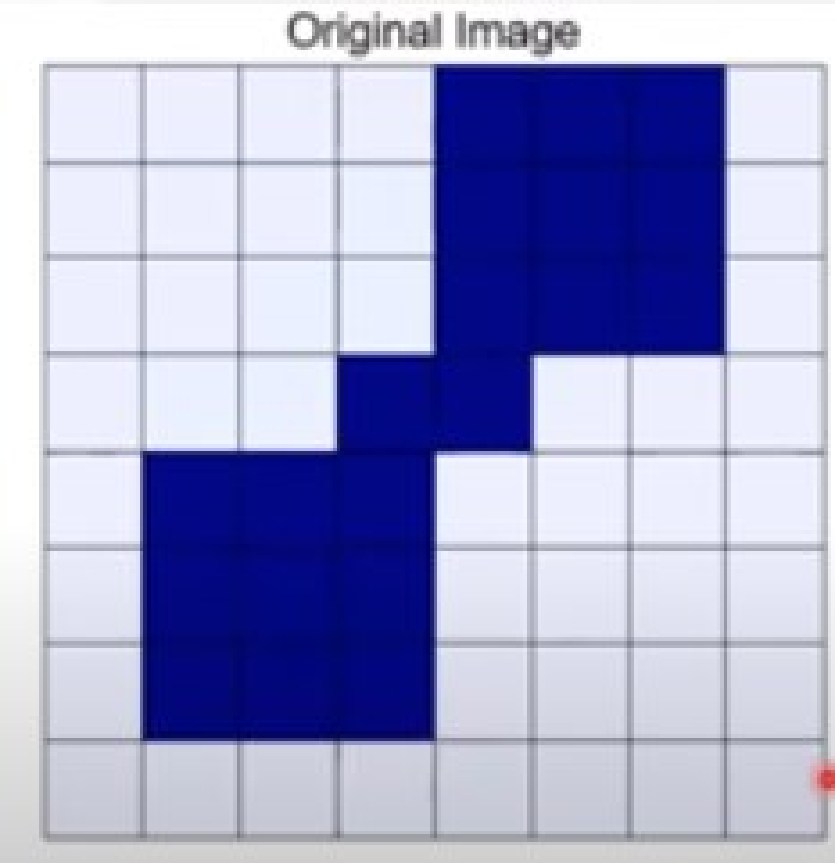


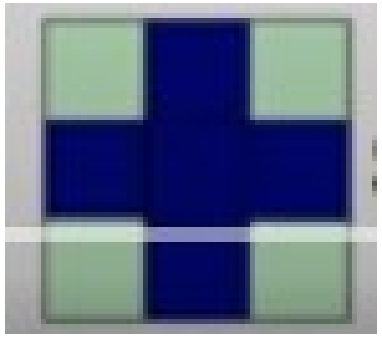
a b
c d

FIGURE 9.9
(a) Image I, composed of set (object) A, and background.
(b) Structuring element B.
(c) Translations of B such that B does not overlap any part of A. (A is shown dark for clarity.)
(d) Closing of A by B.

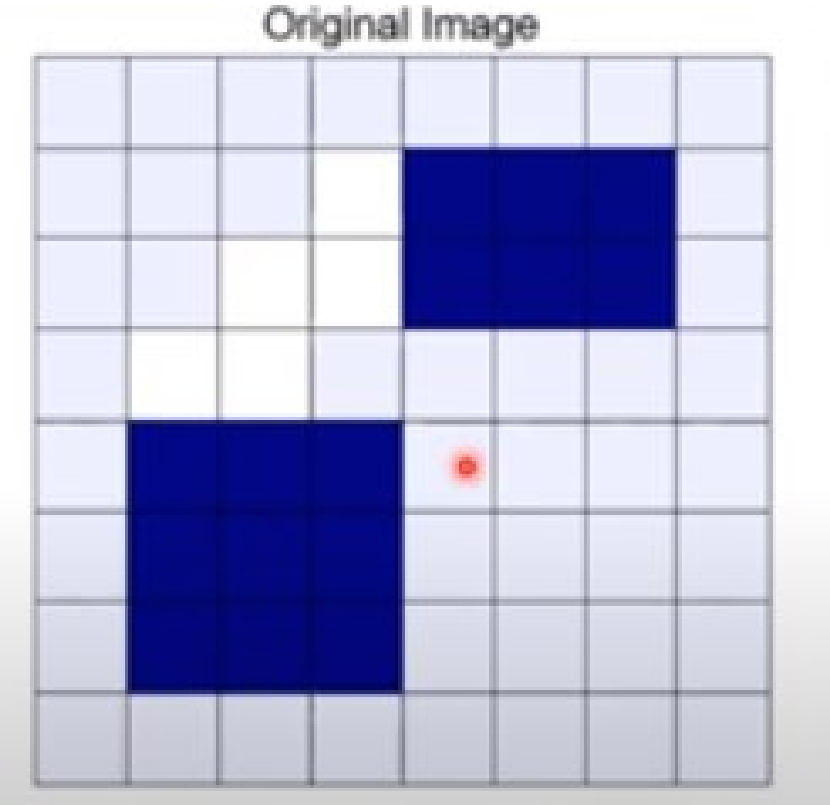


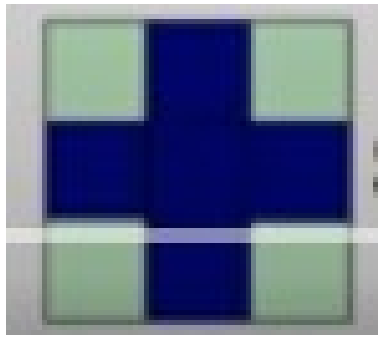
Opening?



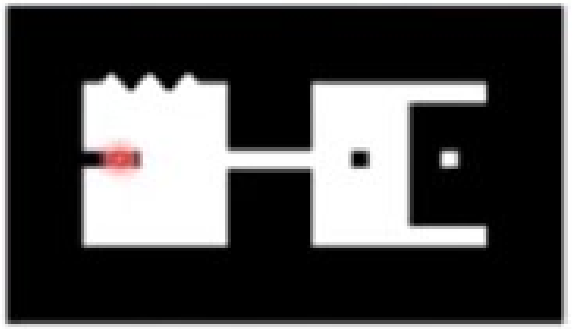


closing





Example



Original Image

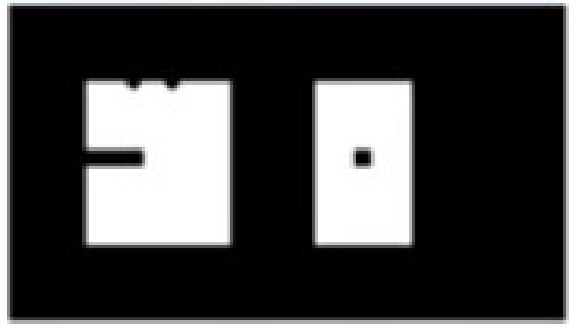


Image After Opening