- Morphology signifies the study of form or structure.
- “***Mathematical Morphology***” is a tool for extracting image components, that are useful in the representation and description of region shape.
- The language of mathematical morphology is – **Set theory**.
- Key areas of application are segmentation together with automated counting and inspection.
- Morphological operations can be applied to images of all types, but the primary use for morphology is for processing binary images.

Common morphological operations are:

- Dilation
- Erosion
- Opening and
- Closing

Dilation and erosion

- The two most important morphological operators are dilation and erosion.
- All other morphological operations can be defined in terms of these primitive operators.

Erosion To perform erosion of a binary image, we successively place the centre pixel of the structuring element on each foreground pixel (value 1). If *any* of the neighbourhood pixels are background pixels (value 0), then the foreground pixel is switched to background. Formally, the erosion of image A by structuring element B is denoted $A \ominus B$.

Erosion : The value of the output pixel is the *minimum* value of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to 0, the output pixel is set to 0.

Preliminaries (2)

- **Structure elements (SE)**

Small sets or sub-images used to probe an image under study for properties of interest

Examples: Structuring Elements (1)

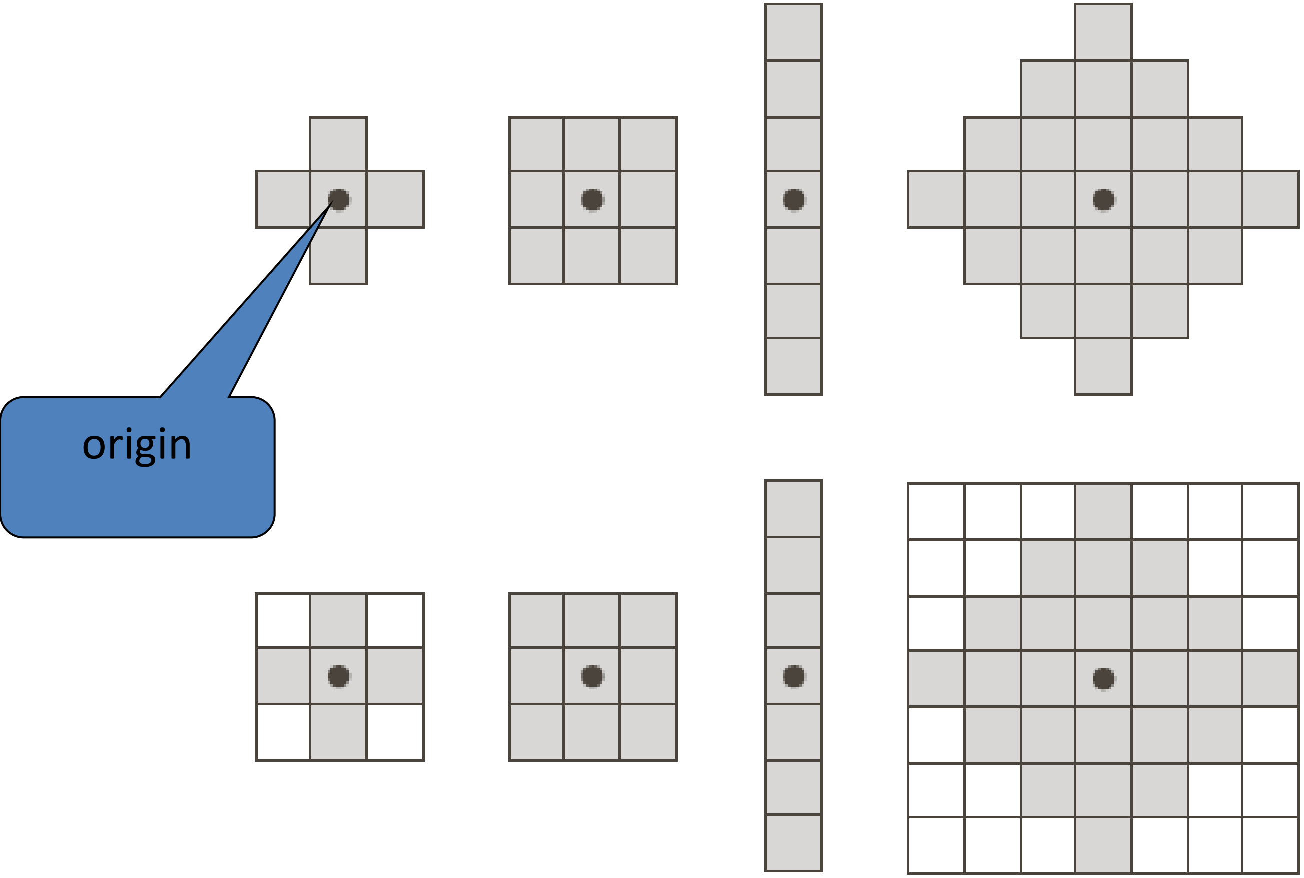
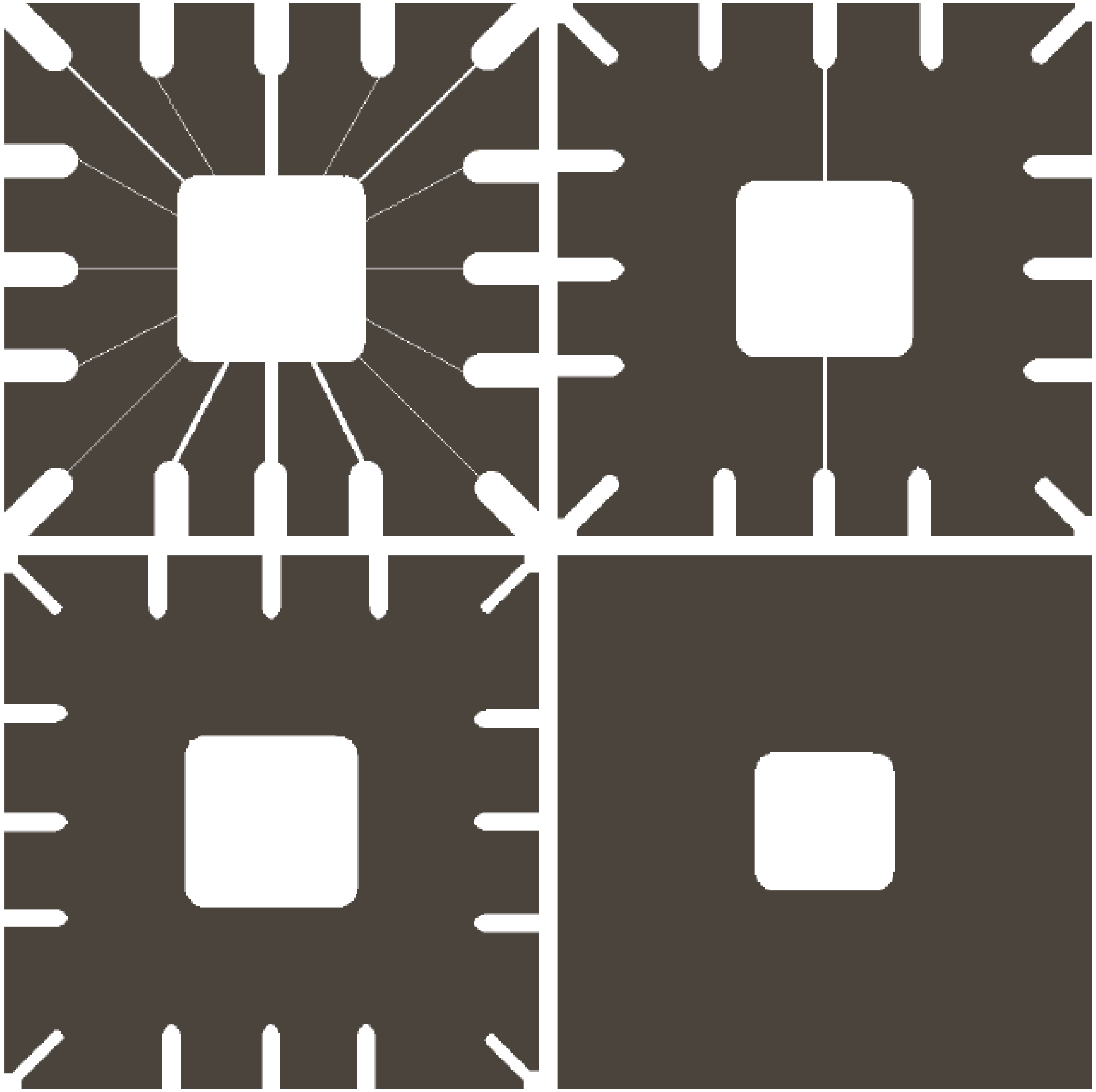


FIGURE 9.2 First row: Examples of structuring elements. Second row: Structuring elements converted to rectangular arrays. The dots denote the centers of the SEs.

Example of Erosion (2)



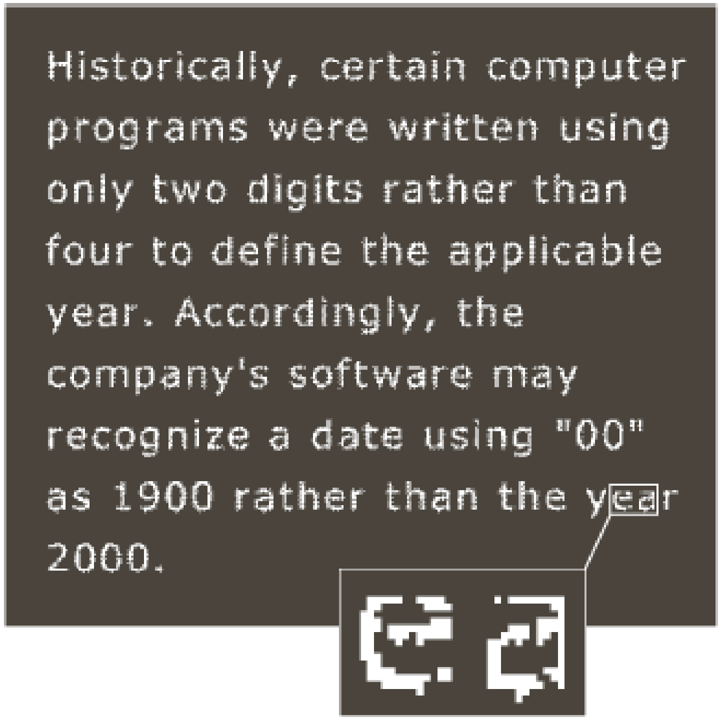
a b
c d

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.

Dilation To perform dilation of a binary image, we successively place the centre pixel of the structuring element on each background pixel. If *any* of the neighbourhood pixels are foreground pixels (value 1), then the background pixel is switched to foreground. Formally, the dilation of image A by structuring element B is denoted $A \oplus B$.

Dilation : The value of the output pixel is the *maximum* value of all the pixels in the input pixel's neighborhood. In a binary image, if any of the pixels is set to the value 1, the output pixel is set to 1.

Examples of Dilation (2)



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.

Opening and Closing

- Opening generally smoothes the contour of an object, breaks narrow isthmuses, and eliminates thin protrusions

- Closing tends to smooth sections of contours but it generates fuses narrow breaks and long thin gulfs, eliminates small holes, and fills gaps in the contour

Opening and Closing

The opening of set A by structuring element B, denoted $A \circ B$, is defined as

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

The closing of set A by structuring element B, denoted $A \bullet B$, is defined as

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

imclose	Dilates an image and then erodes the dilated image using the same structuring element for both operations.
imopen	Erodes an image and then dilates the eroded image using the same structuring element for both operations.

hit-or-miss transformation

The hit-and-miss transform is a general binary morphological operation that can be used to look for particular patterns of foreground and background pixels in an image.

$$A \circledast B = (A \ominus B_1) \cap [A^c \ominus B_2]$$

$$B = (B_1, B_2)$$

- B_1: Set formed from elements of B associated with an object
- B_2: Set formed from elements of B associated with the corresponding background