

CMPE 362

Digital Image Processing

Morphological Image Processing

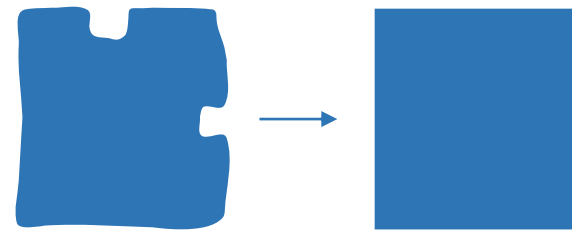
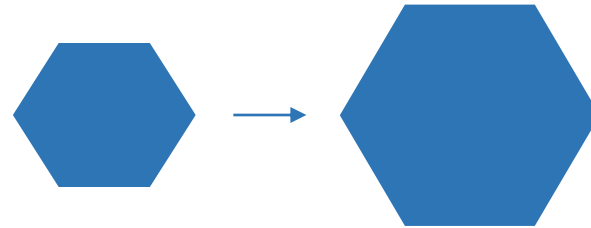
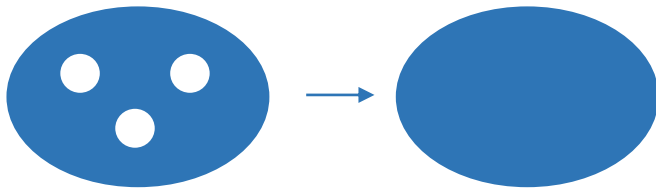
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- The word «morphology» refers to form and structure.
- In computer vision, it is used to refer to the shape of a region.

- Binary images are composed of 1's and 0's:
 - 1 represents foreground
 - 0 represents background
- We will see the following morphological operations for binary images:
 - dilation
 - erosion
 - opening
 - closing

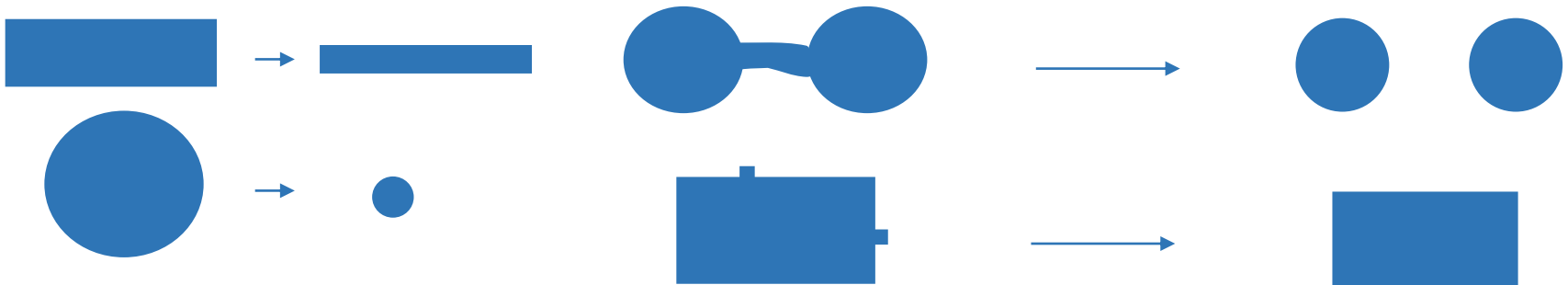
Dilation

- Dilation expands the connected sets of 1s of a binary image.
- It can be used for
 - growing features
 - filling holes and gaps



Erosion

- Erosion shrinks the connected sets of 1s of a binary image.
- It can be used for
 - shrinking features
 - removing bridges, branches and small protrusions



Structuring elements

- Structuring elements are small binary images used as shape masks in basic morphological operations.
- They can be any shape and size that is digitally representable.
- One pixel of the structuring element is denoted as its origin.
- Origin is often the central pixel of a symmetric structuring element but may in principle be any chosen pixel.

Structuring elements

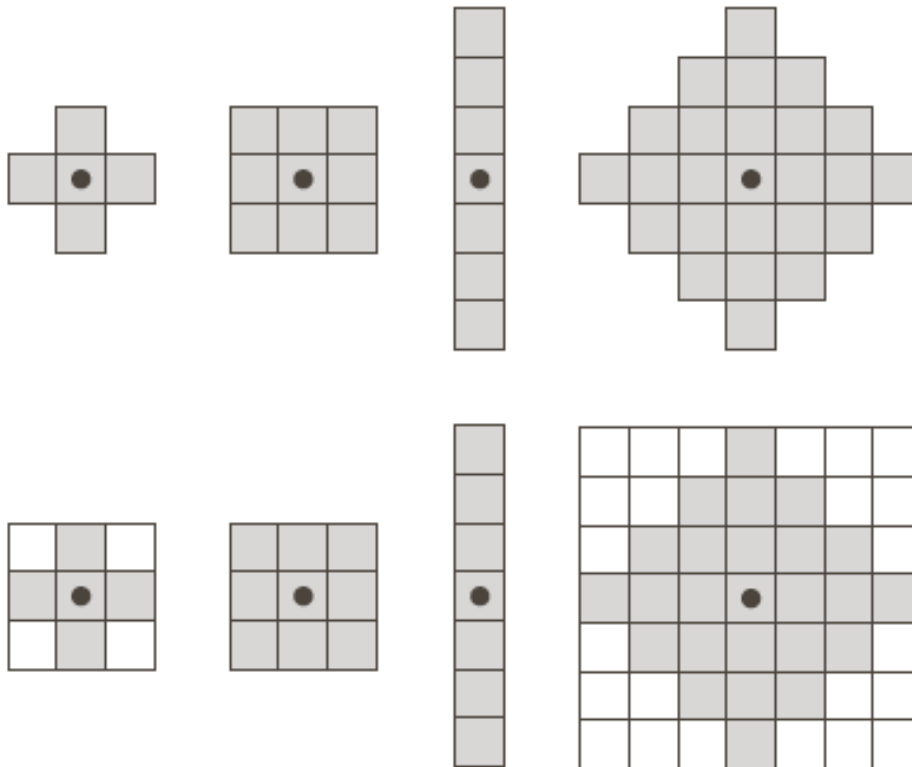


FIGURE 9.2 First row: Examples of structuring elements. Second row: Structuring elements converted to rectangular arrays. The dots denote the centers of the SEs.

Dilation

- The dilation of binary image A by structuring element B is denoted by $A \oplus B$.
 - The structuring element is swept over the image.
 - Each time the origin of the structuring element touches a binary 1-pixel, the entire translated structuring element is ORed to the output image, which was initialized to all zeros.

Dilation

	1	1	1	1	1	1	1	
							1	
				1	1	1	1	
			1	1			1	
				1	1	1	1	
			1	1				

Binary image A

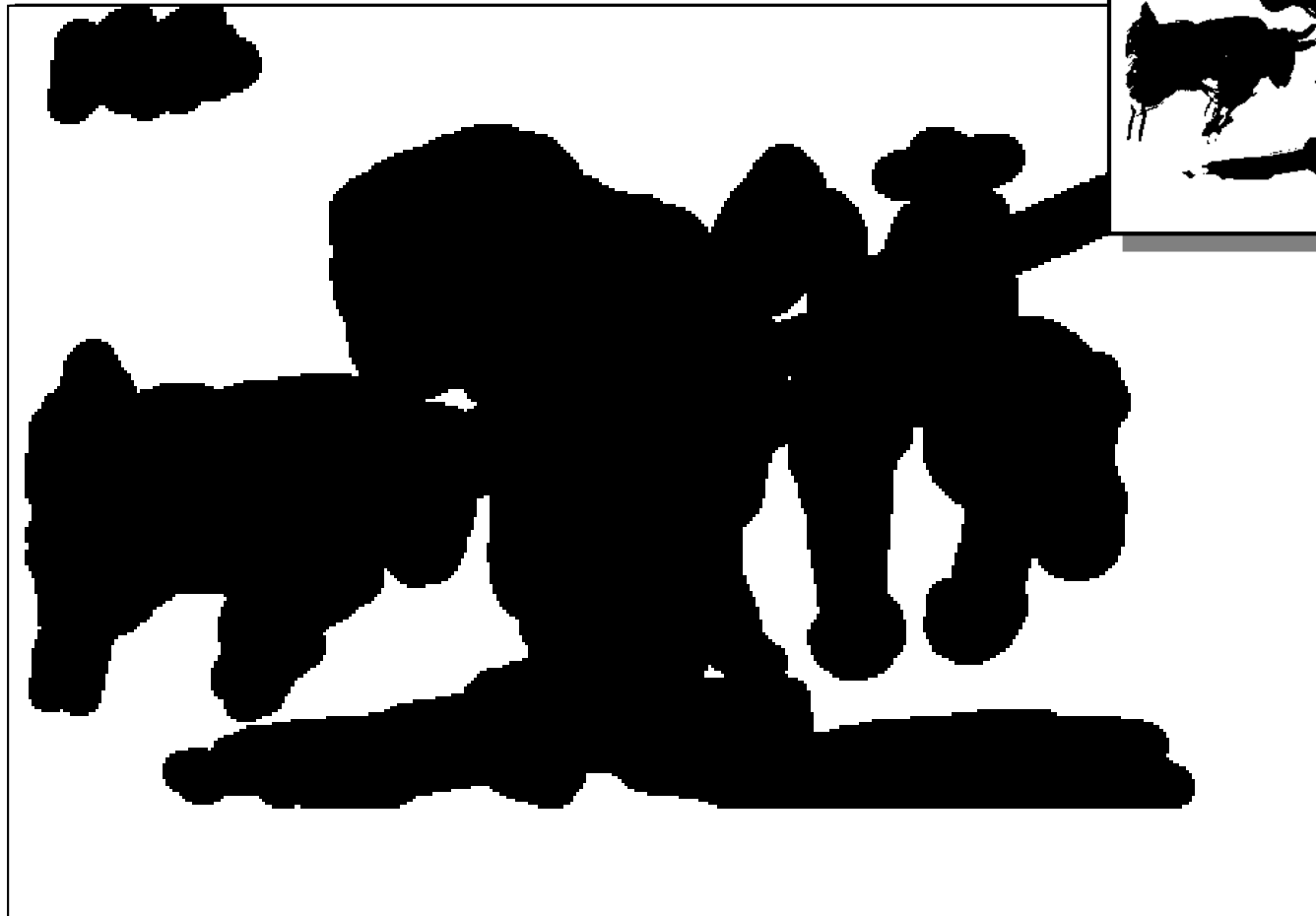
1	1	1
1	1	1
1	1	1

Structuring element B

1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1			

Dilation result

Dilation



Structuring
Element

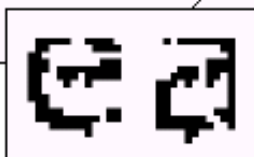


Adapted from John Goutsias, Johns Hopkins Univ.

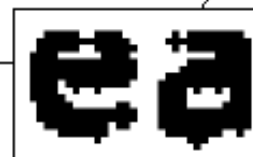
Pablo Picasso, *Pass with the Cape*, 1960

Dilation

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.



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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.

Poll – Dilation

	0	1	2	3
0				
1		1		
2		1	1	
3				

Binary image A

	0	1	2	3
0				
1				
2				
3				

$A \oplus B$

	1	
1	1	1
	1	

Structuring element B

Poll – Dilation

	0	1	2	3
0				
1		1		
2		1	1	
3				

Binary image A

	0	1	2	3
0		1		
1	1	1	1	
2	1	1	1	1
3		1	1	

$A \oplus B$

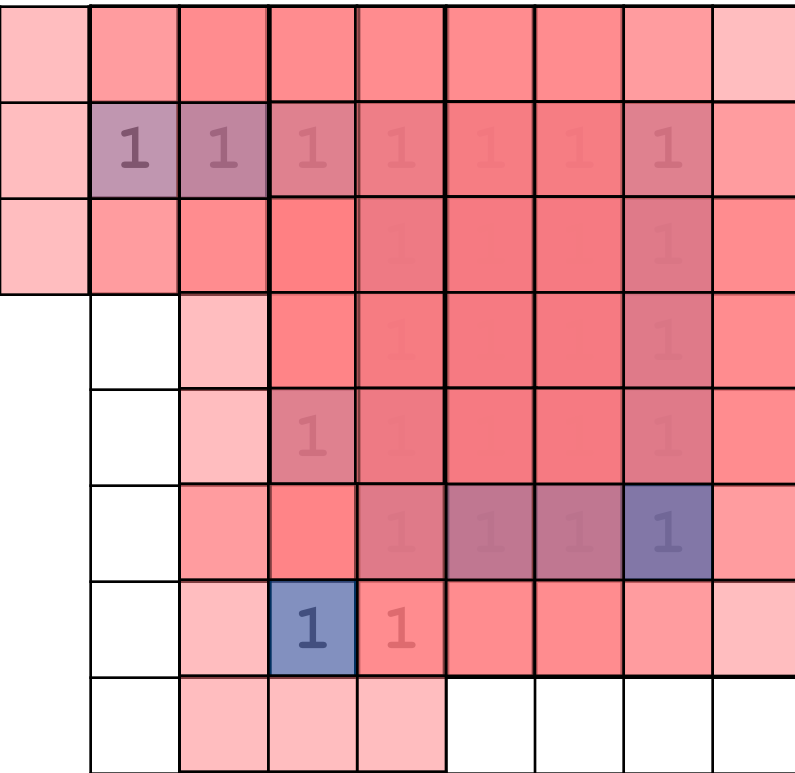
	1	
1	1	1
	1	

Structuring element B

Erosion

- The erosion of binary image A by structuring element B is denoted by $A \ominus B$.
 - The structuring element is swept over the image.
 - At each position where every 1-pixel of the structuring element covers a 1-pixel of the binary image, the binary image pixel corresponding to the origin of the structuring element is ORed to the output image, which was initialized to all zeros.

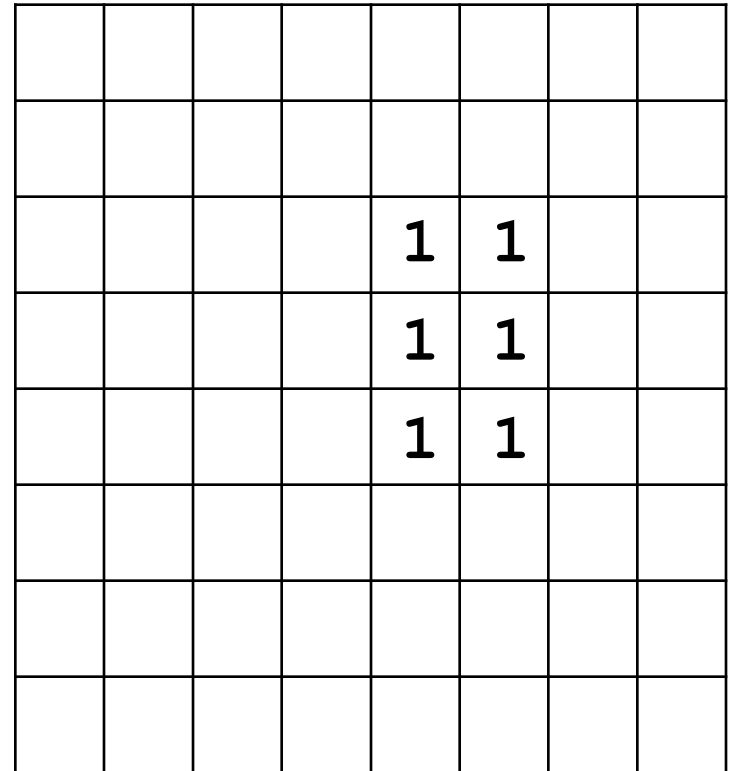
Erosion



Binary image A

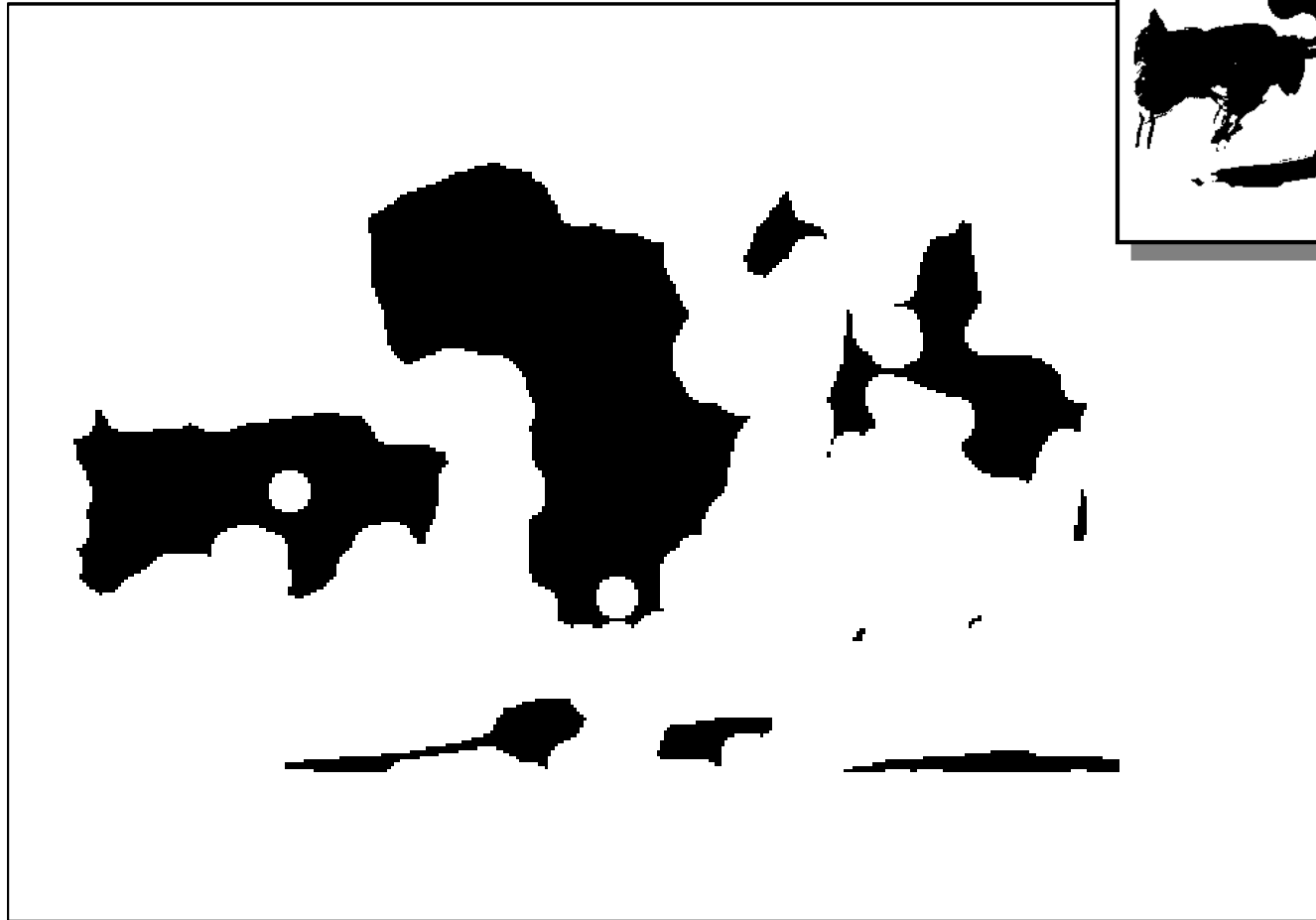
1	1	1
1	1	1
1	1	1

Structuring element B



Erosion result

Erosion

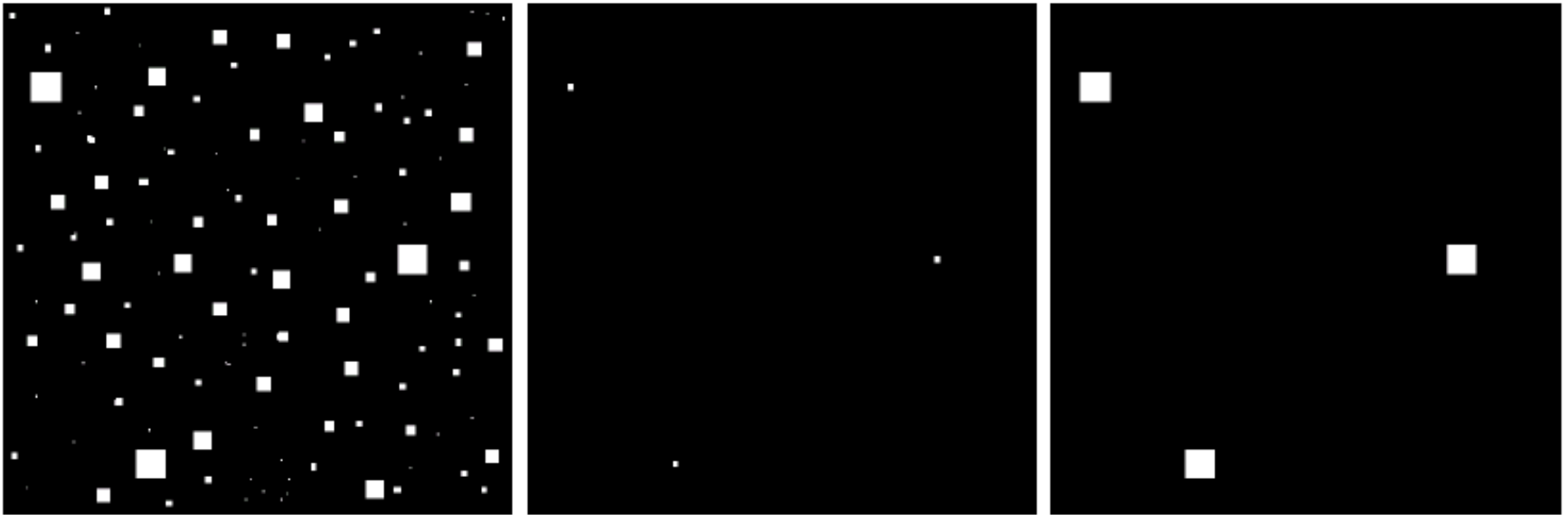


Structuring
Element



Adapted from John Goutsias, Johns Hopkins Univ.
Pablo Picasso, *Pass with the Cape*, 1960

Erosion



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 square structuring element of 1's, 13 pixels on the side. (c) Dilation of (b) with the same structuring element.

Poll – Erosion

	0	1	2	3
0		1		
1	1	1	1	
2	1	1	1	
3		1		

Binary image A

	0	1	2	3
0				
1				
2				
3				

$A \ominus B$

	1	
1	1	1
	1	

Structuring element B

Poll – Erosion

	0	1	2	3
0		1		
1	1	1	1	
2	1	1	1	
3		1		

Binary image A

	0	1	2	3
0				
1		1		
2		1		
3				

$A \ominus B$

	1	
1	1	1
	1	

Structuring element B

Opening

- The opening of a binary image A by structuring element B is denoted by $A \circ B$ is defined by

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

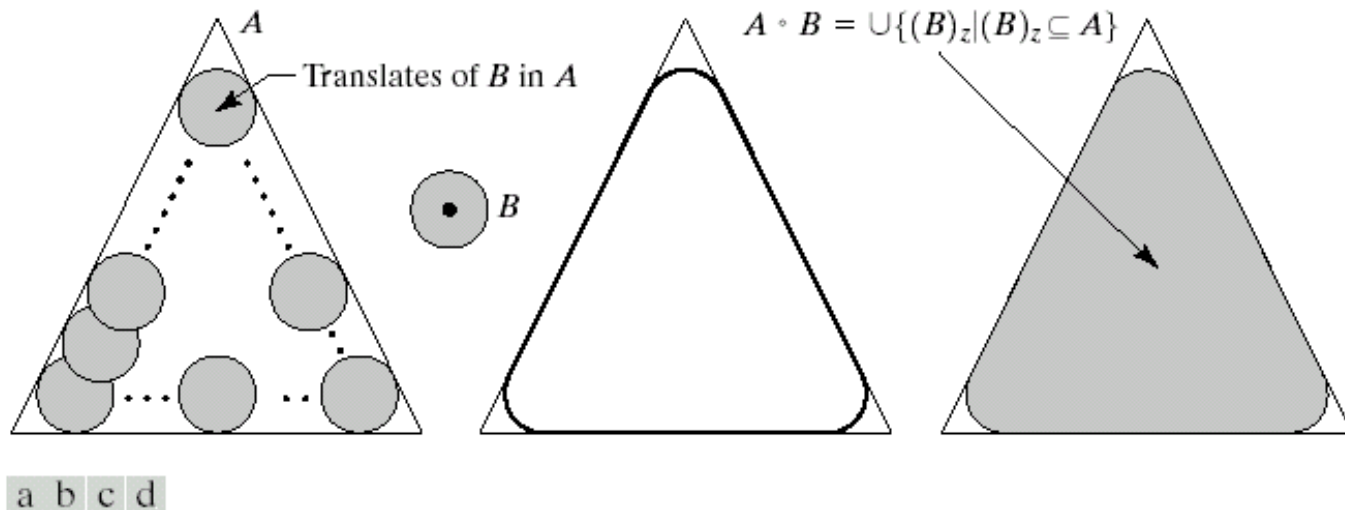


FIGURE 9.8 (a) Structuring element B "rolling" along the inner boundary of A (the dot indicates the origin of B). (c) The heavy line is the outer boundary of the opening. (d) Complete opening (shaded).

Opening

1	1	1	1	1	1	1	
			1	1	1	1	
			1	1	1	1	
		1	1	1	1	1	
			1	1	1	1	
		1	1				

Binary image A

1	1	1
1	1	1
1	1	1

Structuring element B

				1	1		
				1	1		
				1	1		

$A \ominus B$

Opening

1	1	1	1	1	1	1	
			1	1	1	1	
			1	1	1	1	
		1	1	1	1	1	
			1	1	1	1	
		1	1				

Binary image A

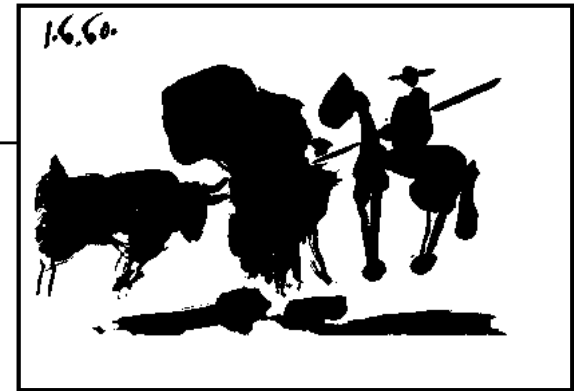
1	1	1
1	1	1
1	1	1

Structuring element B

			1	1	1	1	
			1	1	1	1	
			1	1	1	1	
			1	1	1	1	
			1	1	1	1	

$(A \ominus B) \oplus B$
Opening result

Opening



Structuring
Element



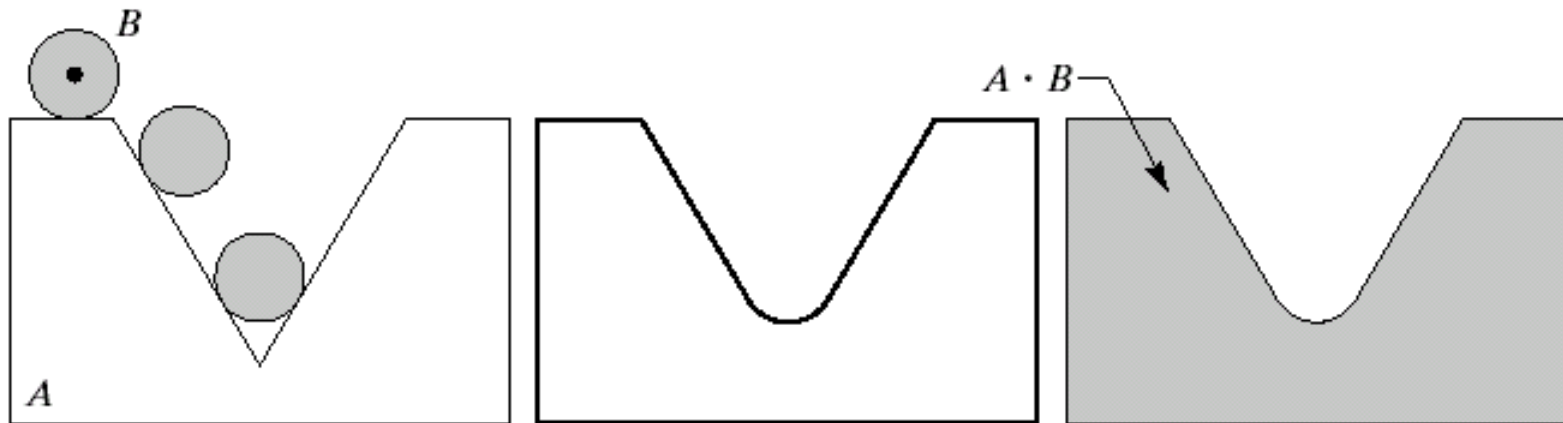
Pablo Picasso, *Pass with the Cape*, 1960

Adapted from John Goutsias, Johns Hopkins Univ.

Closing

- The closing of a binary image A by structuring element B is denoted by $A \cdot B$ is defined by

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



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).

Closing

	1	1	1	1	1	1	
			1	1	1	1	
			1	1	1	1	
		1	1	1	1	1	
			1	1	1	1	
		1	1				

Binary image A

1	1	1
1	1	1
1	1	1

Structuring element B

1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1			

$A \oplus B$

Closing

	1	1	1	1	1	1	
			1	1	1	1	
			1	1	1	1	
		1	1	1	1	1	
			1	1	1	1	
		1	1				

Binary image A

1	1	1
1	1	1
1	1	1

Structuring element B

	1	1	1	1	1	1	
		1	1	1	1	1	
		1	1	1	1	1	
		1	1	1	1	1	
		1	1	1	1	1	
		1	1				

$(A \oplus B) \ominus B$
Closing result

Examples

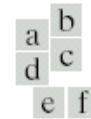
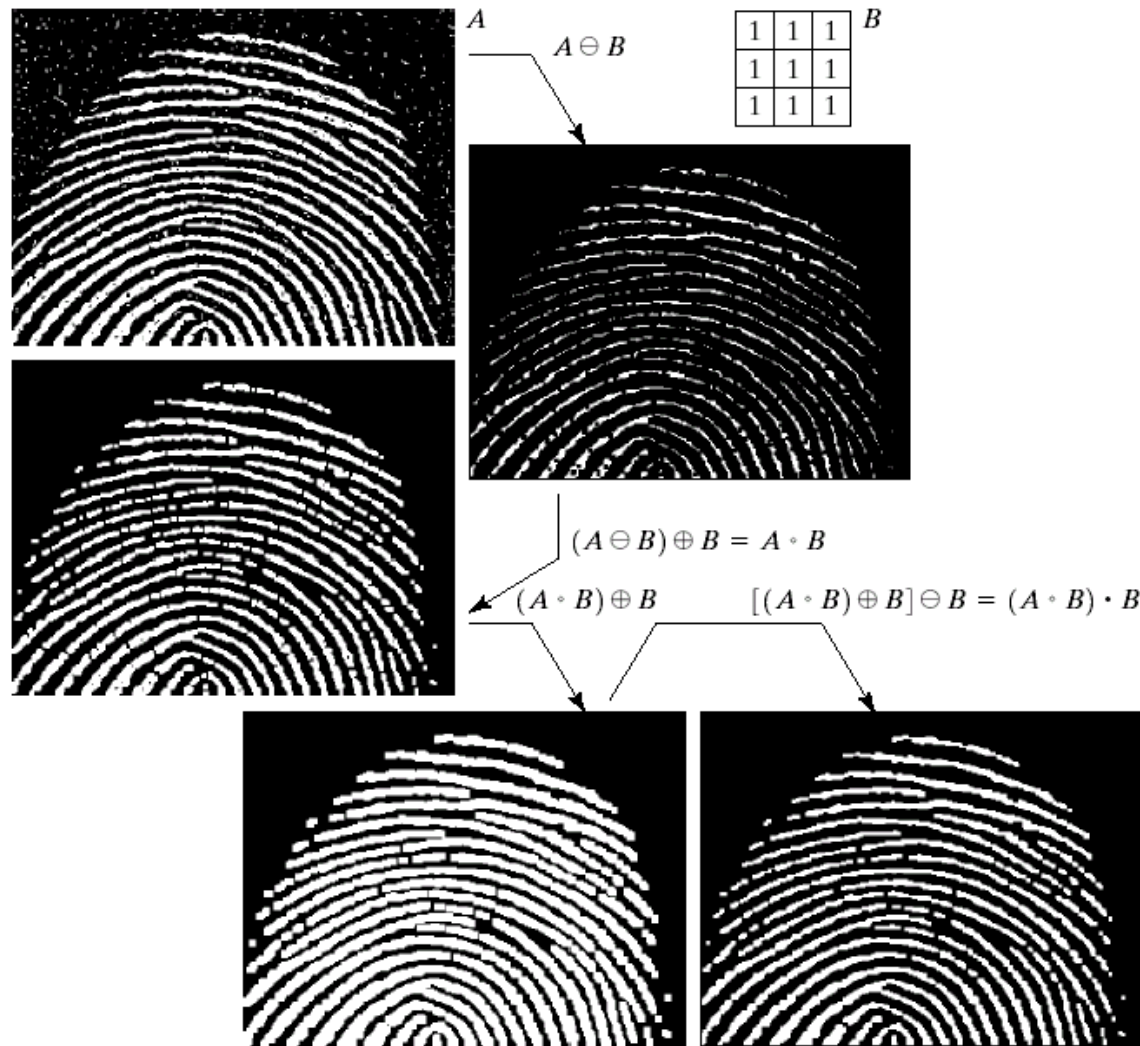


FIGURE 9.11

(a) Noisy image.
 (c) Eroded image.
 (d) Opening of A .
 (d) Dilation of the opening.
 (e) Closing of the opening. (Original image for this example courtesy of the National Institute of Standards and Technology.)

Week 05 – Hands on activity

- Prepare and submit a Jupyter Notebook file containing the code and the results for the following Task

Task

- Read the image rice.png and display it.
- Threshold the image and display the resulting binary image.
- Apply dilation and erosion operations using a structuring element that you choose.