Chapter 9: Morphological Image Processing

Origin42

Question 4. [Marks: 13]

a) Describe two different morphological basic operations along with mathematical equations. Explain the effects of them and give examples of their applications. **[5]**

4. a. **Solution:**

1. Erosion
2. Dilation

Question 4. [Marks: 13]

b) Consider the following image F and structuring element B: **[8]**

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

F

1
1
1

B

Compute the followings:

i. Reflection of B
ii. F dilated by B
iii. F^c eroded by B
iv. (F dilated by B) – F
v. Opening of F by B (and also write the process with mathematical equation)
vi. Closing of F by B (and also write the process with mathematical equation)

4. b. Solution: O24

(i)

Reflection of B, Assuming center is the origin of the structuring element,

1
1
1

(ii)

F dilated by B, Dilation: If HIT then 1 else 0.

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

(iii)

Fc,

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

Fc eroded by B, Erosion: If FIT then 1 else 0.
(4,5) e 1 er jaygay 0 hbe na? - corrected

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

(iv)

(F dilated by B) - F,

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

-

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

=

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

(v)

Opening = Erosion followed by Dilation

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

F opening by B,

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

=>

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

0	0	0	0	0	0
0	0	0	0	0	0

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

(vi)

Closing = Dilation followed by Erosion

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

F closing by B,

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

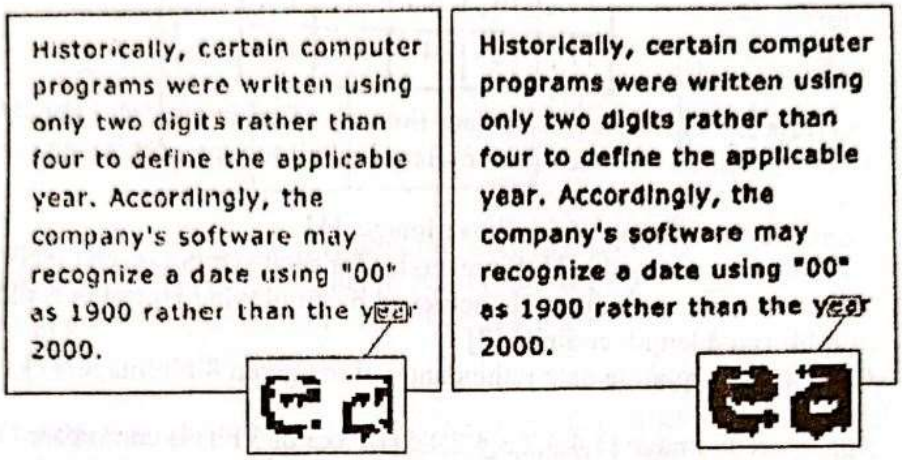
=>

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

Enigma41

Question 1. [Marks: 14]

a) Consider the following image. [8]



i. Which morphological operation is used to join the broken characters? Explain briefly. [3]

ii. Define Opening and Closing operations mathematically with their applications. [3]

iii. Design four Hit-or-Miss transformation SEs for locating four corners from an image. [2]

1.a. .i. Solution:
Dilation

1.a. .ii. Solution:

1.a. .iii. Solution: O24
Structuring elements for representing 4 corners,

x	1	x
0	1	1
0	0	x

x	1	x
1	1	0
x	0	0

0	0	x
0	1	1
x	1	x

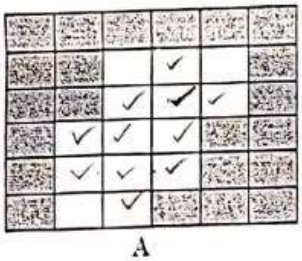
x	0	0
1	1	0
x	1	x

Recursive40

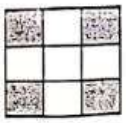
Question 6. [Marks: 14]

a) i. Describe two different morphological basic operations along with mathematical equations. Explain the effects of them and give examples of their applications. [8]

ii. Explain if it is possible to achieve edge detection using morphological basic operations. Write down the algorithm of your operation of edge detection.



A



S

Given an image A and a structuring element S above. Considering white pixels are foreground and dark pixels are background, compute the followings:

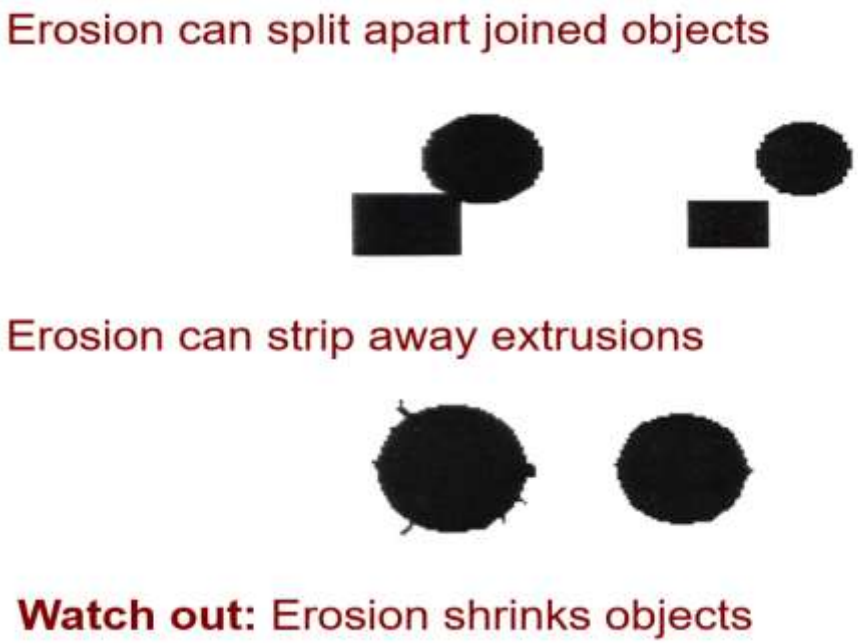
iii. Sketch the result of Erosion of A by S

iv. Sketch the result of Opening of A by S

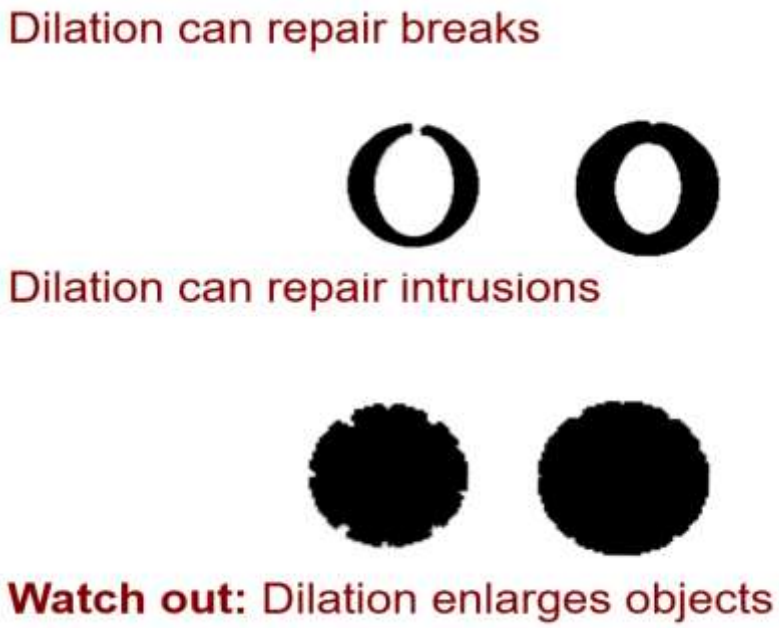
6.a. Solution: Rabab 039

(i)

The different morphological basic operations are:
Erosion (A⊖B): This is a process where all the pixels of the structuring element has to match those of the original image, in other words, have to *fit*. Through erosion, the foreground size shrinks, and extra spiky edges are removed, therefore, object boundaries are smoothened. Holes inside an object, however, are not removed.



Dilation (A⊕B): This is a process any of the pixels of the structuring element has to match those of the original image, in other words, have to *hit*. Through dilation, the foreground size enlarges, and extra outer layers are added, therefore, object boundaries are smoothened. The holes inside the object vanish.



(ii)

It is possible to achieve edge detection. If we dilate an image and subtract the original from the dilated image, the resultant image shows all the edges. Edge image = (A⊕B) - A

(iii)

A⊖B:

			1		
		1			
		1			

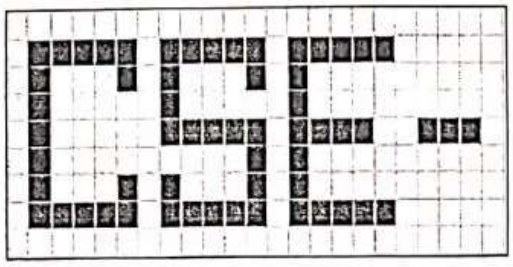
(iv)

A⊕B:

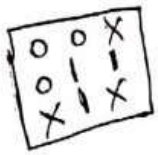
		1	1	1	
	1	1	1	1	1
	1	1	1	1	1
1	1	1	1	1	
1	1	1	1	1	
1	1	1	1		

b) i. What is Hit and Miss transformation in image morphology? [6]

ii. Design four Hit-or-miss transformation structure elements (SEs) for locating four connected endpoints of an image and show them. Perform your all SEs to the image below and use OR/ADD operation to combine the four results. How many corners will be detected in your final output image? Draw your final output image.



12



6.b. Solution: 024

(i)

Commonly known as "HMT"

Hitt and Miss is a high level morphology method. It is specifically designed to find and locate specific patterns or shapes in images by looking for a specific configuration of 'foreground' and 'background' pixels around the 'origin'.

(ii)

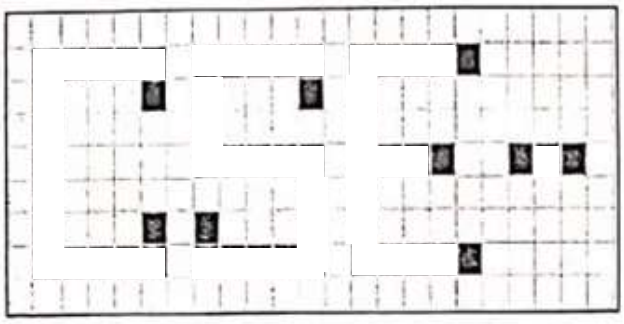
Structuring elements for representing 4 connected endpoints,

x	0	x
0	1	0
x	x	x

x	x	x
0	1	0
x	0	x

x	0	x
0	1	x
x	0	x

x	0	x
x	1	0
x	0	x



In final output 9 corners will be detected.

Prototype39

3.

a) i. Define Erosion and Dilation with set theory. [3]

ii. The figure shows an 8 × 8 image (A) and a disk structuring element(B)

9

Image A

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

Structuring Element B

	1	
1	1	1
	1	

[6]

a. Sketch the result of Erosion of A by B. [1]
b. Sketch the result of Dilation of A by B. [1]
c. Sketch the result of Closing of A by B. [1]

Solution:

b) i. Consider the binary image A shown below on the left. Show the result of applying the following (as mentioned the operations on the right) with a 3x3 structuring element S.

9

$$B = (A \oplus S) \cap A^c$$
$$B = (A \oplus S) \cup A^c$$

Just draw the resulting images B. Indicate it clearly on your drawing the white and black parts. No need to show your calculations. [3]

Solution:

5.

b) Figure presents the result of applying a filter to an image below. Now answer the following questions. [3]

3

i. What type of filter do you think was used? Justify your answer.

ii. Propose at least one way to improve the result.

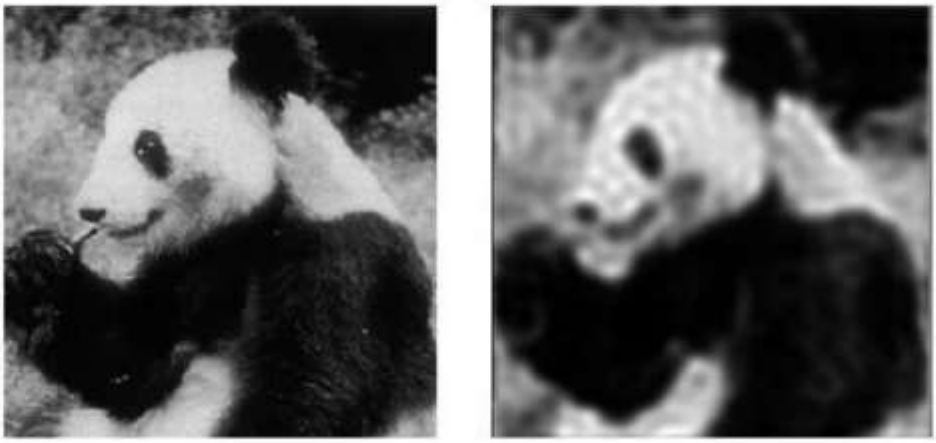


Figure: Image before filtering (left) and after filtering(right)

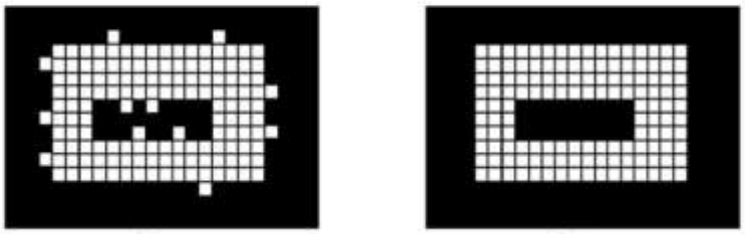
Solution:

Return38

4.

a) Consider the following images: [2]

9



(a) (b)

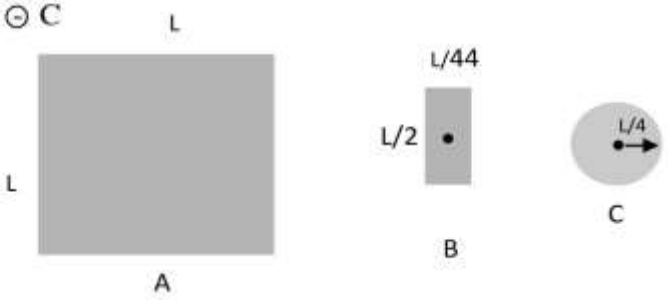
Now propose a morphological procedure to clear the edge artifacts of the image given in (a) such that the image in (b) is obtained. Clearly state the structuring element(s) and number of iterations that you would use in your procedure.

Solution:

b) Define the term **Dilation** and **Erosion** in morphological operations of image processing. **[5]**
Sketch the following morphological operations: (must show the calculations.)

I. $A \oplus B$

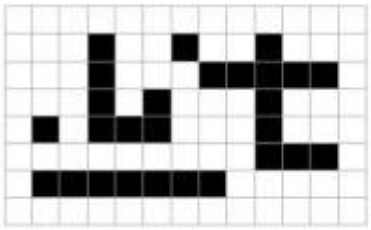
II. $A \ominus C$



Solution:

c) i. Design Hit-or-miss transformation SEs for locating **4-connected endpoints** of an image. **[5]**

ii. Locate all the 4-connected endpoints of the following image using SEs obtained from the previous question i.



iii. Explain with example, if it is possible to achieve **edge detection** using morphological operations.

Solution:

Malware37

2.

a) Image Thinning process subtract the pixels from a shape to thin the line to one pixel width. Thin the image of Fig 2.1 using the given structuring element of Fig 2.2. Show the set of SEs those will be used in your thin process. Illustrate the thinning process and show your results after each passes of your structuring elements until the convergence was achieved and also show your final thinned image after eliminating multiple paths. **[6]**

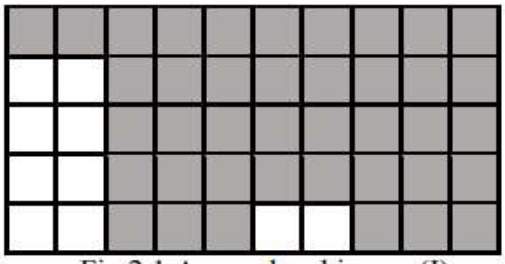


Fig 2.1 A gray-level image (I)

Fig 2.2 Structuring Element (SE)

Solution:

b) Considering the image of Fig. 2.3 and structuring element of Fig. 2.4, find the output of the following operations: **[4]**

i. $(A \ominus s) \oplus s$

ii. $(A \oplus s) \ominus s$

iii. Prove the duality relationship between Dilation and Erosion.

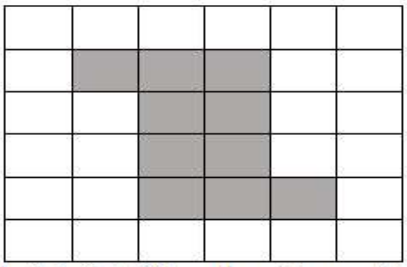


Fig 2.3 6 × 6 Gray-level Image (A)

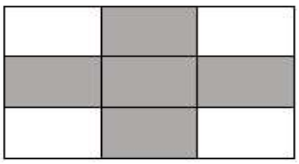


Fig 2.4 Structuring Element (s)

Solution:

COREi36

6. a) Define **Erosion** and **Dilation** mathematically. L-13 **[2]**

Solution:45

Erosion

Definition 1:

Fit: All "***ON"*** *pixels* in the structuring element cover "***ON"*** *pixels* in the image

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

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

- Erosion of a set A by structuring element B:
  - Set of all points z, such that B translated by z is contained in A.

If YES, output pixel g(x,y) will be foreground (i.e. 1)

,

Dilation

Definition 1:

Hit: Any "***ON"*** *pixel* in the structuring element covers an "***ON"*** *pixel* in the image

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

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

- Dilation of a set A by structuring element B:
  - all z in A such that B hits A when origin of B=z
  - such that overlap A by at least one element

b) Explain with an example, if it is possible to achieve **edge detection** using morphological operation. [2]

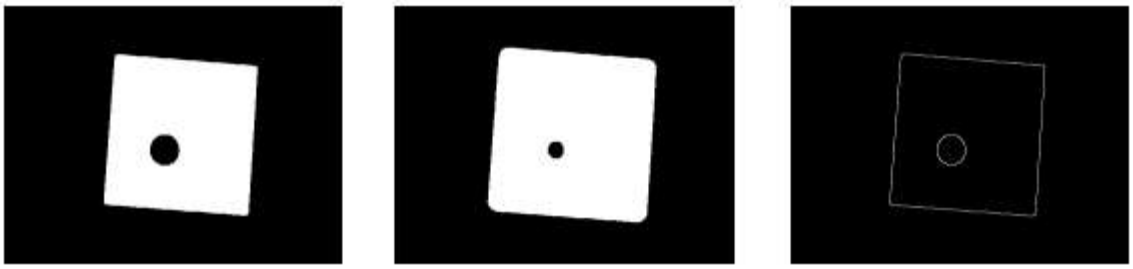
Yes

Solution:45

Dilation: Example 7

- Edge Detection

1. Dilate input image
2. Subtract input image from dilated image
3. Edges remain!



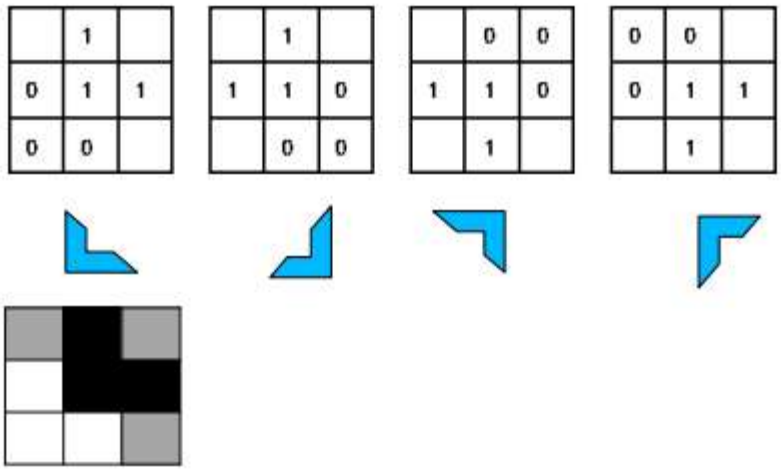
c) Design Hit-or-miss transformation **structuring elements** for locating **all four corners** of an image. [4]

L-14

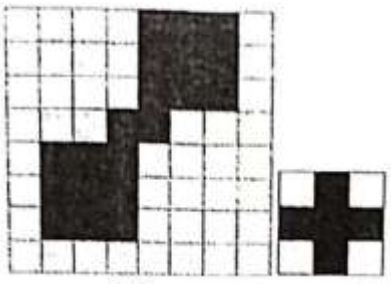
Solution:45

Corner Detection with Hit-and-miss Transform

- Structuring Elements representing four corners



d) The following figure shows an 8 ×8 image (A) and a disk structuring element (B) [6]

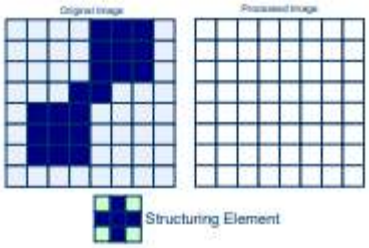


(A) (B)

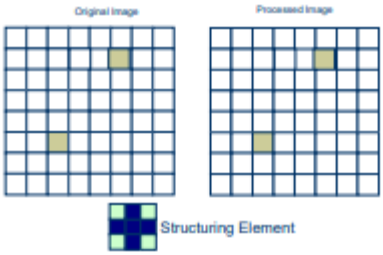
. i. Sketch the result of **Erosion** of **A** by **B**.
ii. Sketch the result of **Dilation** of **A** by **B**.
iii. Sketch the result of **Opening** of **A** by **B**.
iv. Sketch the result of **Closing** of **A** by **B**.

Solution:45

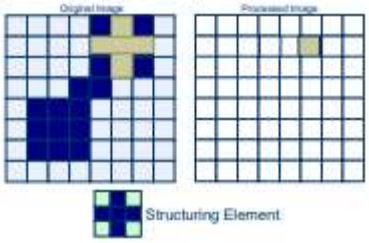
Opening: Example



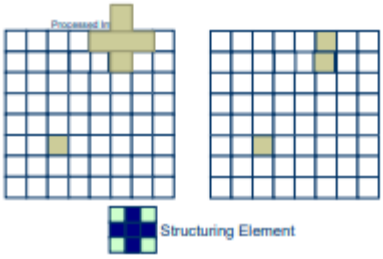
Opening: Example (performing dilation to errored image)



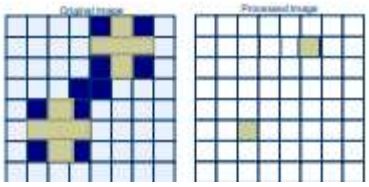
Opening: Example (performing erosion)



Opening: Example (performing dilation to errored image)



Opening: Example (performing erosion)



Opening: Example (performing dilation to errored image)