CST382-3 Morphological Operation in Images

Chapter-5

What is Morphology

- Morphological image processing (or morphology) describes a range of image processing techniques that deal with the shape (or morphology) of features in an image
- Morphological operations are typically applied to remove imperfections introduced during segmentation, and so typically operate on bi-level images

Morphological operations

- Once segmentation is complete, morphological operations can be used to remove imperfections in the segmented image and provide information on the form and structure of the image

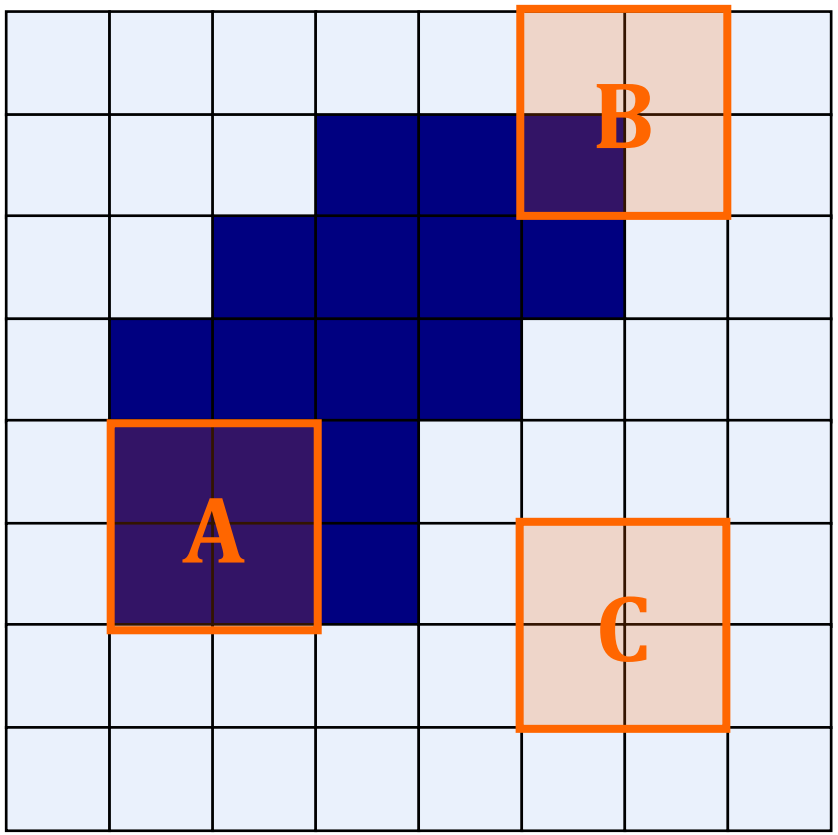
Example

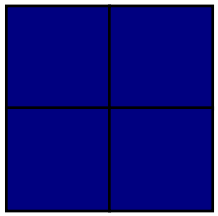
Images taken from Gonzalez & Woods, Digital Image Processing (2002

Image after segmentation

Image after segmentation and morphological processing

Structuring Elements HIT & FIT





Structuring Element

Fit: All *on pixels* in the structuring element cover *on pixels* in the image

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

All morphological processing operations are based on these simple ideas

Structuring Elements

Structuring elements can be any size and make any shape

However, for simplicity, we will use rectangular structuring elements with their origin at the middle pixel

1	1	1
1	**1**	1
1	1	1

0	1	0
1	**1**	1
0	1	0

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

Fitting & Hitting

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	0	1	**B**	1	1	1	0	**C**	0	0	0
0	1	1	1	1	1	1	1	0	0	0	0
0	1	1	1	1	1	1	1	0	0	0	0
0	0	1	1	1	1	1	1	0	0	0	0
0	0	1	1	1	1	1	1	1	0	0	0
0	0	1	1	1	1	1	**A**	1	1	1	0
0	0	0	0	0	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0

1	1	1
1	1	1
1	1	1

Structuring Element 1

0	1	0
1	1	1
0	1	0

Structuring Element 2

Fundamental Operations

Fundamentally morphological image processing is very like spatial filtering

The structuring element is moved across every pixel in the original image to give a pixel in a new processed image

The value of this new pixel depends on the operation performed

There are two basic morphological operations: **erosion** and **dilation**

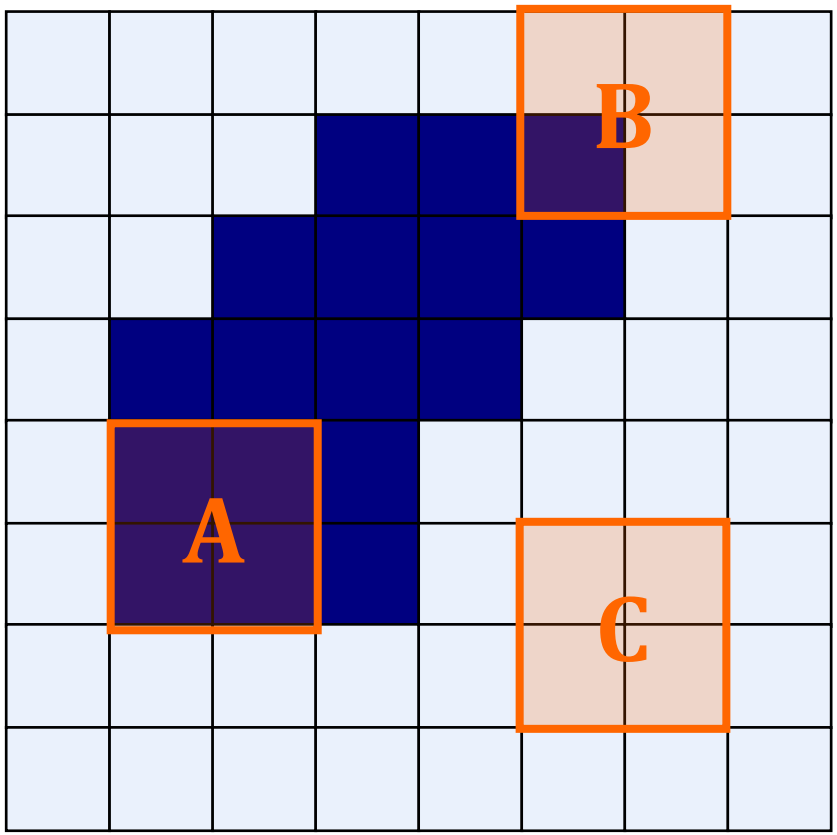
Erosion

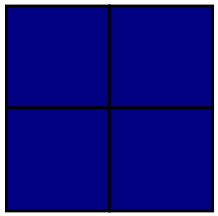
Erosion of image f by structuring element s is given by $f \ominus s$

The structuring element s is positioned with its origin at (x, y) and the new pixel value is determined using the rule:

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

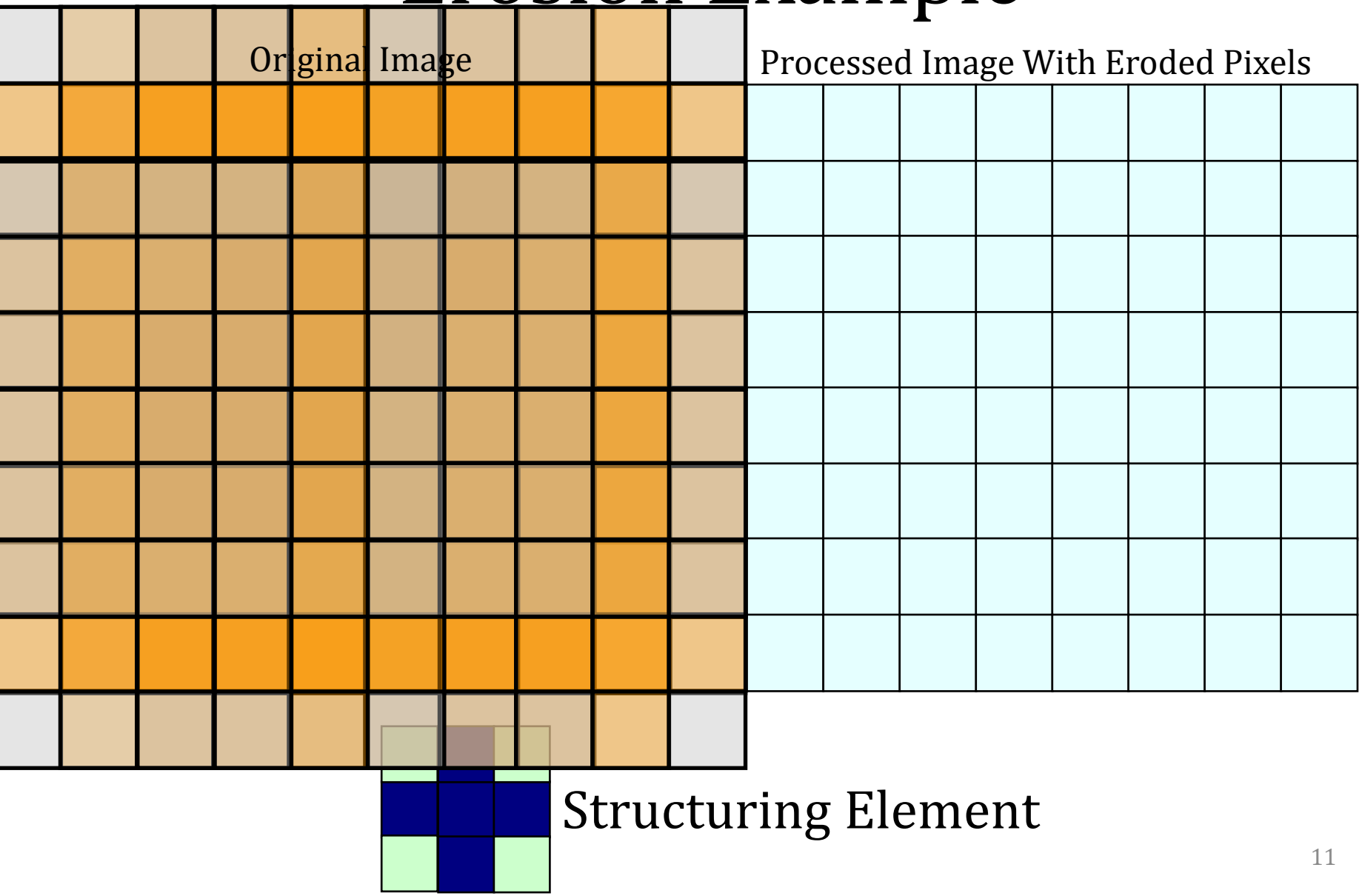
Erosion Scenario





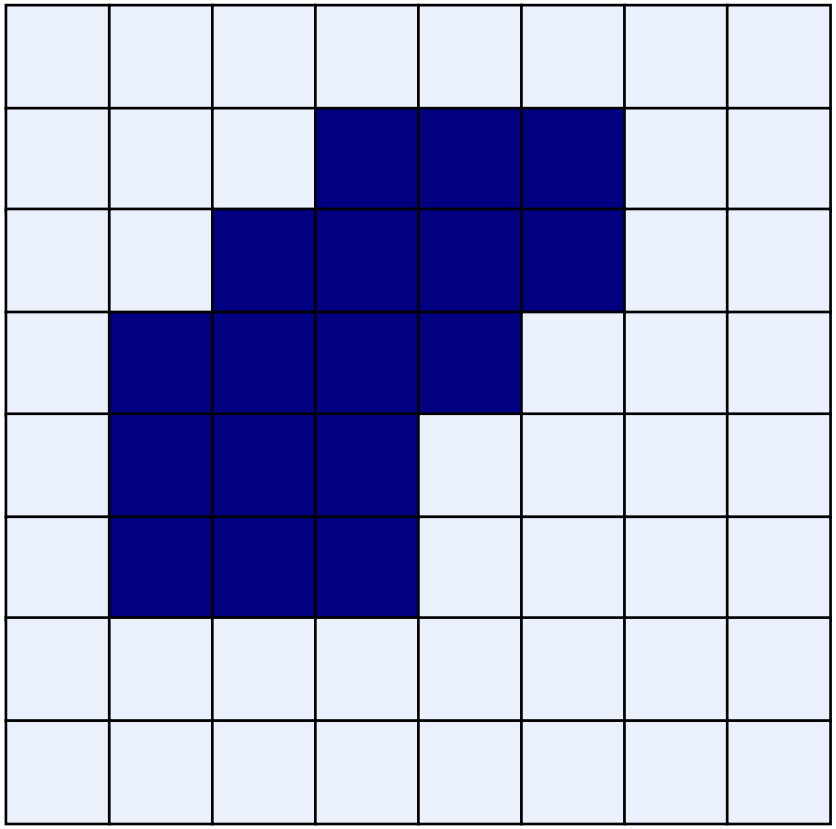
Structuring Element

Erosion Example

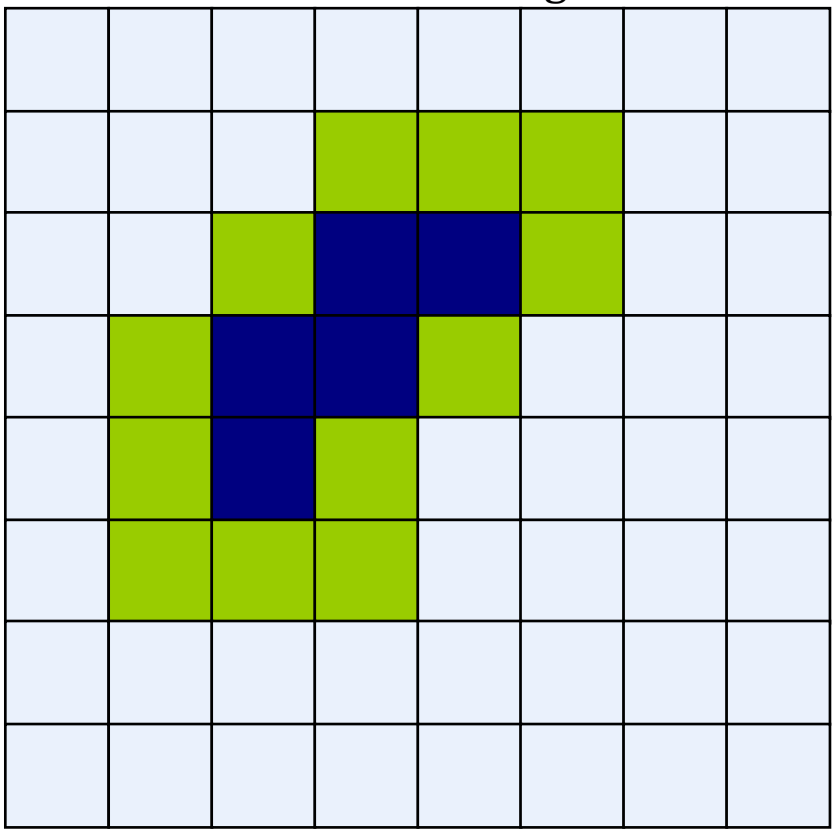


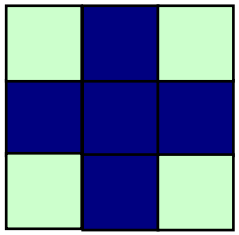
Erosion Example

Original Image



Processed Image

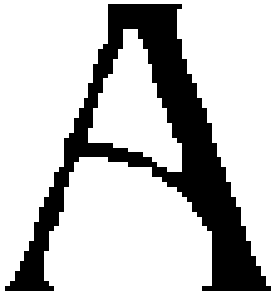




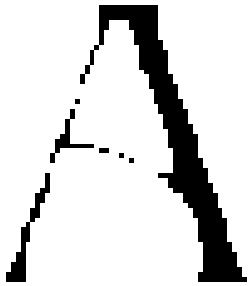
Structuring Element

Erosion Example 1

Original image



Erosion by 3*3 square structuring element

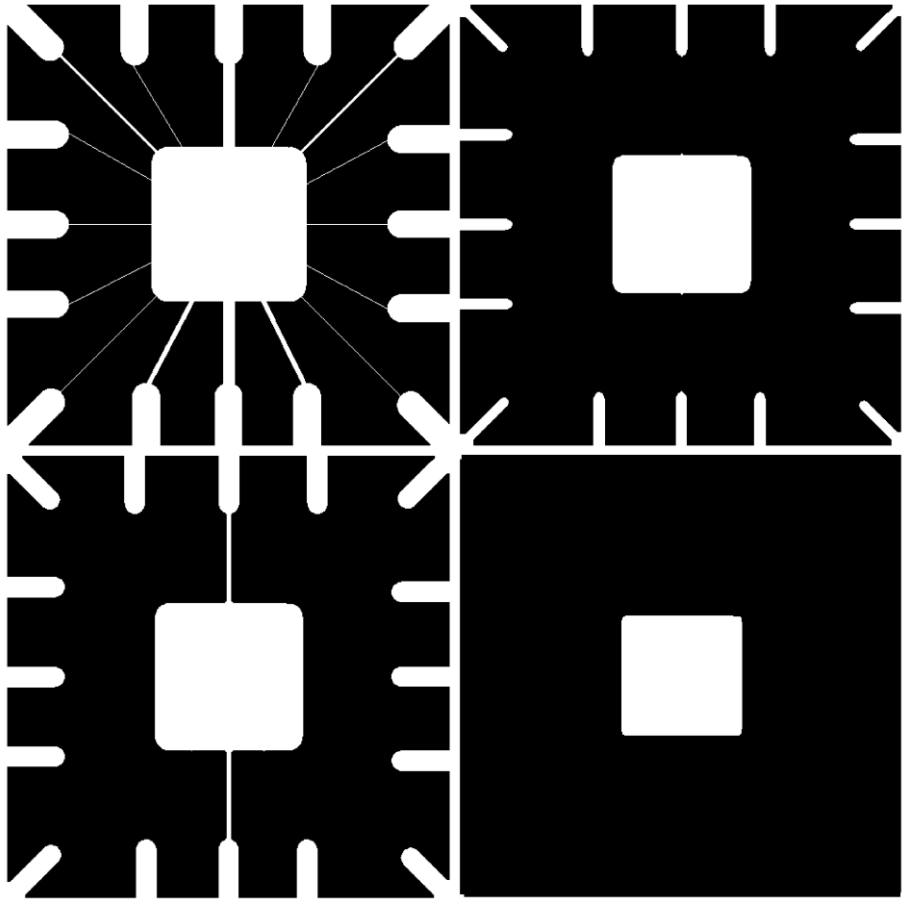


Erosion by 5*5 square structuring element

Images taken from Gonzalez & Woods, Digital Image Processing (2002

Watch out: In these examples a 1 refers to a black pixel!

Erosion Example 2



Original image

After erosion with a disc of radius 10

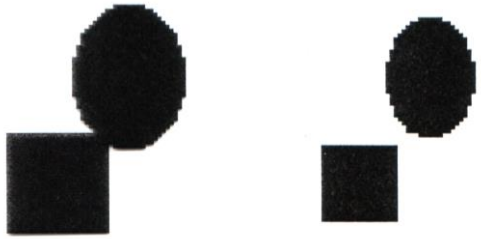
After erosion with a disc of radius 5

After erosion with a disc of radius 20

Images taken from Gonzalez & Woods, Digital Image Processing (2002

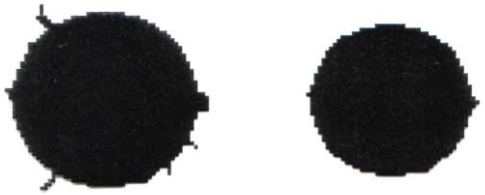
What Is Erosion For?

Erosion can split apart joined objects



Erosion can split apart

Erosion can strip away extrusions



Watch out: Erosion shrinks objects

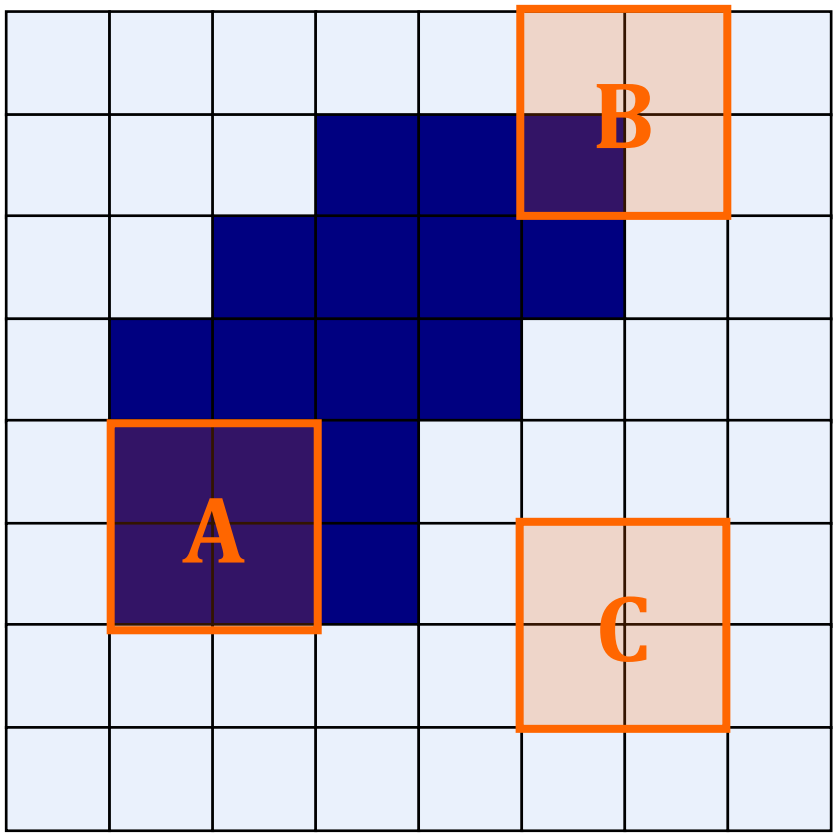
Dilation

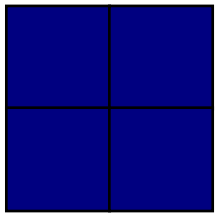
Dilation of image f by structuring element s is given by $f \oplus s$

The structuring element s is positioned with its origin at (x, y) and the new pixel value is determined using the rule:

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

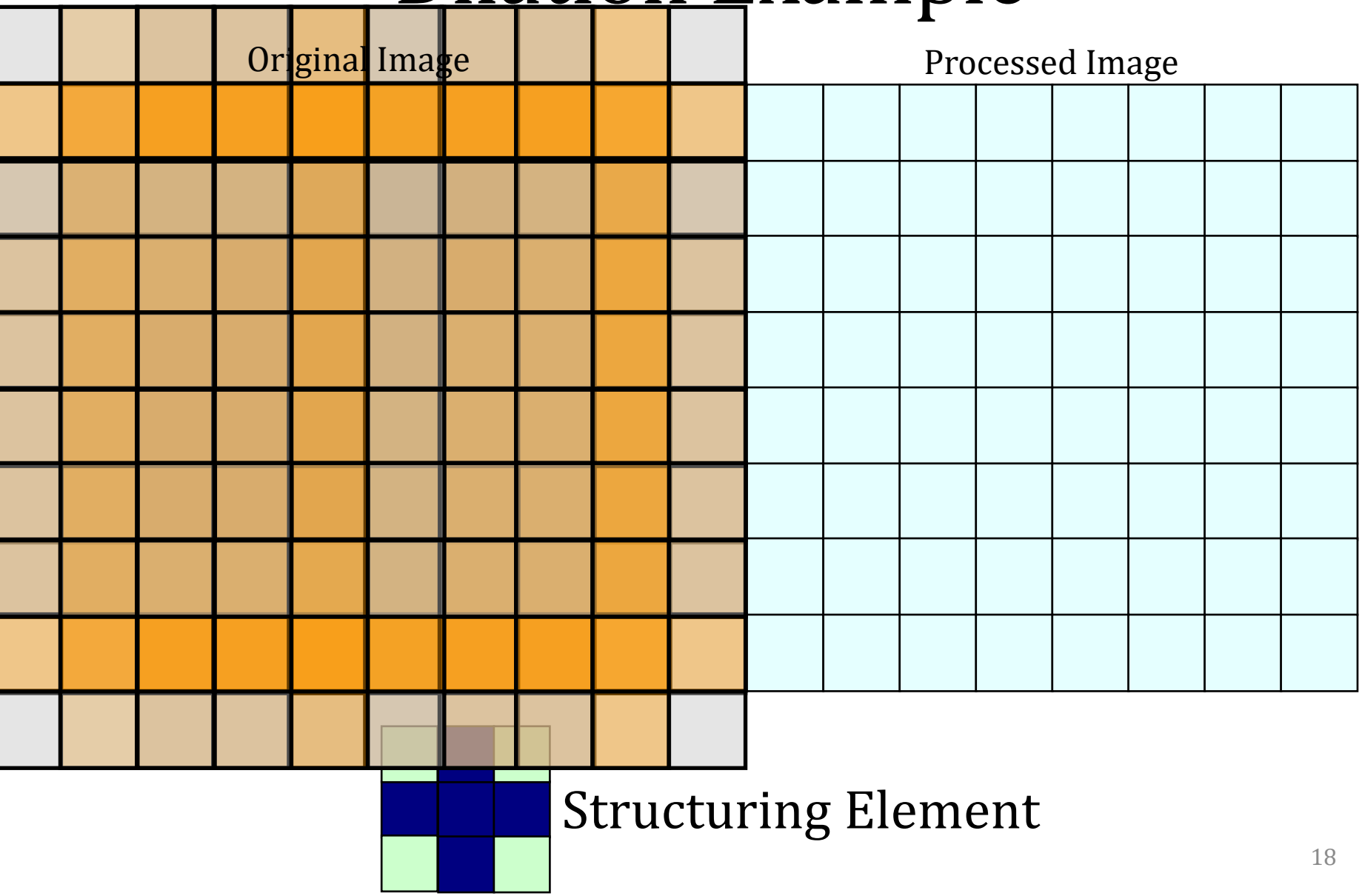
Dilation Scenario





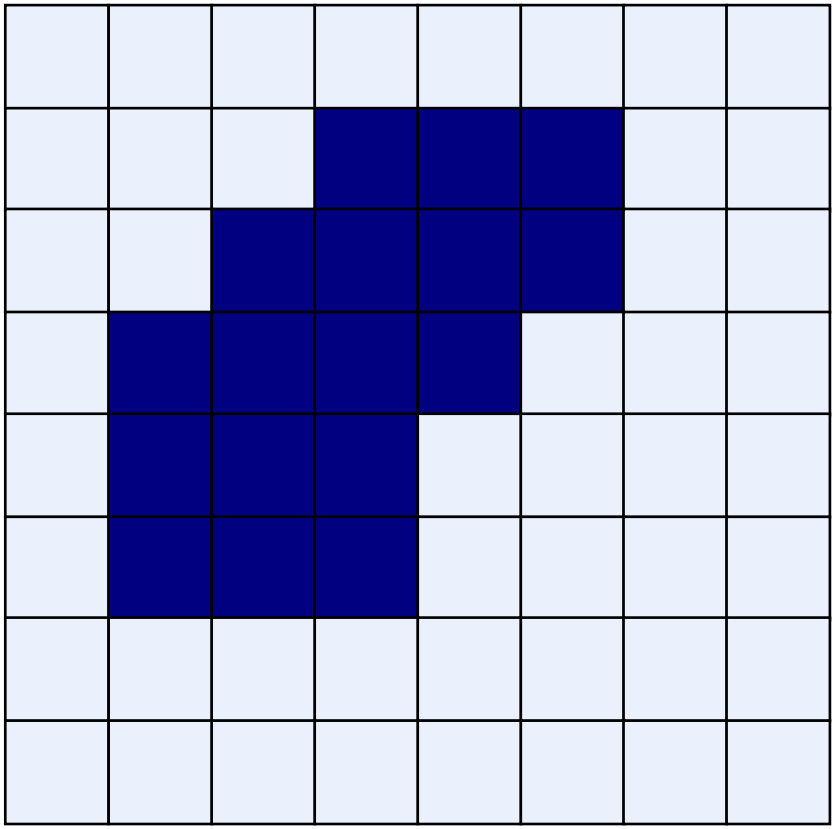
Structuring Element

Dilation Example

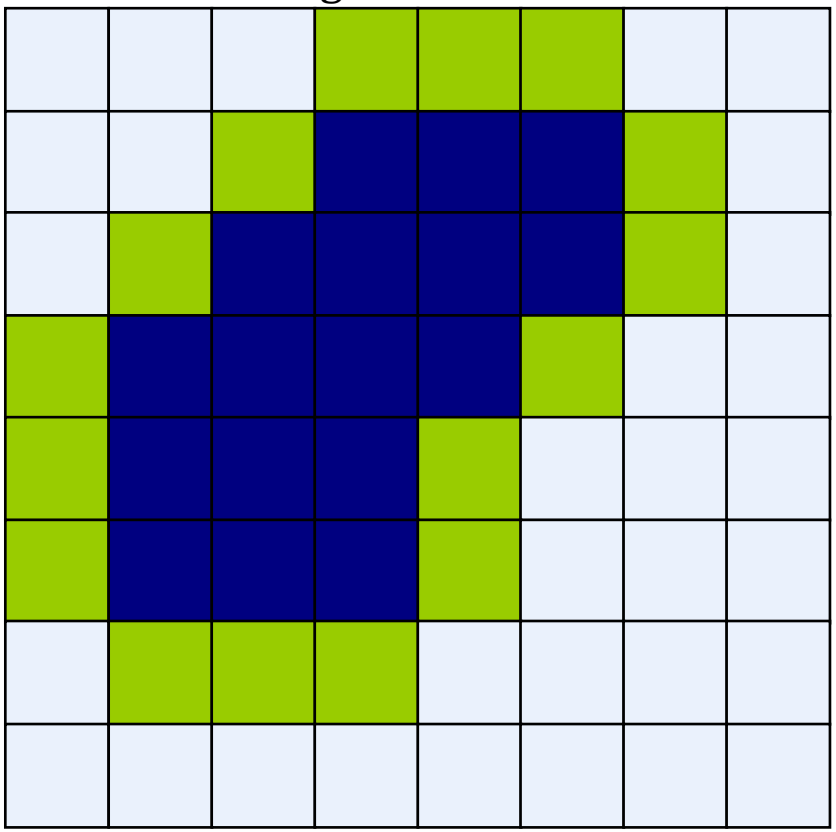


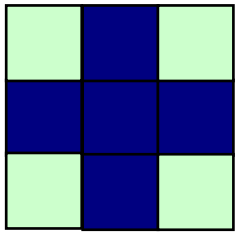
Dilation Example

Original Image



Processed Image With Dilated Pixels





Structuring Element

Dilation Example 1

Original image

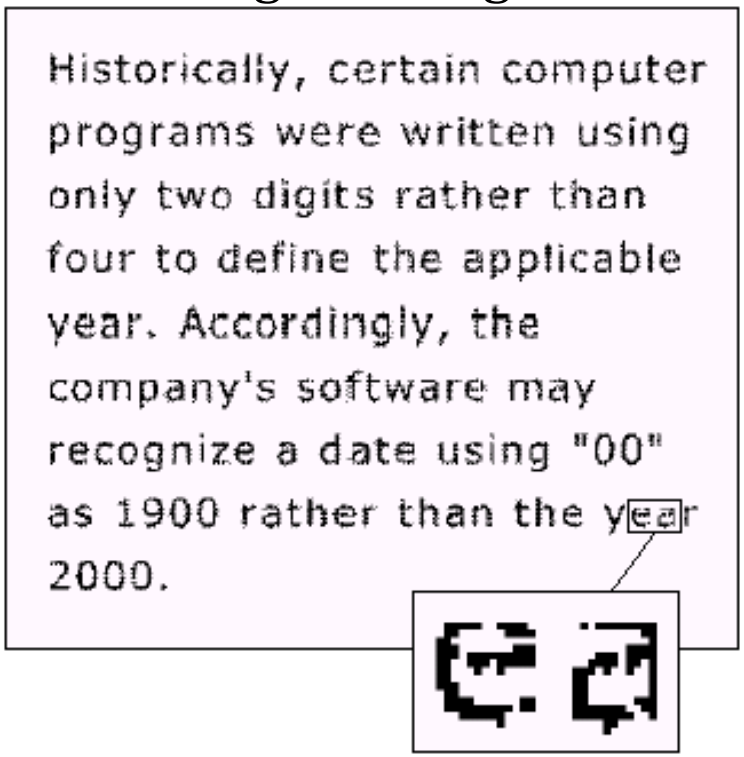
Dilation by 3*3 square structuring element

Dilation by 5*5 square structuring element

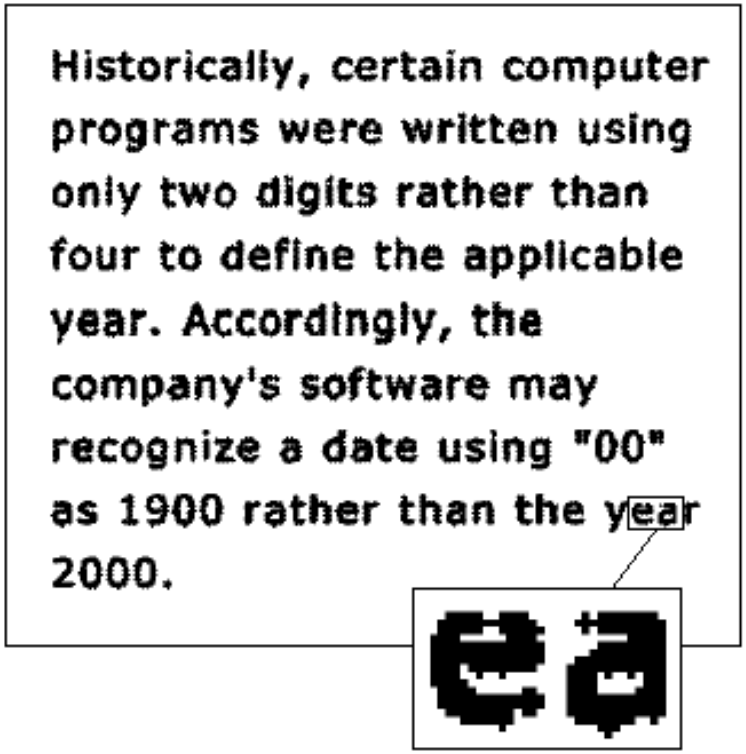
Watch out: In these examples a 1 refers to a black pixel!

Dilation Example 2

Original image



After dilation



0	1	0
1	1	1
0	1	0

Structuring element

What Is Dilation For?

Dilation can repair breaks

Dilation can repair intrusions

Watch out: Dilation enlarges objects

Compound Operations

More interesting morphological operations can be performed by performing combinations of erosions and dilations

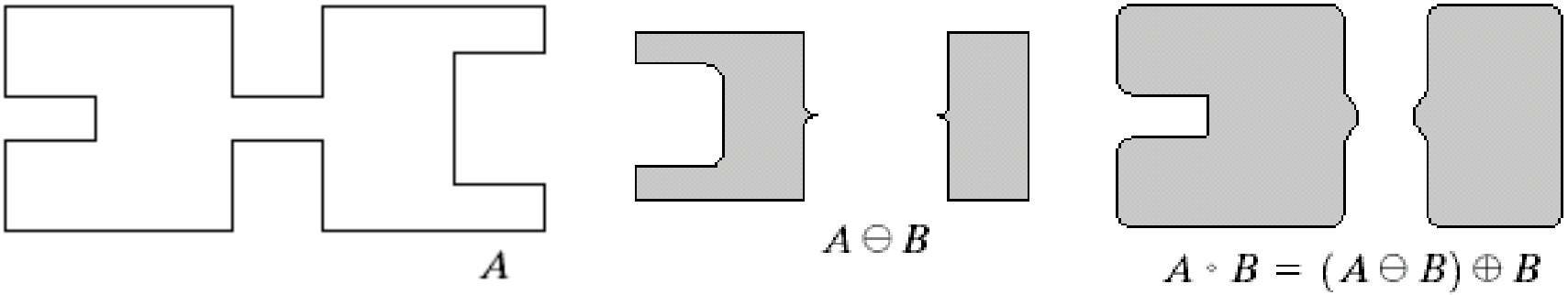
The most widely used of these *compound operations* are:

- Opening
- Closing

Opening

The opening of image f by structuring element s, denoted $f \circ s$ is simply an erosion followed by a dilation

$$f \circ s = (f \ominus s) \oplus s$$



Original shape | After erosion | After dilation (opening)

Note a disc shaped structuring element is used

Opening Example

Original Image

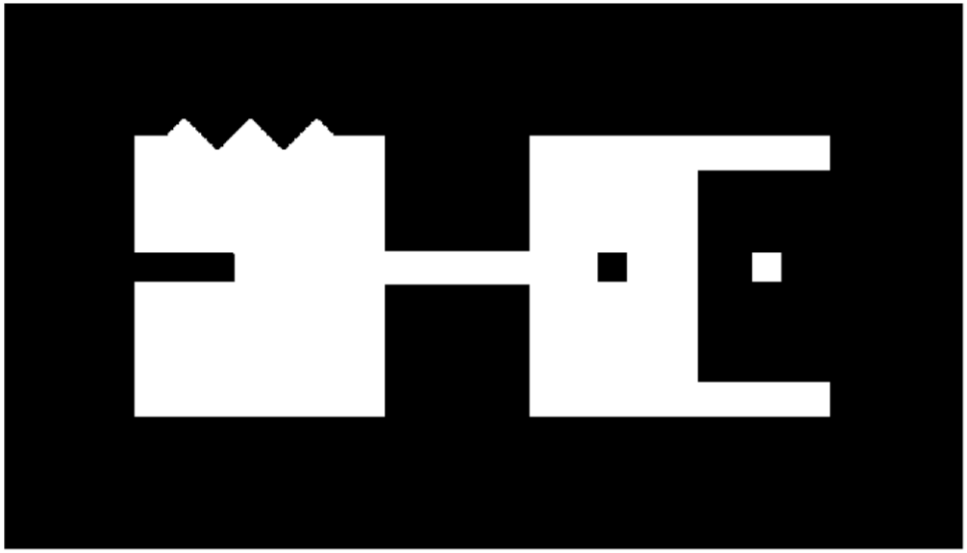
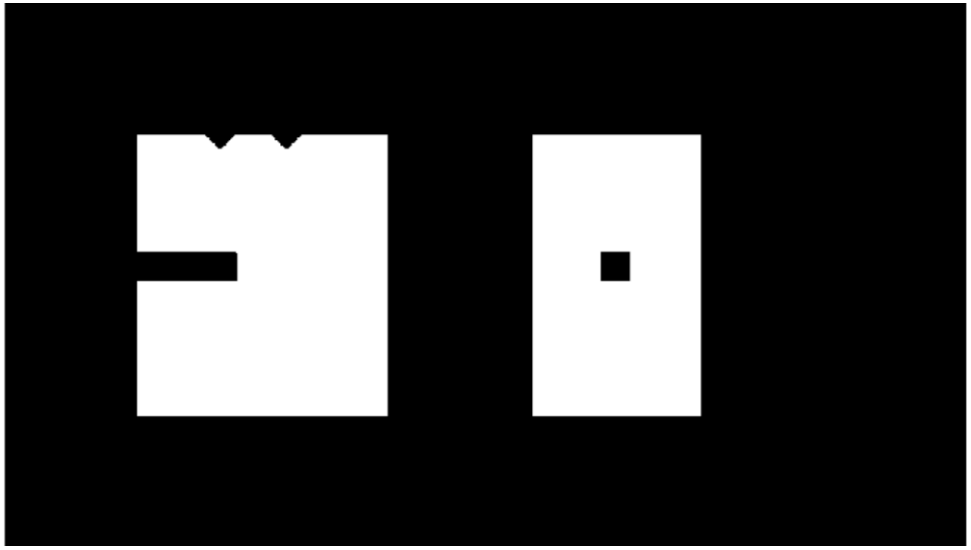
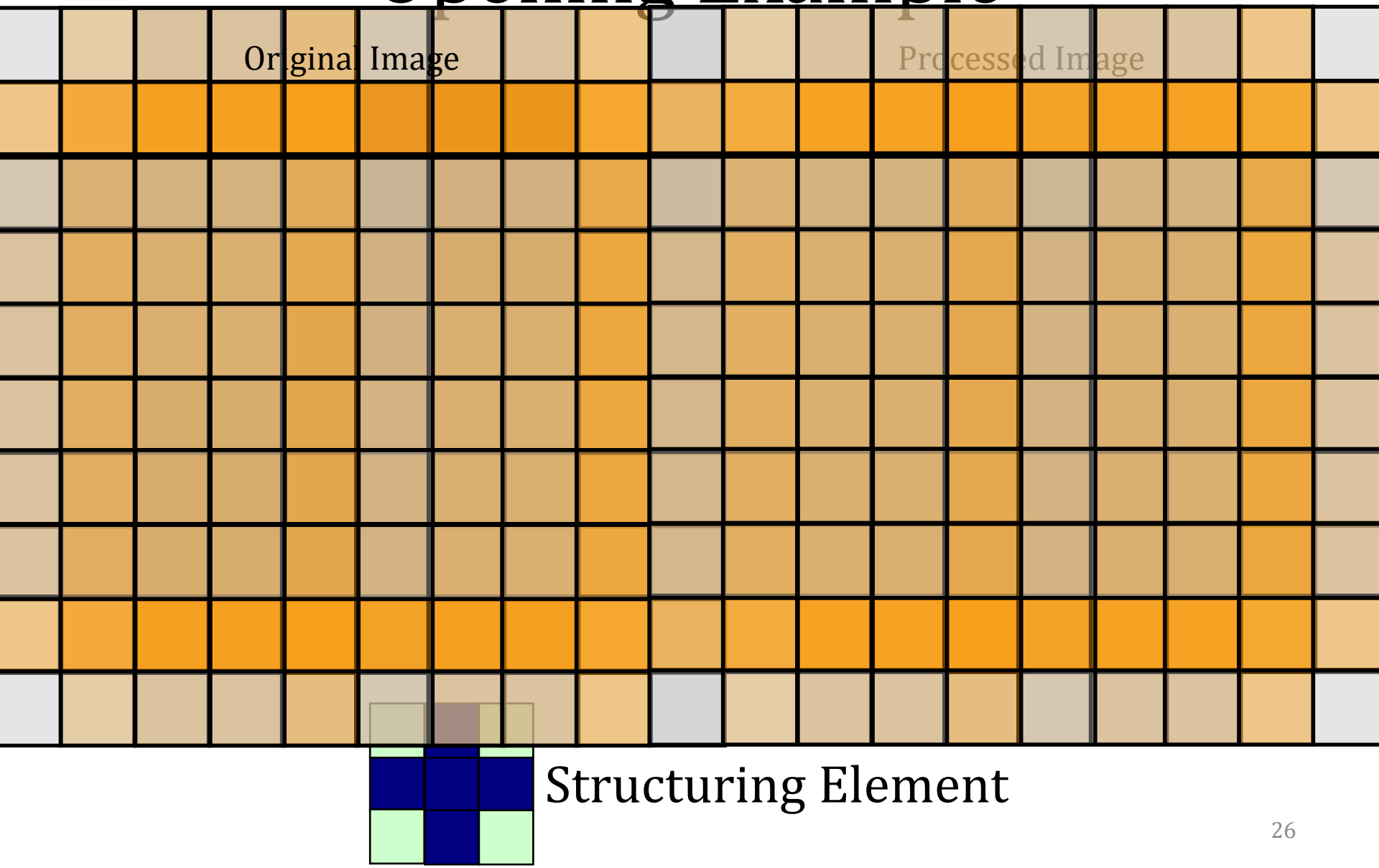


Image After Opening

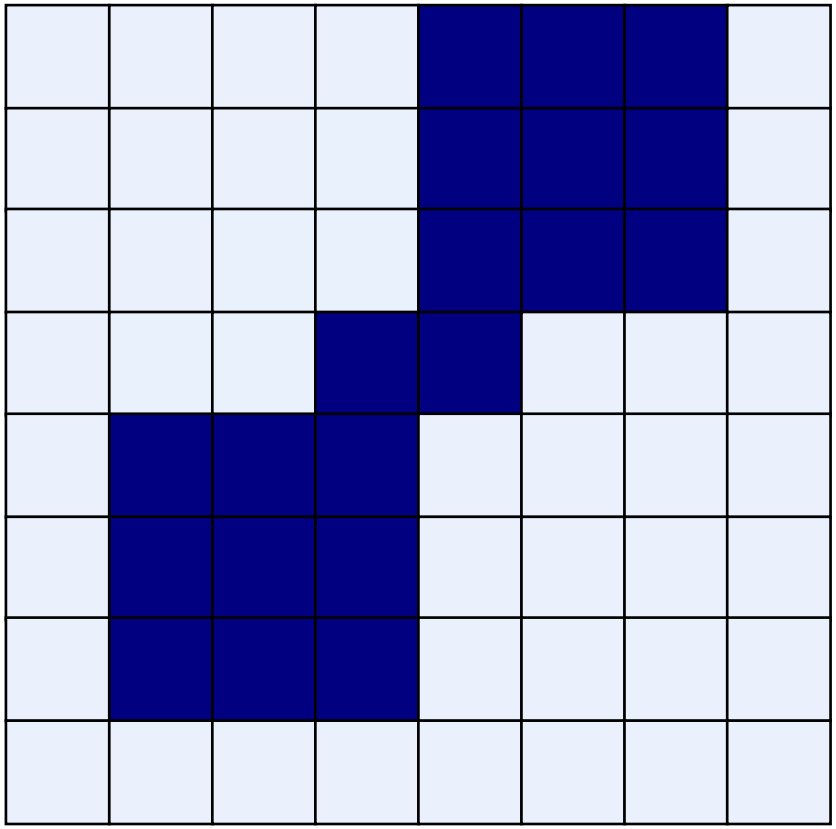


Opening Example

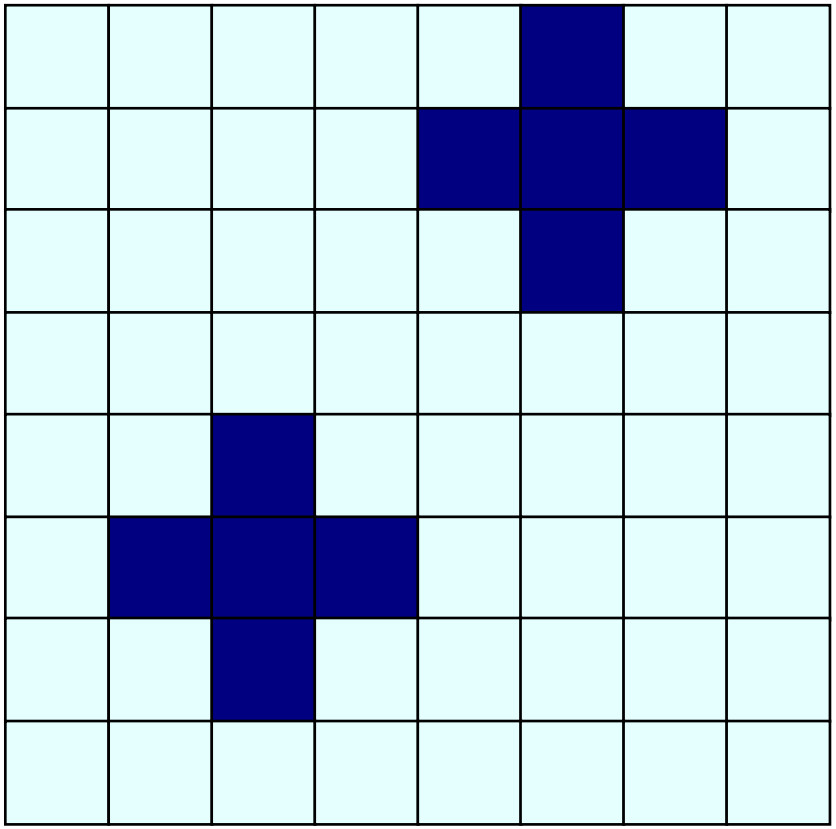


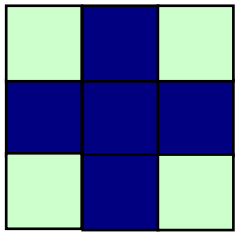
Opening Example

Original Image



Processed Image



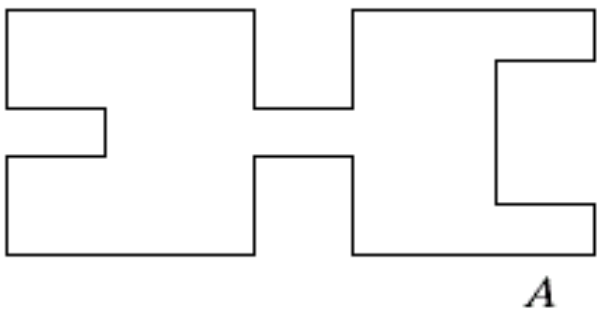


Structuring Element

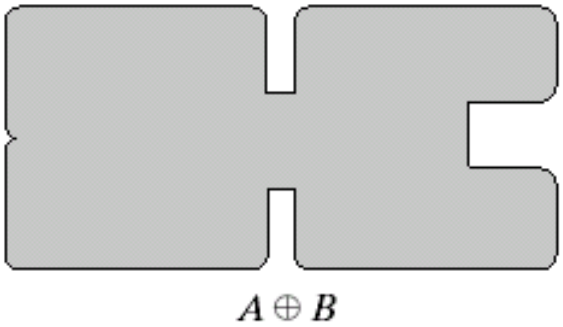
Closing

The closing of image f by structuring element s, denoted $f \bullet s$ is simply a dilation followed by an erosion

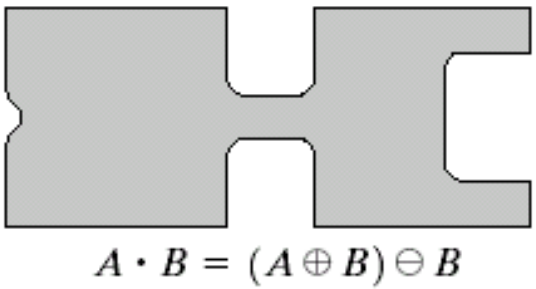
$$f \bullet s = (f \oplus s) \ominus s$$



Original shape



After dilation



After erosion (closing)

Note a disc shaped structuring element is used

Closing Example

Original Image

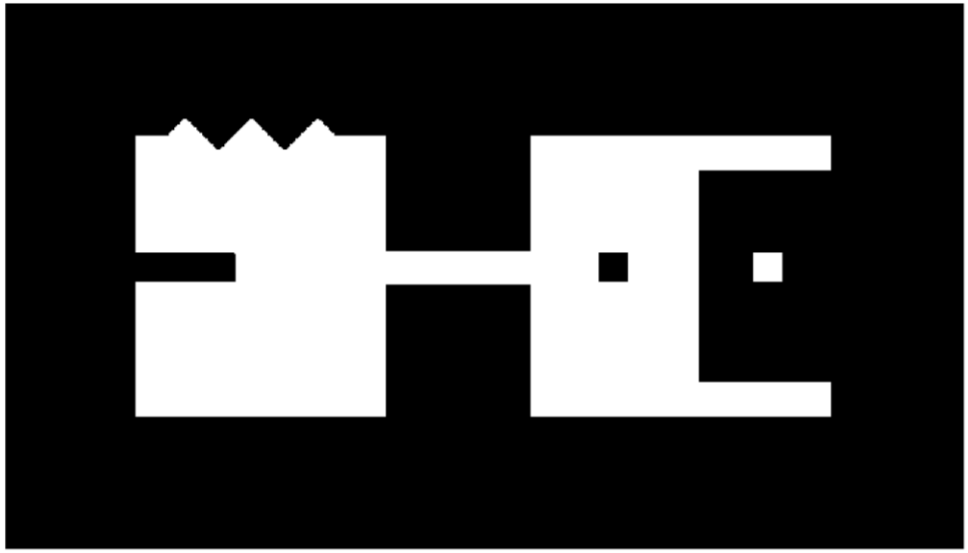
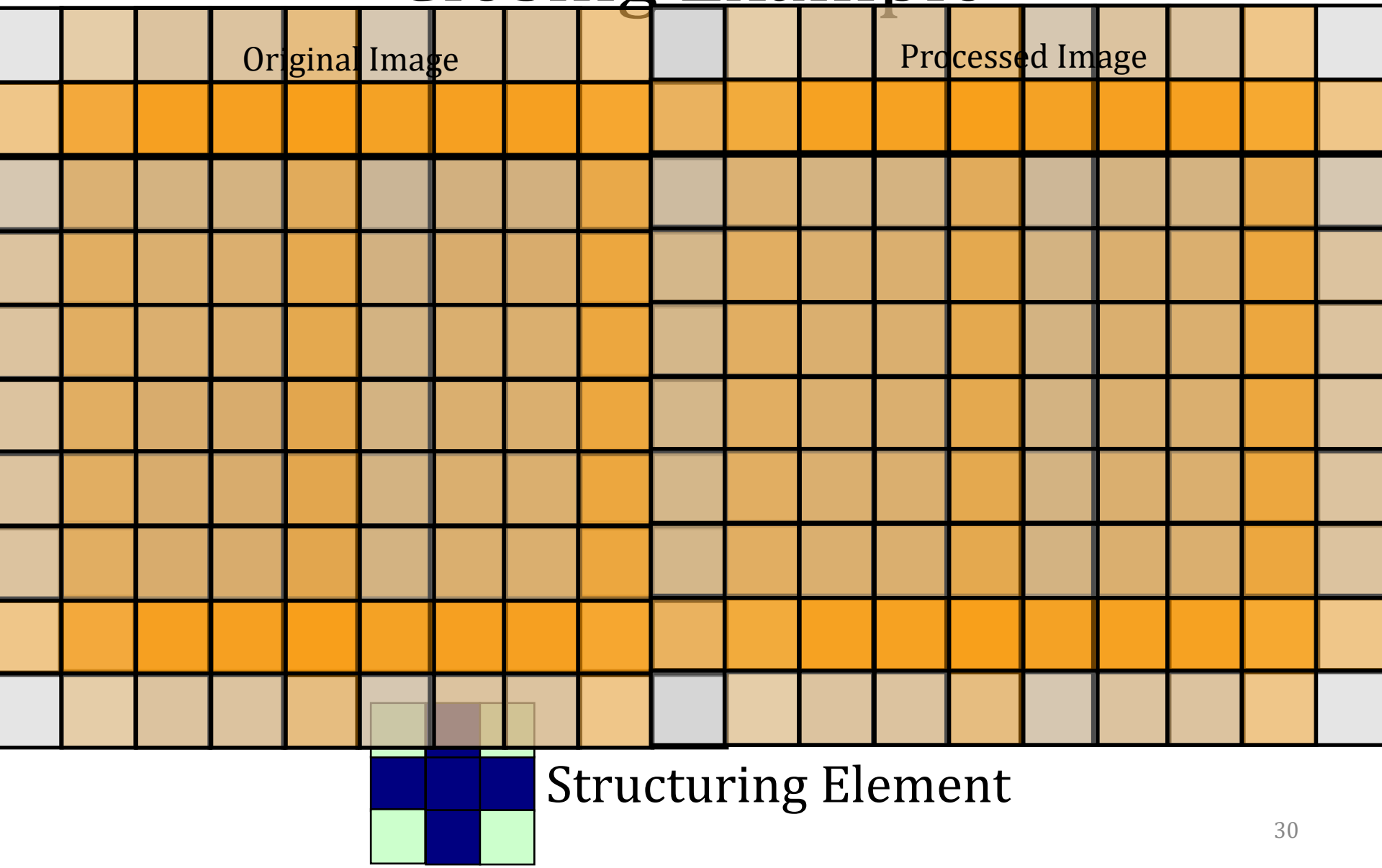


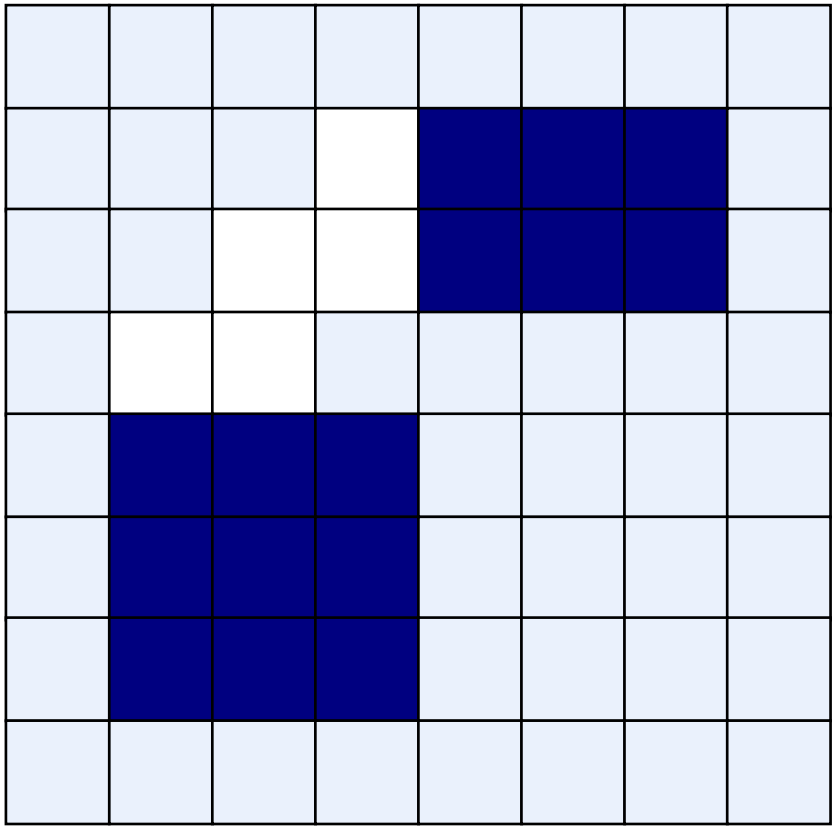
Image After Closing

Closing Example

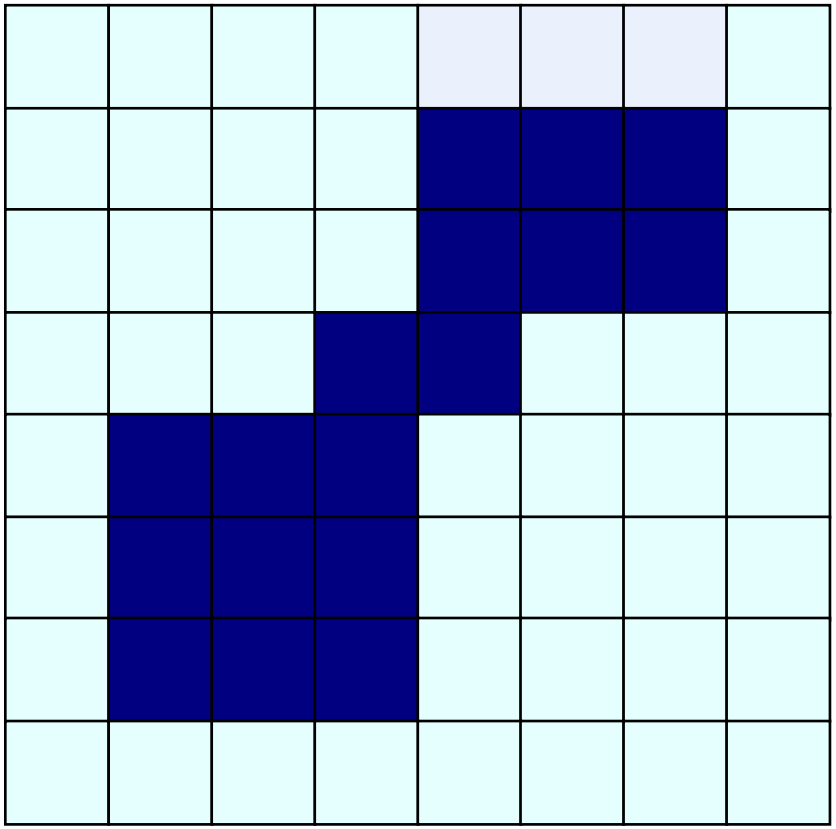


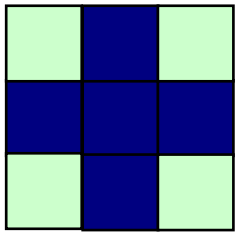
Closing Example

Original Image



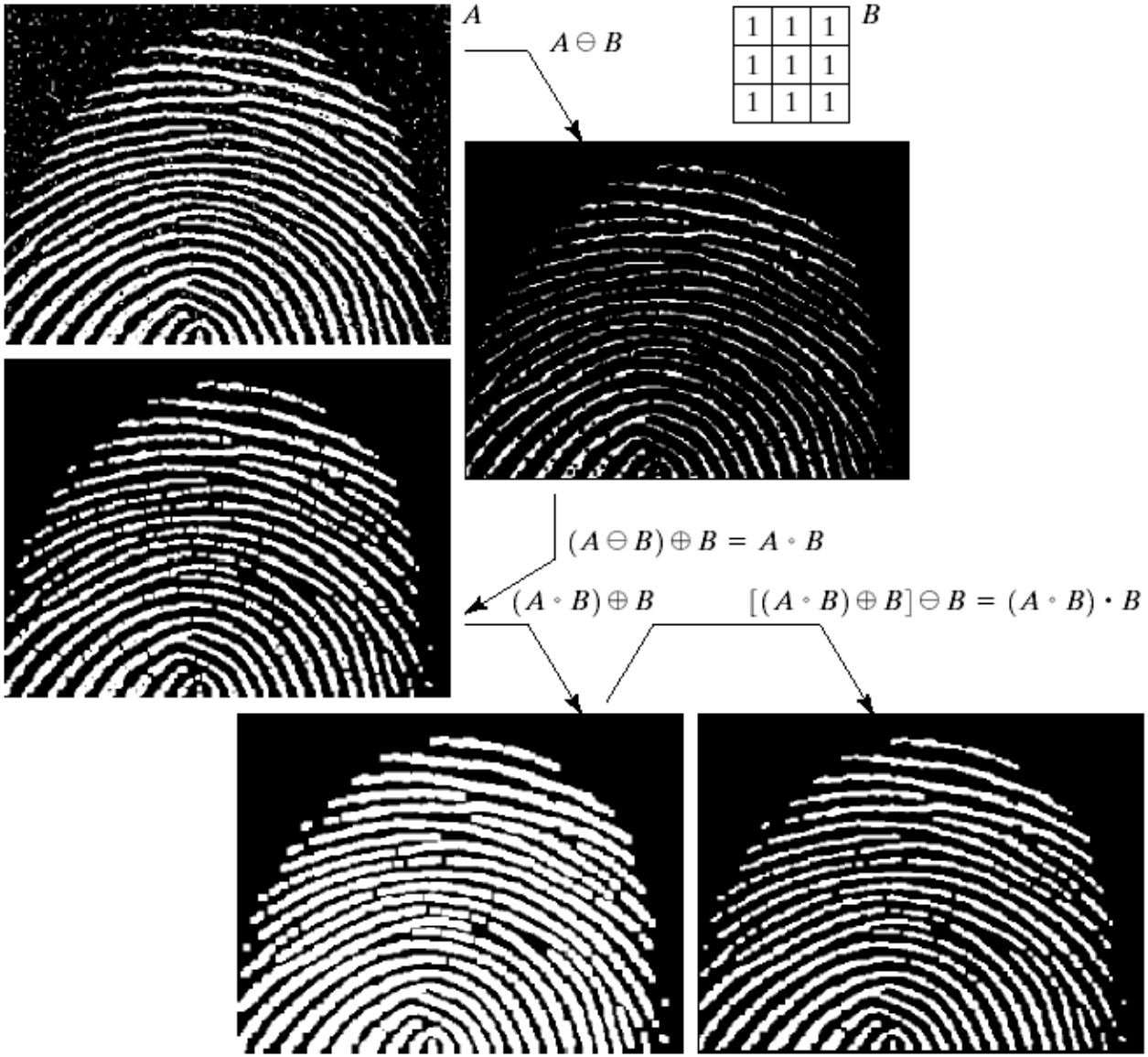
Processed Image





Structuring Element

Morphological Processing Example



Morphological Algorithms

Using the simple technique we have looked at so far we can begin to consider some more interesting morphological algorithms

We will look at:

- Boundary extraction
- Region filling

There are lots of others as well though:

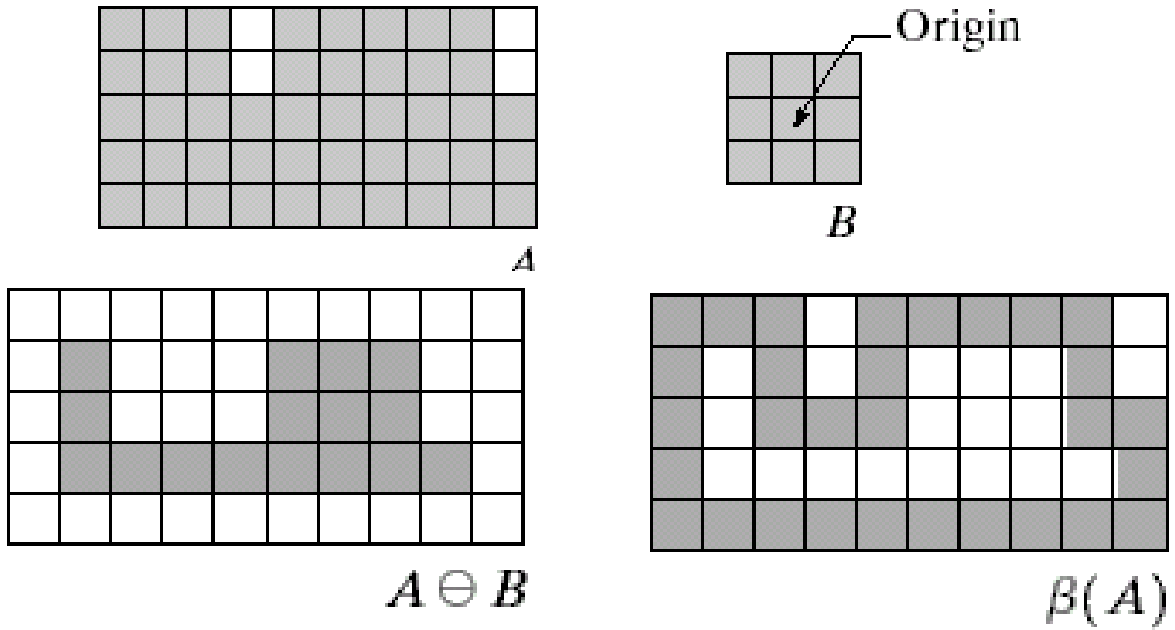
- Extraction of connected components
- Thinning/thickening
- Skeletonization

Boundary Extraction

Extracting the boundary (or outline) of an object is often extremely useful

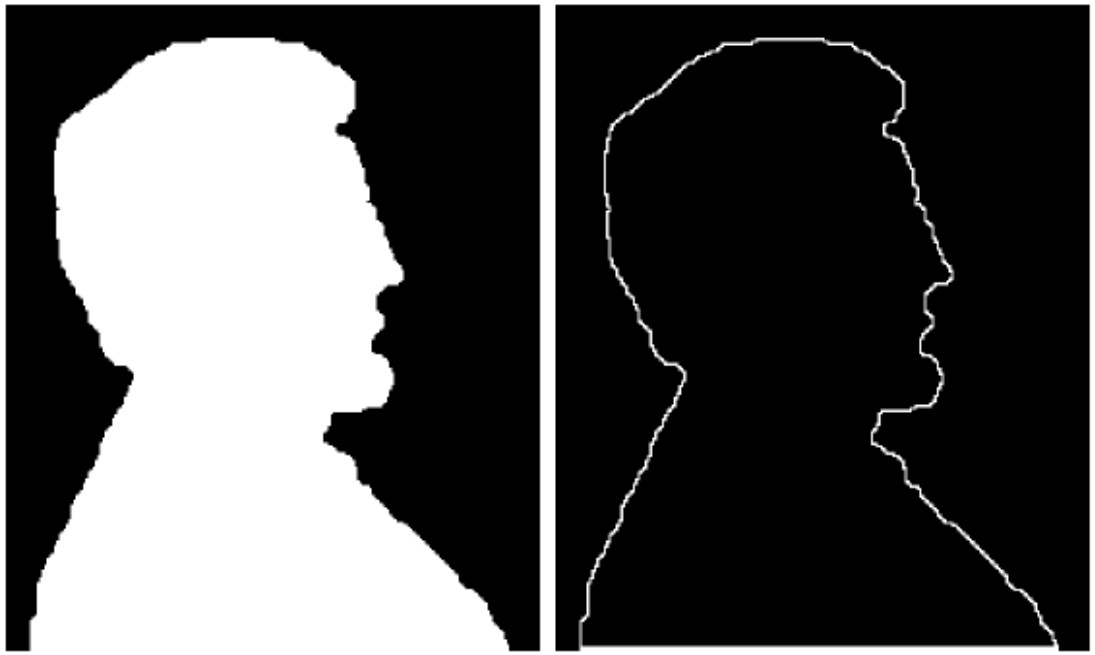
The boundary can be given simply as

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



Boundary Extraction Example

A simple image and the result of performing boundary extraction using a square 3*3 structuring element

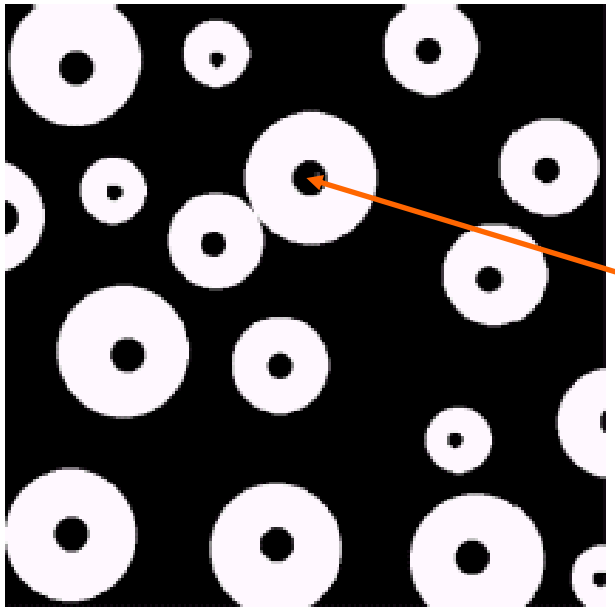


Original Image Extracted Boundary

Images taken from Gonzalez & Woods, Digital Image Processing (2002

Region Filling

Given a pixel inside a boundary, *region filling* attempts to fill that boundary with object pixels (1s)



Given a point inside here, can we fill the whole circle?

Images taken from Gonzalez & Woods, Digital Image Processing (2002

Region Filling (cont…)

The key equation for region filling is

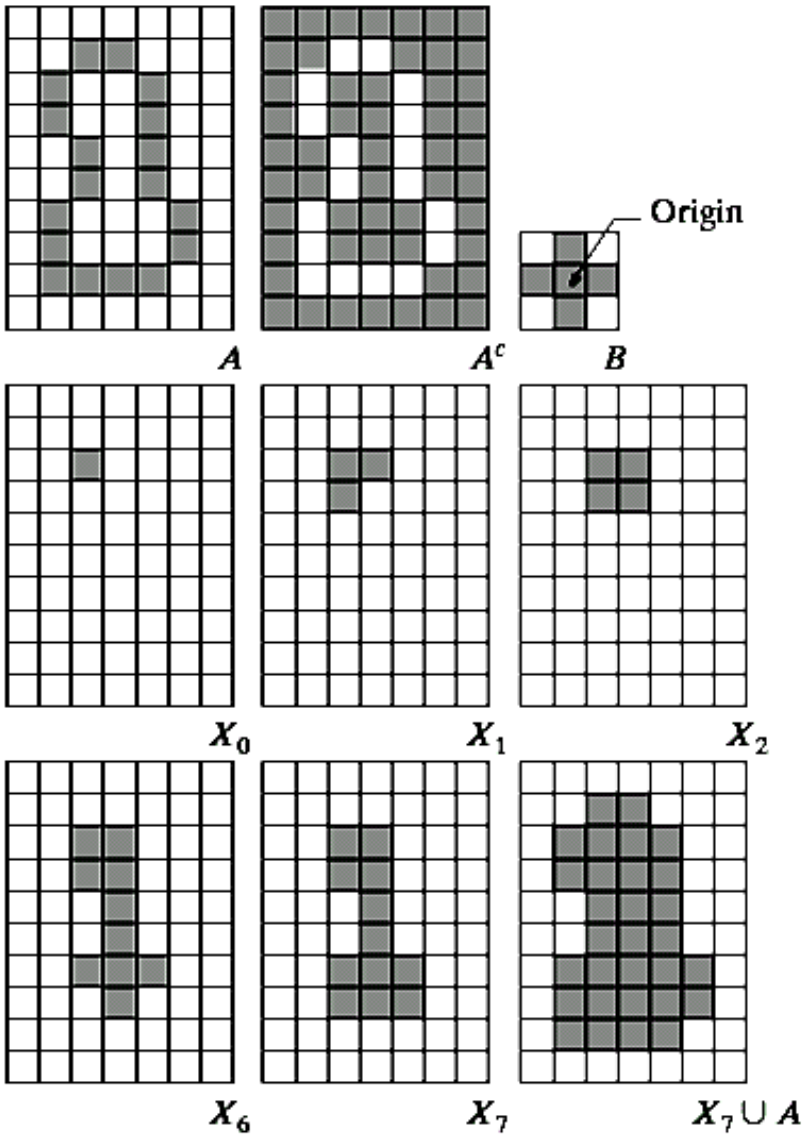
$$X_k = (X_{k-1} \oplus B) \cap A^c \qquad k = 1,2,3.....$$

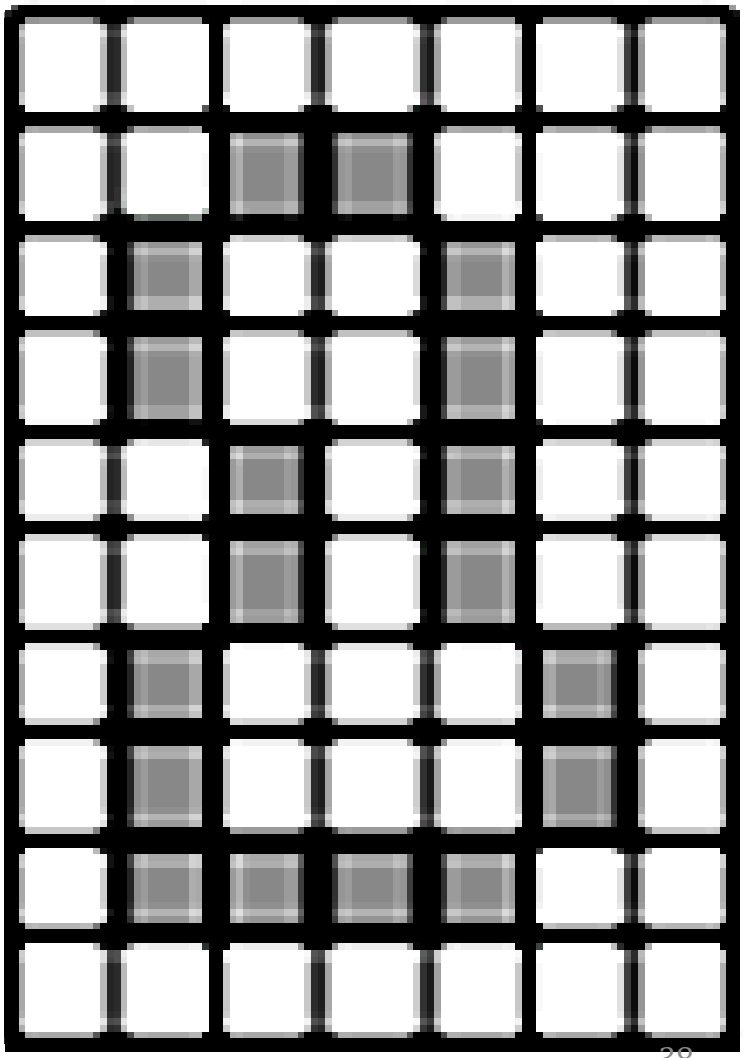
Where X_0 is simply the starting point inside the boundary, B is a simple structuring element and A^c is the complement of A

This equation is applied repeatedly until X_k is equal to X_{k-1}

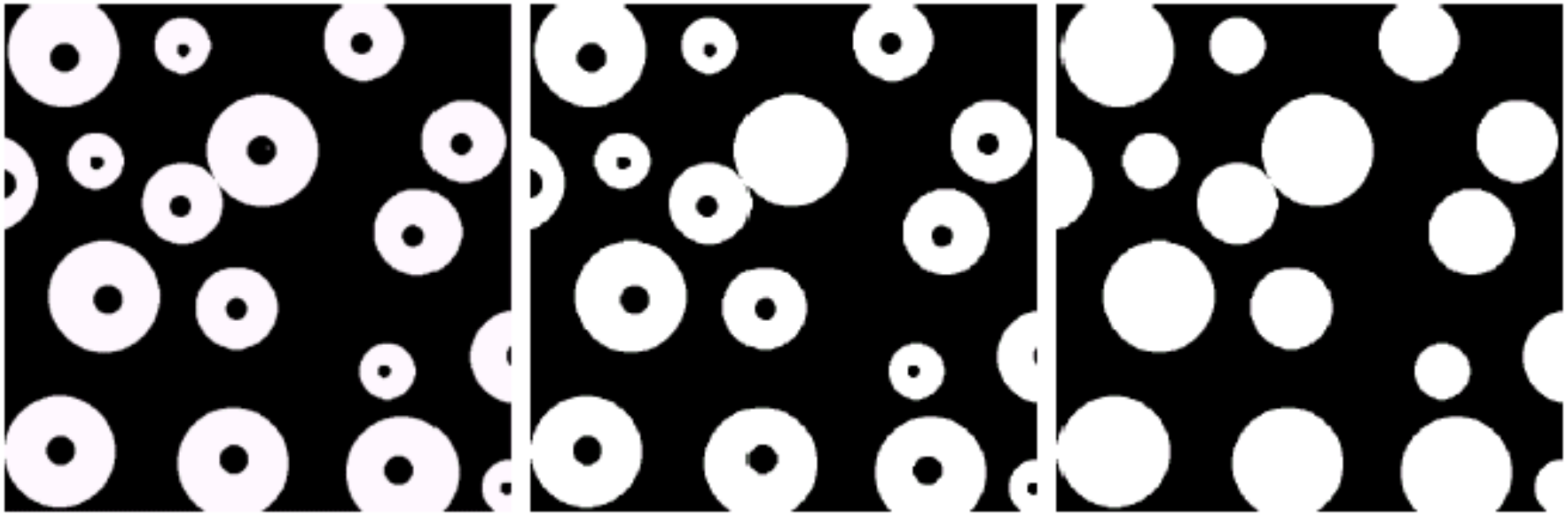
Finally the result is unioned with the original boundary

Region Filling Step By Step





Region Filling Example



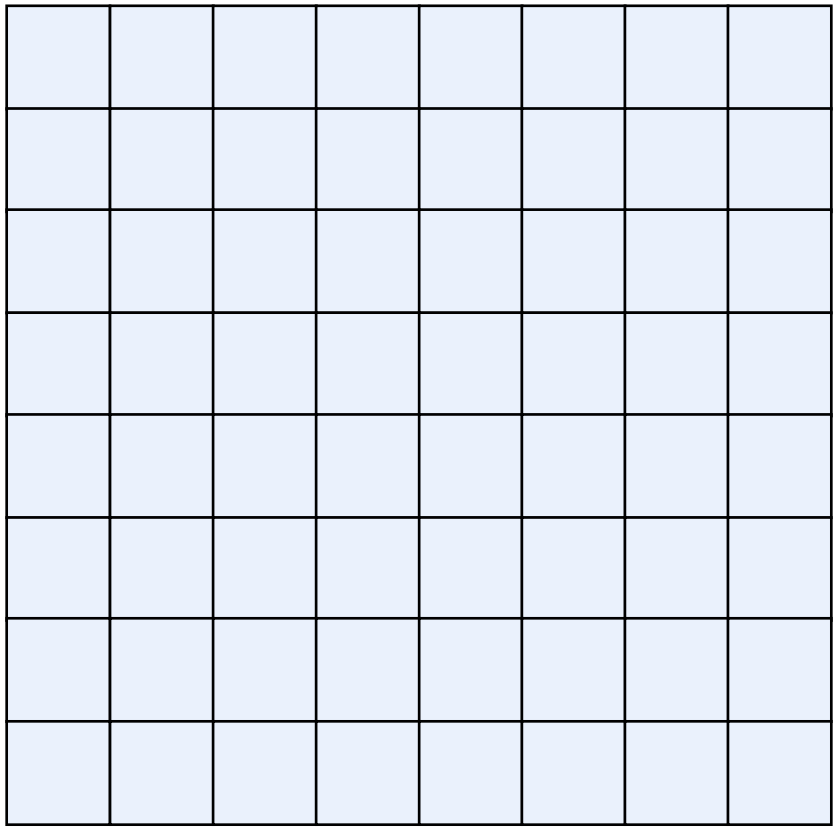
Original Image

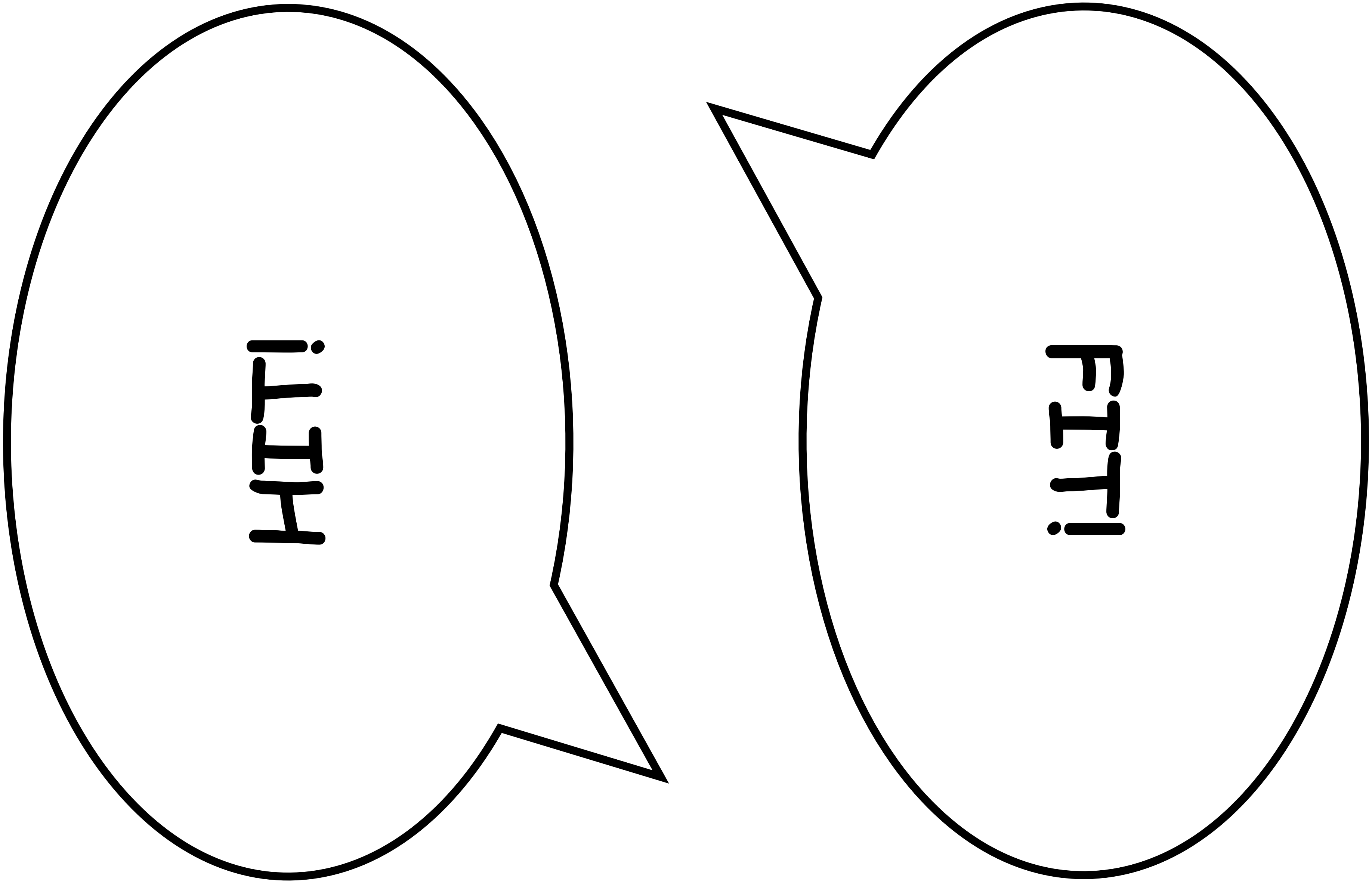
One Region Filled

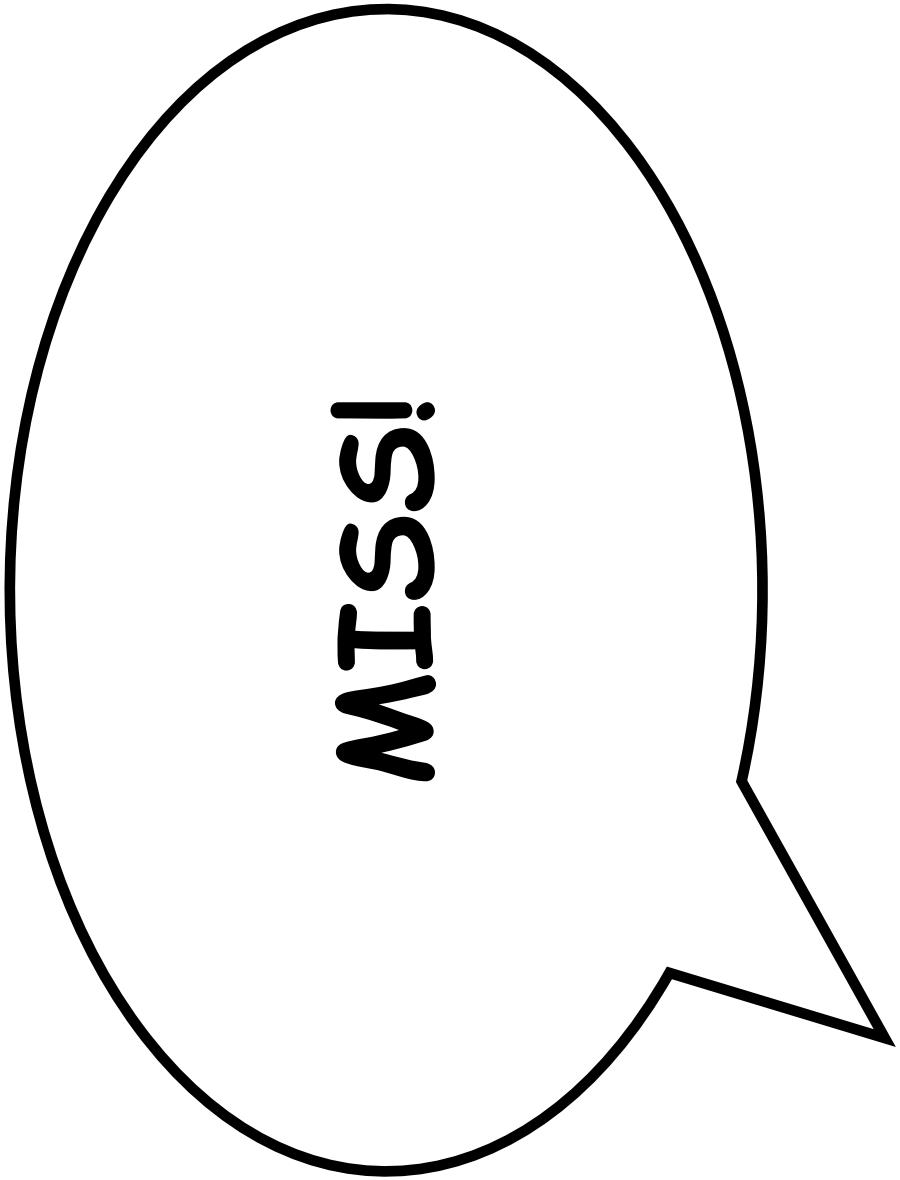
All Regions Filled

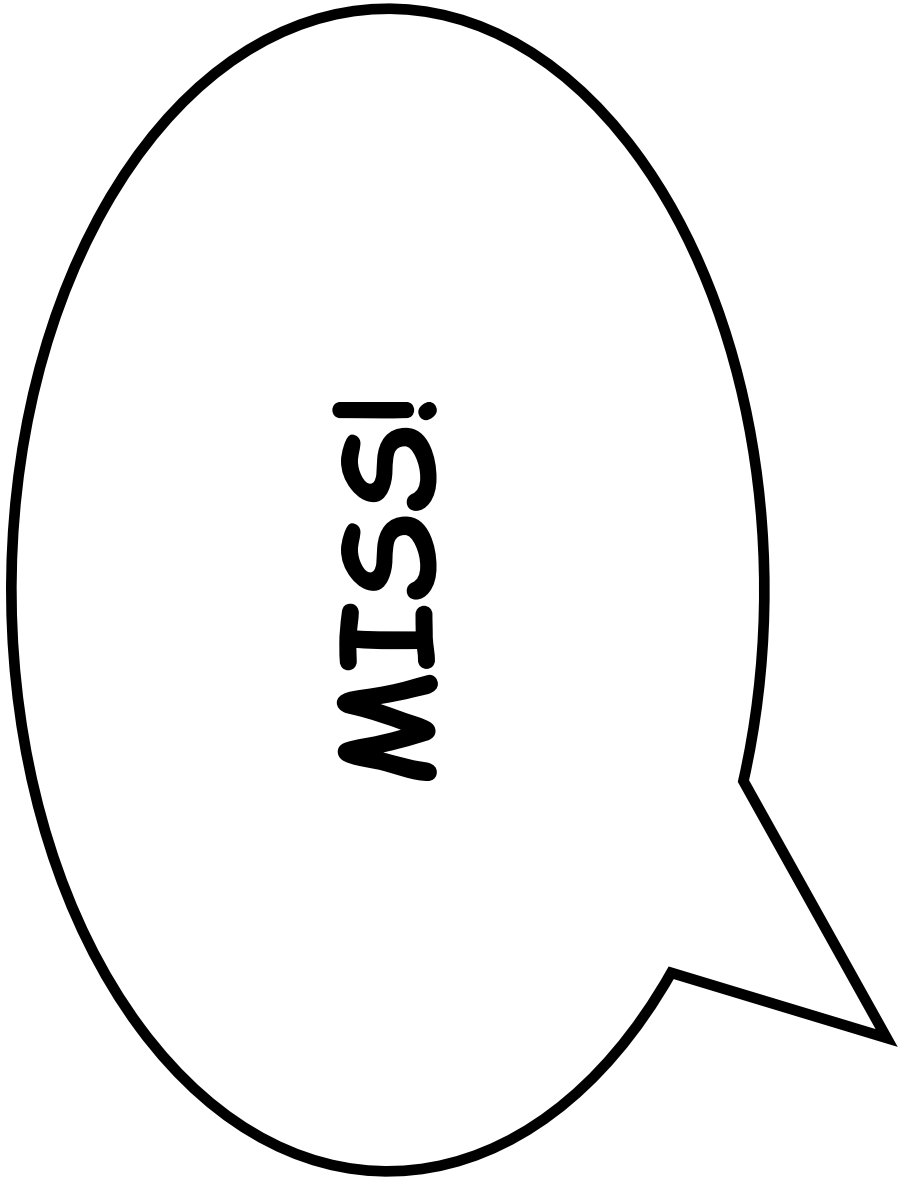
Images taken from Gonzalez & Woods, Digital Image Processing (2002

Structuring Elements, Hits & Fits

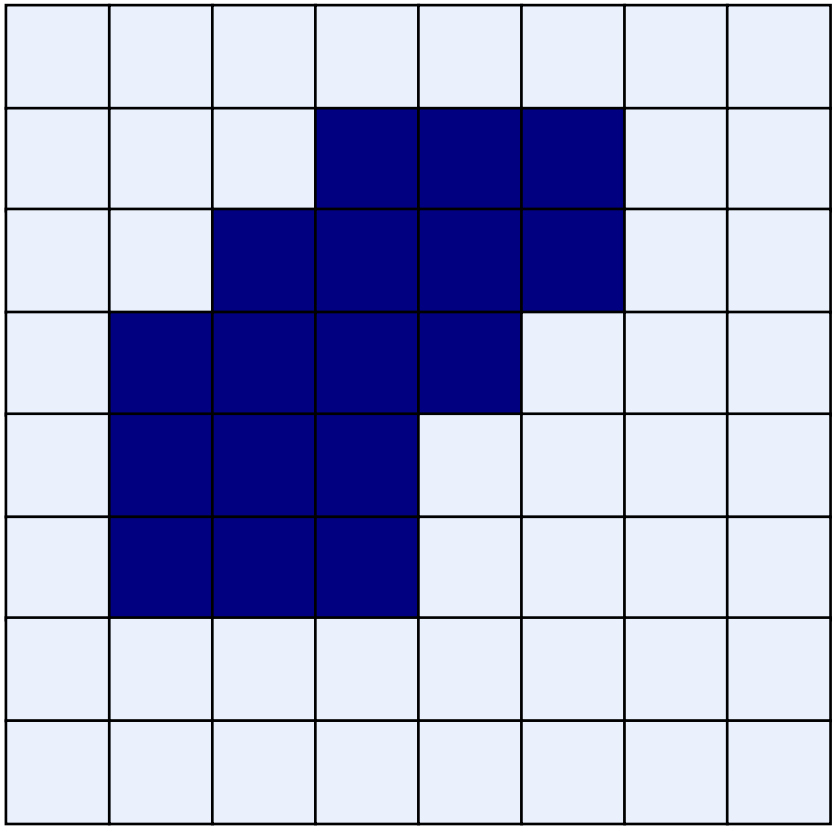


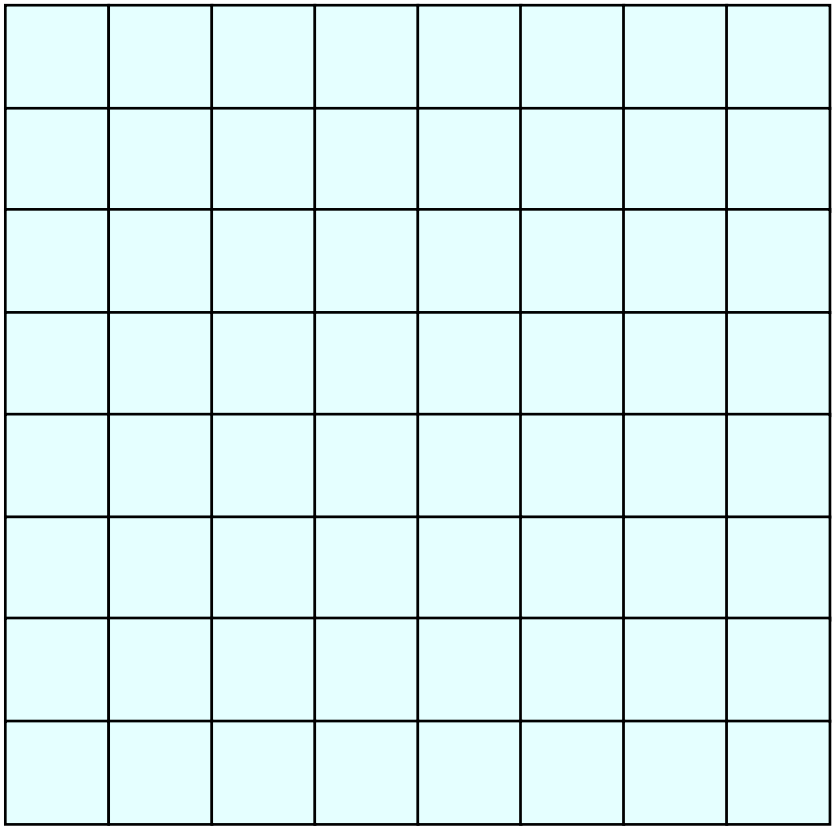

HIT!
FIT!

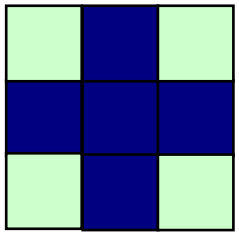

MISS!


MISS!

Erosion Example

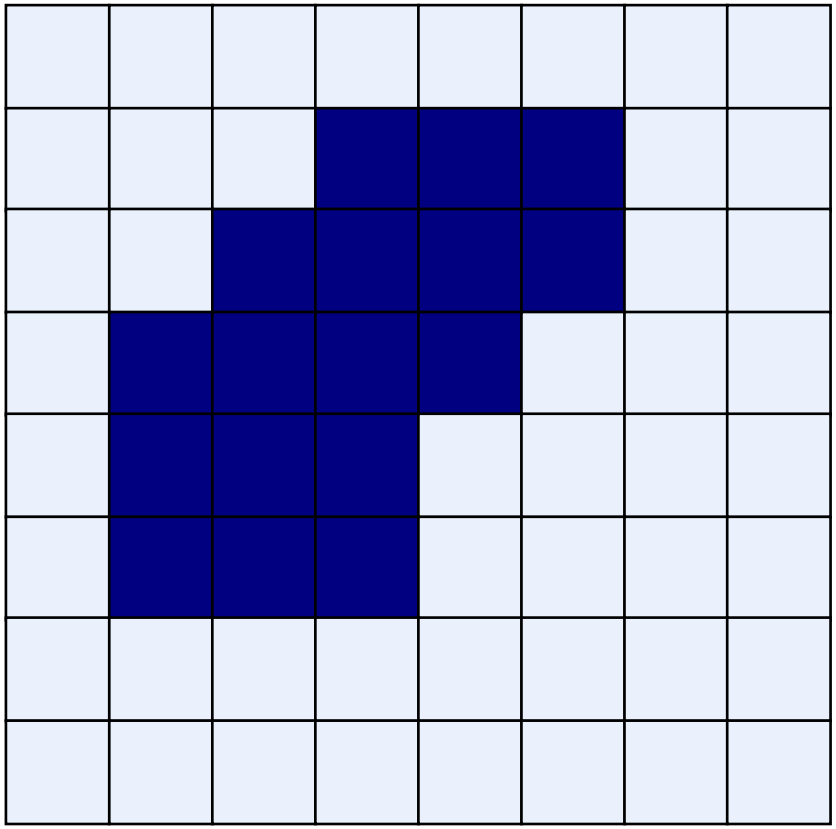


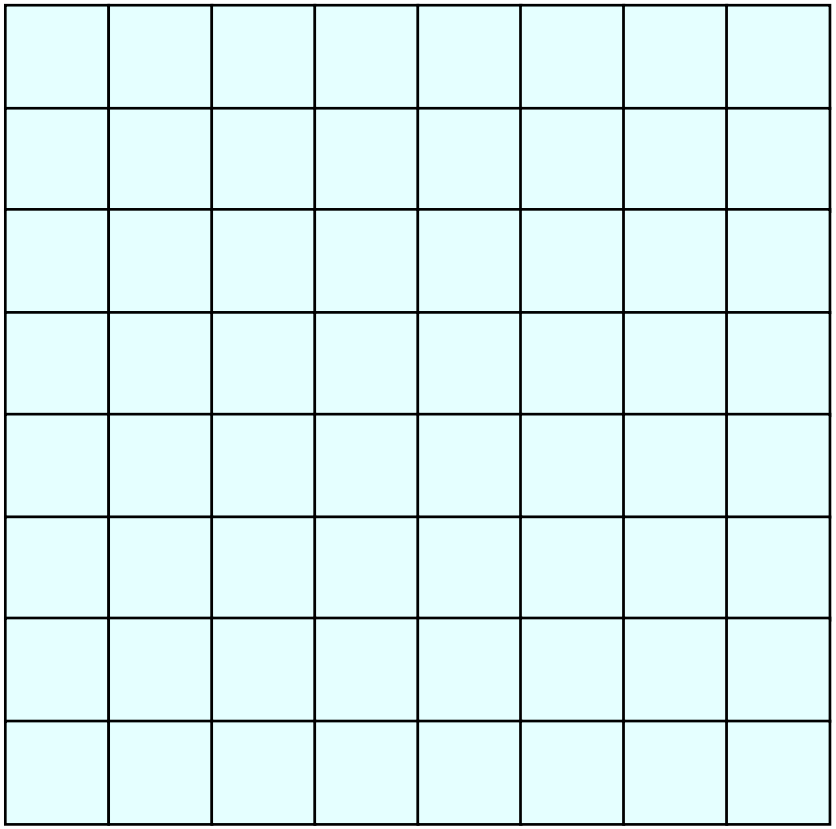


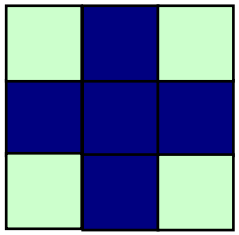


Structuring Element

Dilation Example



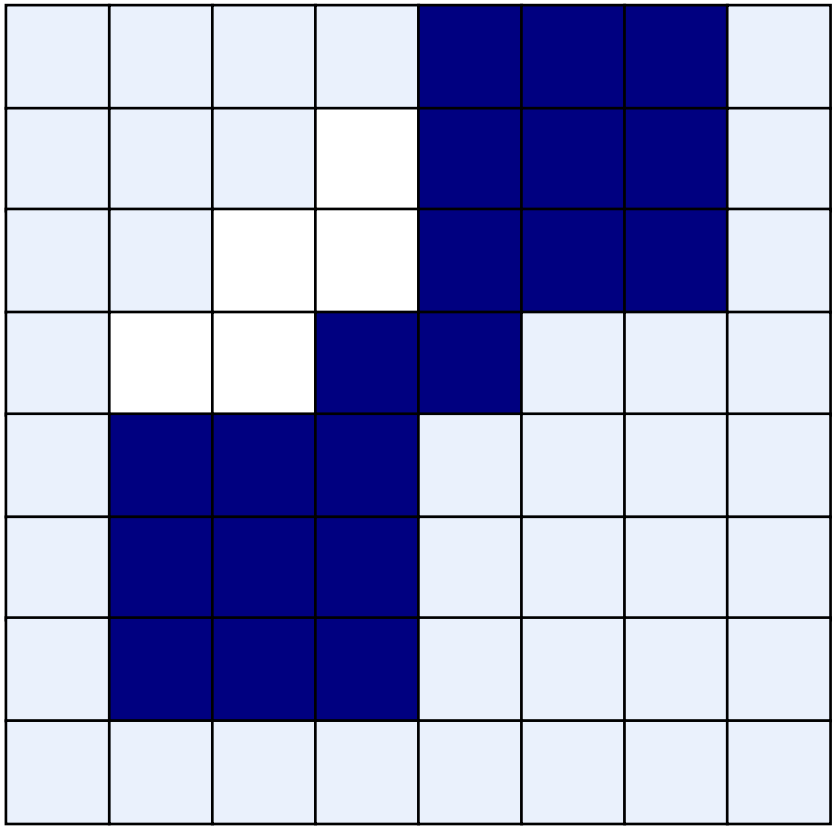




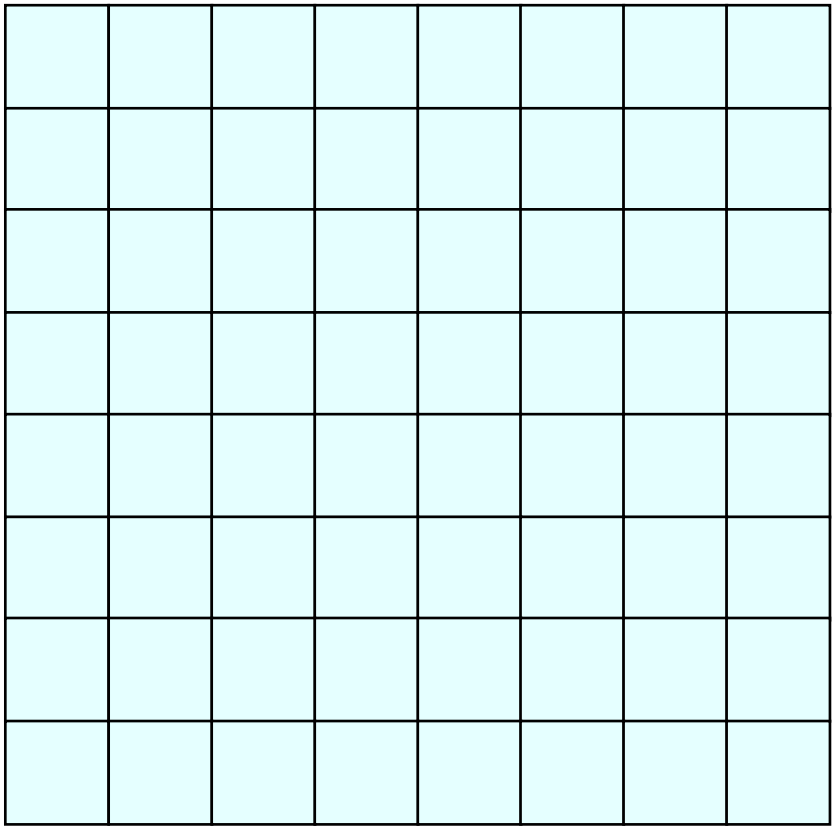
Structuring Element

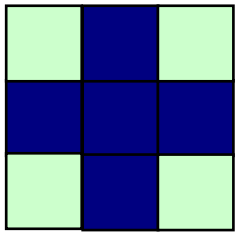
Opening Example

Original Image



Processed Image

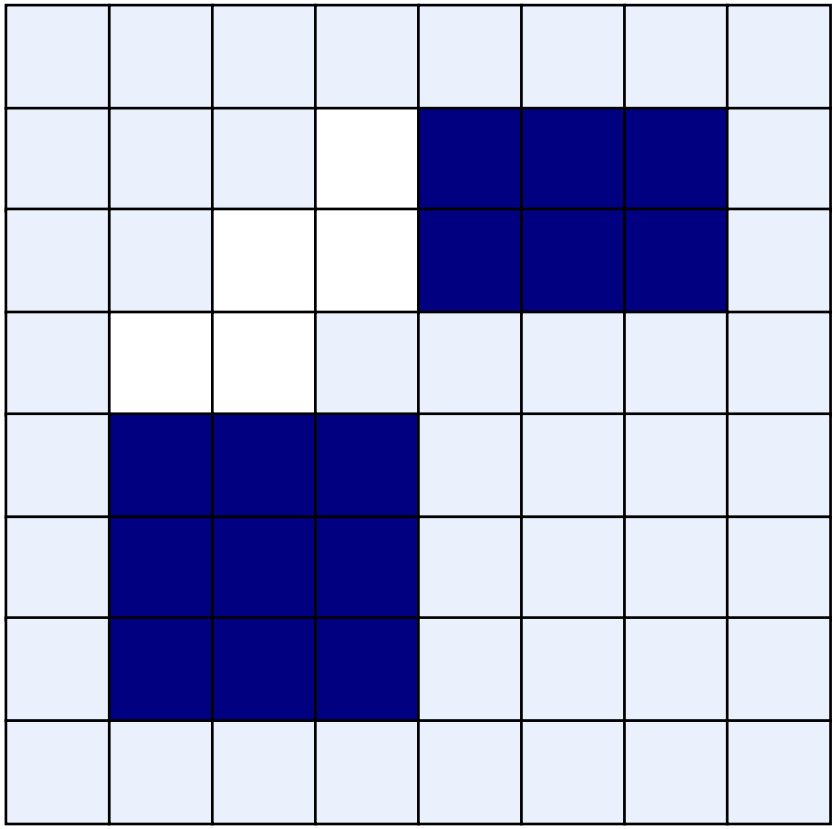




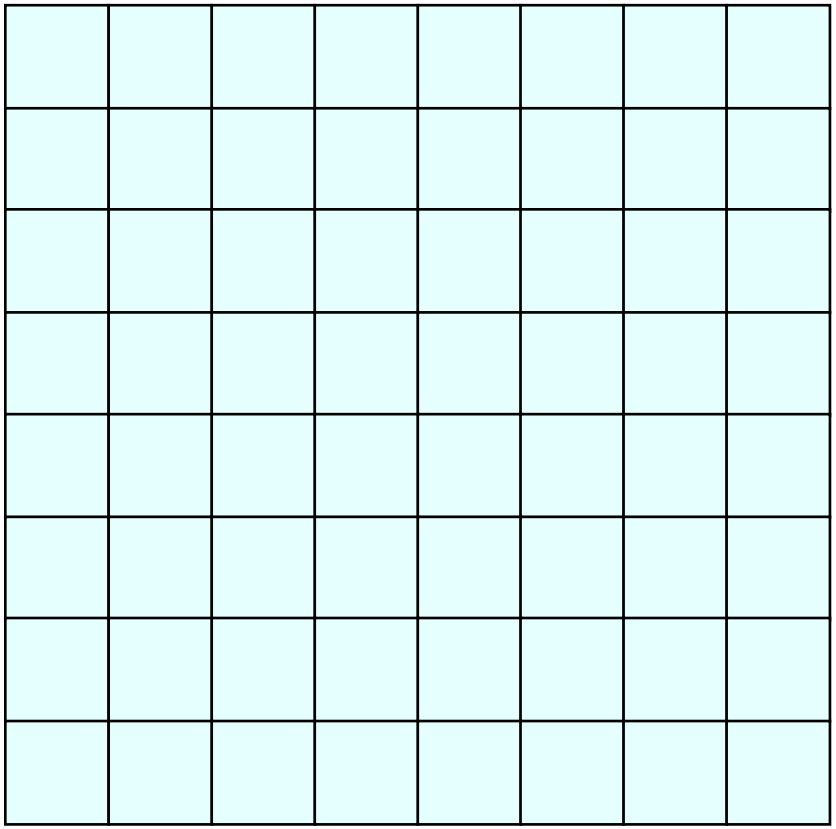
Structuring Element

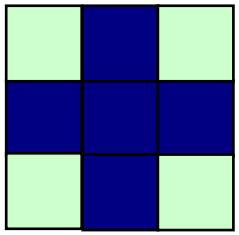
Closing Example

Original Image



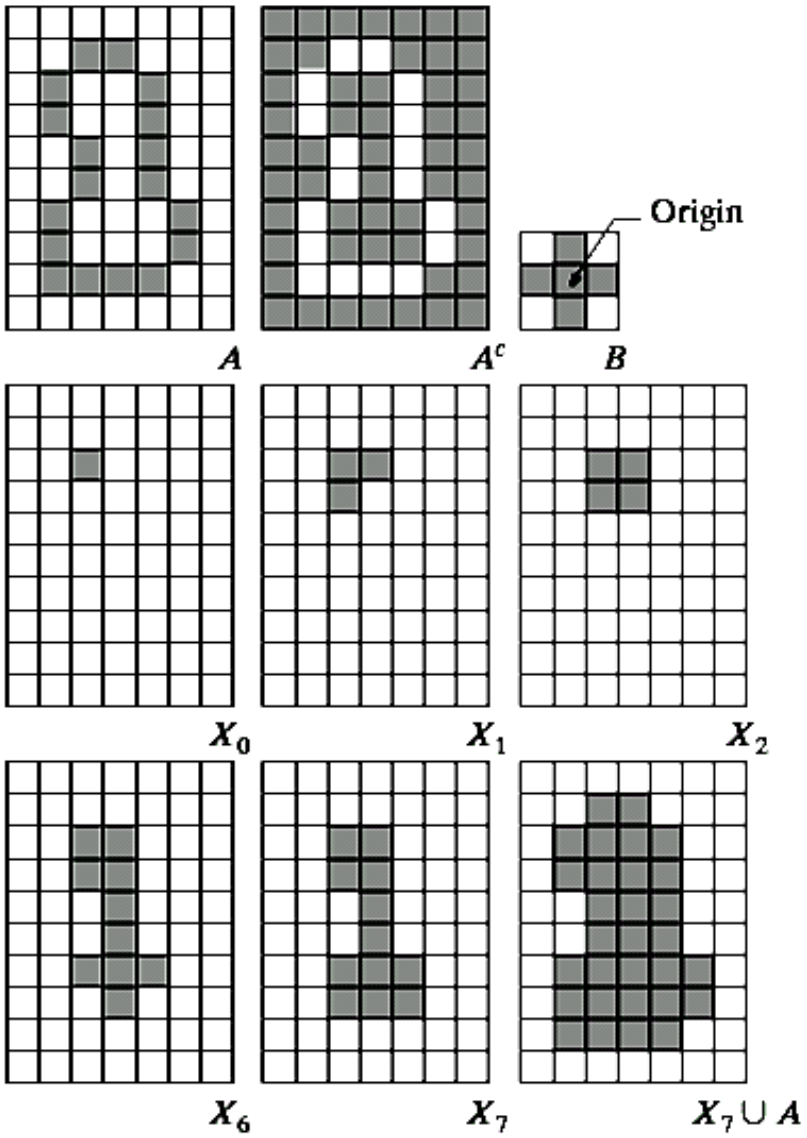
Processed Image

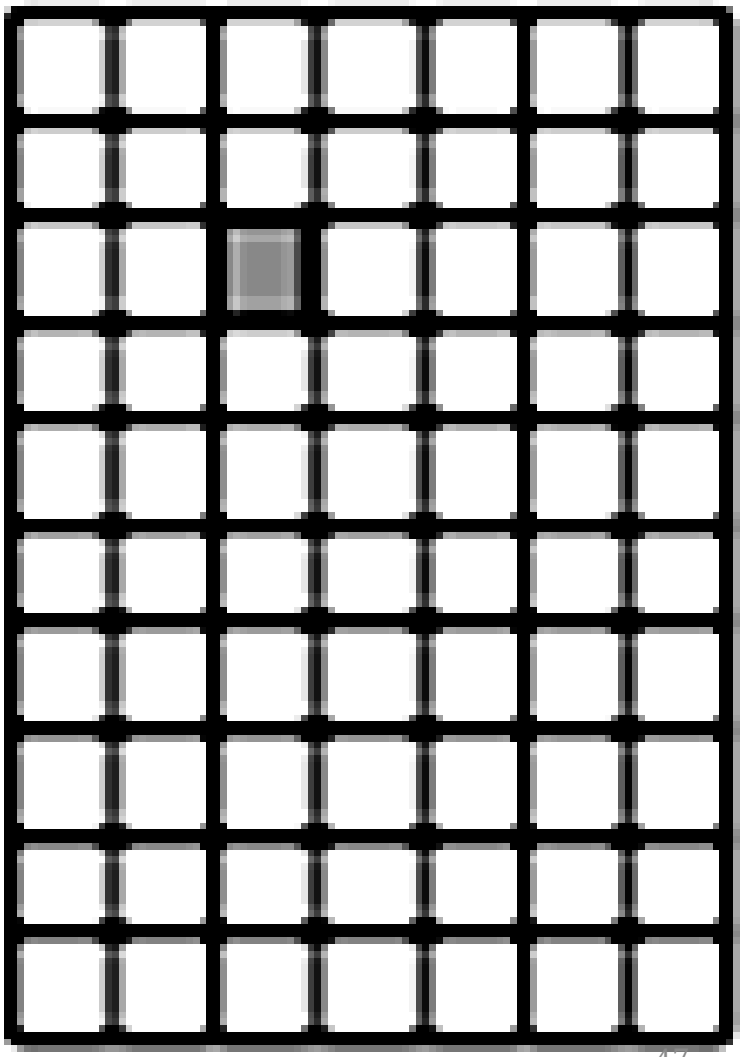




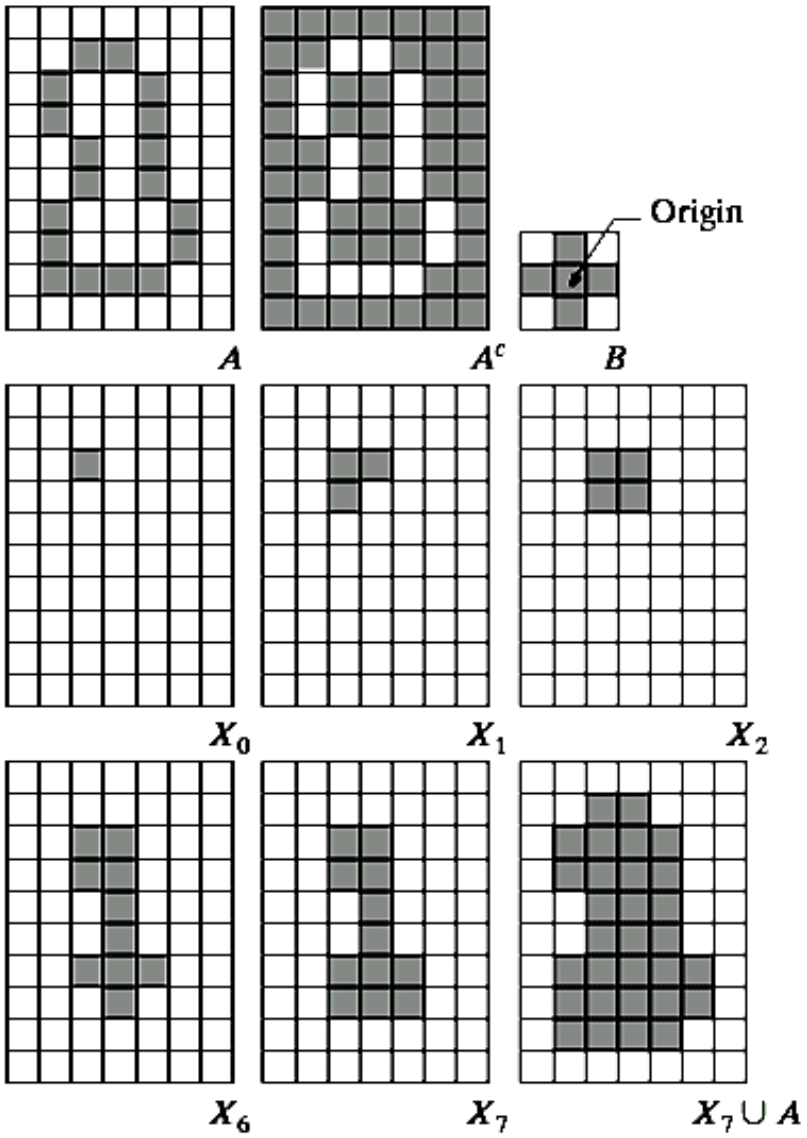
Structuring Element

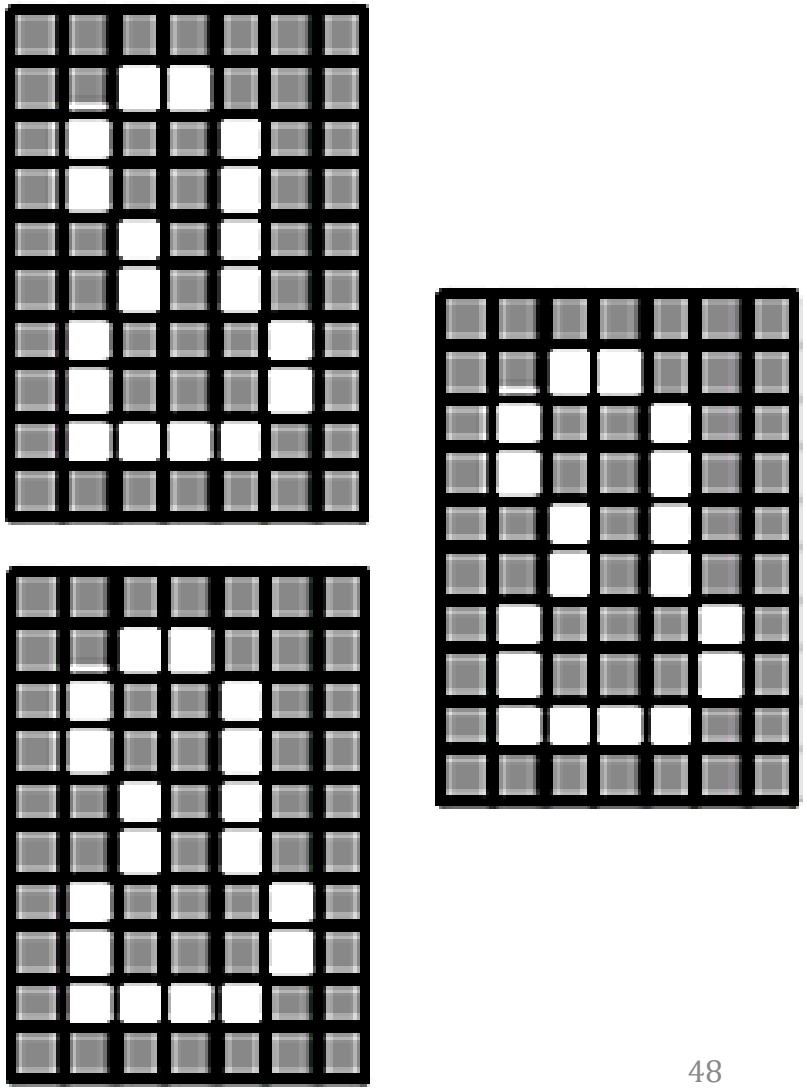
Region Filling Step By Step





Region Filling Step By Step





Summary

The purpose of morphological processing is primarily to remove imperfections added during segmentation

The basic operations are *erosion* and *dilation*

Using the basic operations we can perform *opening* and *closing*

More advanced morphological operation can then be implemented using combinations of all of these