

Image Processing and Pattern Recognition (IPPR)

Chapter 6: Introduction to Morphological Image Processing

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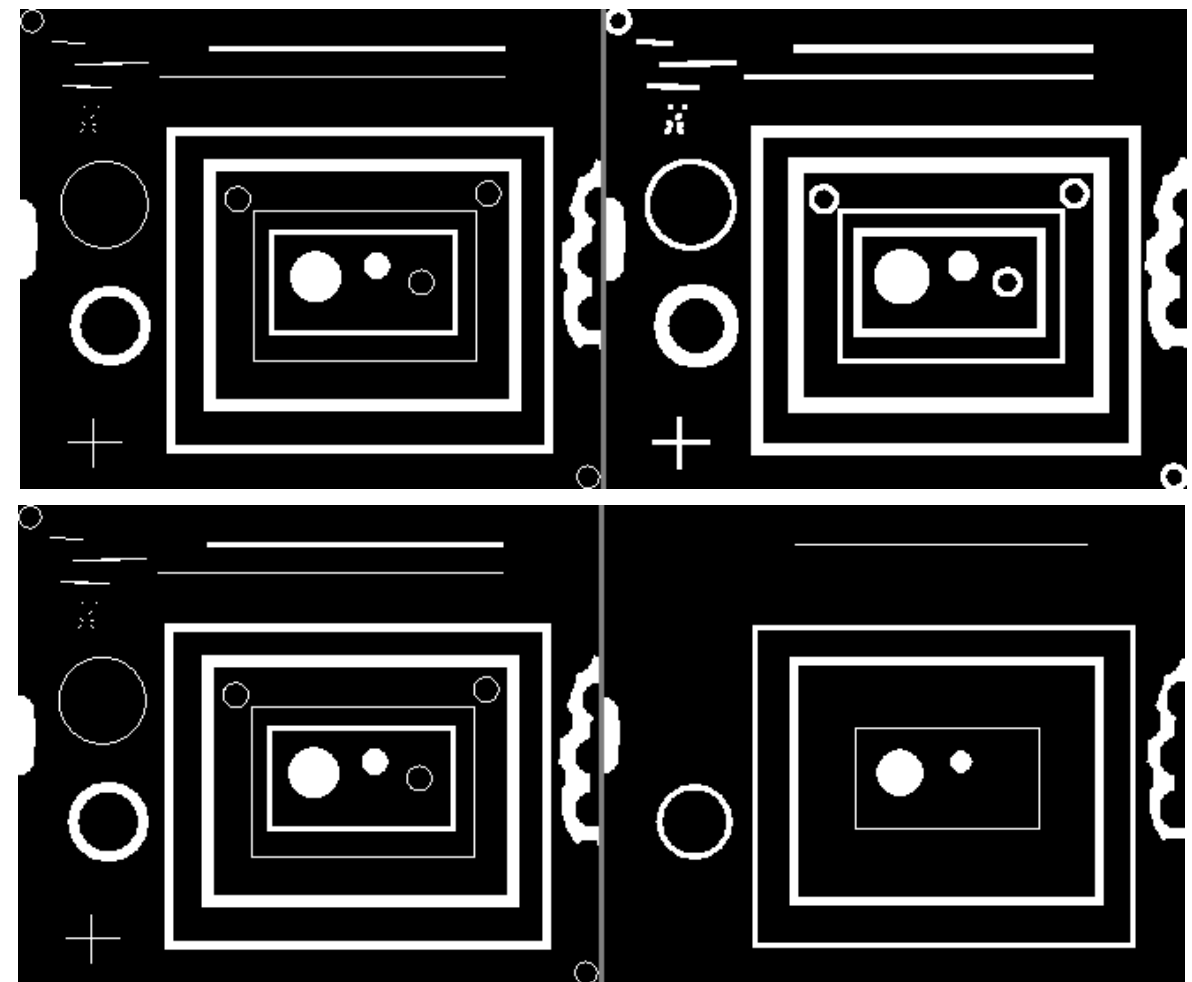
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<http://www.basantajoshi.com.np>

<https://scholar.google.com/citations?user=iocLiGcAAAAJ>

https://www.researchgate.net/profile/Basanta_Joshi2



<https://www.mathworks.com/help/images/morphological-dilation-and-erosion.html>



Contents

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

In this lecture we will consider

- What is morphology?
- Simple morphological operations
- Compound operations
- Morphological algorithms



1, 0, Black, White?

Throughout all of the following slides whether 0 and 1 refer to white or black is a little interchangeable

All of the discussion that follows assumes segmentation has already taken place and that images are made up of 0s for background pixels and 1s for object pixels

After this it doesn't matter if 0 is black, white, yellow, green.....



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

Quick Example

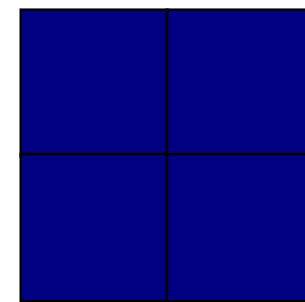
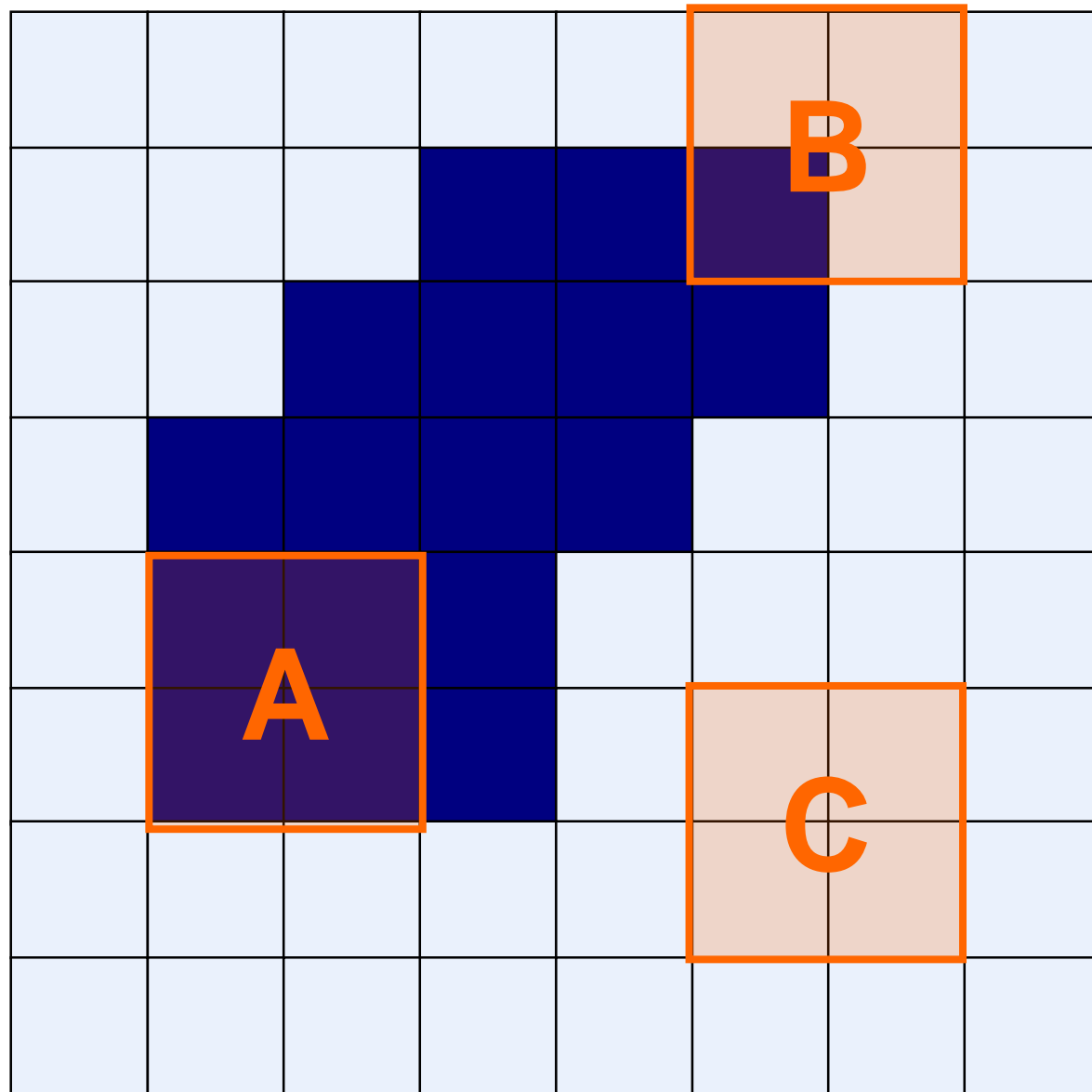


Image after segmentation



Image after segmentation and
morphological processing

Structuring Elements, Hits & Fits



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



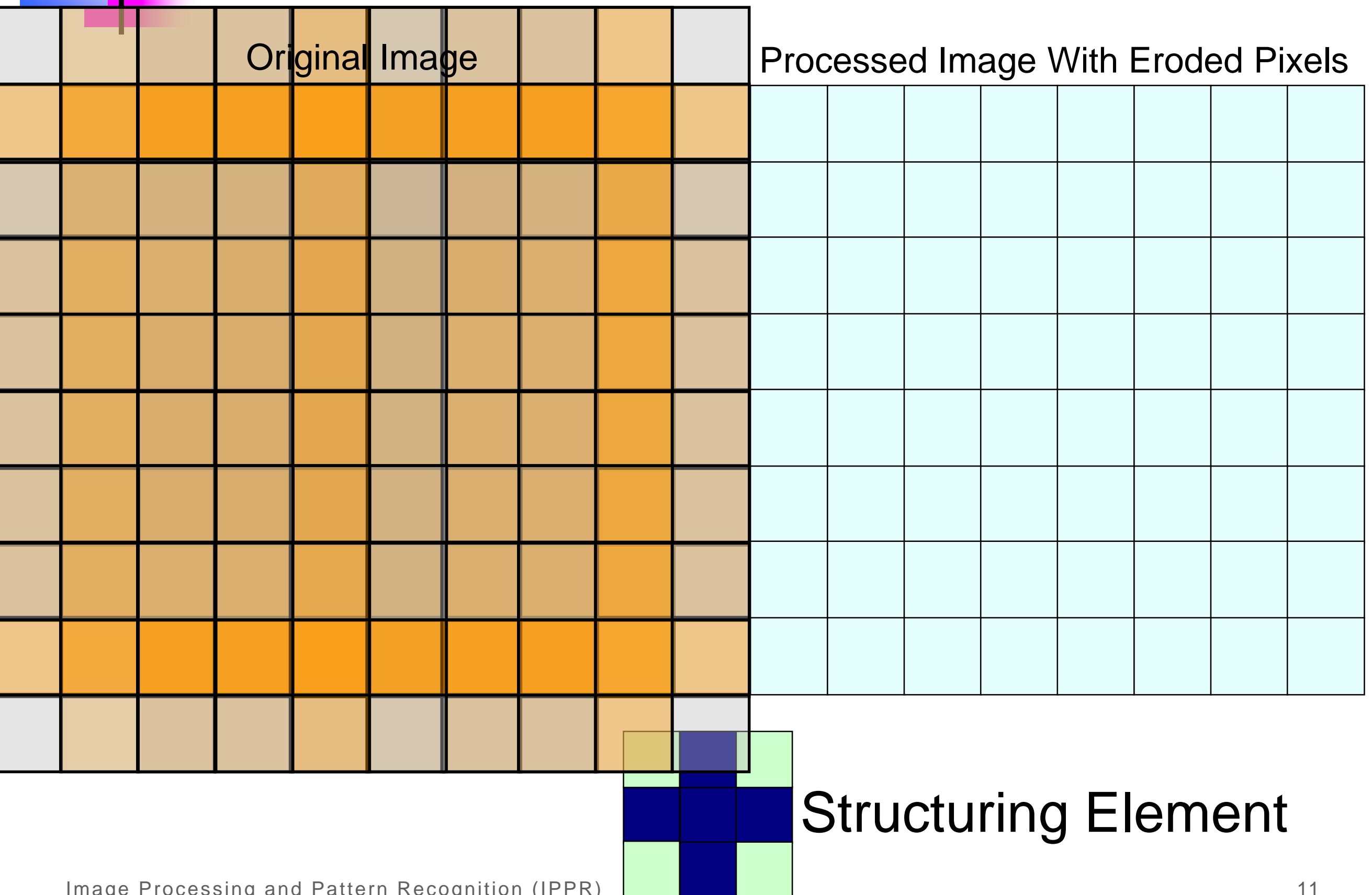
Erosion

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:

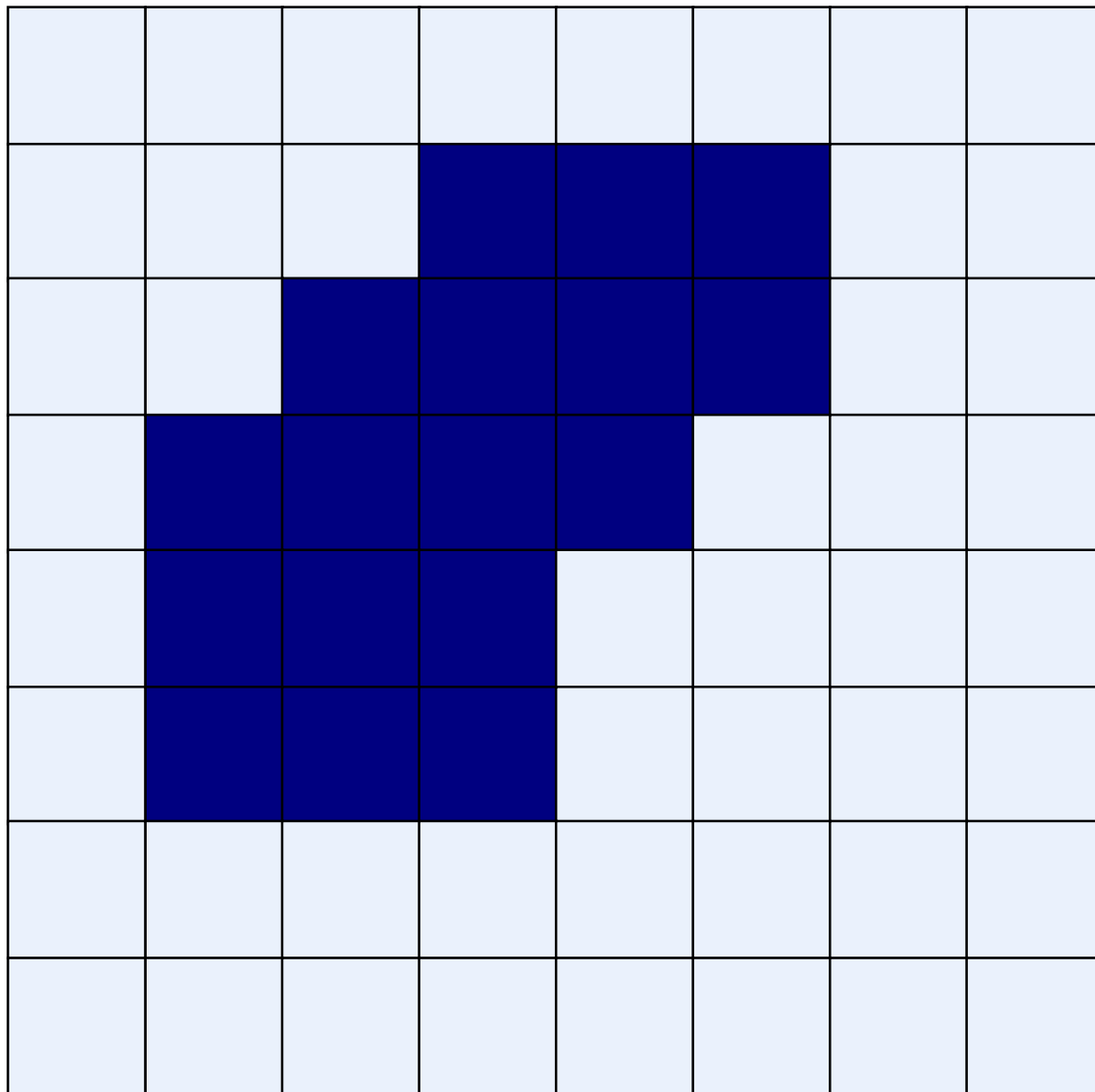
$$g(x, y) = \begin{cases} 1 & \text{if } s \text{ fits } f \\ 0 & \text{otherwise} \end{cases}$$

Erosion Example

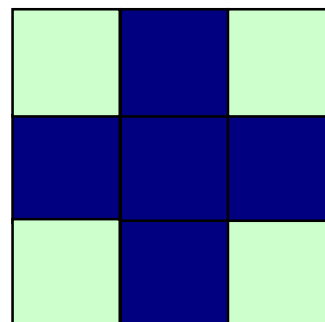
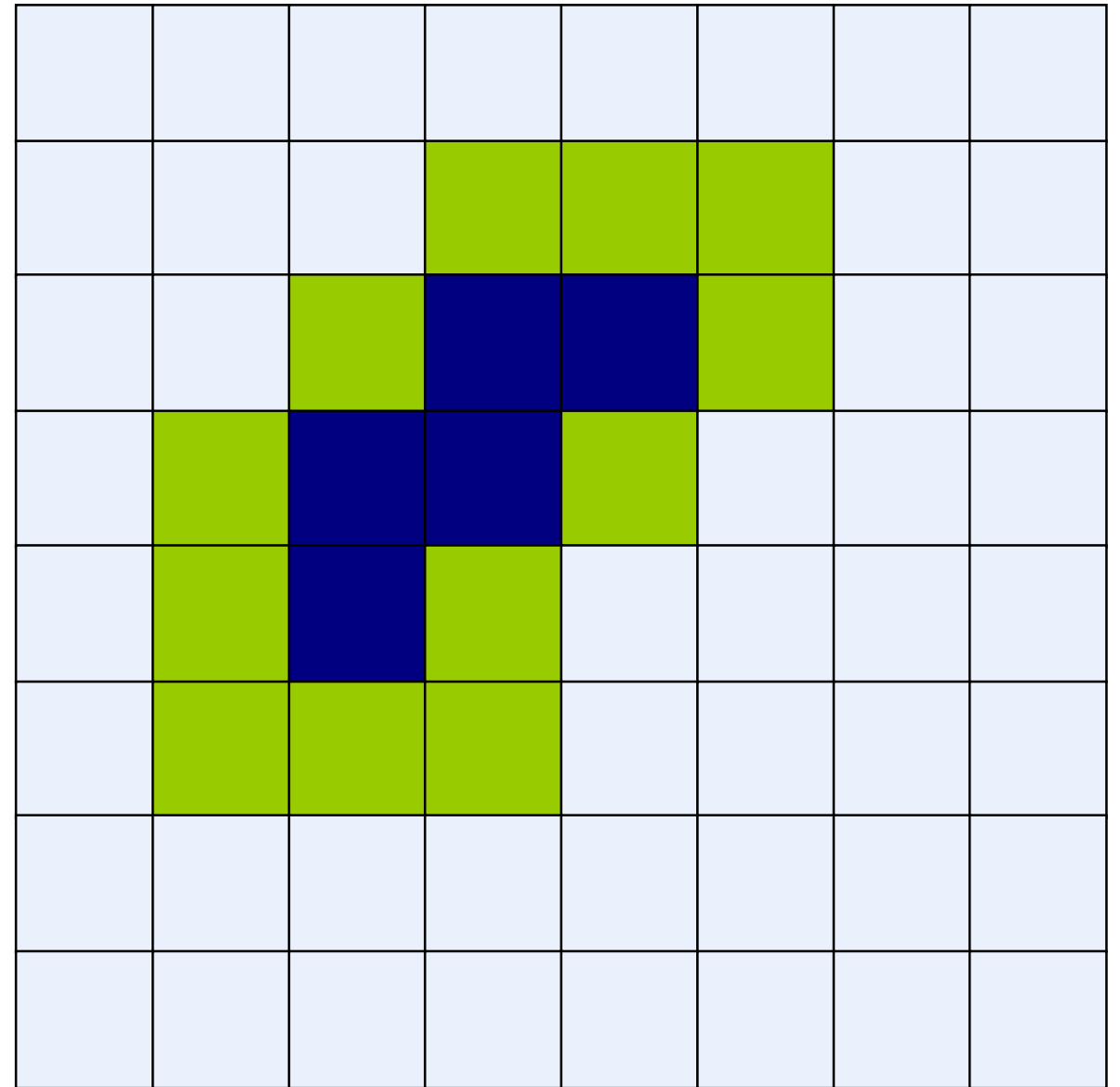


Erosion Example

Original Image



Processed Image

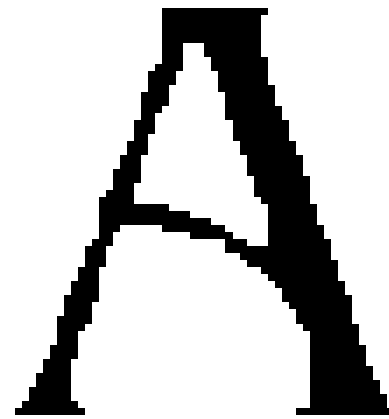


Structuring Element

Erosion Example 1



Original image



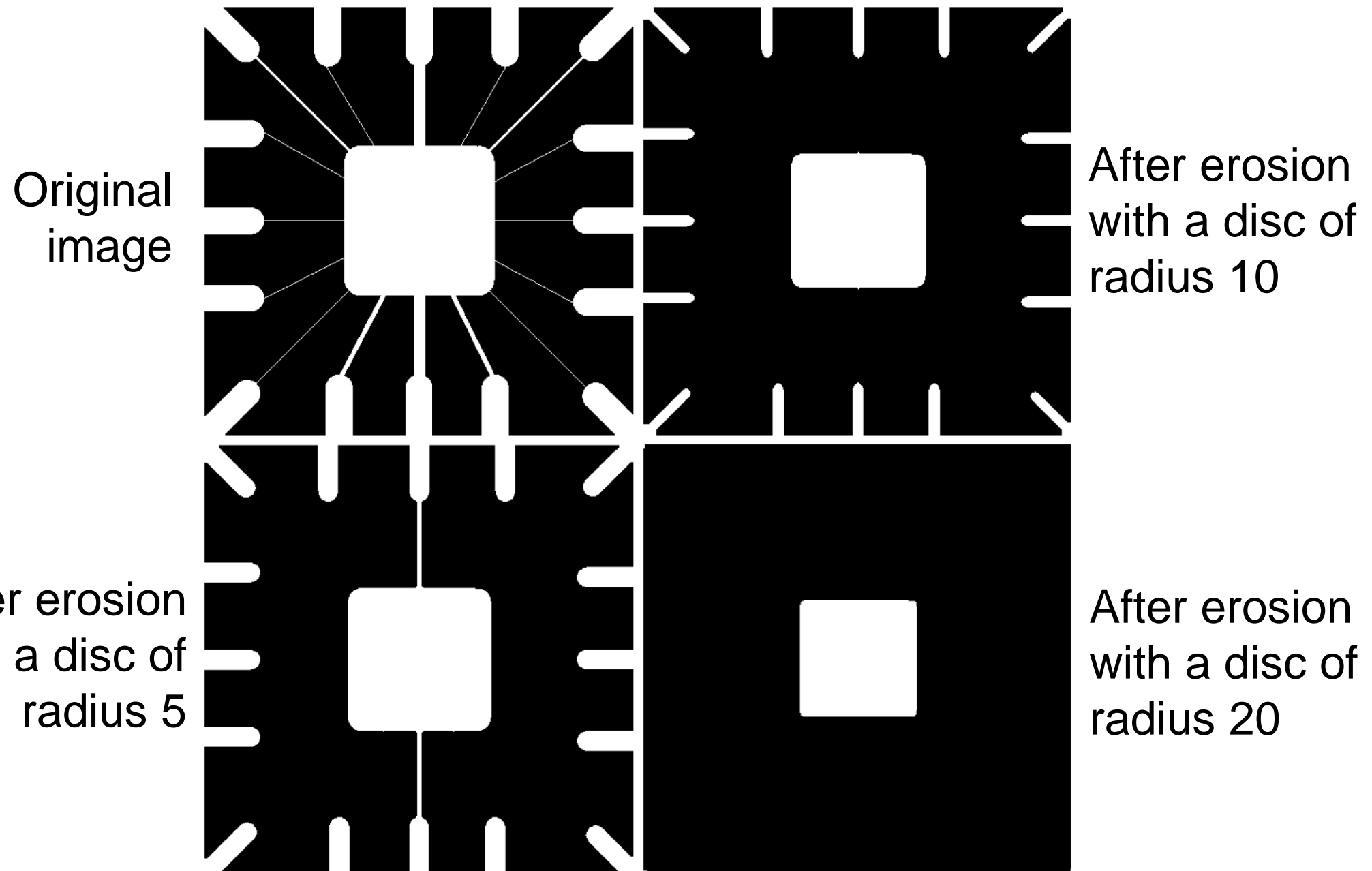
Erosion by 3*3
square structuring
element



Erosion by 5*5
square structuring
element

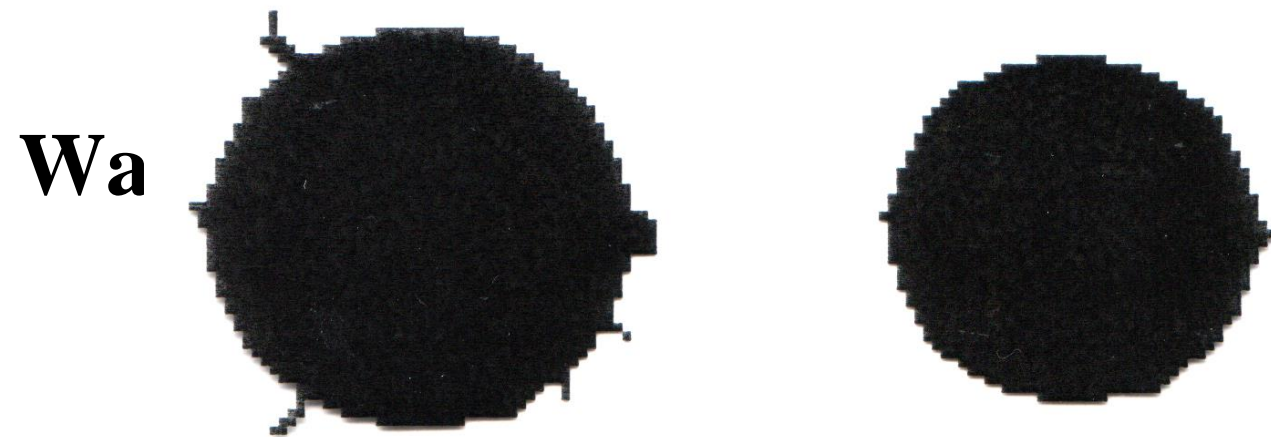
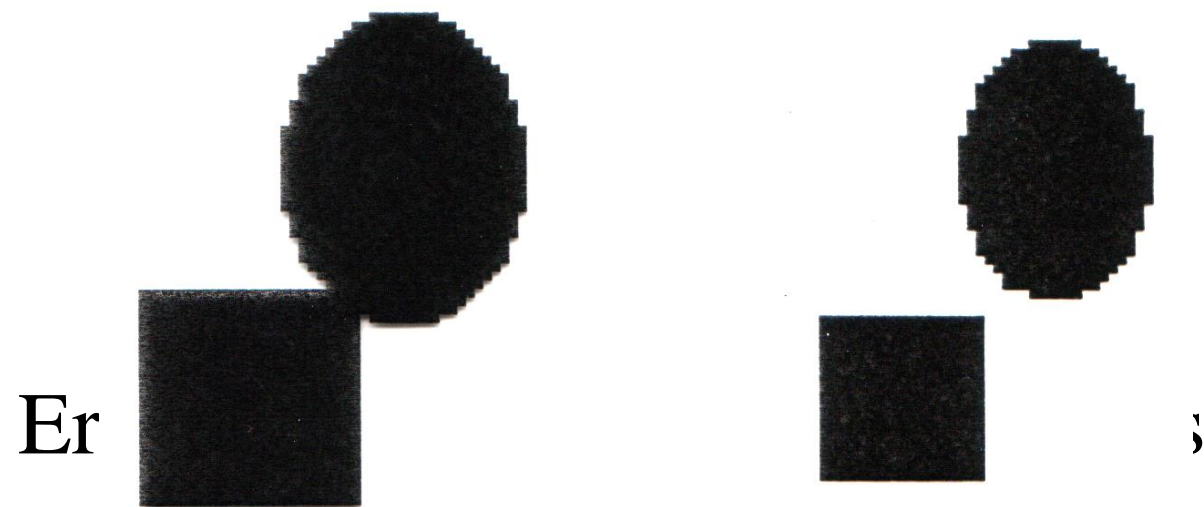
Watch out: In these examples a 1 refers to a black pixel!

Erosion Example 2



What Is Erosion For?

Erosion can split apart joined objects





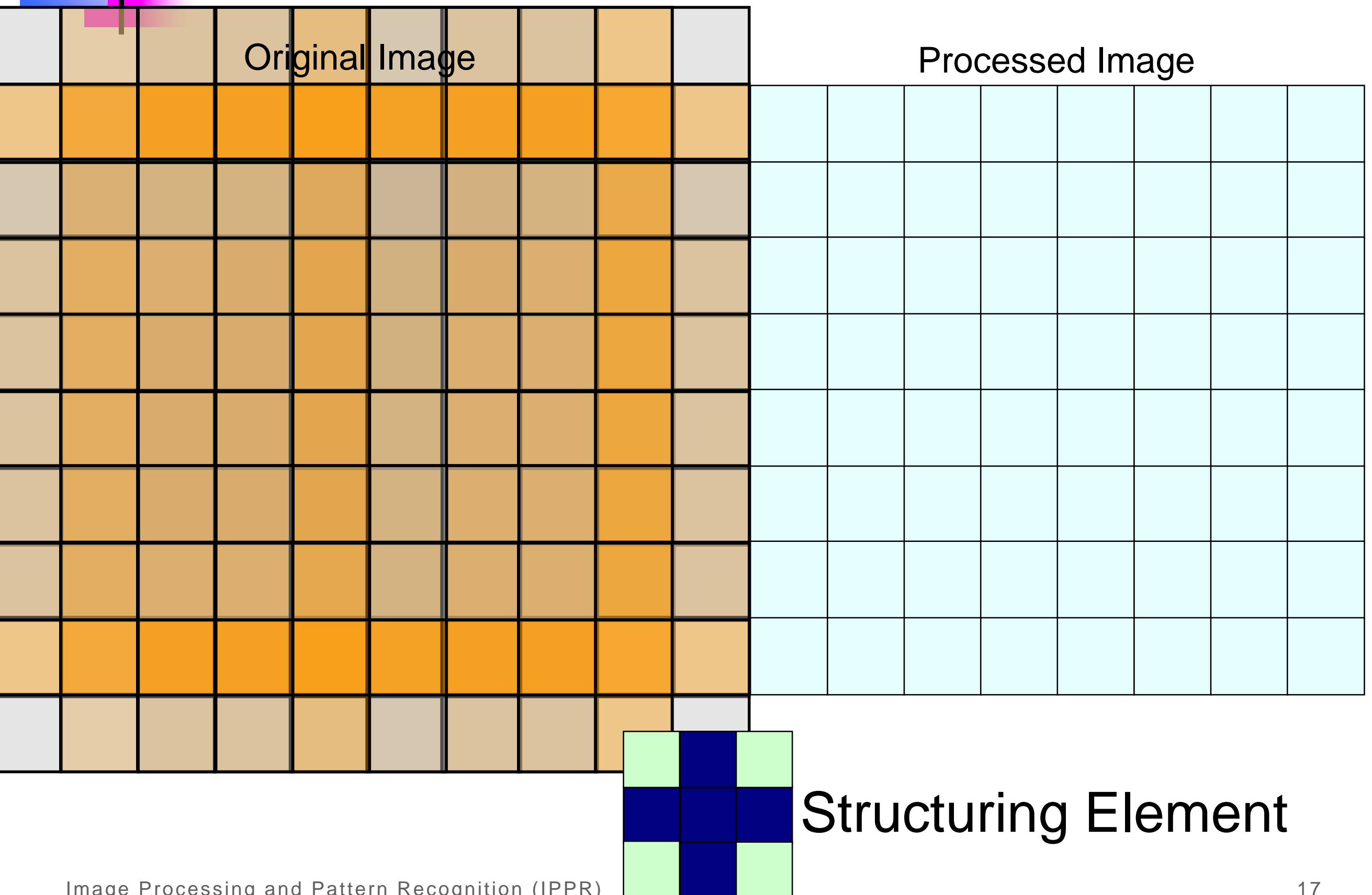
Dilation

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:

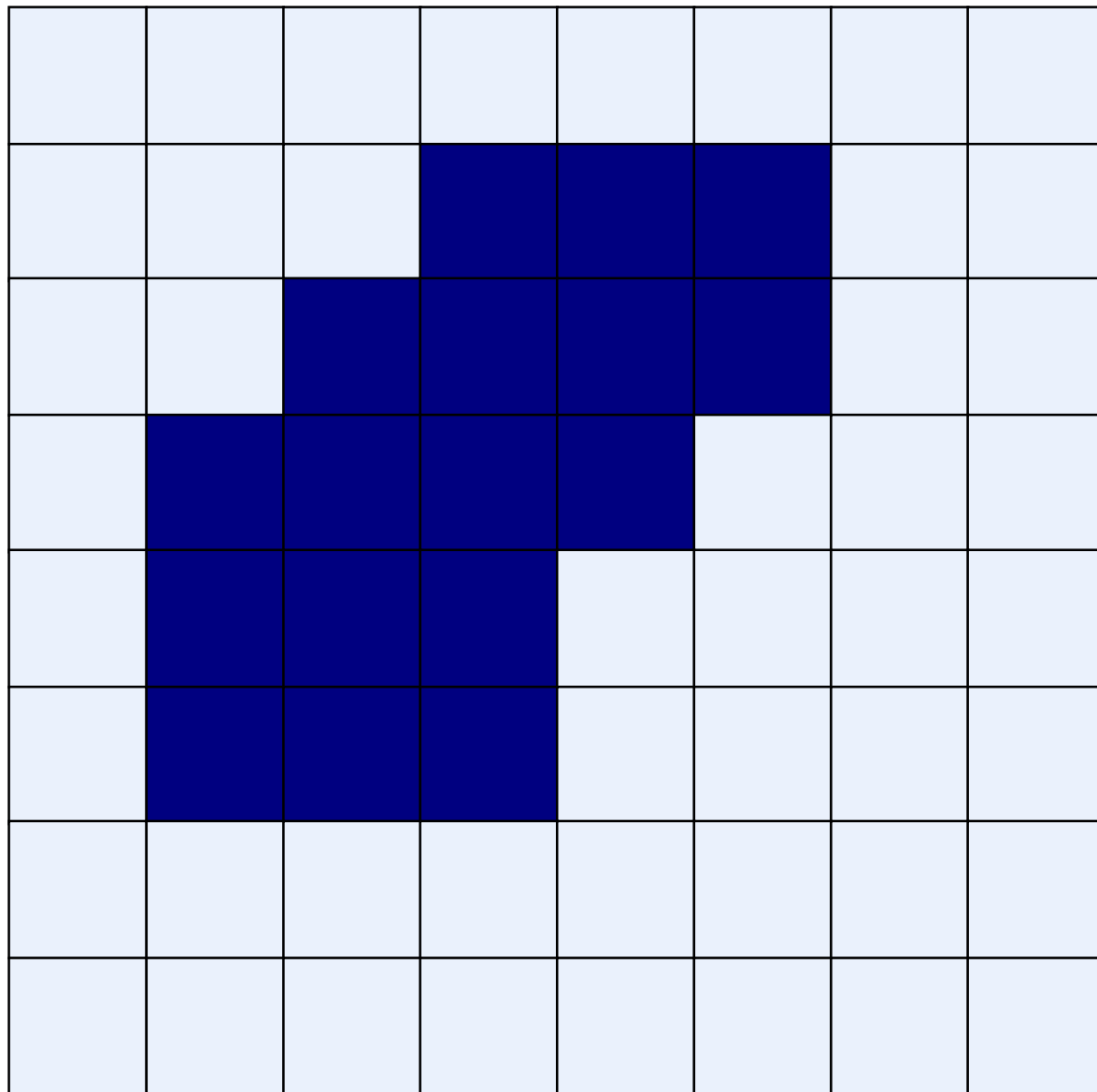
$$g(x, y) = \begin{cases} 1 & \text{if } s \text{ hits } f \\ 0 & \text{otherwise} \end{cases}$$

Dilation Example

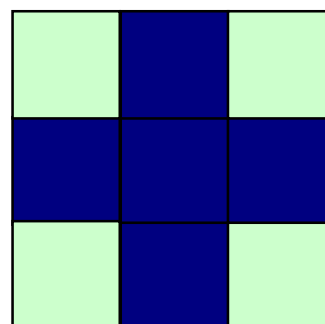
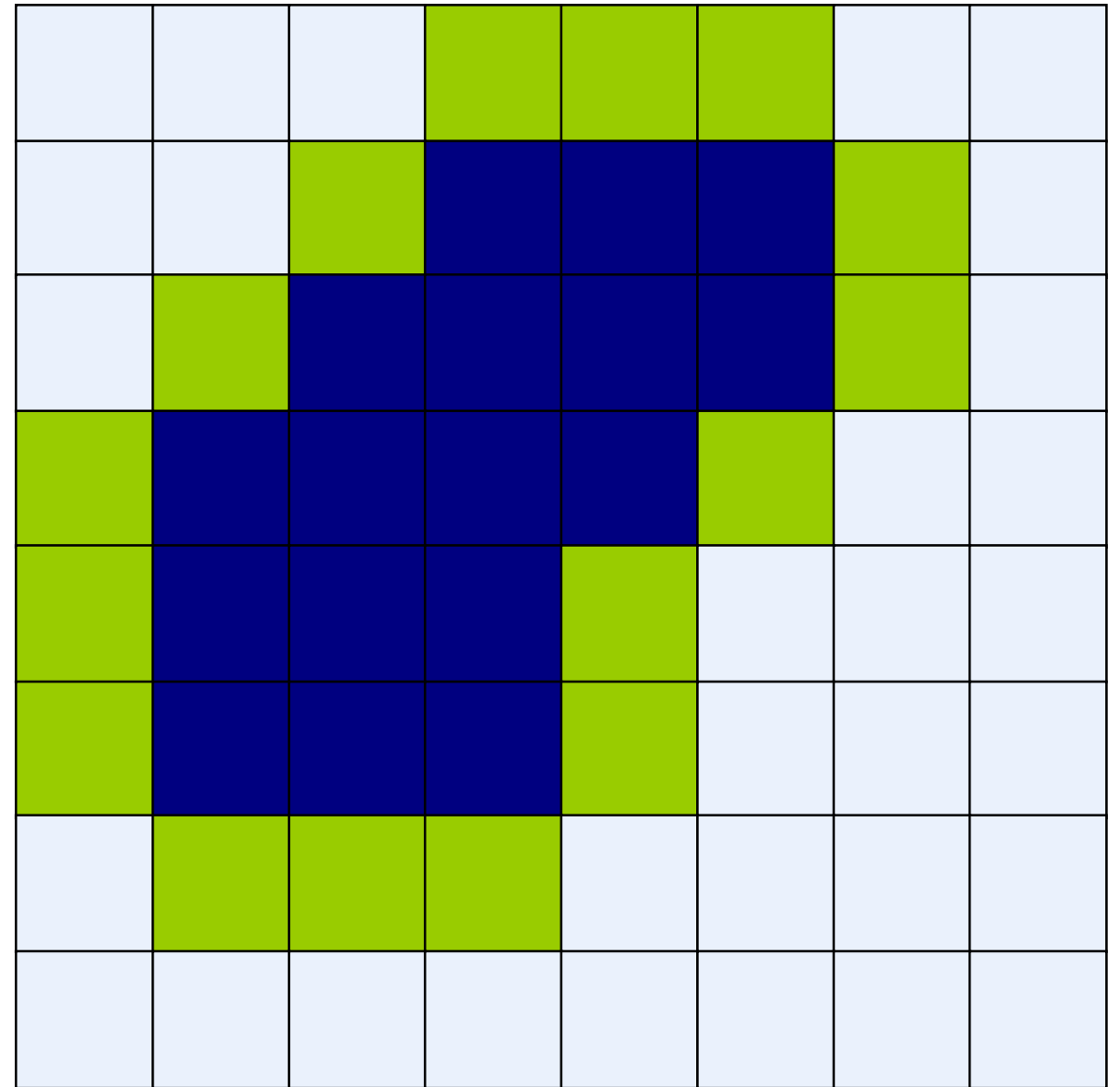


Dilation Example

Original Image



Processed Image With Dilated Pixels



Structuring Element

Dilation Example 1



Original image



Dilation by 3*3
square structuring
element



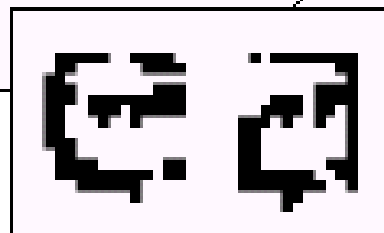
Dilation by 5*5 square
structuring element

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

Dilation Example 2

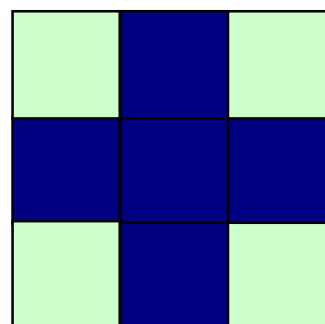
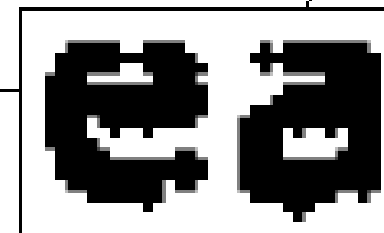
Original image

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.



After dilation

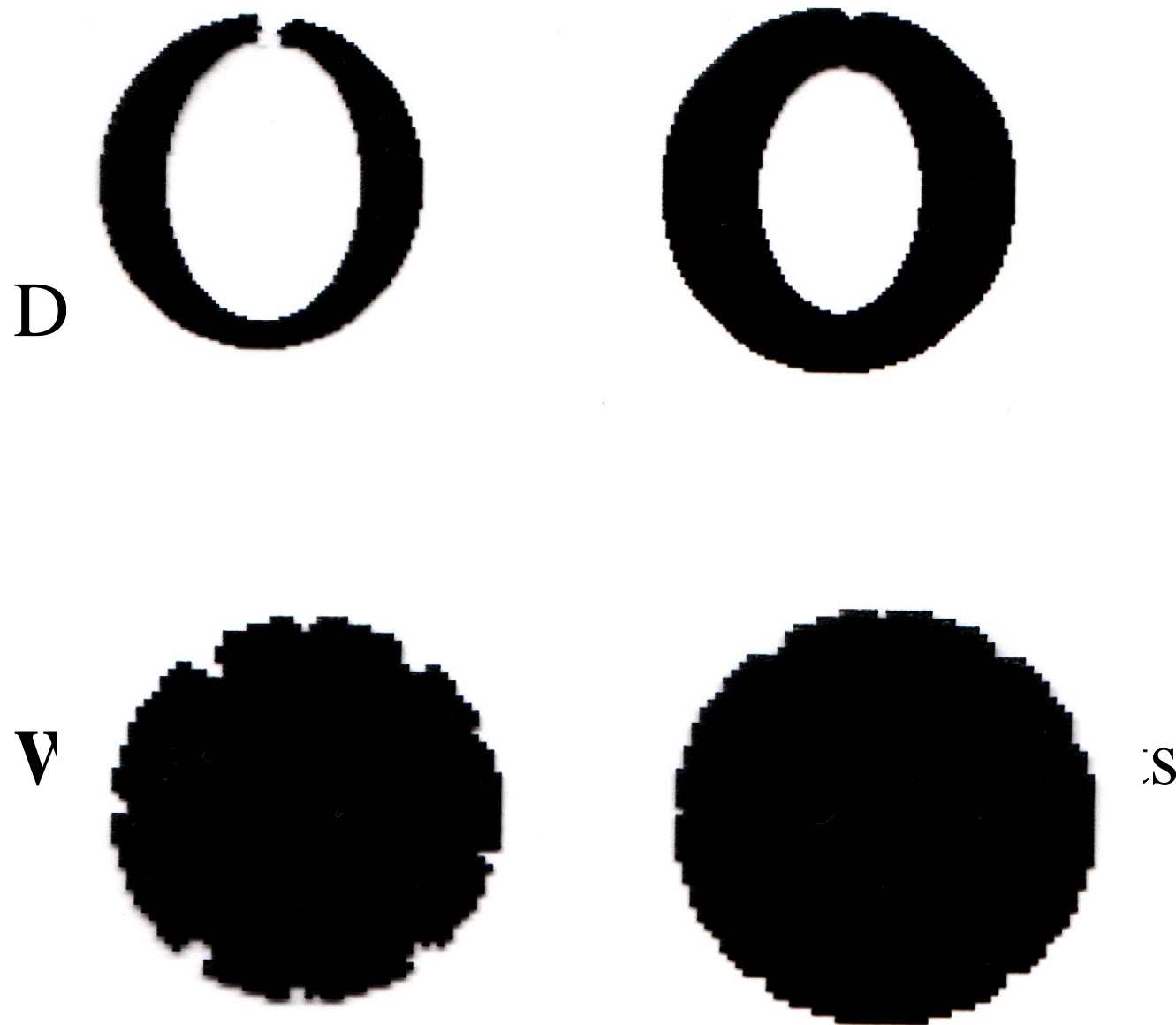
Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.



Structuring Element

What Is Dilation For?

Dilation can repair breaks



Example (Original and Processed Image)

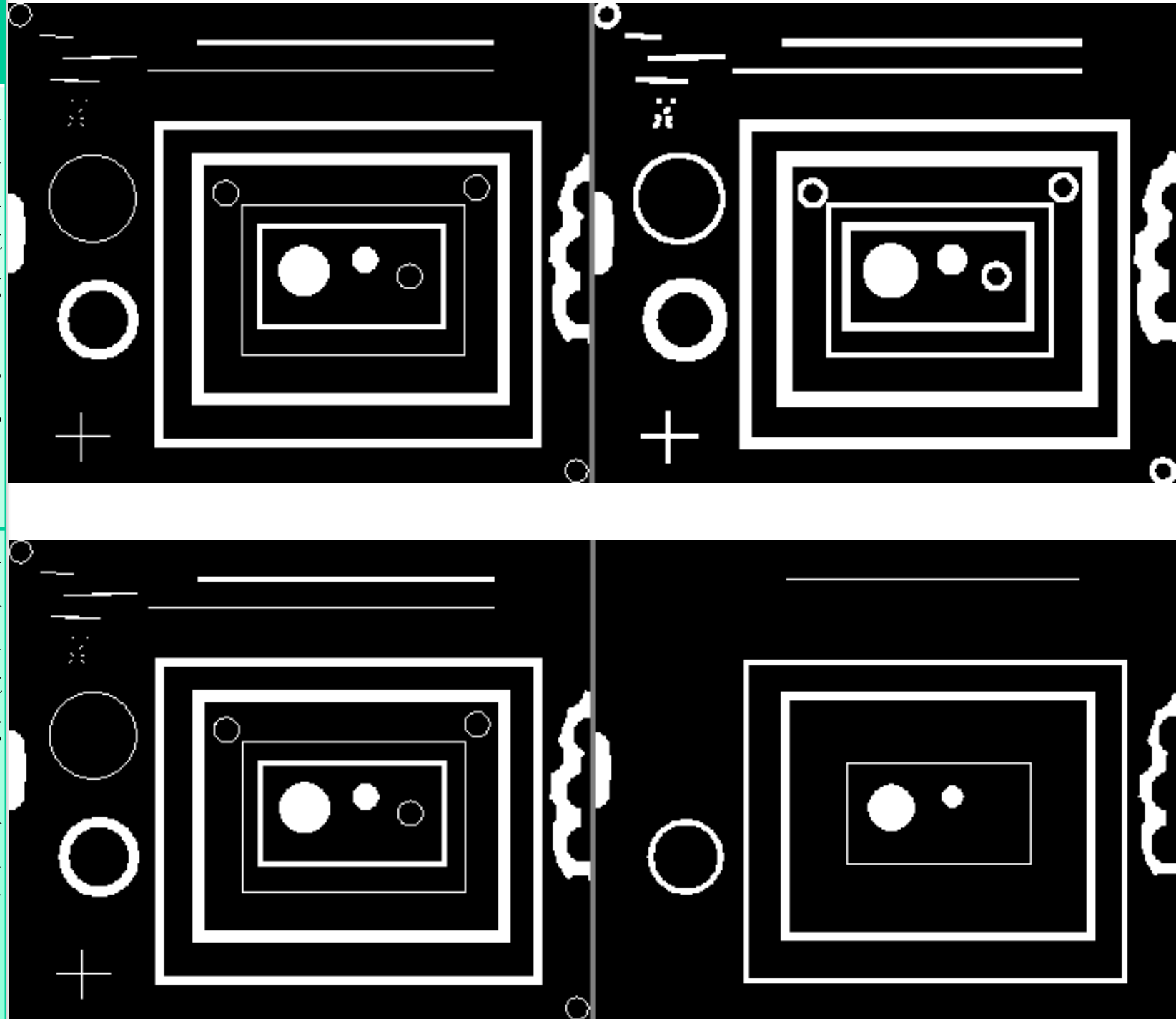
Operation Rule

Dilation

The value of the output pixel is the maximum value of all pixels in the neighborhood. In a binary image, a pixel is set to 1 if any of the neighboring pixels have the value 1. Morphological dilation makes objects more visible and fills in small holes in objects.

Erosion

The value of the output pixel is the minimum value of all pixels in the neighborhood. In a binary image, a pixel is set to 0 if any of the neighboring pixels have the value 0. Morphological erosion removes islands and small objects so that only substantive objects remain.





Compound Operations

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

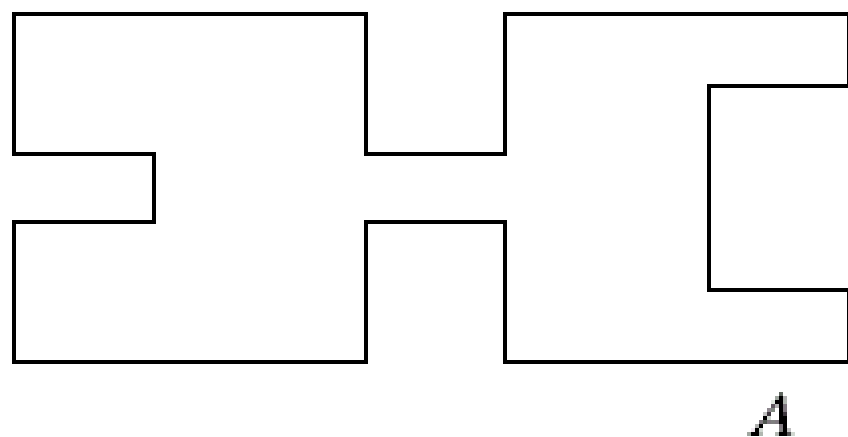
The most widely used of these *compound operations* are:

- Opening
- Closing

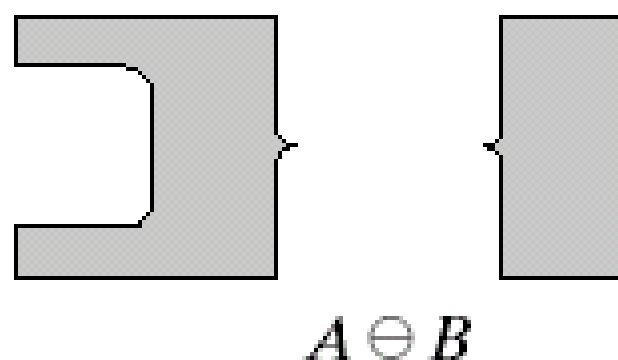
Opening

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

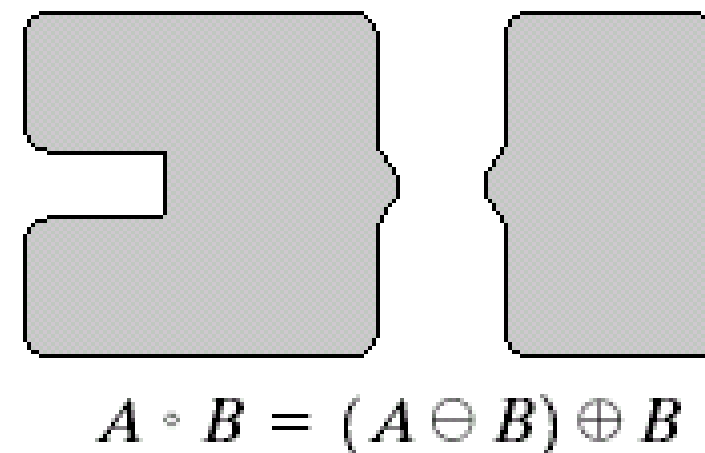
$$f \circ s = (f \ominus s) \oplus s$$



Original shape



After erosion



After dilation
(opening)

Note a disc shaped structuring element is used

Opening Example

Original
Image

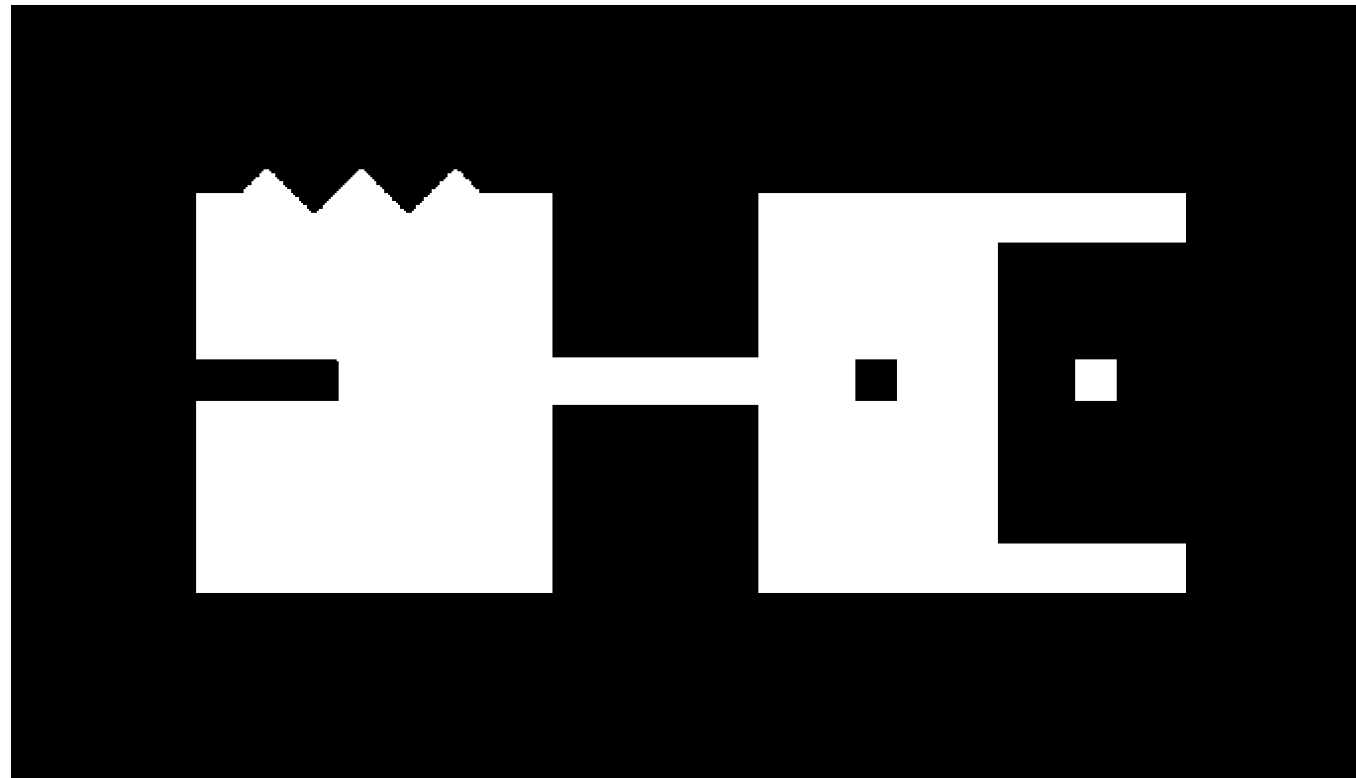
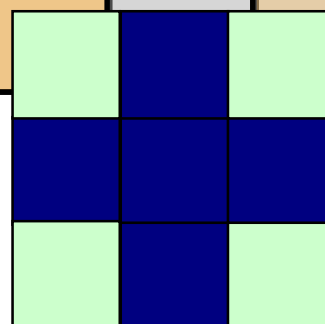
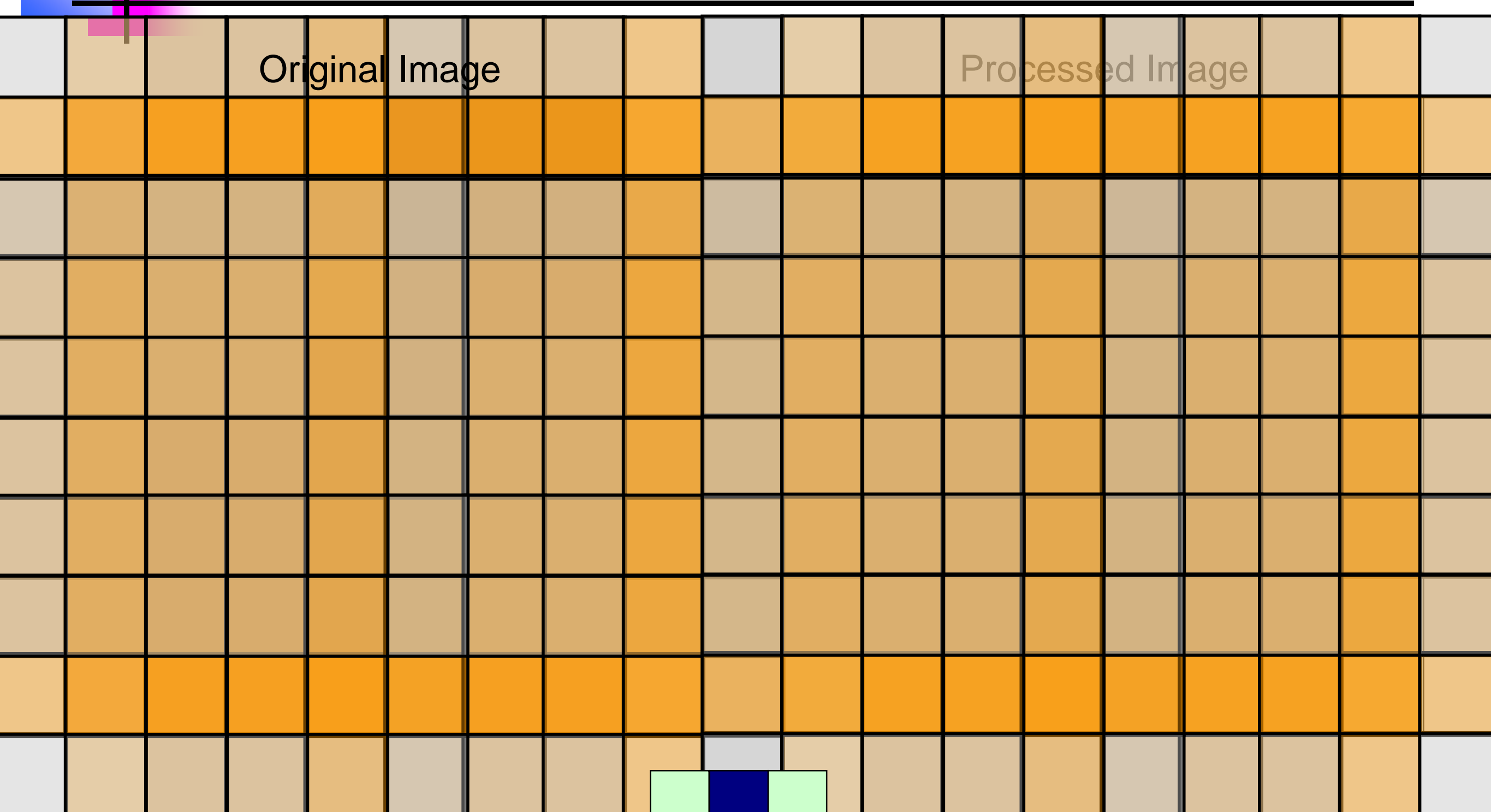


Image
After
Opening



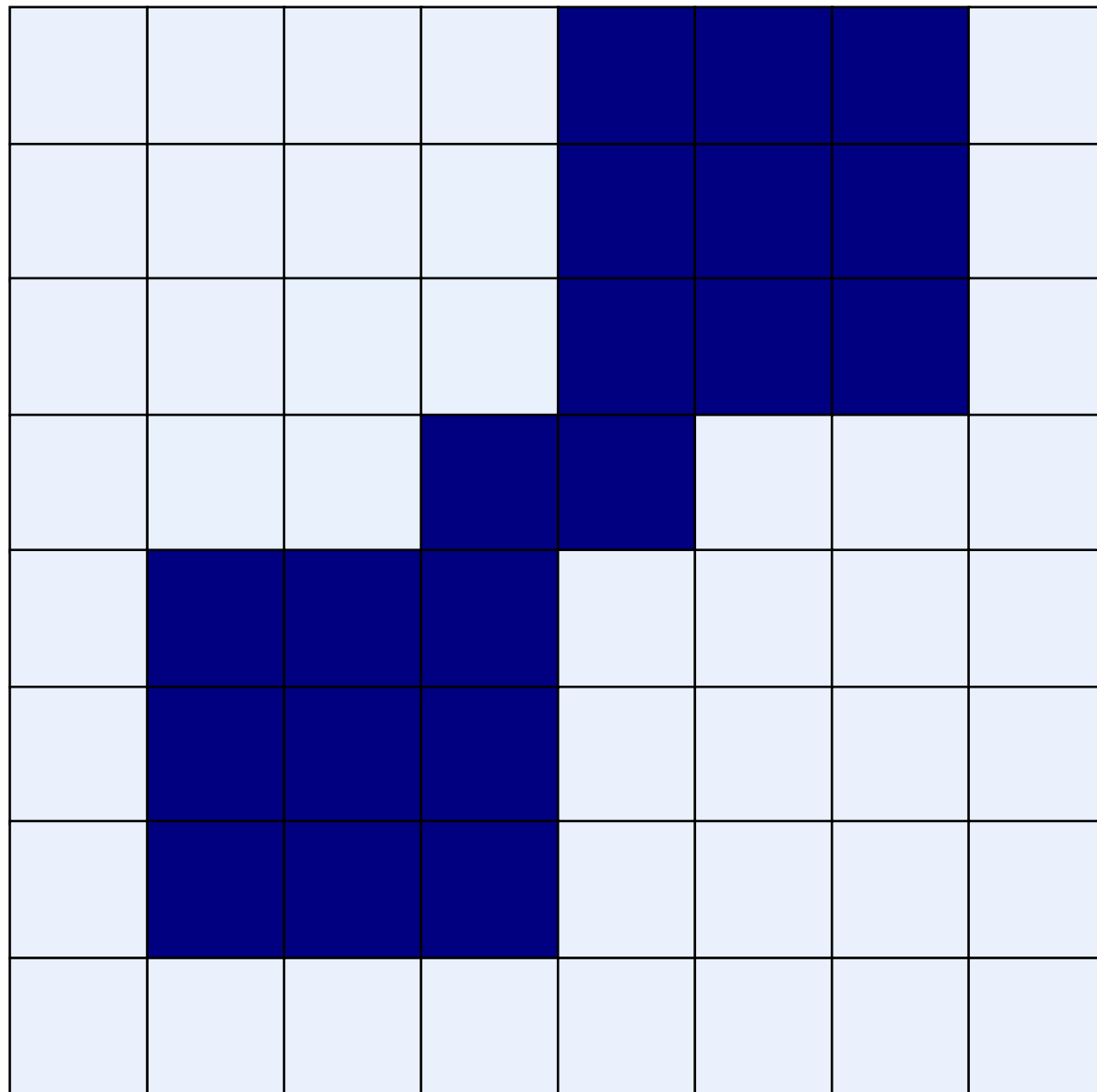
Opening Example



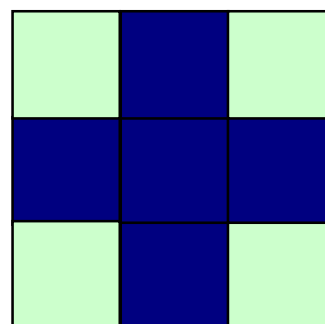
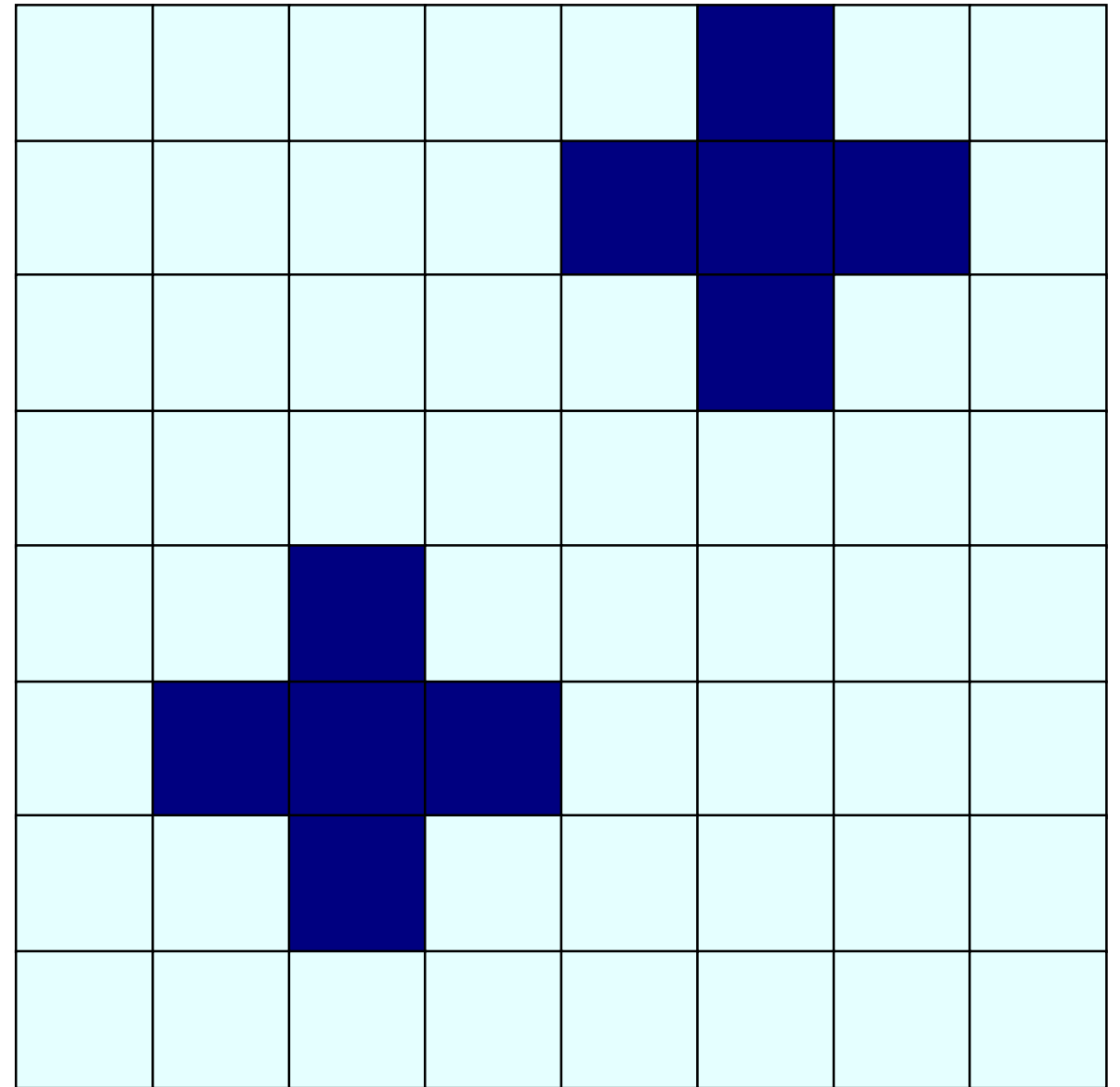
Structuring Element

Opening Example

Original Image



Processed Image

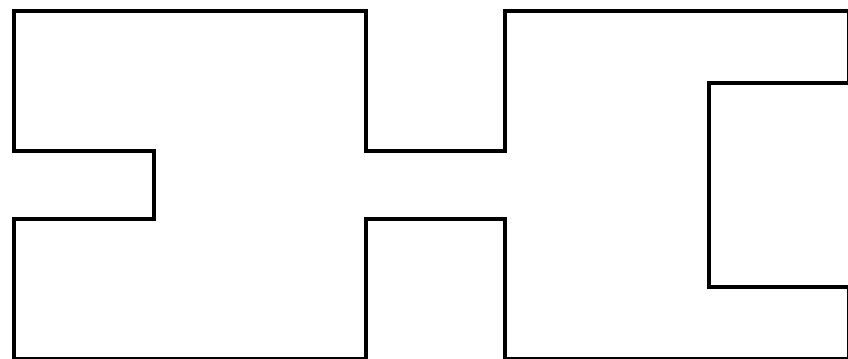


Structuring Element

Closing

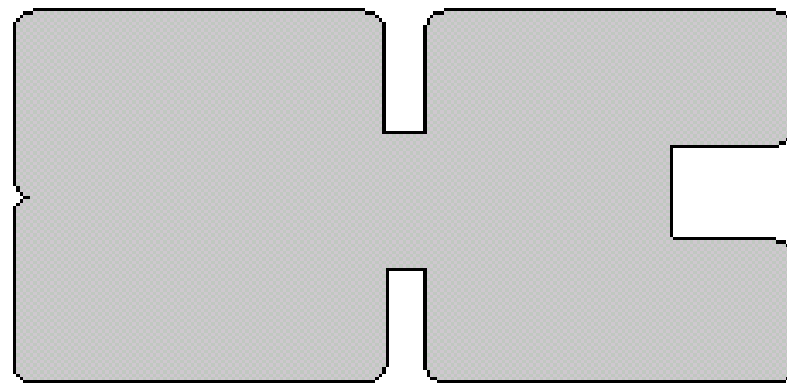
The closing of image f by structuring element s , denoted $f \bullet s$ is simply a dilation followed by an erosion

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



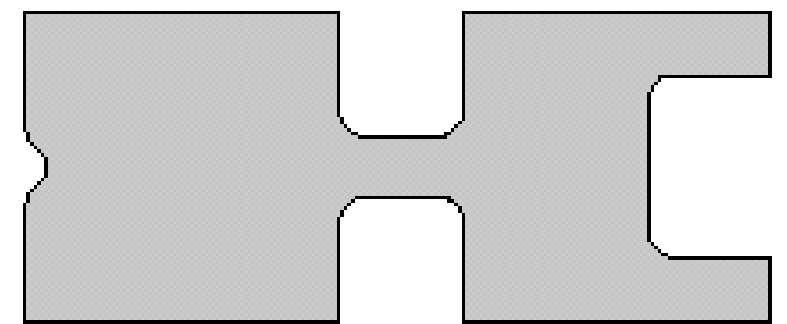
A

Original shape



$A \oplus B$

After dilation



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

After erosion
(closing)

Note a disc shaped structuring element is used

Closing Example

Original Image

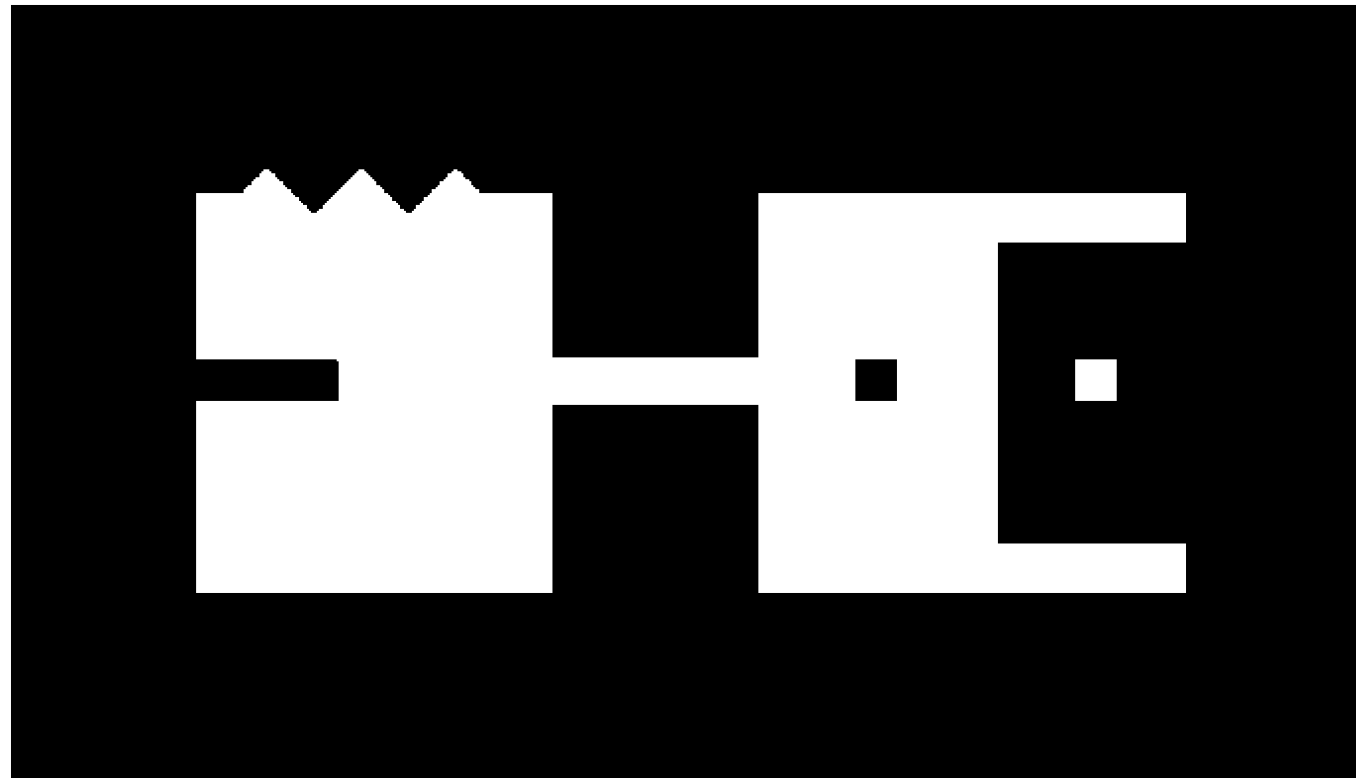
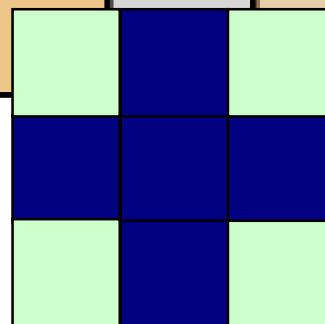
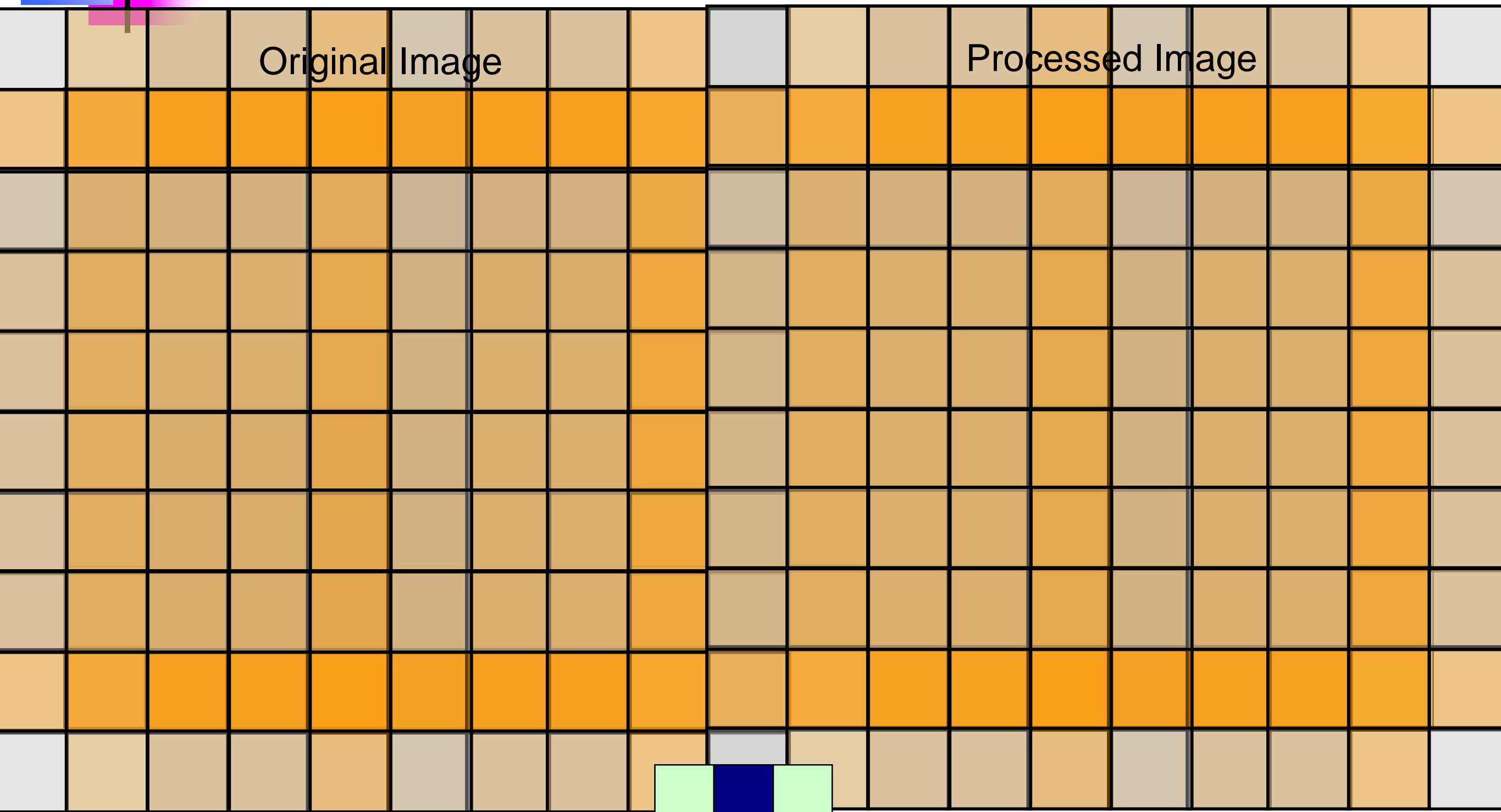


Image After Closing



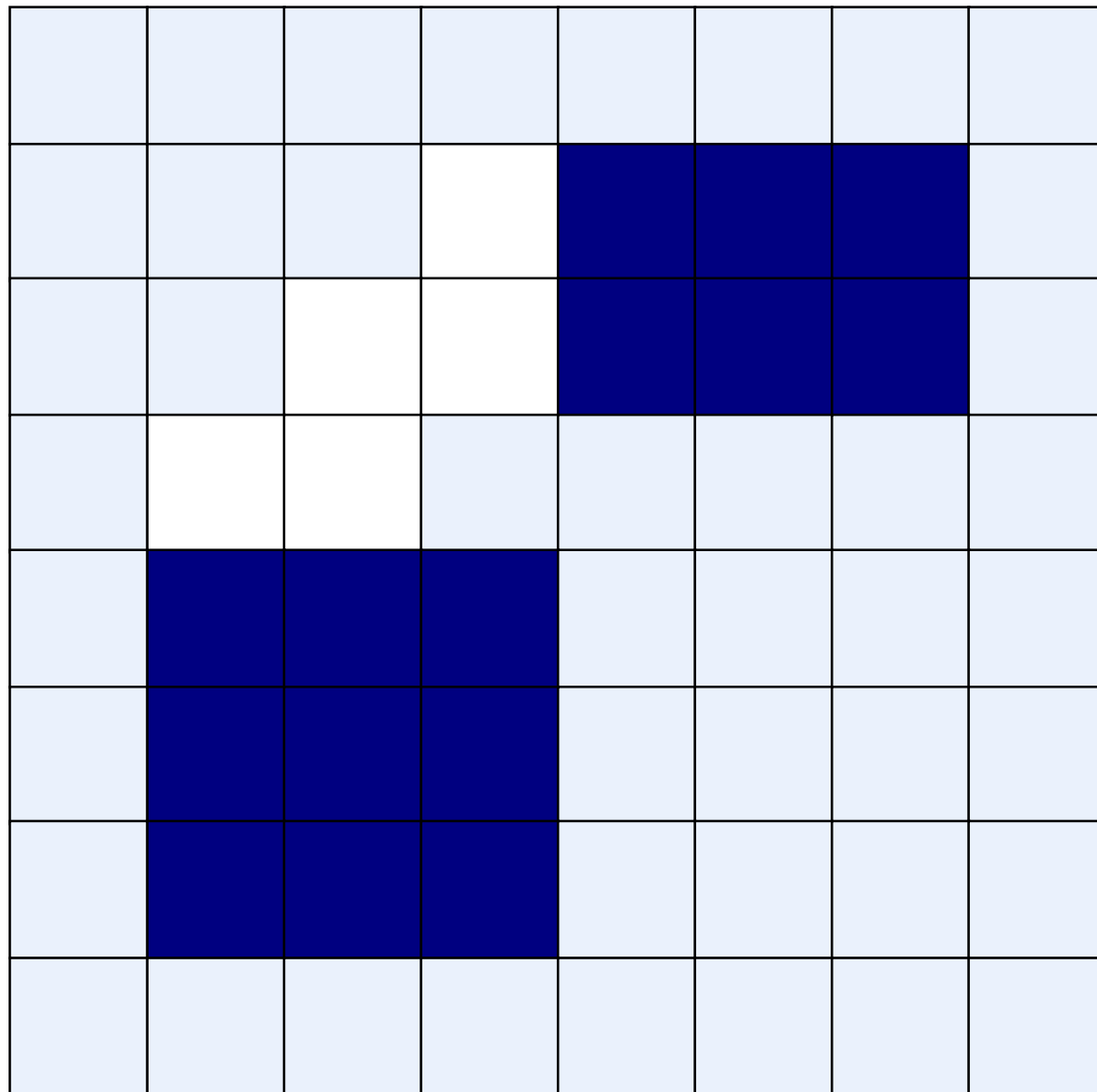
Closing Example



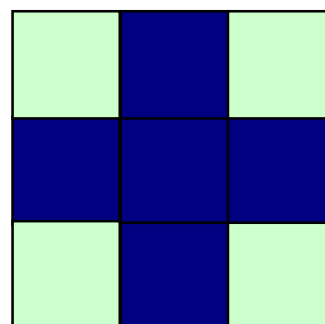
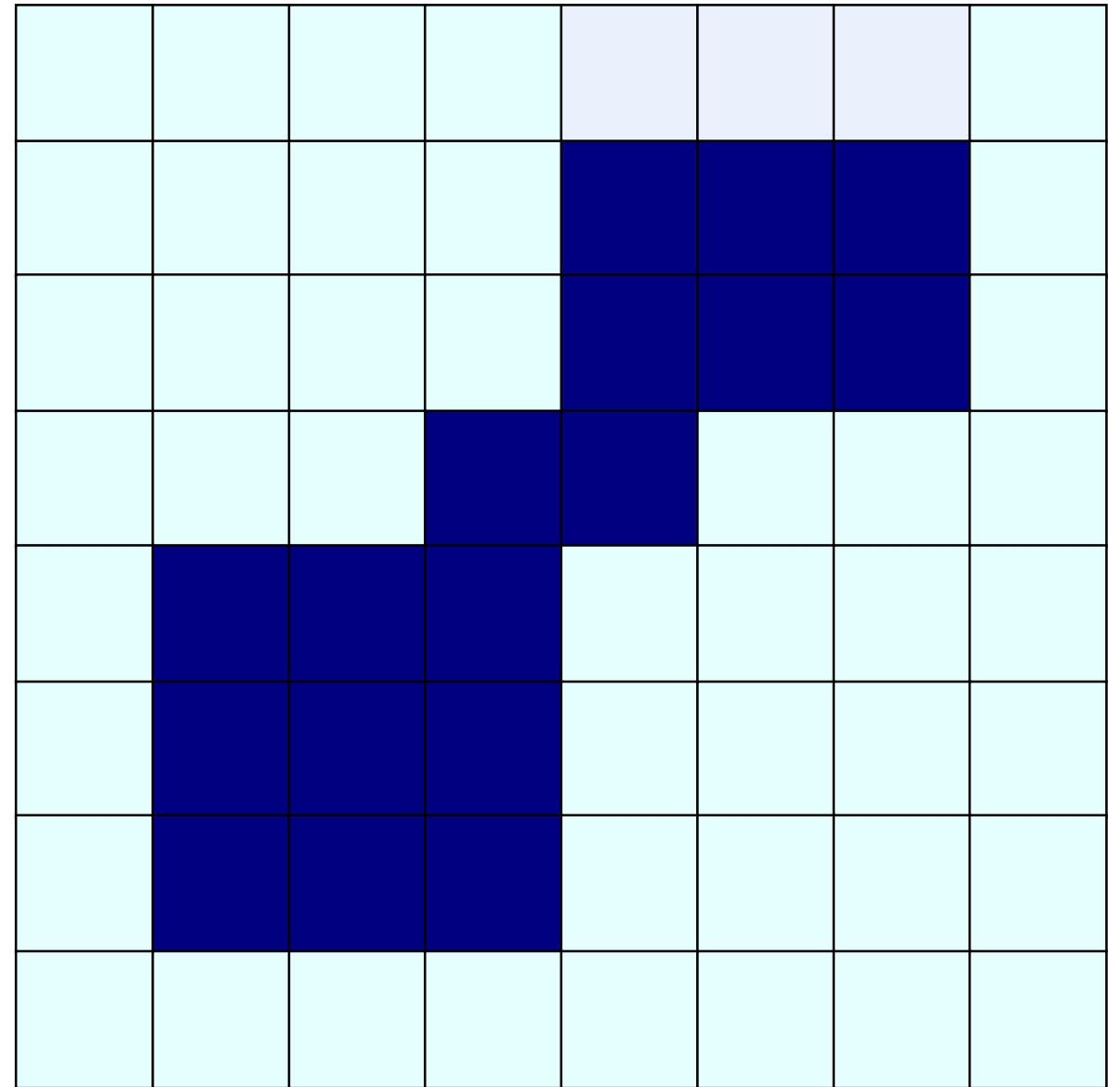
Structuring Element

Closing Example

Original Image

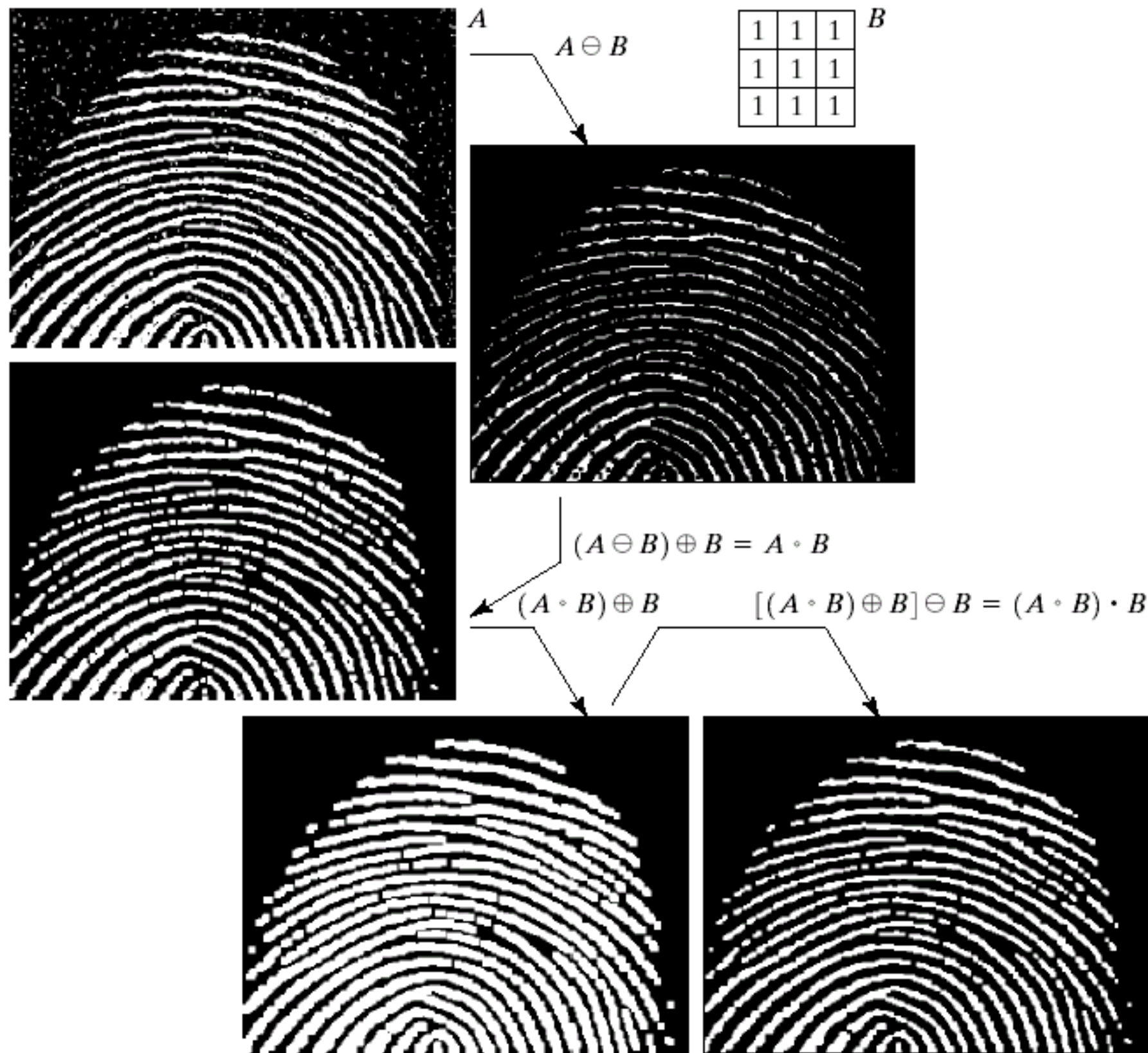


Processed Image

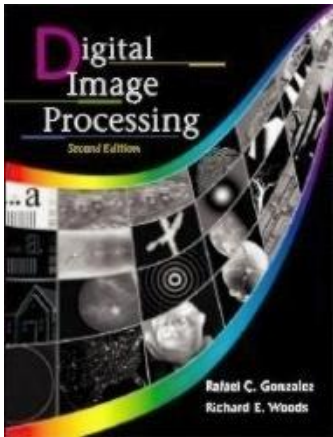


Structuring Element

Morphological Processing Example



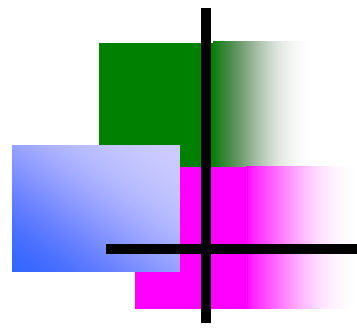
References



“Digital Image Processing”, Rafael C. Gonzalez & Richard E. Woods, Addison-Wesley, 2002

–“Fundamentals of Digital Image Processing” Anil K. Jain, 1989

–Image Processing and Pattern Recognition Slides of Dr. Sanjeeb Prasad Panday



Thank you !!!