

# FBSP: Morphological operations

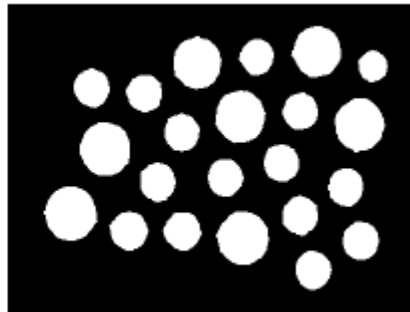
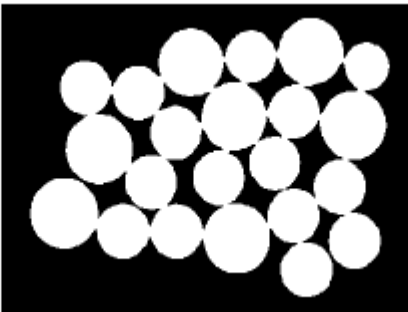
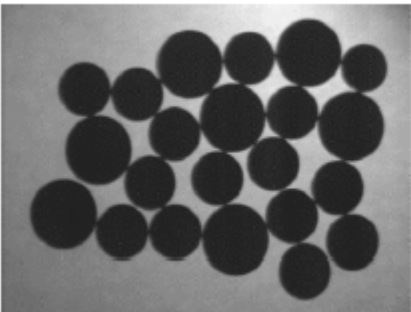
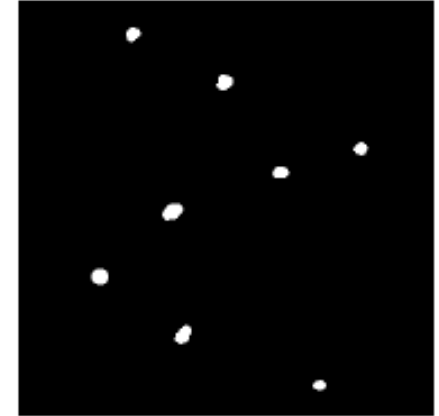
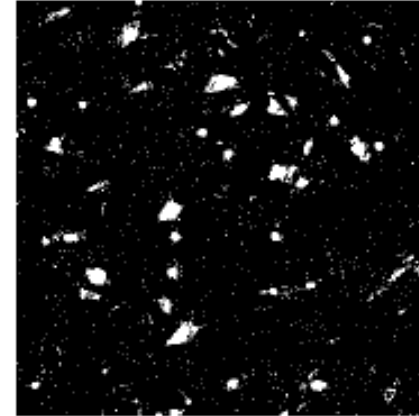
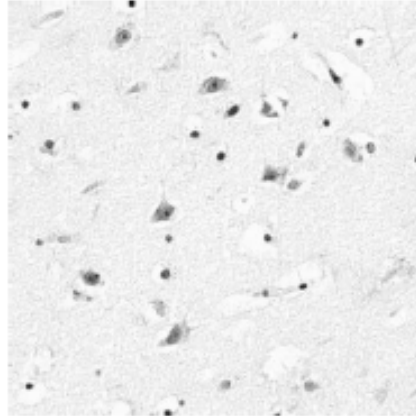
Nick Yao Larsen  
nylarsen@cfin.au.dk

# What can it be used for?

Remove noise

- Small objects
- Fill holes

Isolate objects

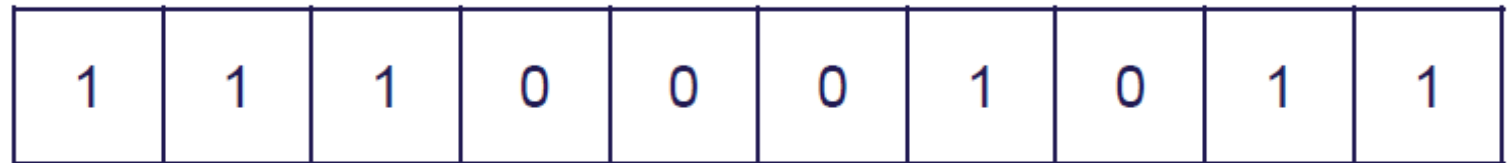


# Definition 1D

- Structuring Element (SE)



- Input image



- Output image



Hit: If just one of the 1's in the SE overlap with a 1 in the input  $\rightarrow$  output = 1, otherwise output = 0

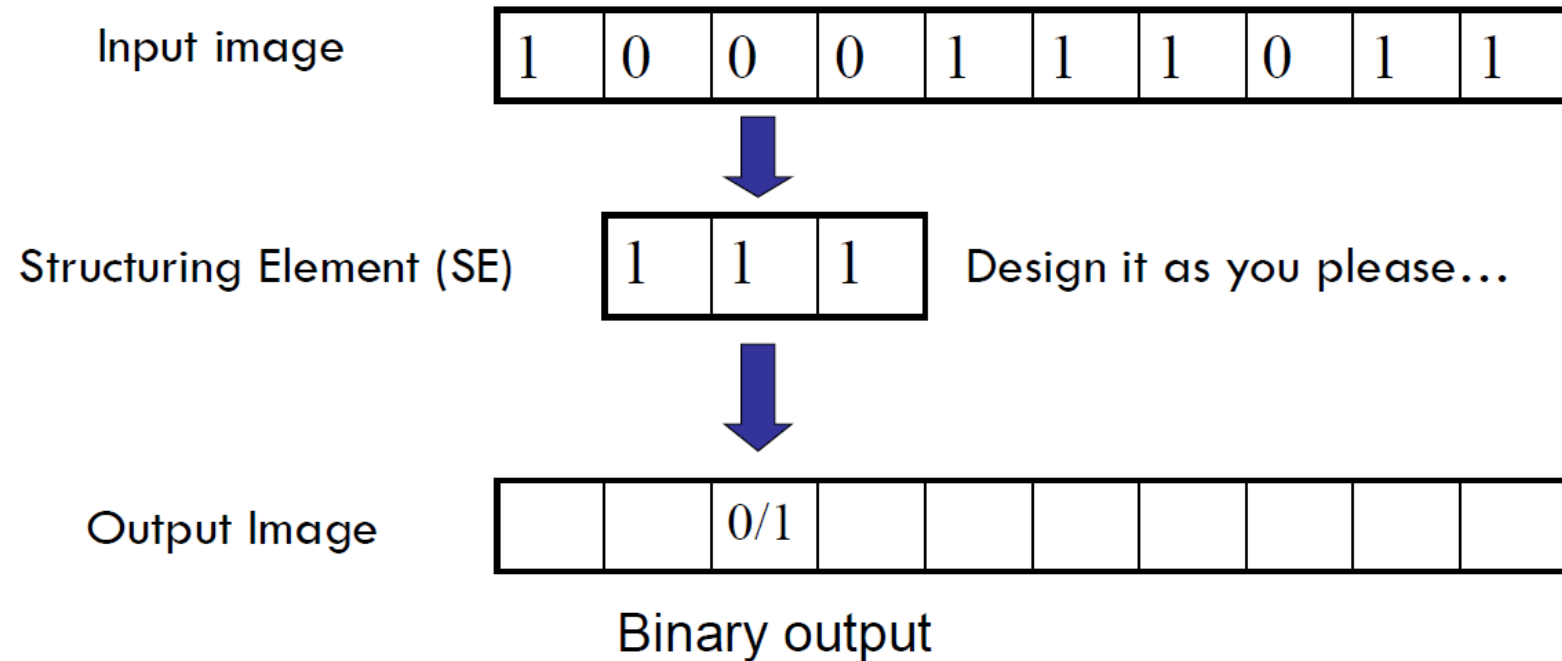
Fit: If all 1's in the SE overlap with '1's in the input  $\rightarrow$  output = 1, otherwise output = 0

# Dilation

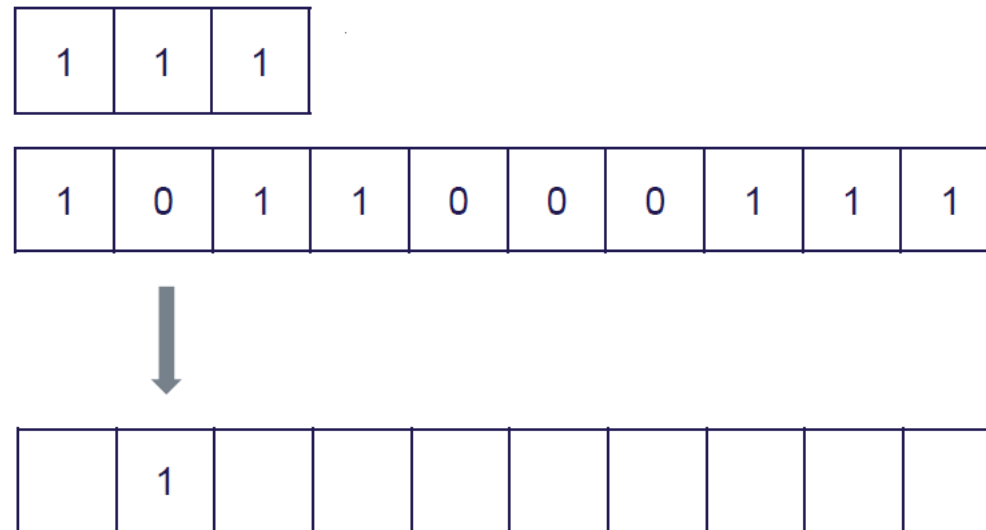
Dilation is based on “Hit”:

- If just one of the '1's in the SE overlap with a 1 in the input => output = 1, otherwise output = 0

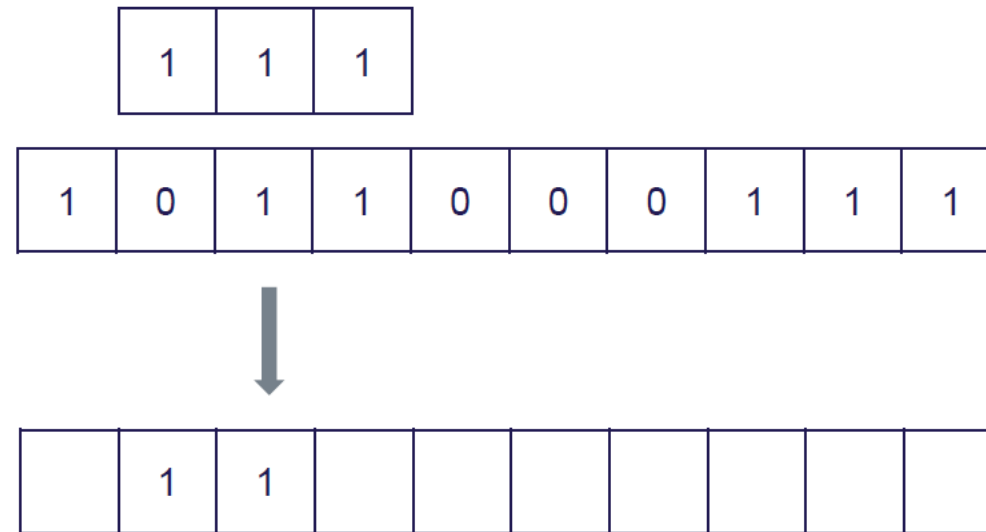
## Definitions (1D)



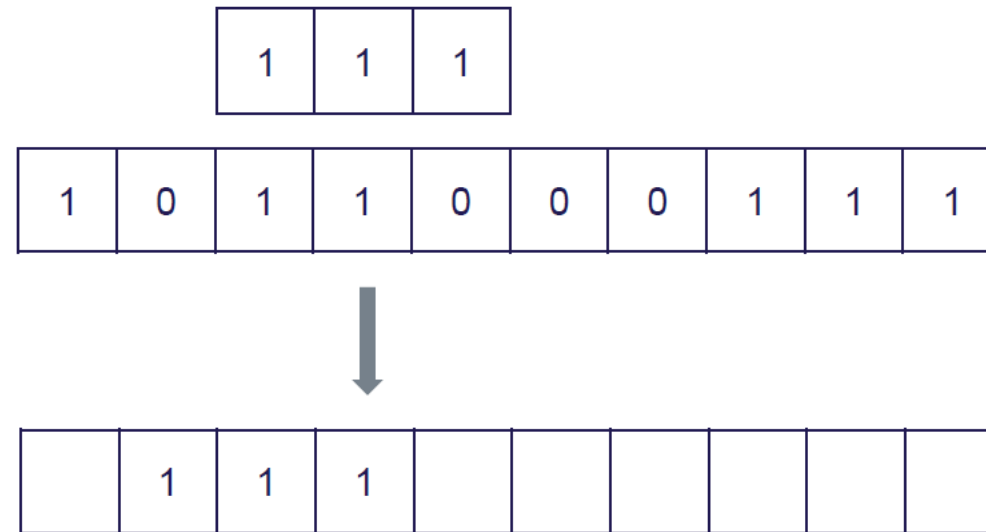
# Dilation: Multiple hit operations



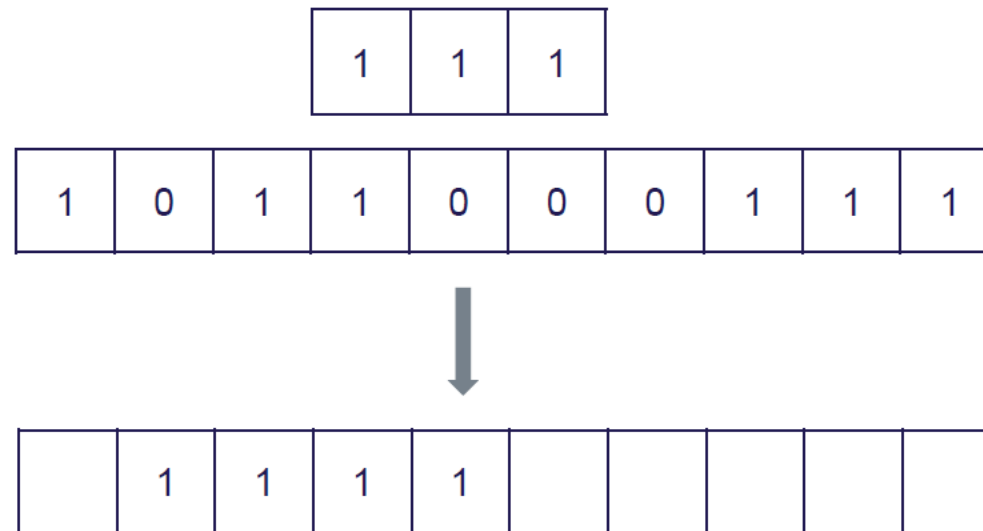
# Dilation: Multiple hit operations



# Dilation: Multiple hit operations

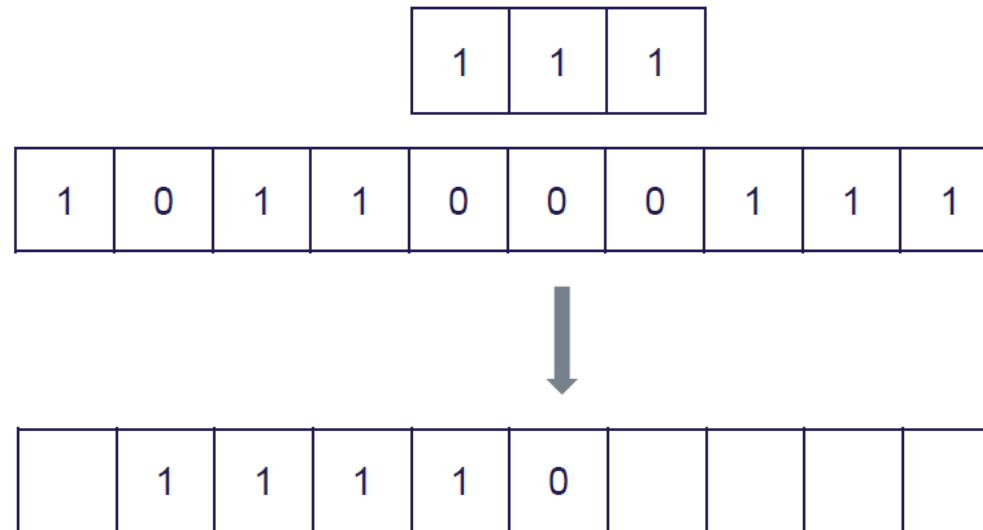


# Dilation: Multiple hit operations

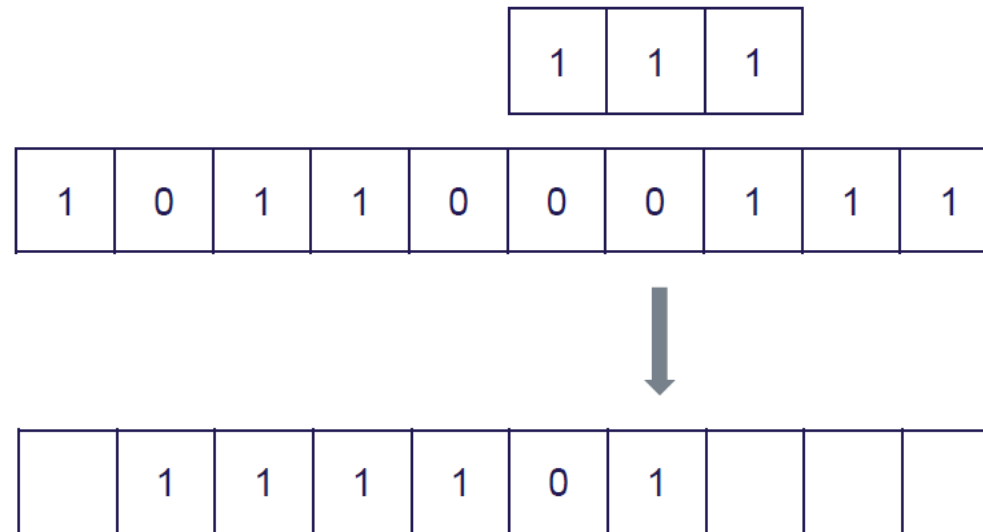




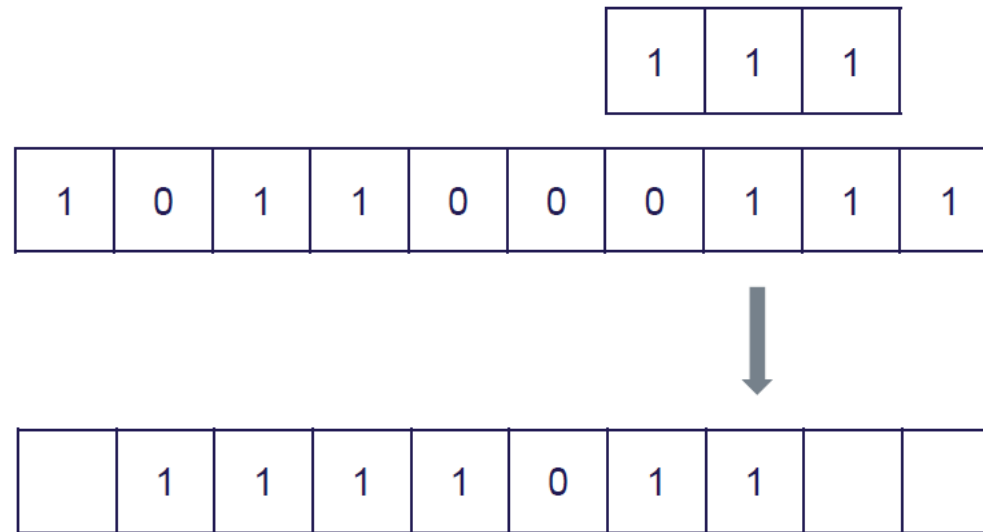
# Dilation: Multiple hit operations



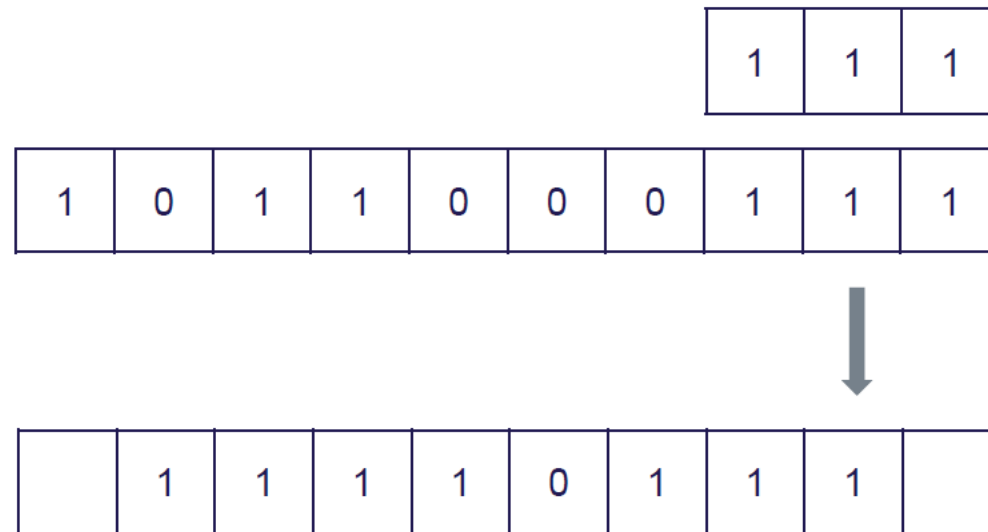
# Dilation: Multiple hit operations



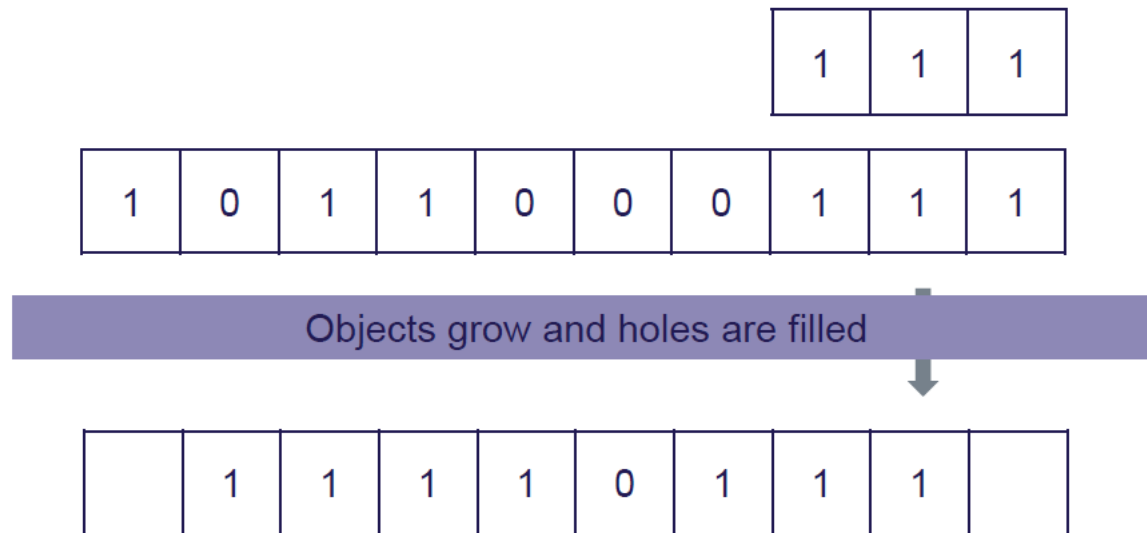
# Dilation: Multiple hit operations



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# Dilation: Multiple hit operations

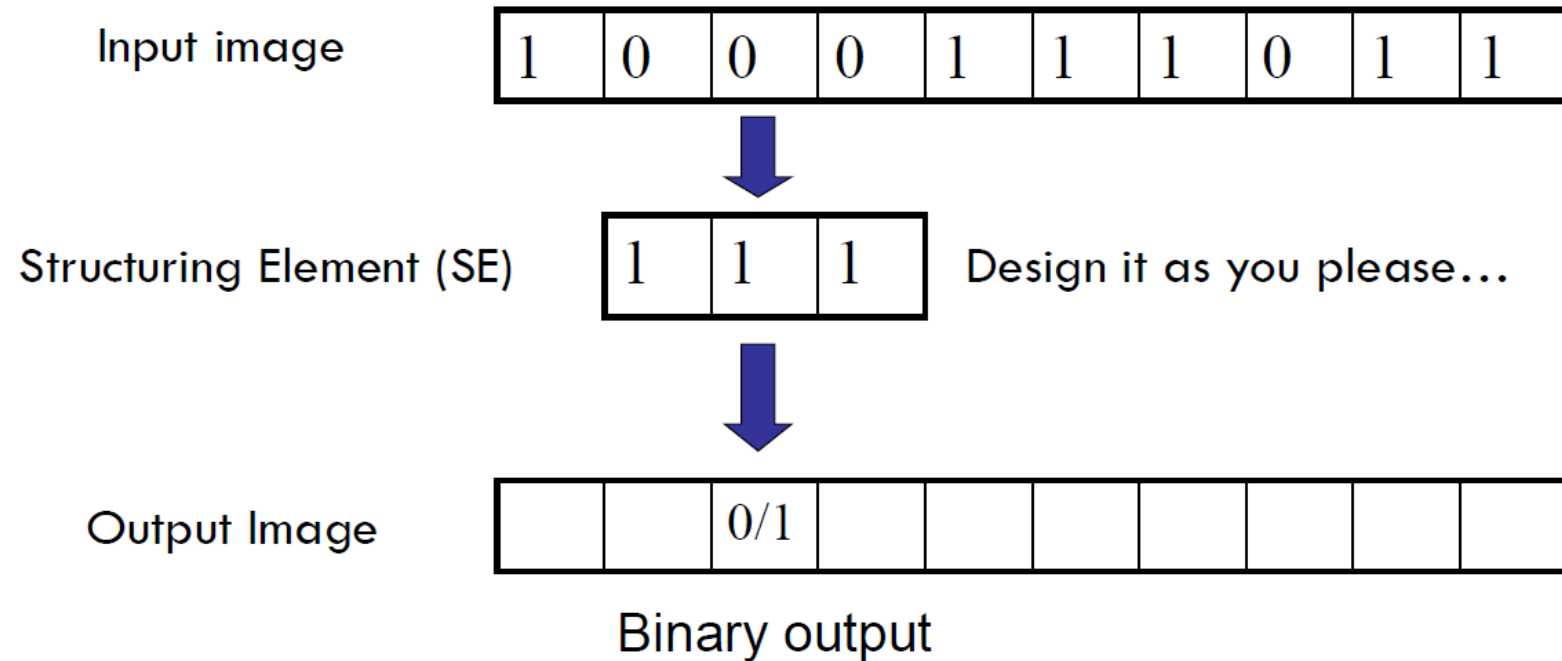


# Erosion

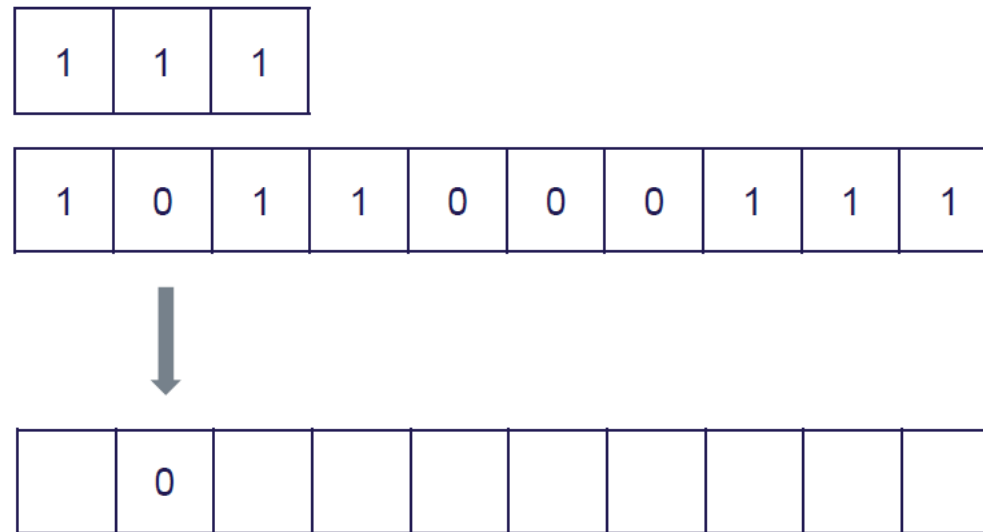
Erosion is based on “Fit”:

- If all '1's in the SE overlap with '1's in the input => output = 1, otherwise output = 0

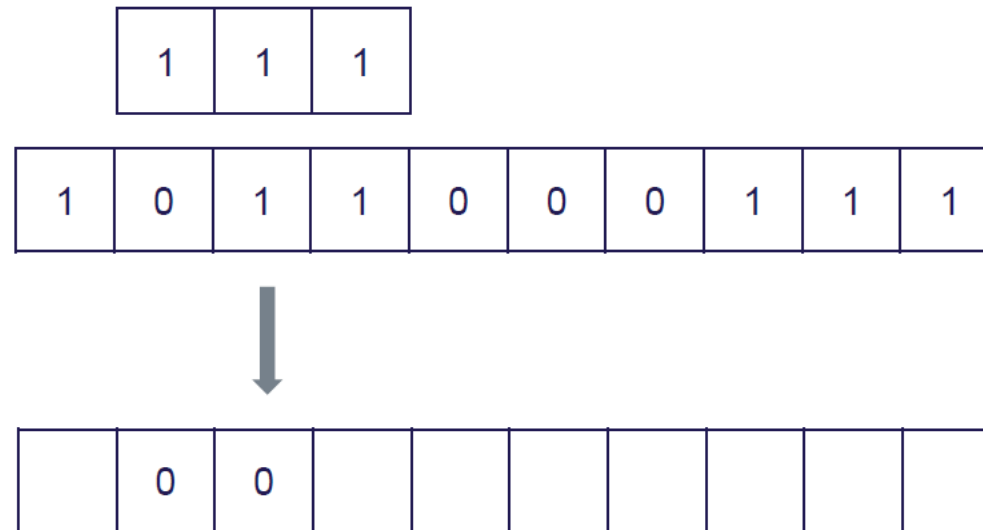
## Definitions (1D)



# Erosion: Multiple hit operations

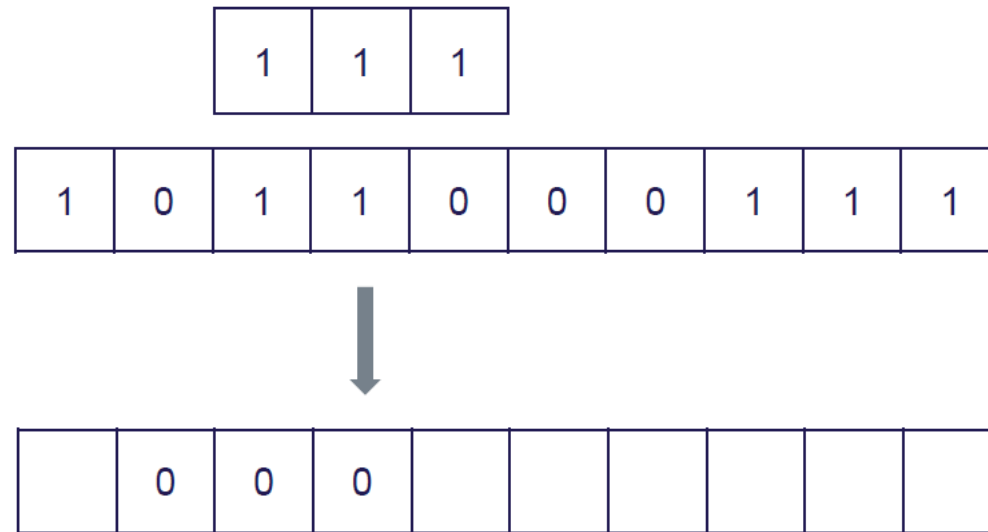


# Erosion: Multiple hit operations

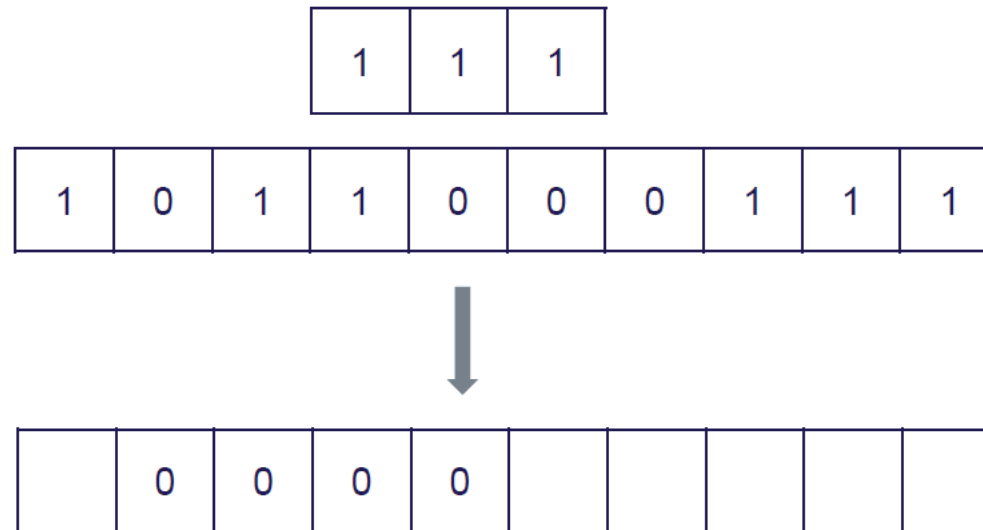




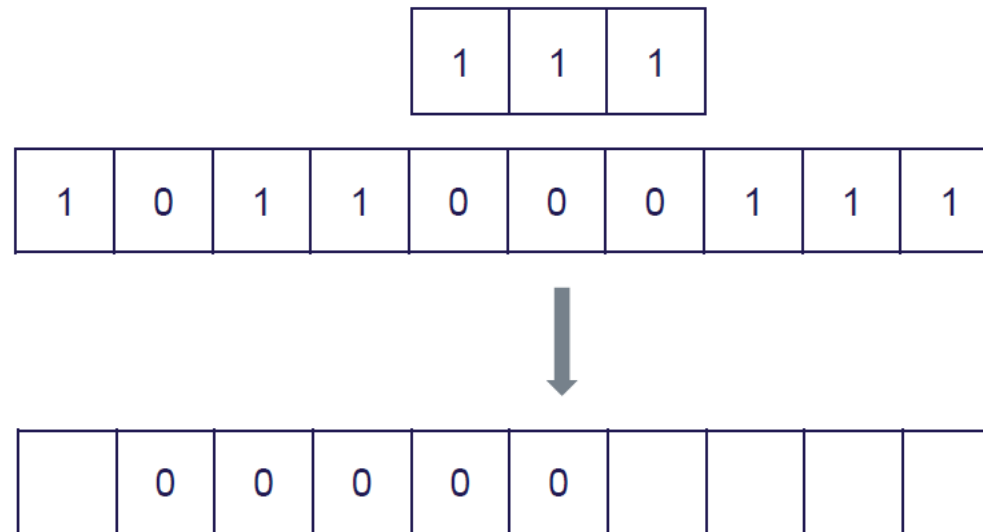
# Erosion: Multiple hit operations



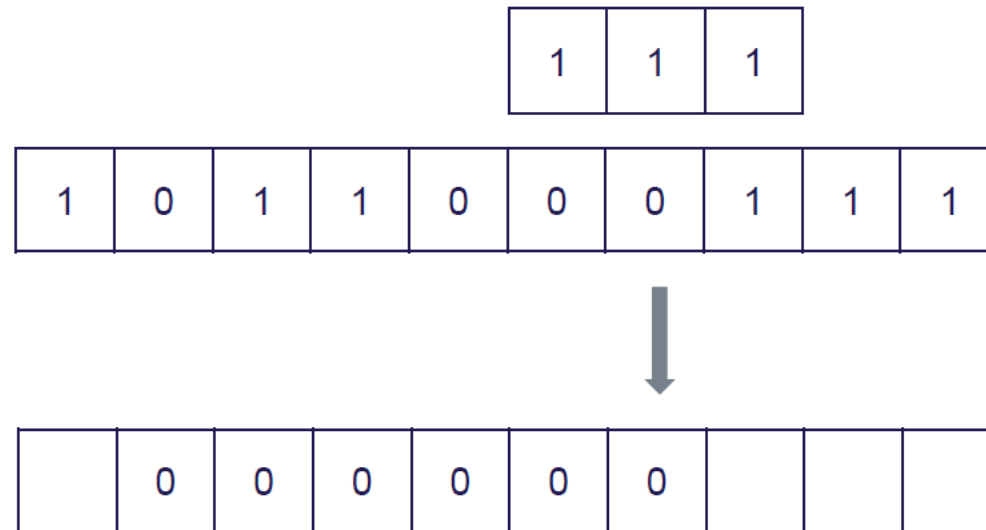
# Erosion: Multiple hit operations



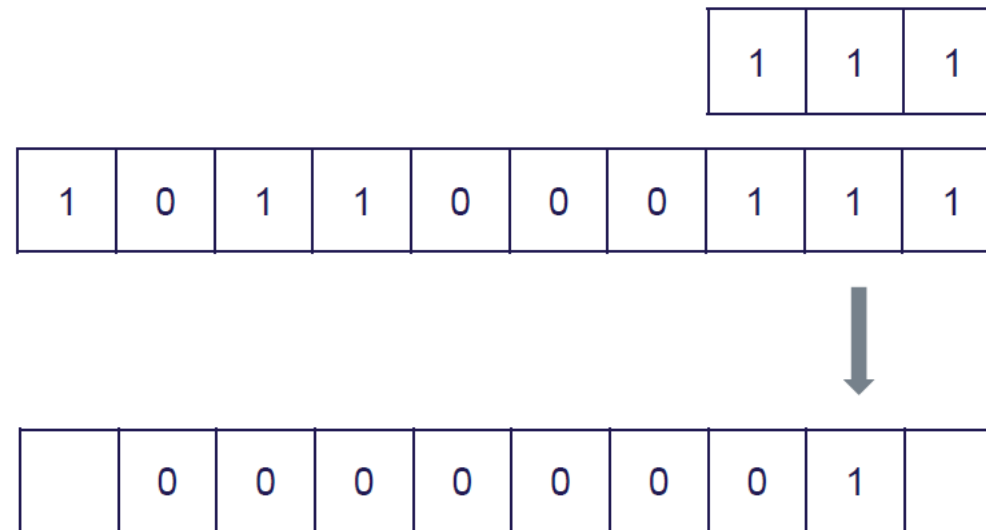
# Erosion: Multiple hit operations



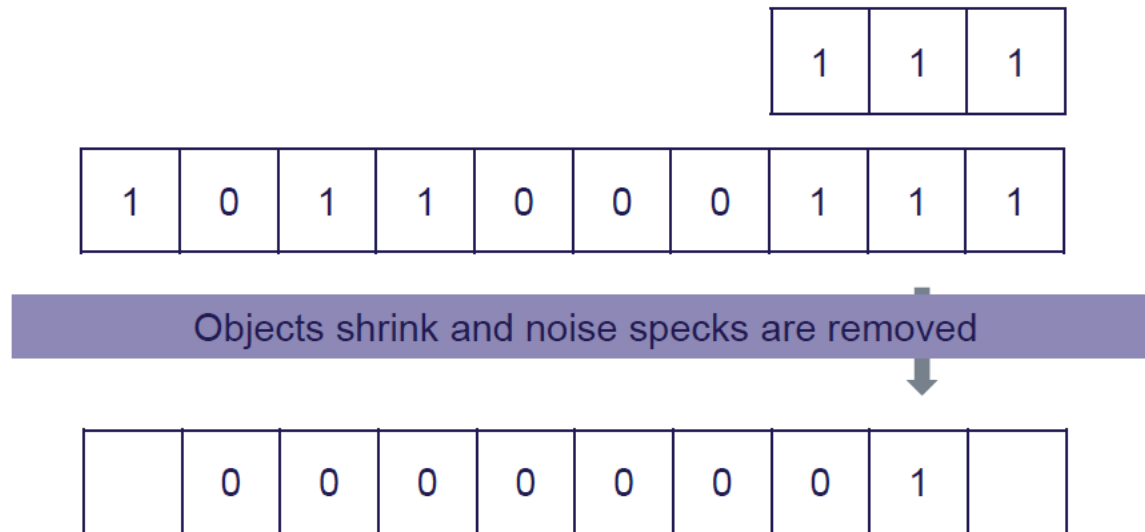
# Erosion: Multiple hit operations



# Erosion: Multiple hit operations



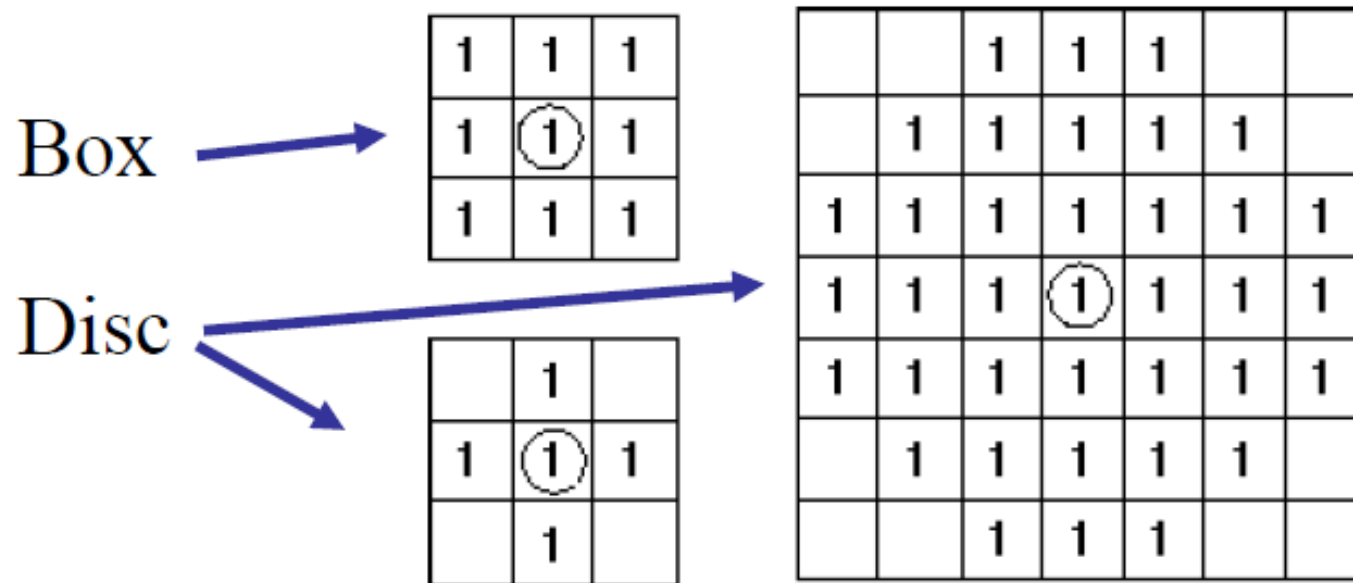
# Erosion: Multiple hit operations



# Morphology 2D

Structuring element (kernel)

- Structuring elements can have varying sizes and shapes!
- Structuring elements have an origin
- Zeros or empty spots/zeros in the structuring element are “don’t care’s”!



# Dilation – images

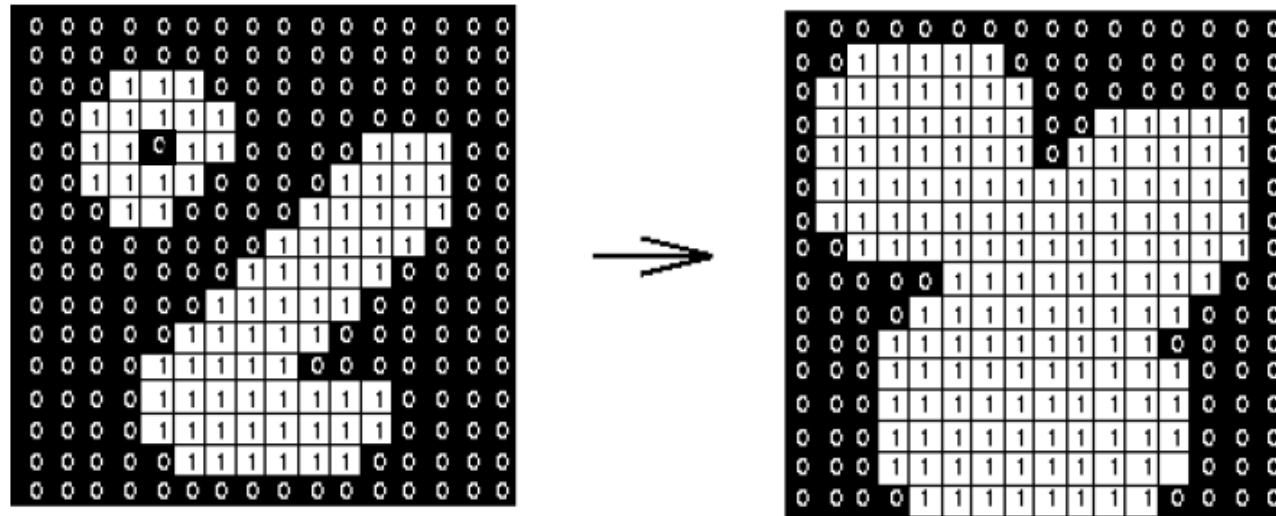
- Objects are merged (holes are filled)
- Box shape: Sharp corners are preserved

$$g(x, y) = f(x, y) \oplus SE$$

- $\oplus$  denote dilation

Structuring element

1	1	1
1	1	1
1	1	1

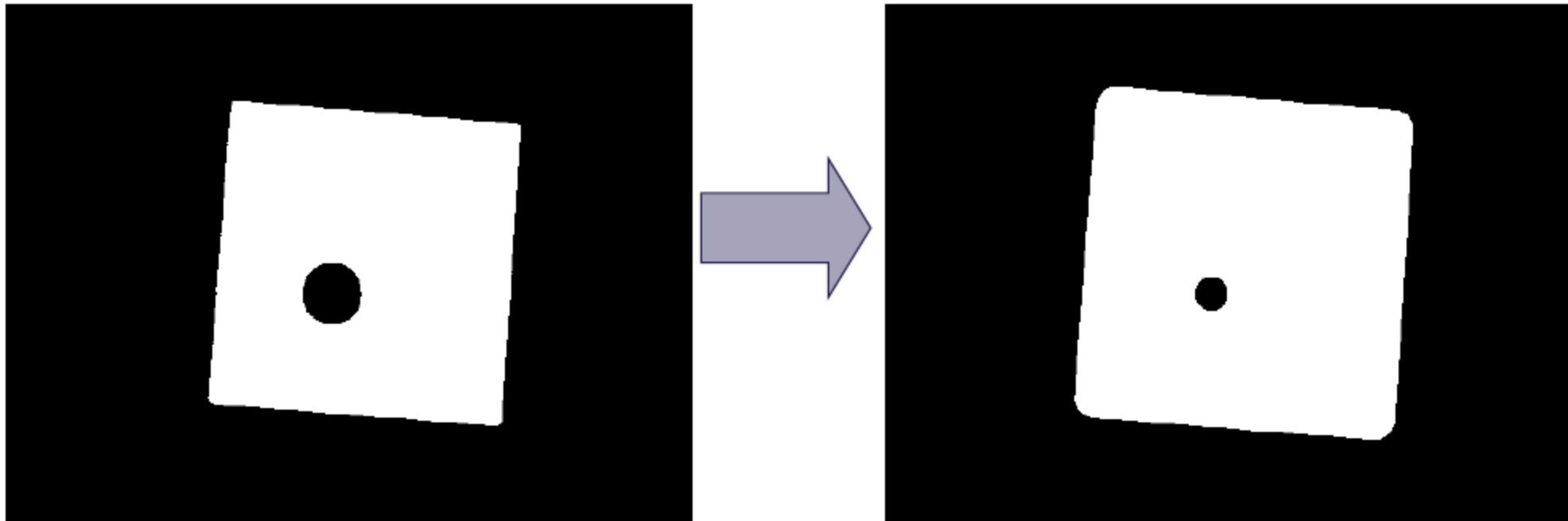




# Dilation – images

- Objects are merged (holes are filled)
- Box shape: Sharp corners are preserved

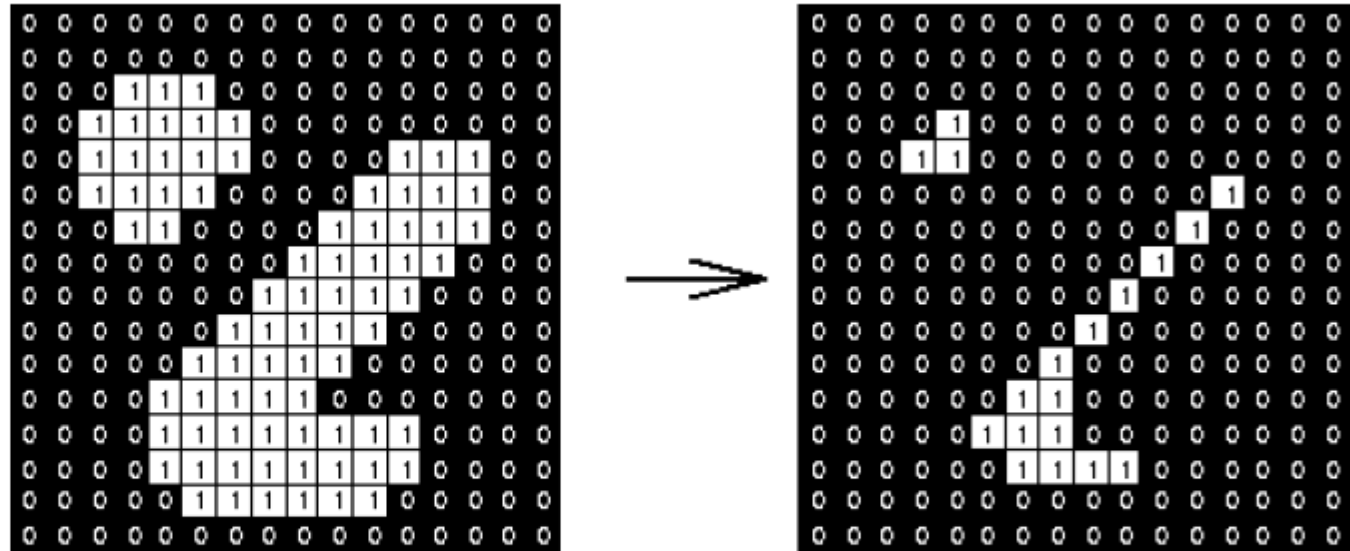
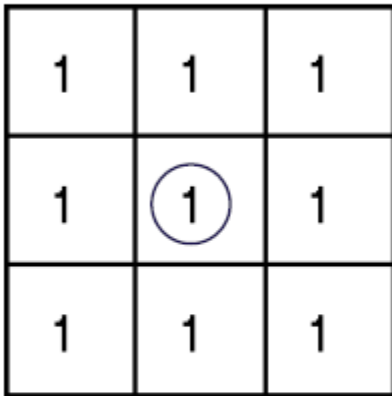
		1	1	1		
	1	1	1	1	1	
1	1	1	1	1	1	1
1	1	1	1	1	1	1
1	1	1	1	1	1	1
	1	1	1	1	1	
		1	1	1		



# Erosion – images

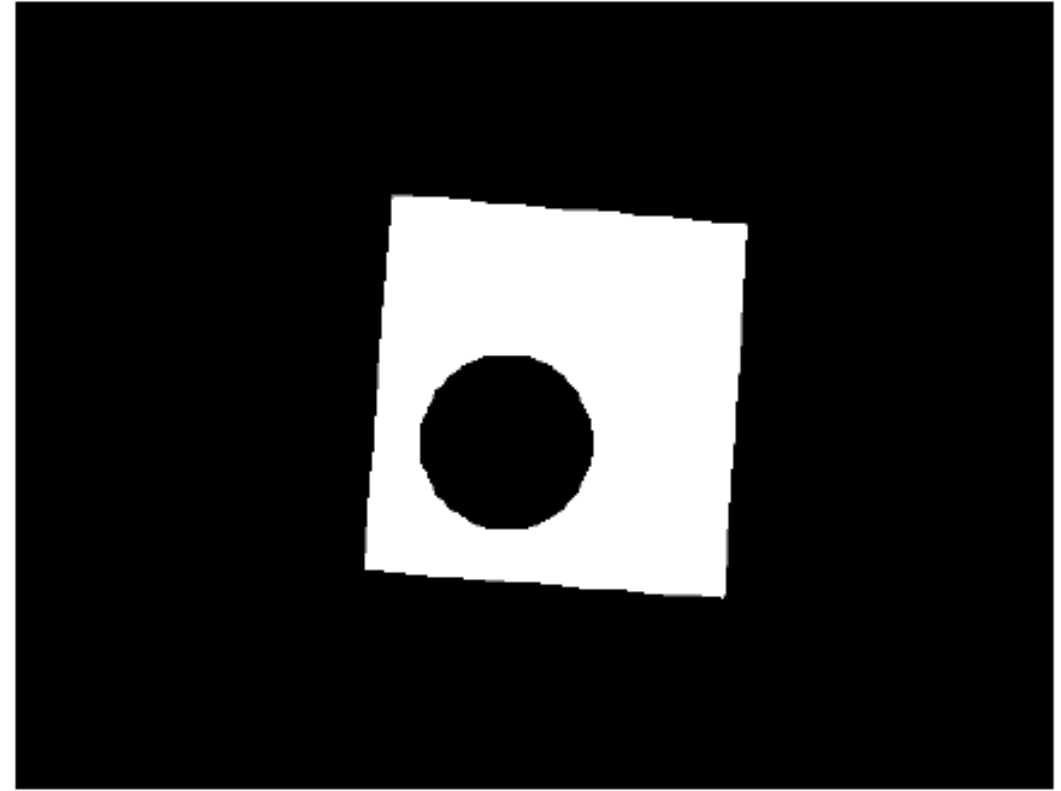
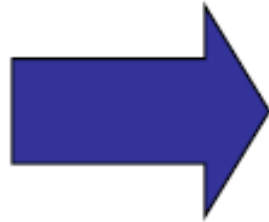
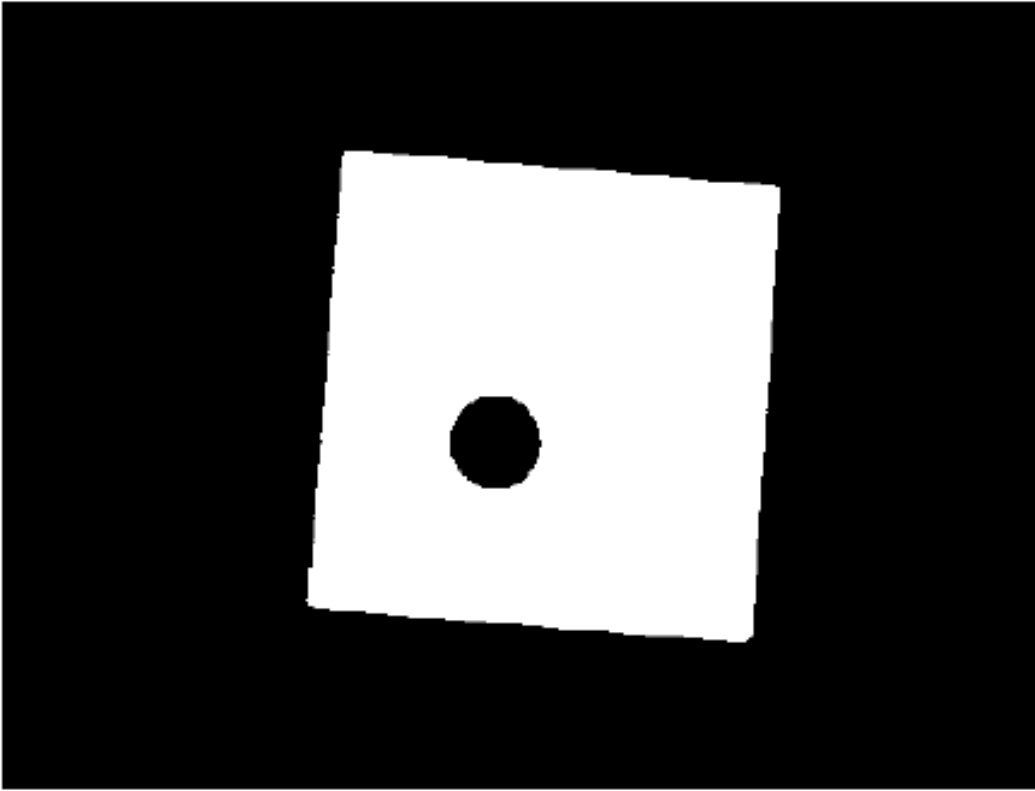
$$g(x, y) = f(x, y) \ominus SE$$

- $\ominus$  denote erosion



Objects shrink

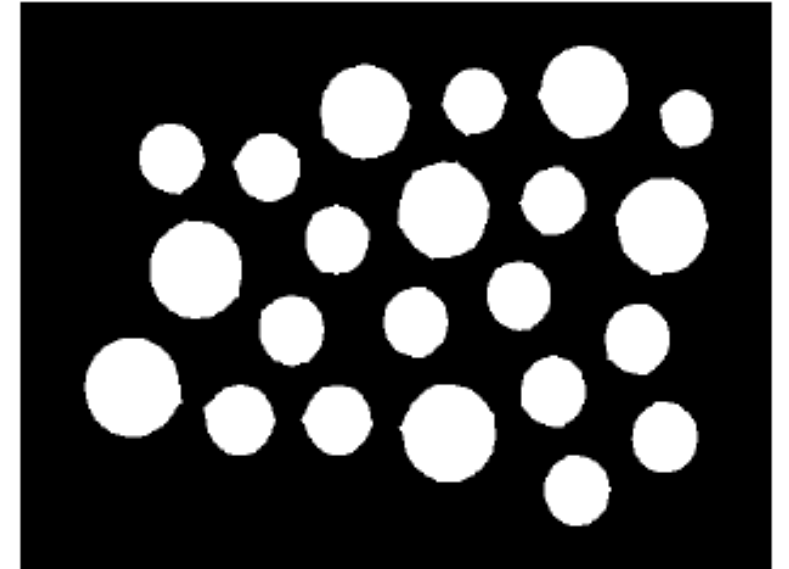
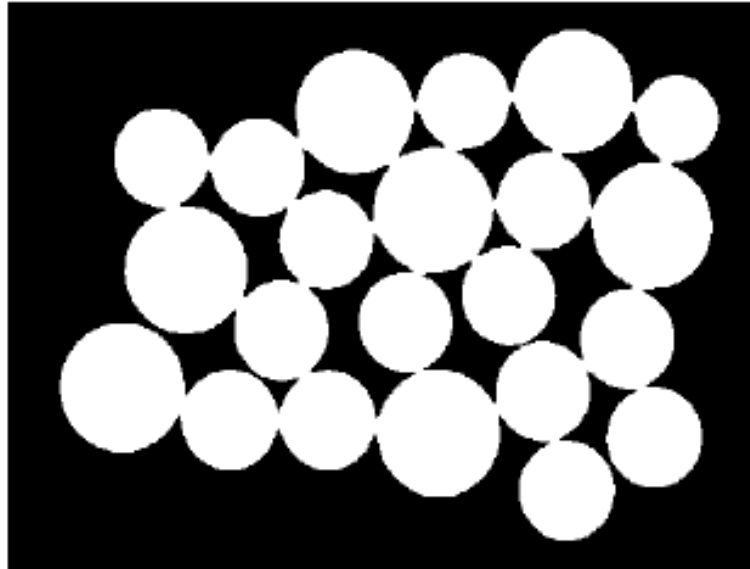
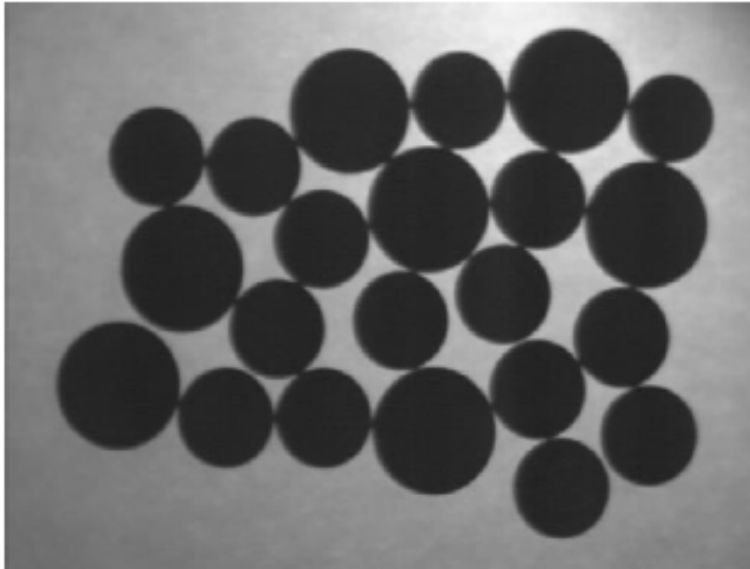
# Erosion – images



# Erosion – images

Application example: Counting objects

- –Counting these coins is difficult because they touch each other!
- –Solution: Thresholding and Erosion separates them

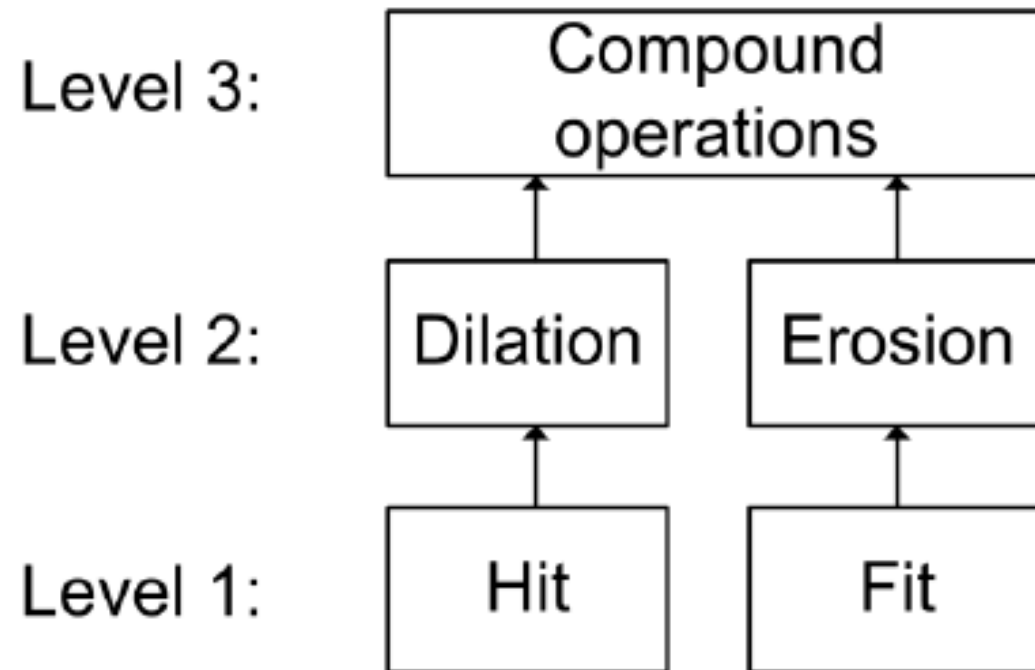


# Compound operations

Combining Erosion and Dilation into higher level (more advanced) operations

## Main properties:

- Opening: Isolate objects and remove small objects (better than Erosion)
- Closing: Fill holes (better than Dilation)



# Opening

Remove small objects but, keep original size (and partially shape)

- Opening = Erosion + Dilation
  - Use the **same** structuring element!
  - Similar to erosion, but less destructive

- Math:

$$g(x, y) \circ SE = (f(x, y) \ominus SE) \oplus SE$$

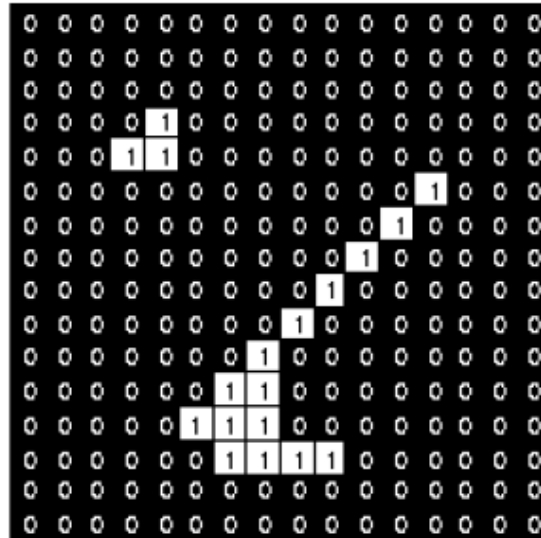
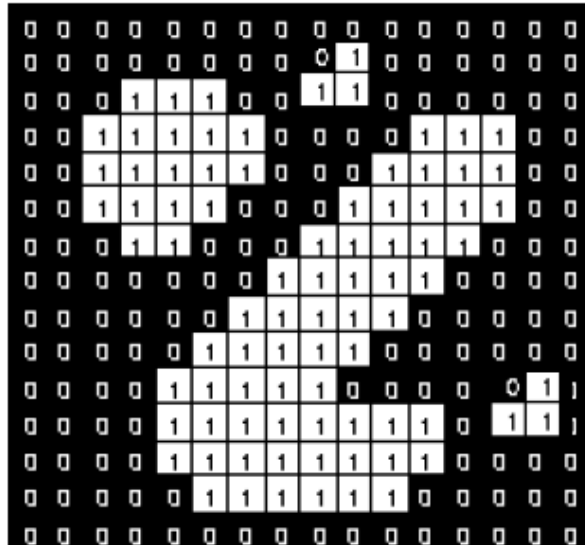
- Opening is idempotent: Repeated operations have no further effects! In other words you always get the same results

# Opening example

Structuring element:

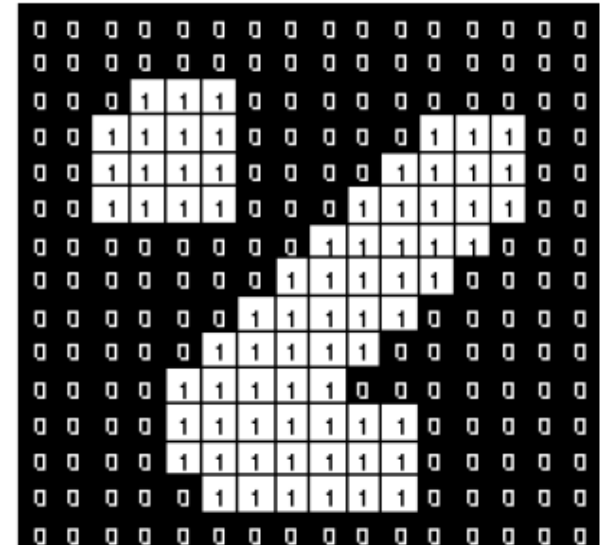
1	1	1
1	1	1
1	1	1

Erosion



+ Dilation

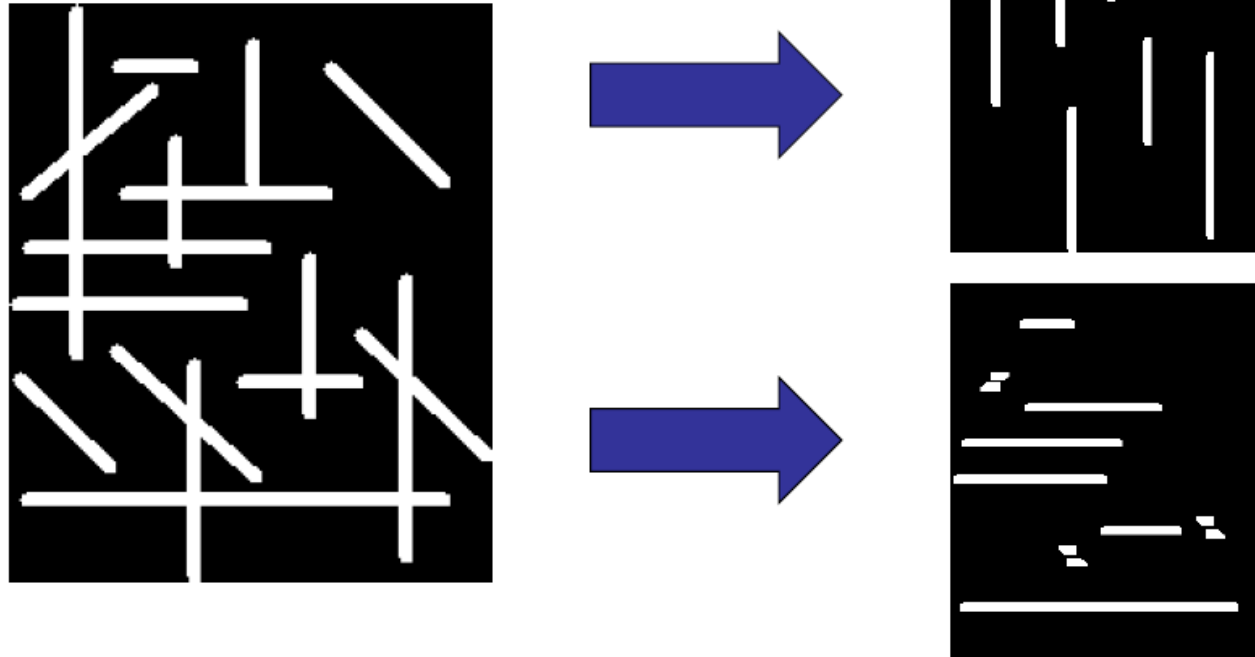
= Opening



# Opening

## Example

- 9x3 and 3x9 structuring element

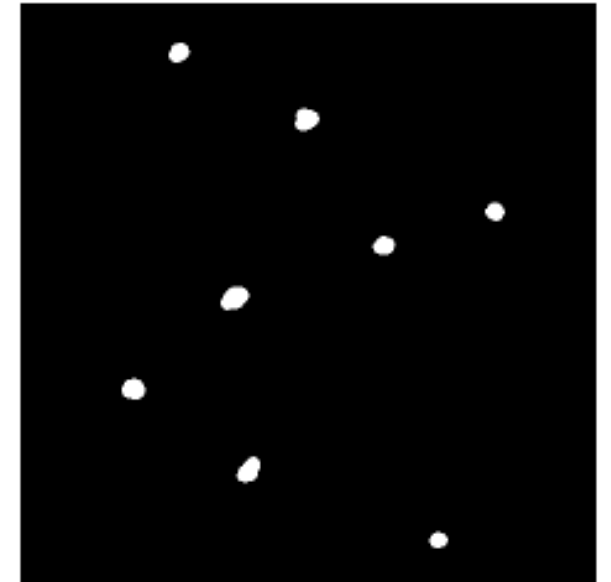
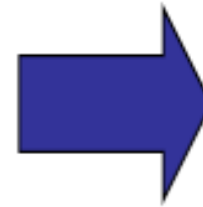
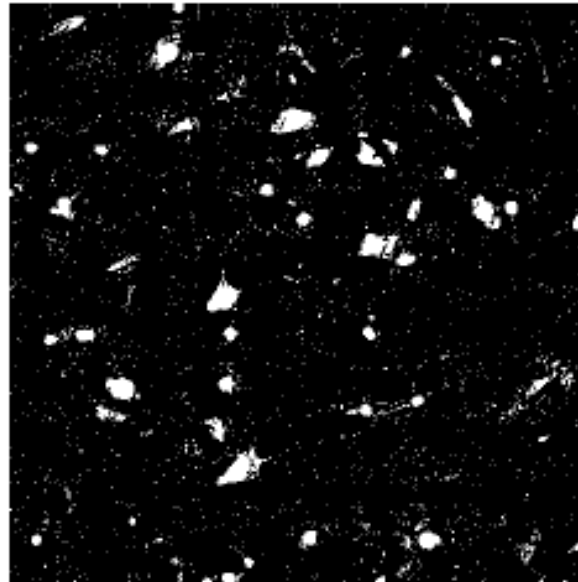
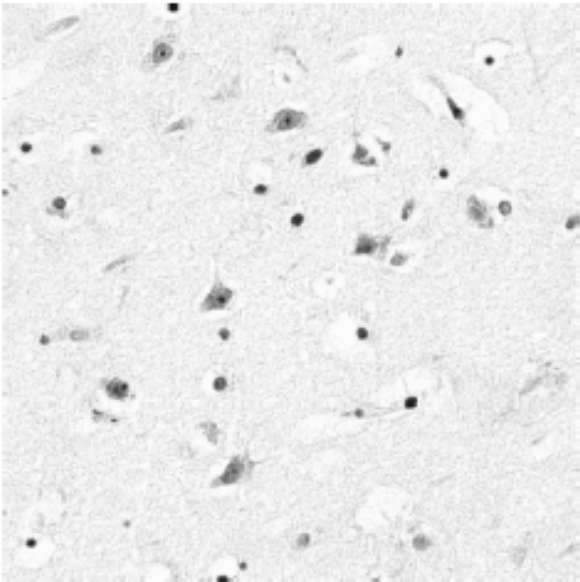




# Opening

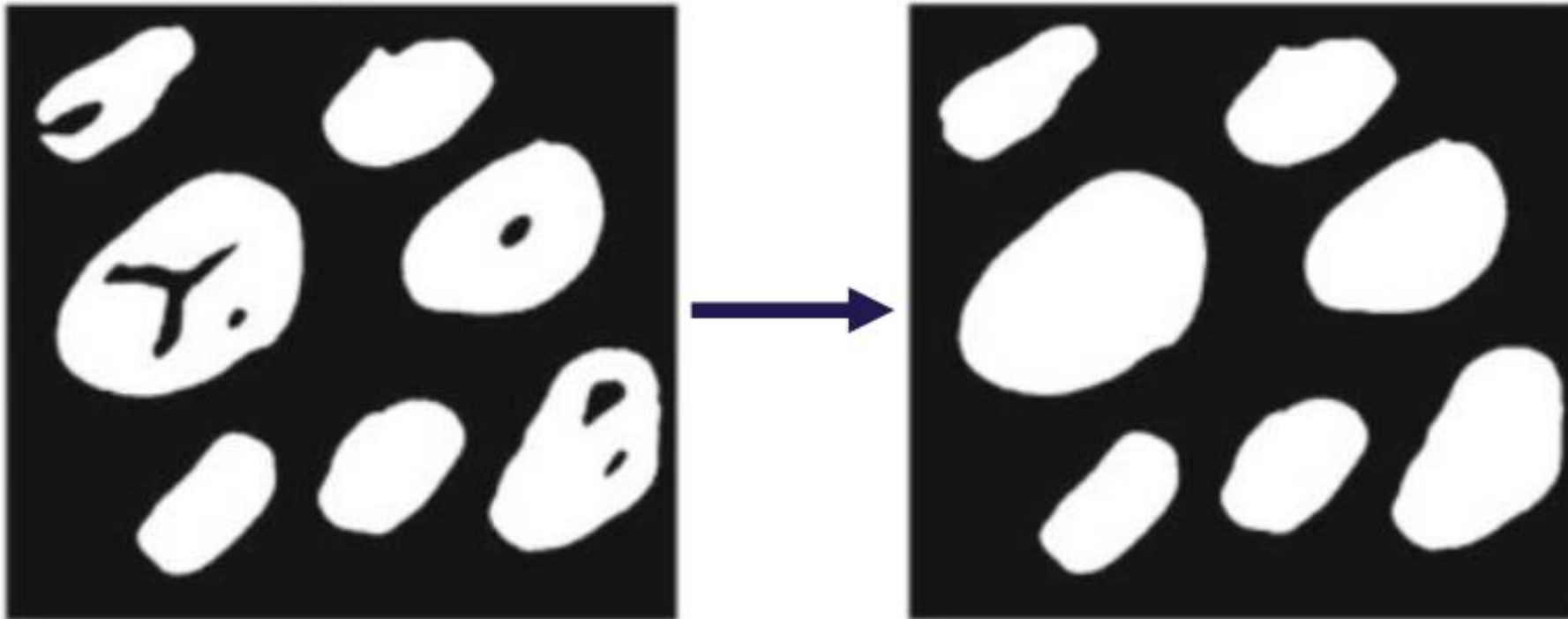
## Example

- Use large structuring element that fits into the big objects
- Structuring element: 11 pixels disc



# Closing

Motivation: Fill holes, but keep original size (and shape)



# Closing

Fill holes but keep original size (and partially shape)

Closing = Dilation + Erosion

- Use the same structuring element
- Similar to dilation, but less destructive
- Math:

$$g(x, y) \circ SE = (f(x, y) \oplus SE) \ominus SE$$

Closing is idempotent: Repeated operations has no further effects!

structur

# Closing

- Given the binary image as input, find the Closing (dilation + erosion) for the following structuring element:

Original

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

Dilation

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

Dilation + erosion

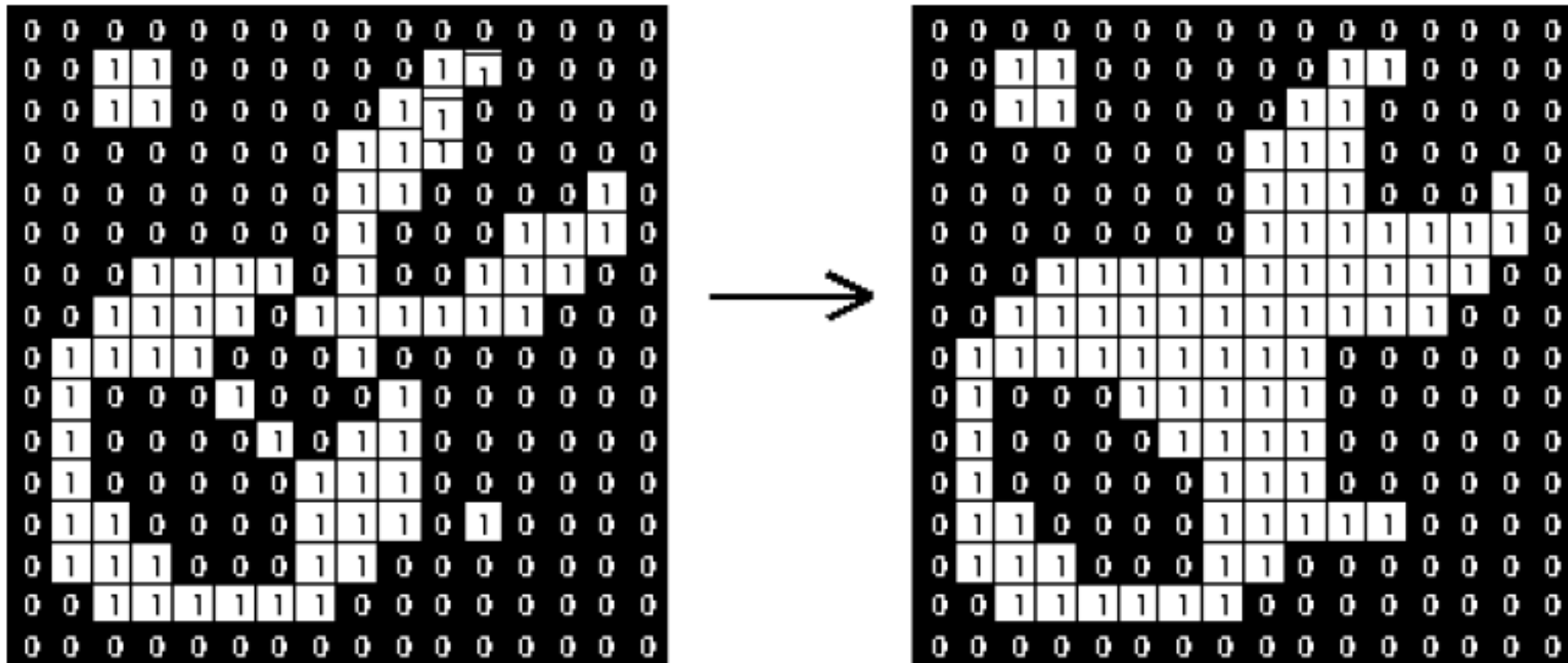
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	1	1	1	1	1	0	0	0
0	0	1	1	1	1	1	1	0	0
0	0	1	1	1	1	1	0	0	0
0	0	1	1	1	1	1	0	0	0
0	0	1	1	1	1	1	0	0	0
0	0	0	1	1	1	1	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

1	1	1
1	1	1
1	1	1

# Closing

## Example

- Structuring element: 3x3 square

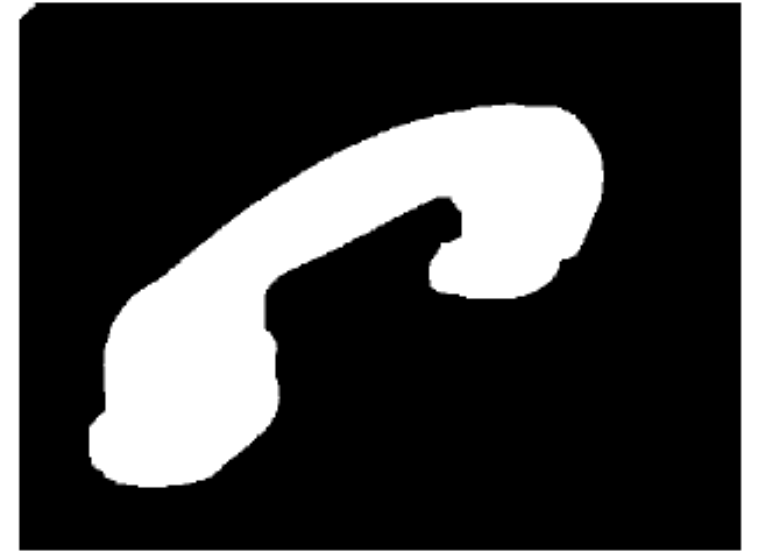
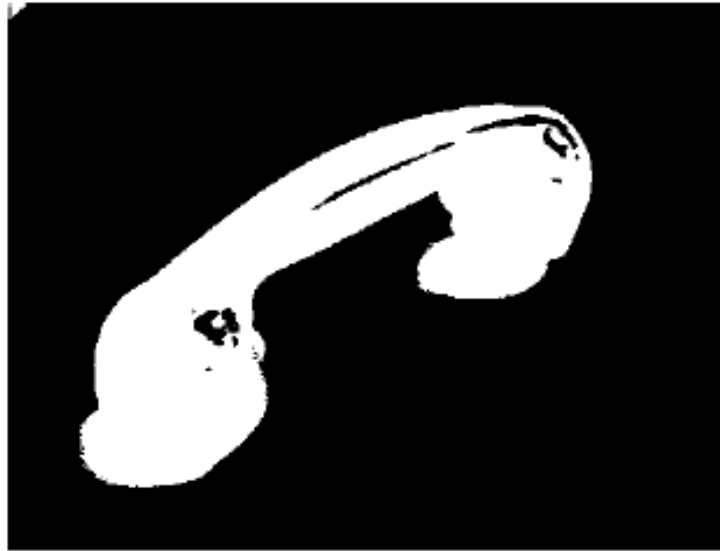


# Closing

## Example

1.Threshold

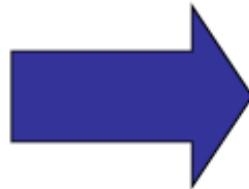
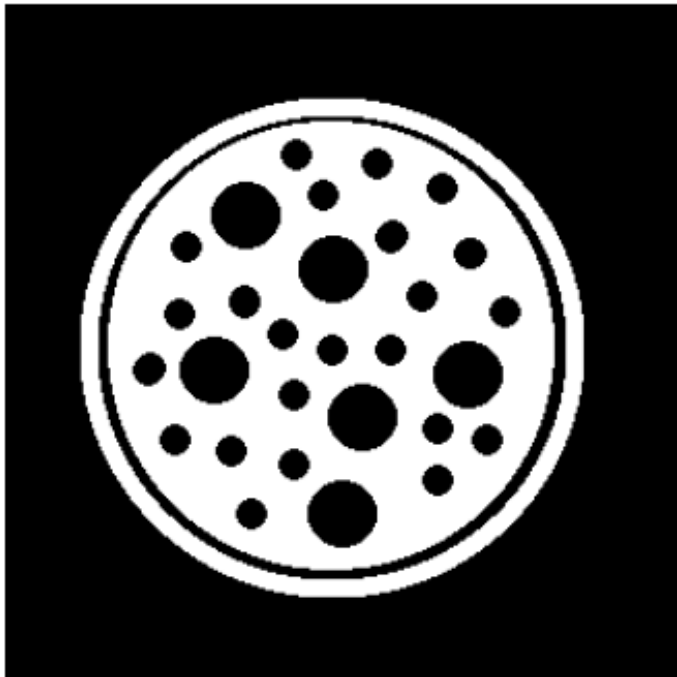
2.Closing with a disc of size 20



# Closing

## Example

- Closing operation with a 22 pixel disc
- Closes small holes



# Question

Which morphological operation has been done to each of the 4 image below?



1



2



3



4

- A: Erosion
- B: Dilation
- C: Opening
- D: Closing

Original Image

