

计算机辅助手术讲座 (8)  
Image Guided Surgery (8)

二值形态学应用

**Binary morphology application**

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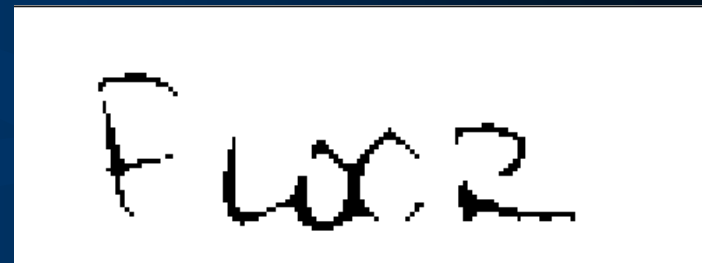
上海交通大学 *Med-X*研究院

*2009.11*

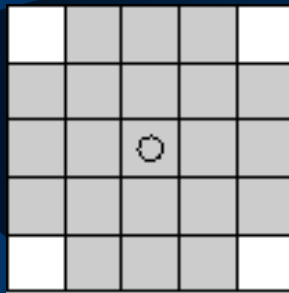
# Binary Morphological Operation



$P$



$P \$ S$



$S$



$P \oplus S$



$P \$ S \oplus S$

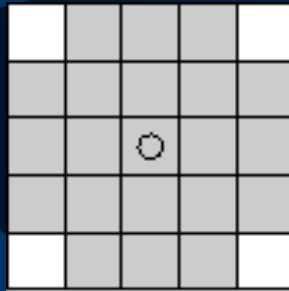
# Binary Morphological Operation



P



$$P \ominus S \oplus S = P \circ S$$



S



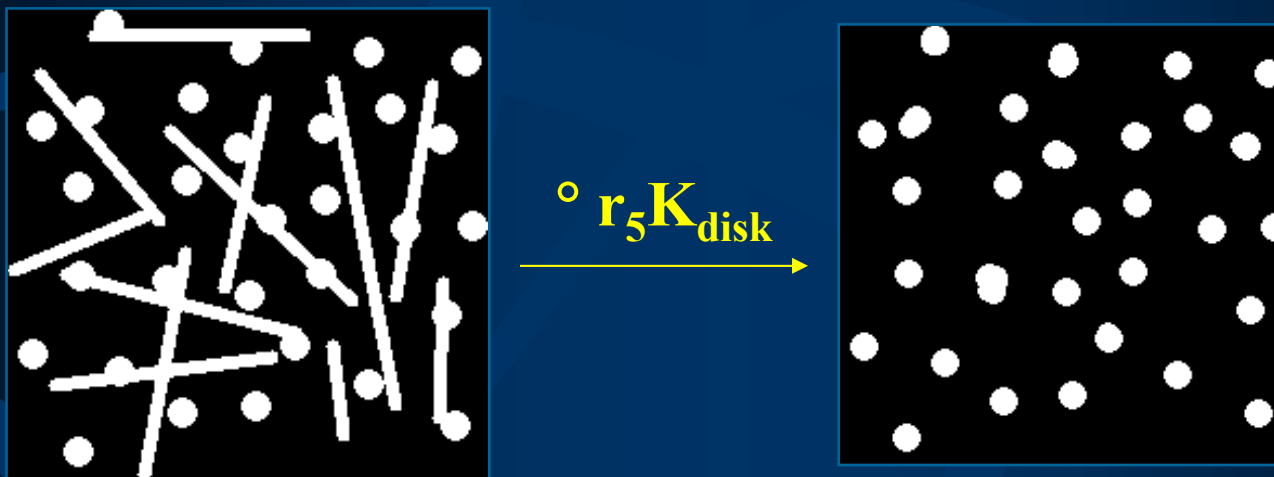
$$P \oplus S \ominus S = P \bullet S$$

# Applications

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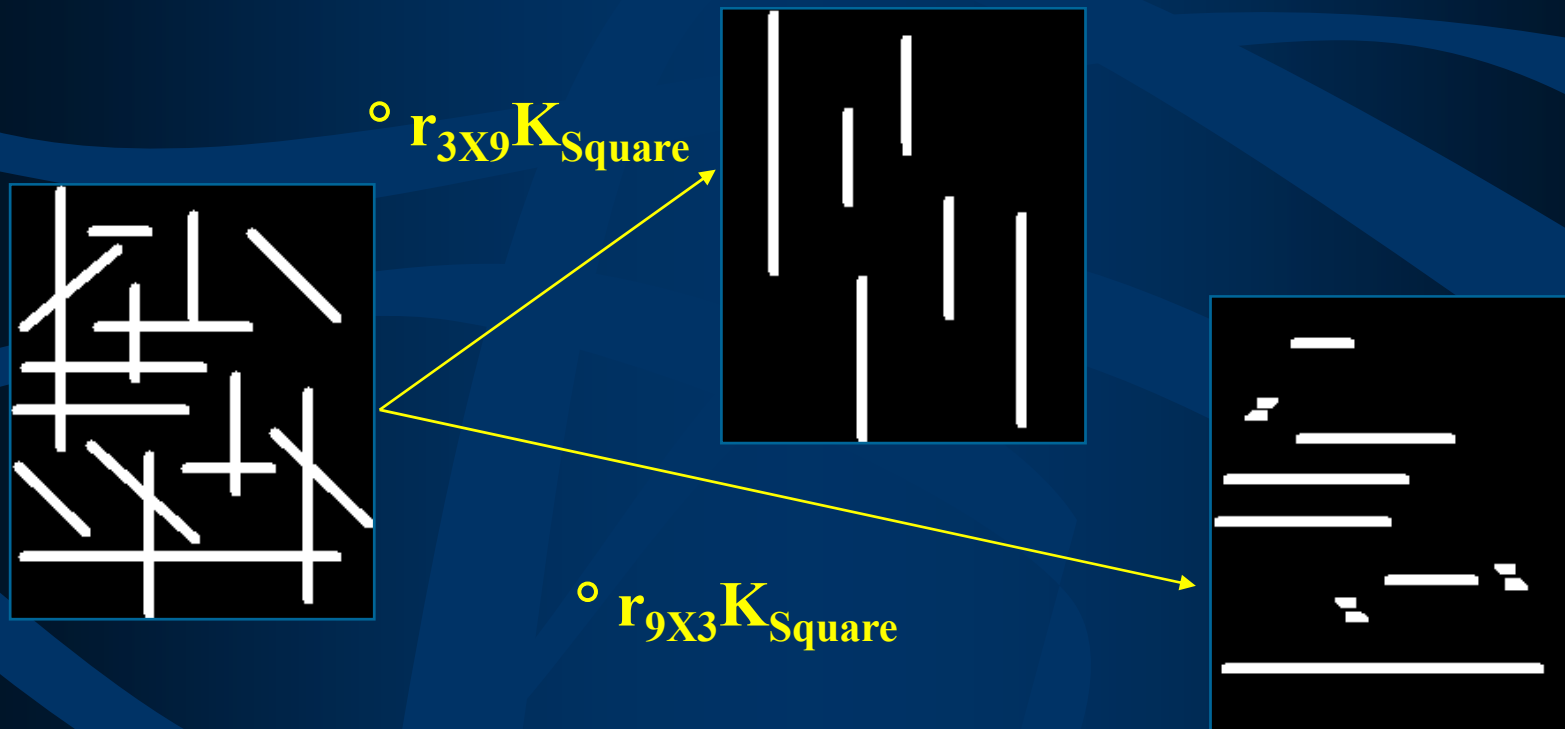
# Shape Inspection

- **Binary Opening** is a powerful shape detector by using different structuring elements
- Example: Distinguish circles and lines



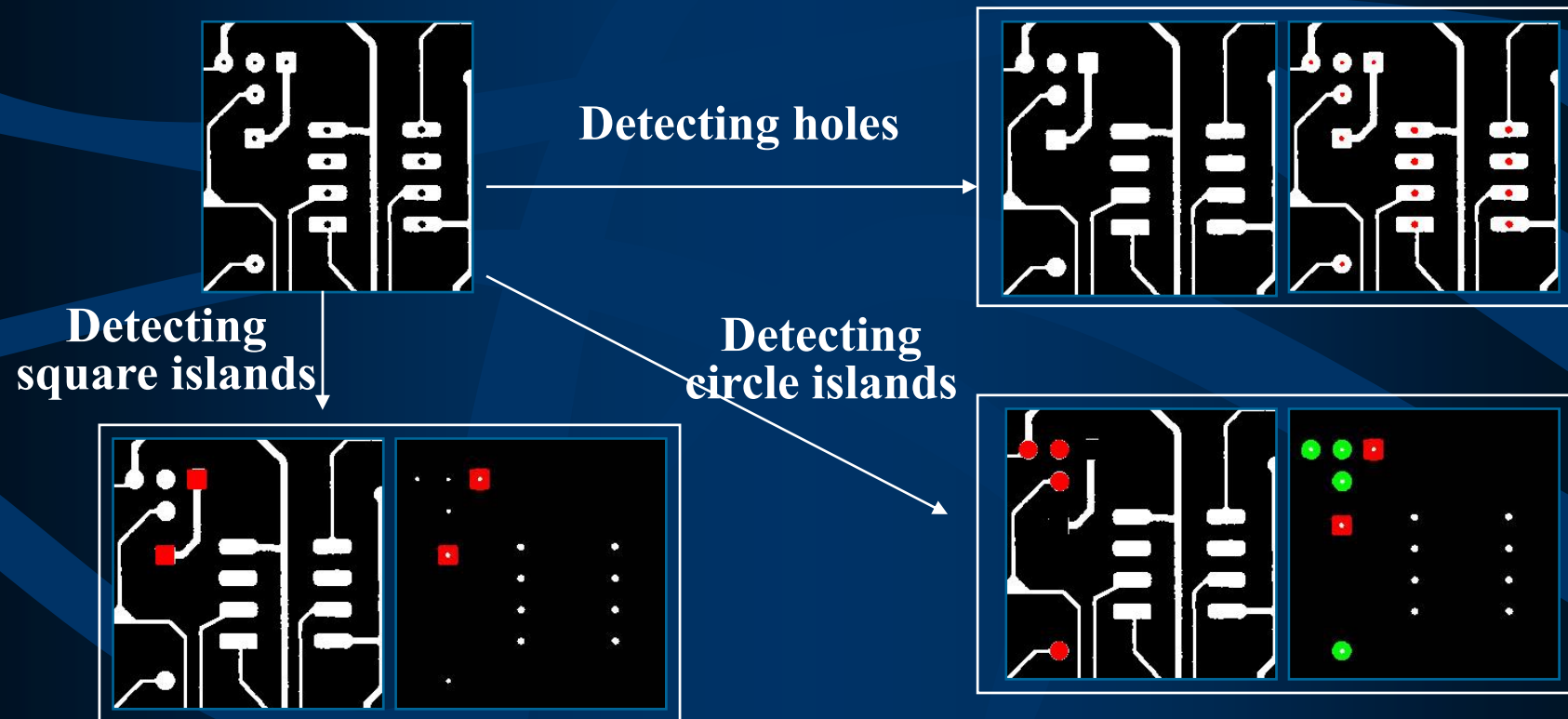
# Shape Inspection

- Example: Distinguish circles and lines

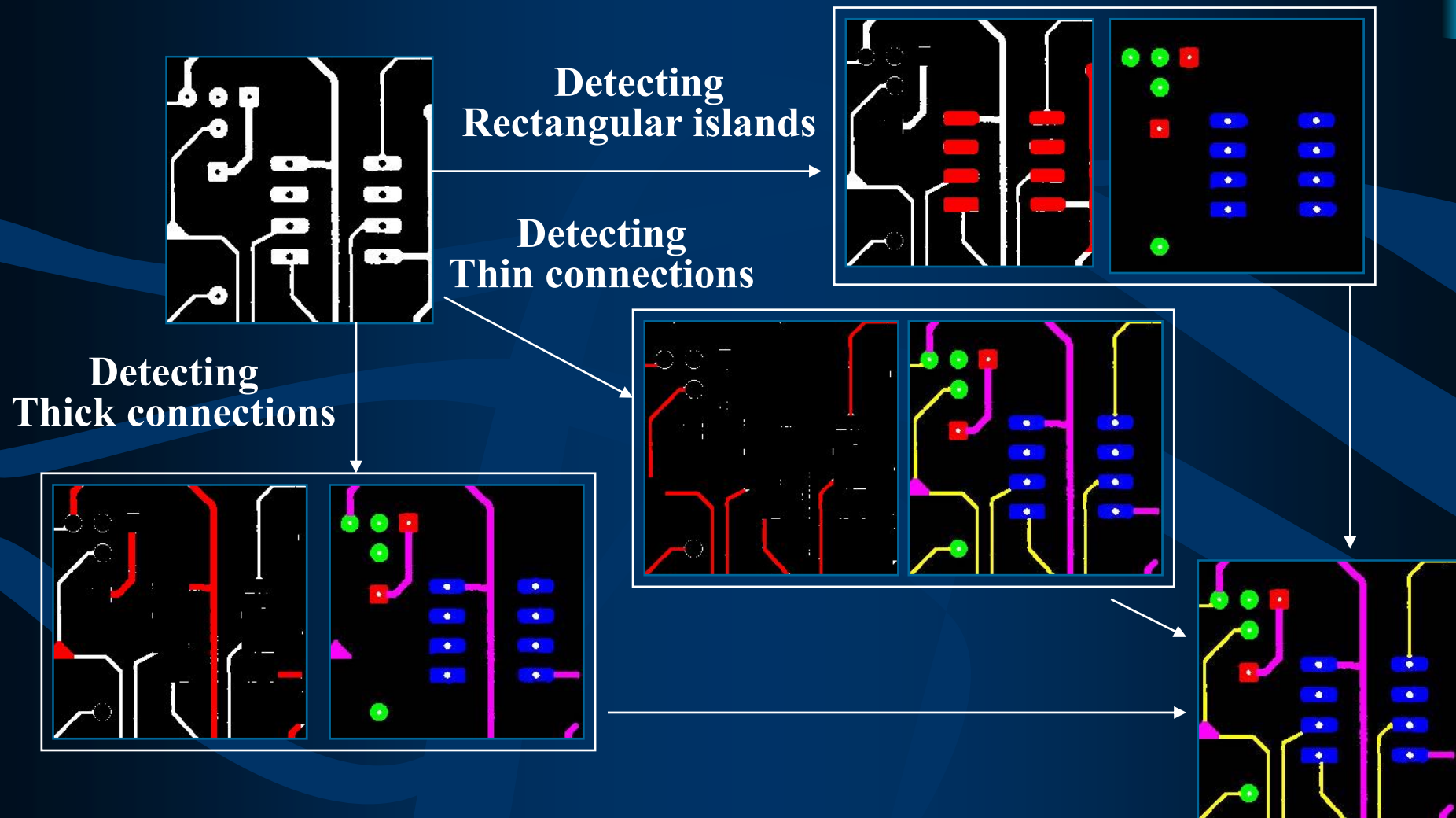


# Shape Inspection

- Example: Decompose a printed circuit board in its main parts.



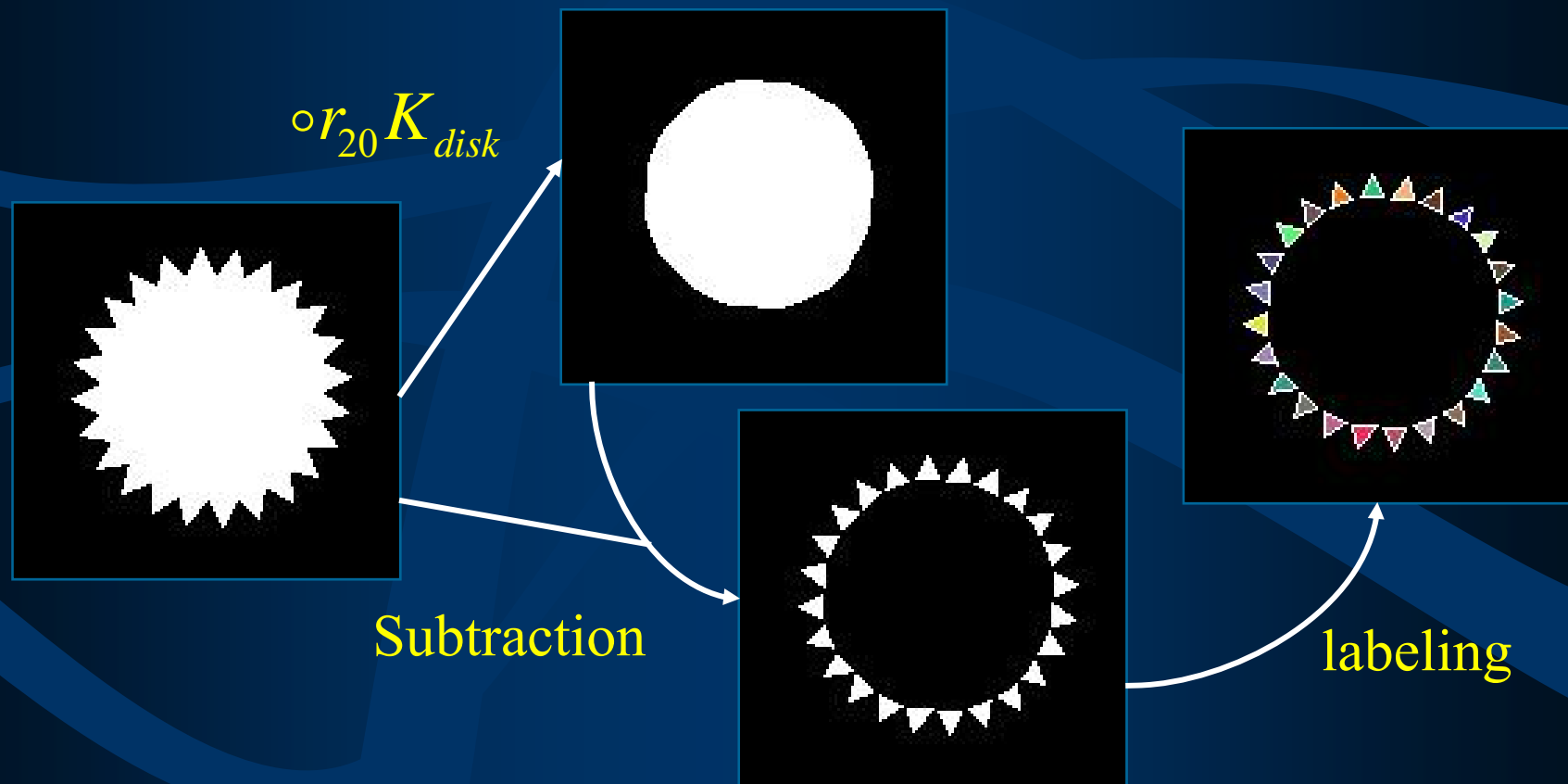
# Shape Inspection



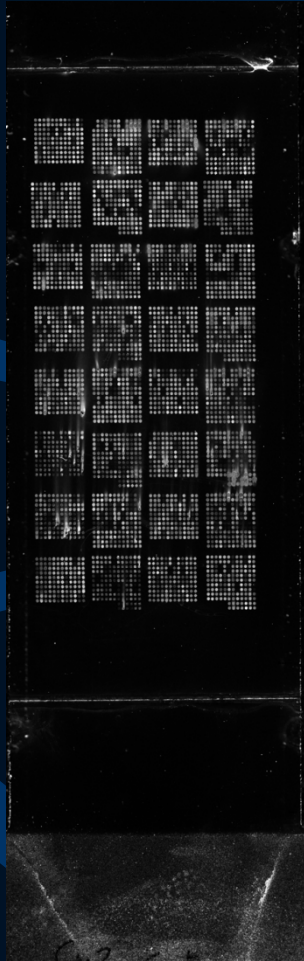


# Application 1

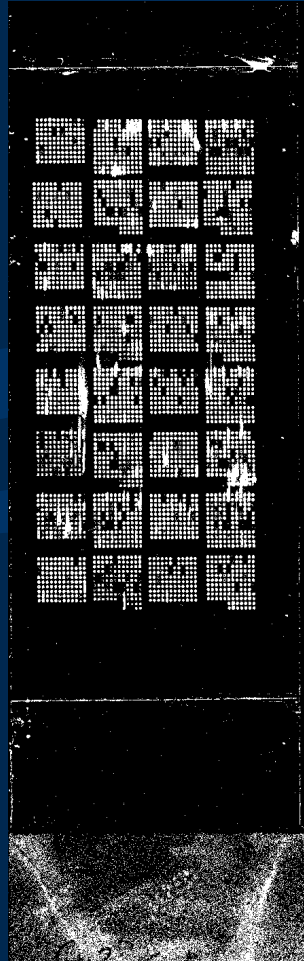
- Detect the teeth of a gear:



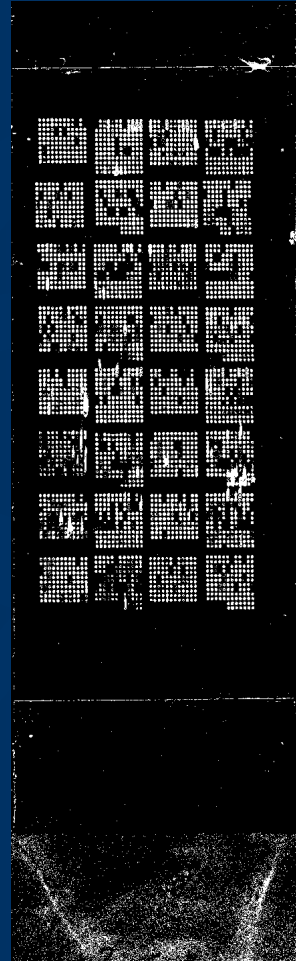
## Application 2: Grid identification from Biochip image



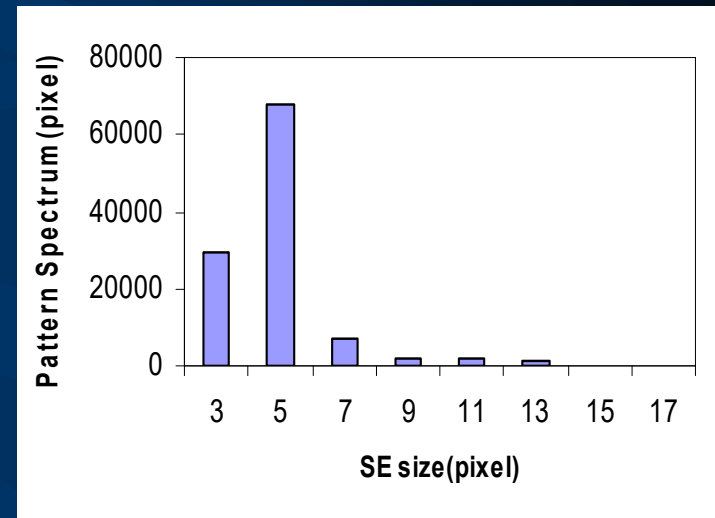
Origin



Otsu threshold



entropy threshold



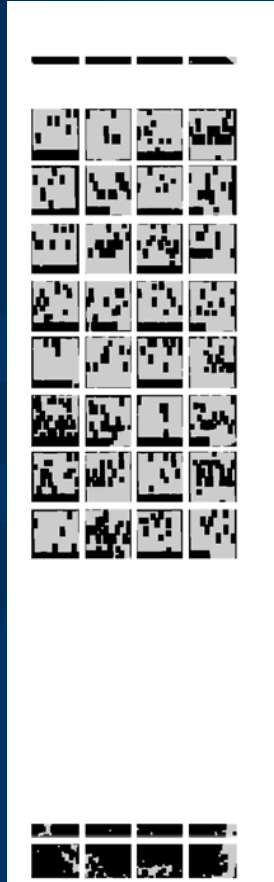
Pattern Spectrum  
Spot size = 5 (pixel)

# Application 2:

## Grid identification from Biochip image



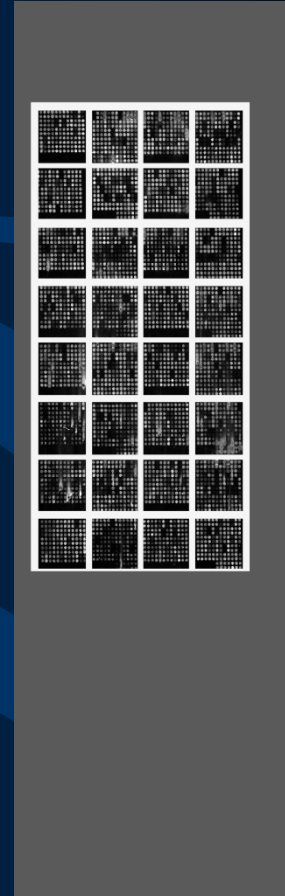
Morphological  
noise reduction



Grid identified  
with noise



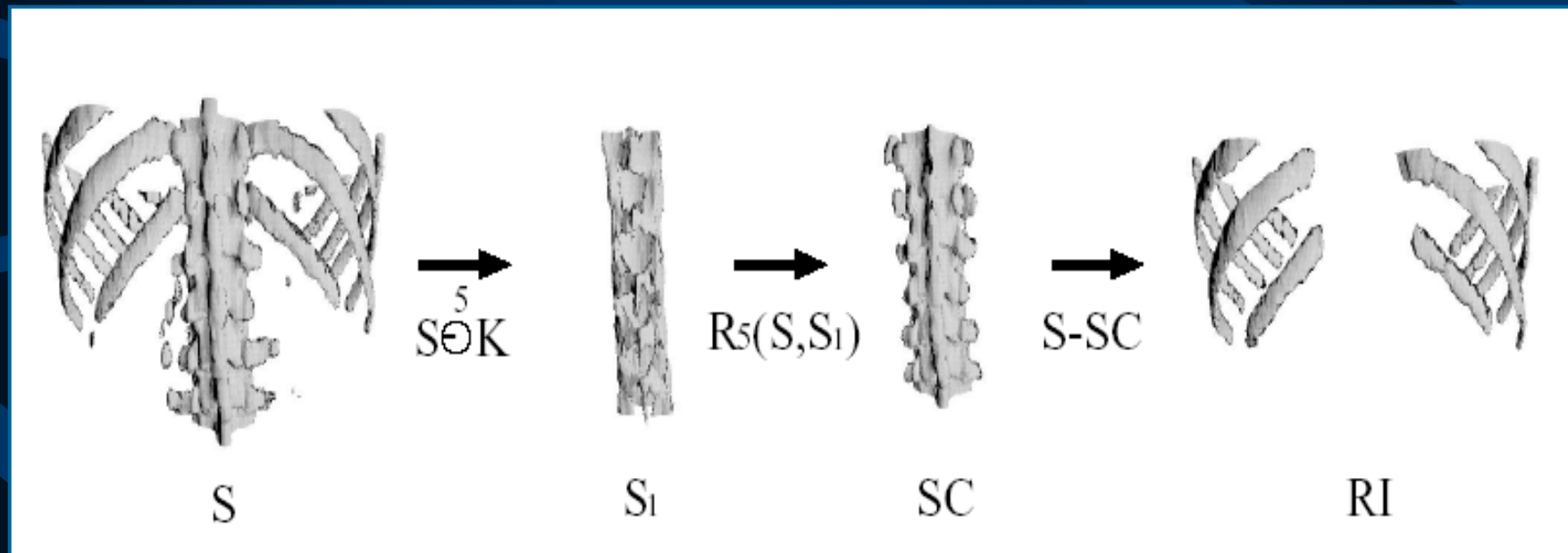
Grid identified  
without noise



Grid identification  
final result

# Application 3

- Segment vertebra and ribs:



# Application 4

A



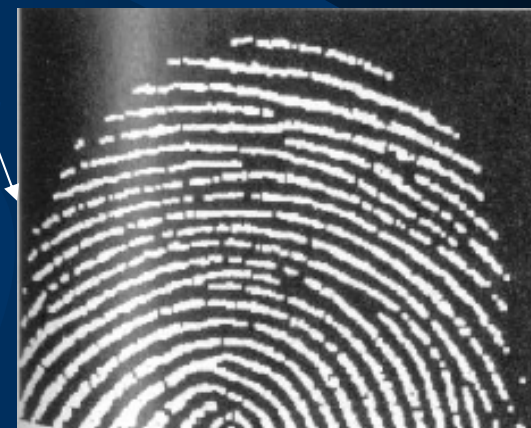
$A \$ B$



1	1	1
1	1	1
1	1	1

B

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





# Application 4

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



$$[(A \circ B) \oplus B] \& B = (A \circ B) \bullet B$$



# Exercise

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# Basic Operation

$$A = \{(0, 1), (1, 1), (2, 1), (2, 2), (3, 0)\}$$

$$B = \{(0, 0), (0, 1)\}$$

$$A \oplus B =$$

$$\{(0, 1), (1, 1), (2, 1), (3, 0), (0, 2), (1, 2), (2, 2), (2, 3), (3, 1)\}$$

+	•	
	•	
	•	•
•		

 $\oplus$ 

+	•
---	---

	+	•	•	
		•	•	
		•	•	•
	•	•		



# Basic Operation

$$A = \{(1, 0), (1, 1), (1, 2), (1, 3), (1, 4), (1, 5), (2, 1), (3, 1), (4, 1), (5, 1)\}$$

$$B = \{(0, 0), (0, 1)\}$$

$$A \ominus B = \{(1, 0), (1, 1), (1, 2), (1, 3), (1, 4)\}$$

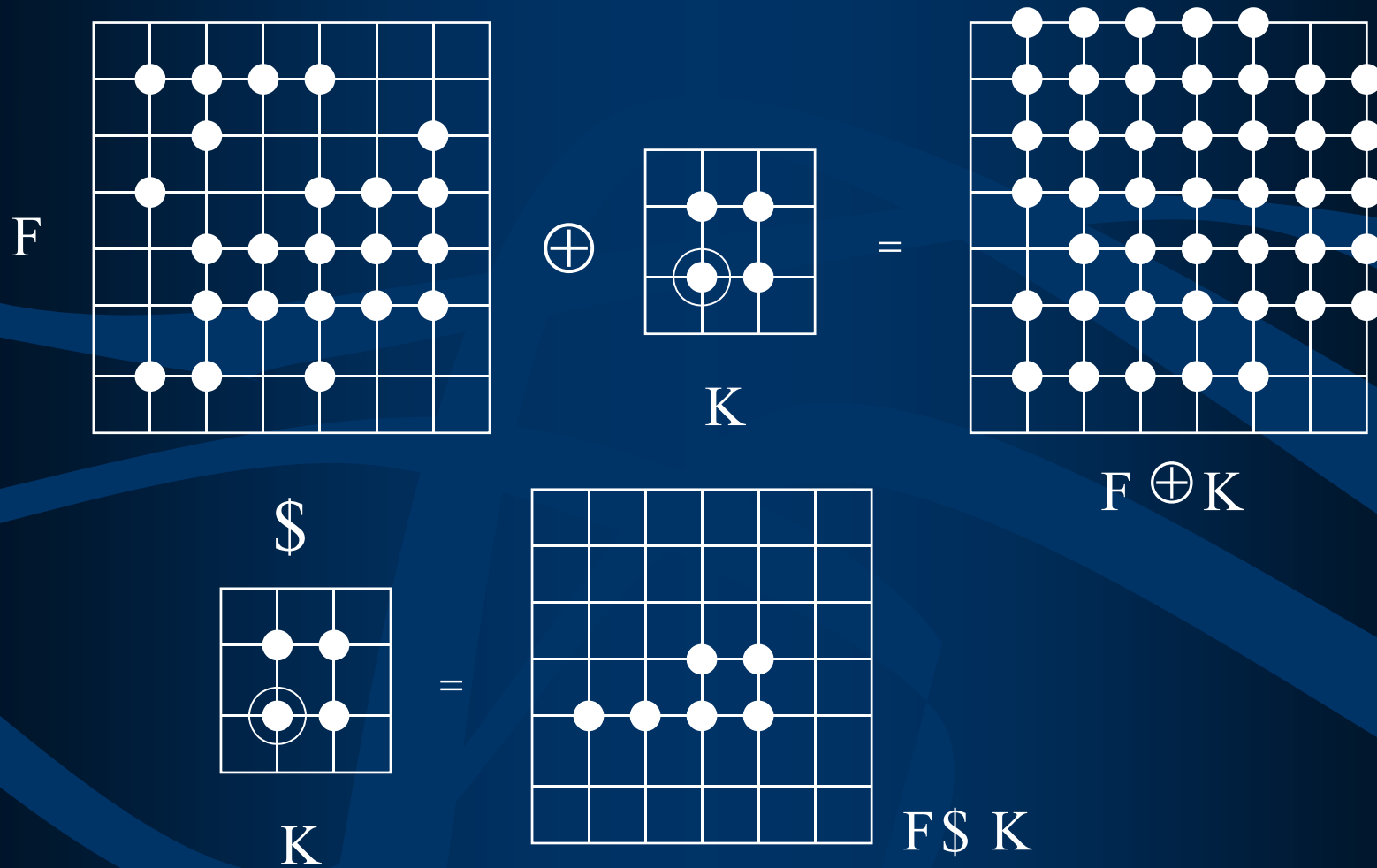
+					
•	•	•	•	•	•
	•				
	•				
	•				
	•				

\$

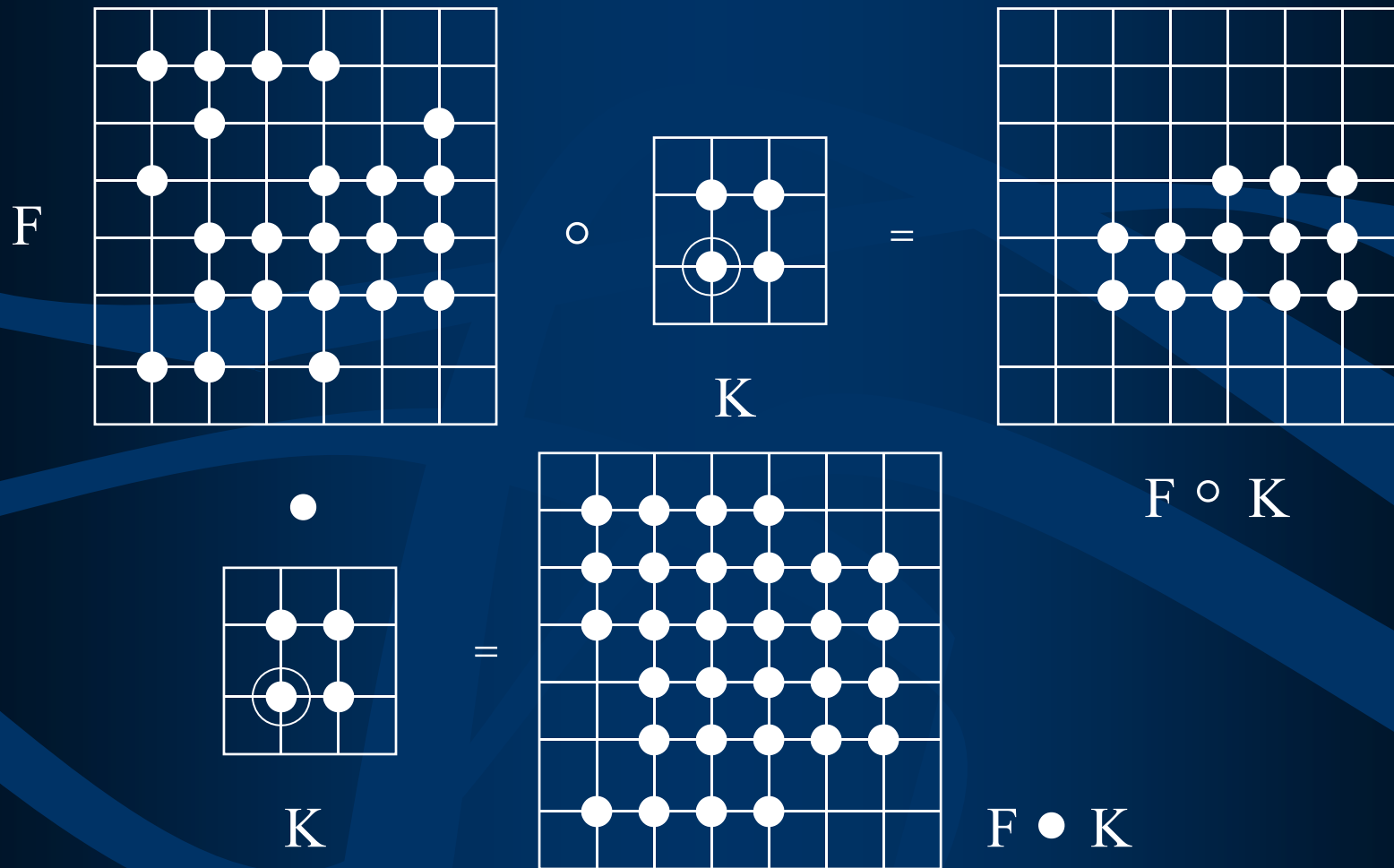


	+				
	•	•	•	•	•

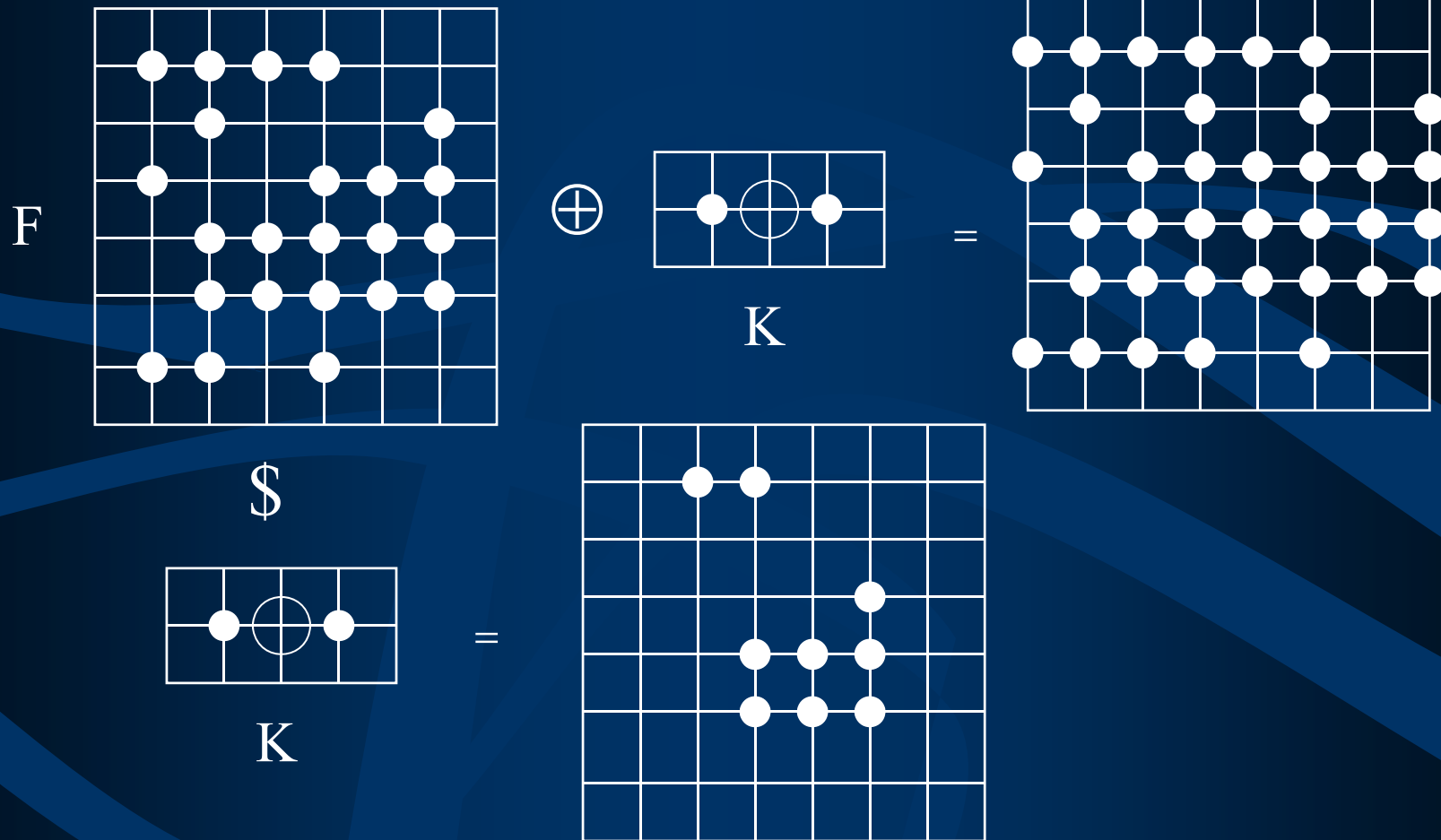
# Basic Operation



# Basic Operation



# Basic Operation



# Distance Transform

	•	•	•	•	•		
			•	•	•		•
	•	•	•	•	•		•
	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
	•	•	•	•	•	•	
•	•	•			•	•	



	1	1	1	1	1		
			1	2	1		1
	1	1	1	2	1		1
	1	2	2	2	1	1	1
1	1	2	3	2	2	2	1
1	2	2	3	3	2	2	1
1	1	2	2	2	2	1	1
	1	1	1	1	1	1	
1	1	1			1	1	

# Skeleton

	1	1	1	1	1		
			1	2	1		1
	1	1	1	2	1		1
	1	2	2	2	1	1	1
1	1	2	3	2	2	2	1
1	2	2	3	3	2	2	1
1	1	2	2	2	2	1	1
	1	1	1	1	1	1	
1	1	1			1	1	



	1	1	1	1	1		
			1	2	1		1
	1	1	1	2	1		1
	1	2	2	2	1	1	1
1	1	2	3	2	2	2	1
1	2	2	3	3	2	2	1
1	1	2	2	2	2	1	1
	1	1	1	1	1	1	
1	1	1			1	1	

# Restoration

	1	1					
				2			1
				2			1
			3			2	
	2		3	3		2	
1	1	1			1	1	



	1	1	1	1	1		
			1	2	1		1
	1	1	1	2	1		1
	1	2	2	2	1	1	1
1	1	2	3	2	2	2	1
1	2	2	3	3	2	2	1
1	1	2	2	2	2	1	1
	1	1	1	1	1	1	
1	1	1			1	1	

## Q & A

1. What would be the effect of a dilation, erosion, opening and closing using the cross-shaped structuring element
2. What problems occur when using dilation to fill small noisy holes in objects?

	1	
1	1	1
	1	

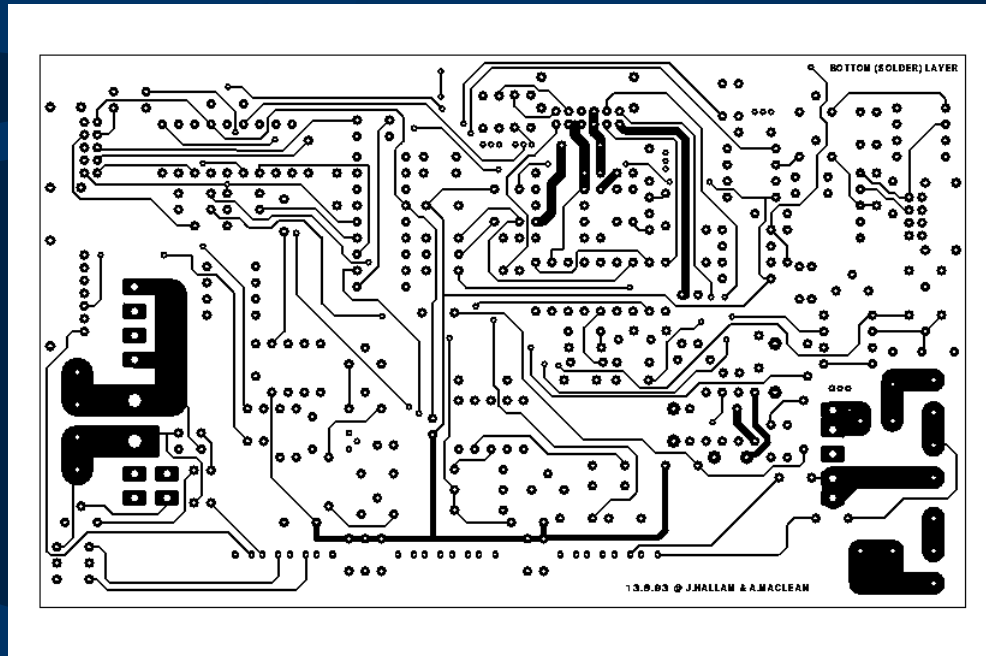


## Q & A

3. Is there any difference in the final result between applying a  $3 \times 3$  square structuring element twice to an image, and applying a  $5 \times 5$  square structuring element just once to the image? Which do you think would be faster and why?
4. Can you explain why the position of the origin within the structuring element does not affect the result of the opening, when it *does* make a difference for both erosion and dilation?

# Q & A

5. Use closing to remove the lines from whereas the circles should remain. Do you manage to remove all the lines? Then use closing to remove the circles while keeping the lines. Is it possible to achieve this with only one SE?



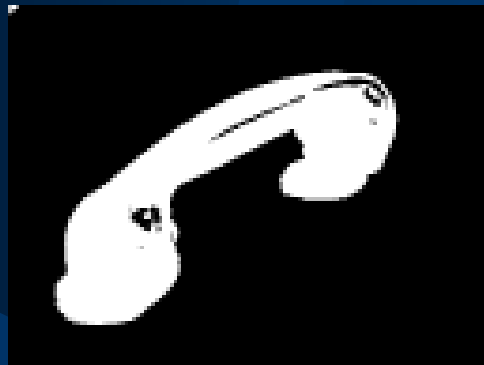
## Q & A

6. Combine closing and opening to remove the pepper noises from the right picture.



## Q & A

7. What would the skeleton of a perfect circular disk look like?
8. Try to improve the next image so that its skeleton becomes less complex and better represents the shape of the receiver.



# Projects

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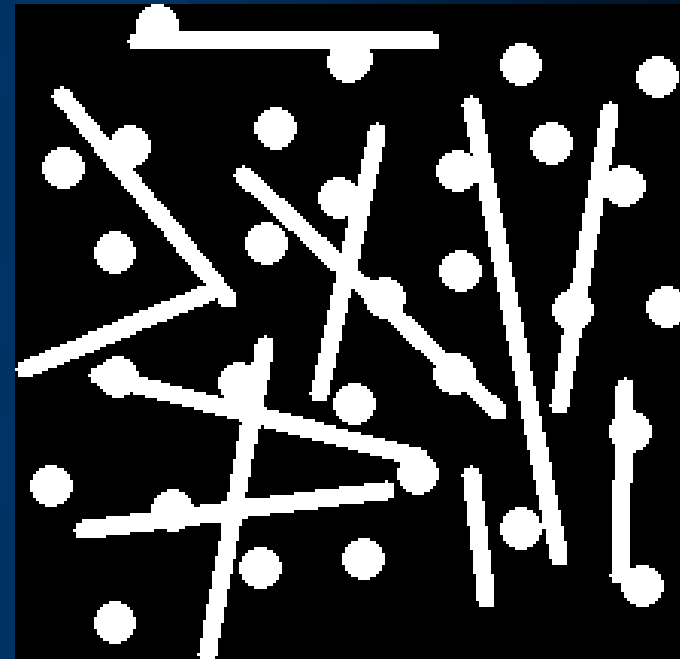
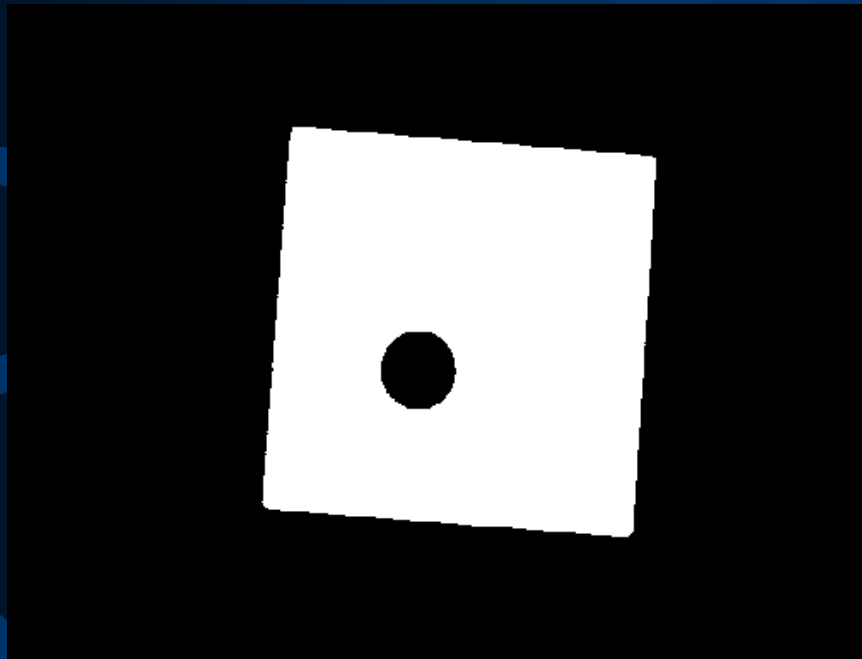
# Project-3

- Write your own code to realize binary dilation, erosion, opening and closing operations.
- Requirement:
  - Design your own UI and display I/O images
  - Try to apply fast operations in case

# Project-4

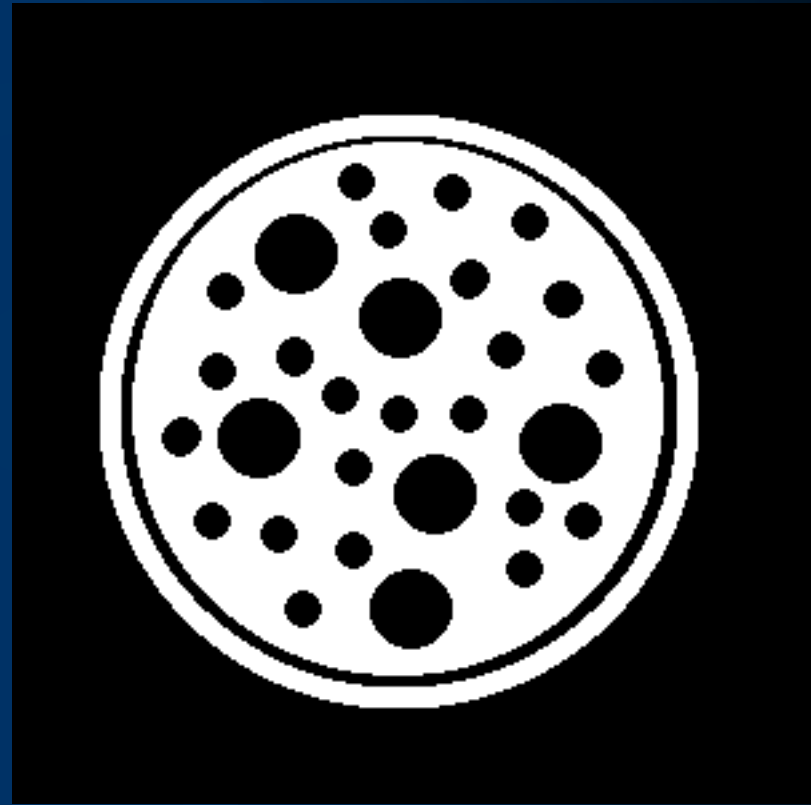
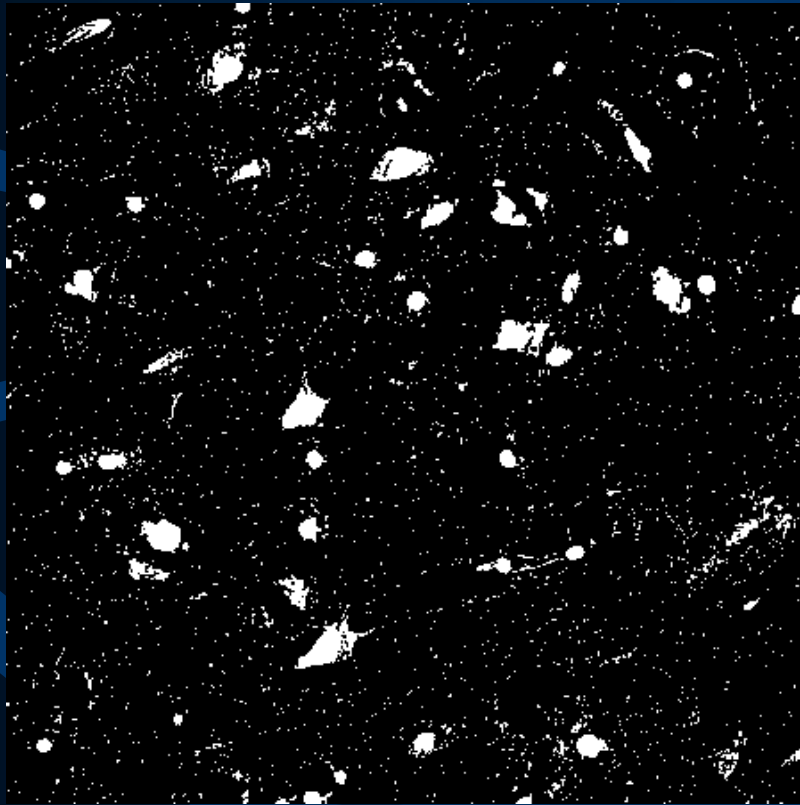
- Write code to realize the next functions:
  - Morphological distance transform
  - Morphological skeleton
  - Morphological skeleton restoration
- Requirement:
  - Design your own UI and display I/O images

# Test Images

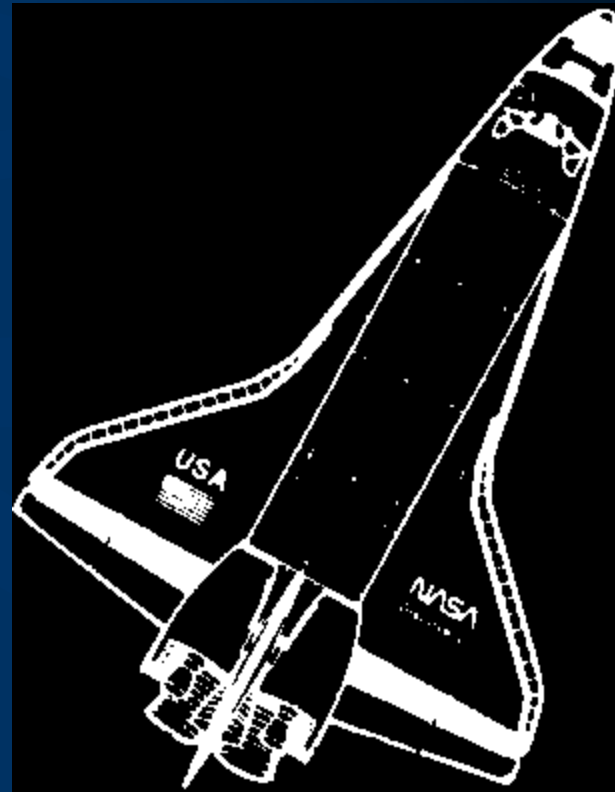
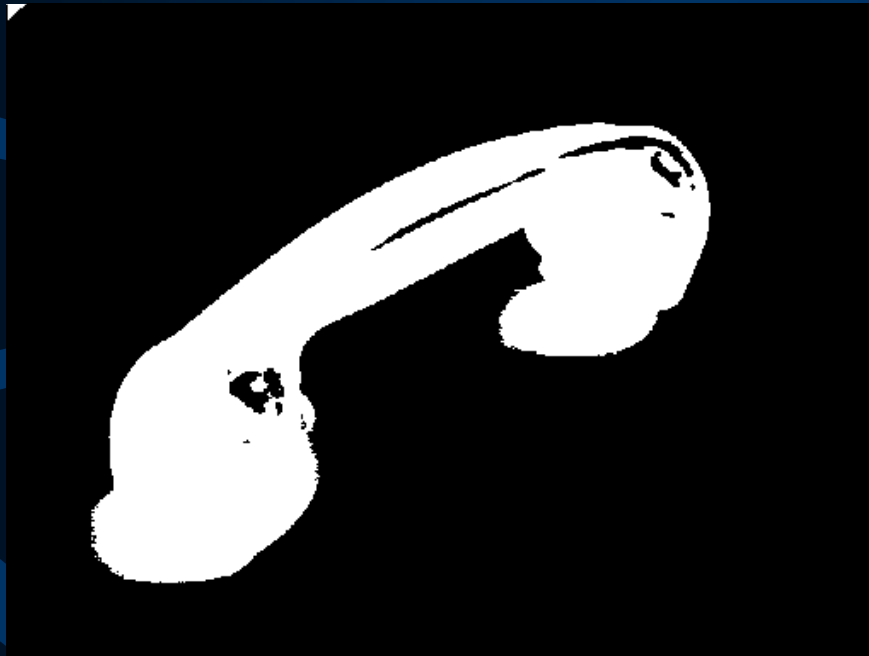




# Test Images



# Test Images



# Discussion



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