

Morphological Image Processing

Image Processing

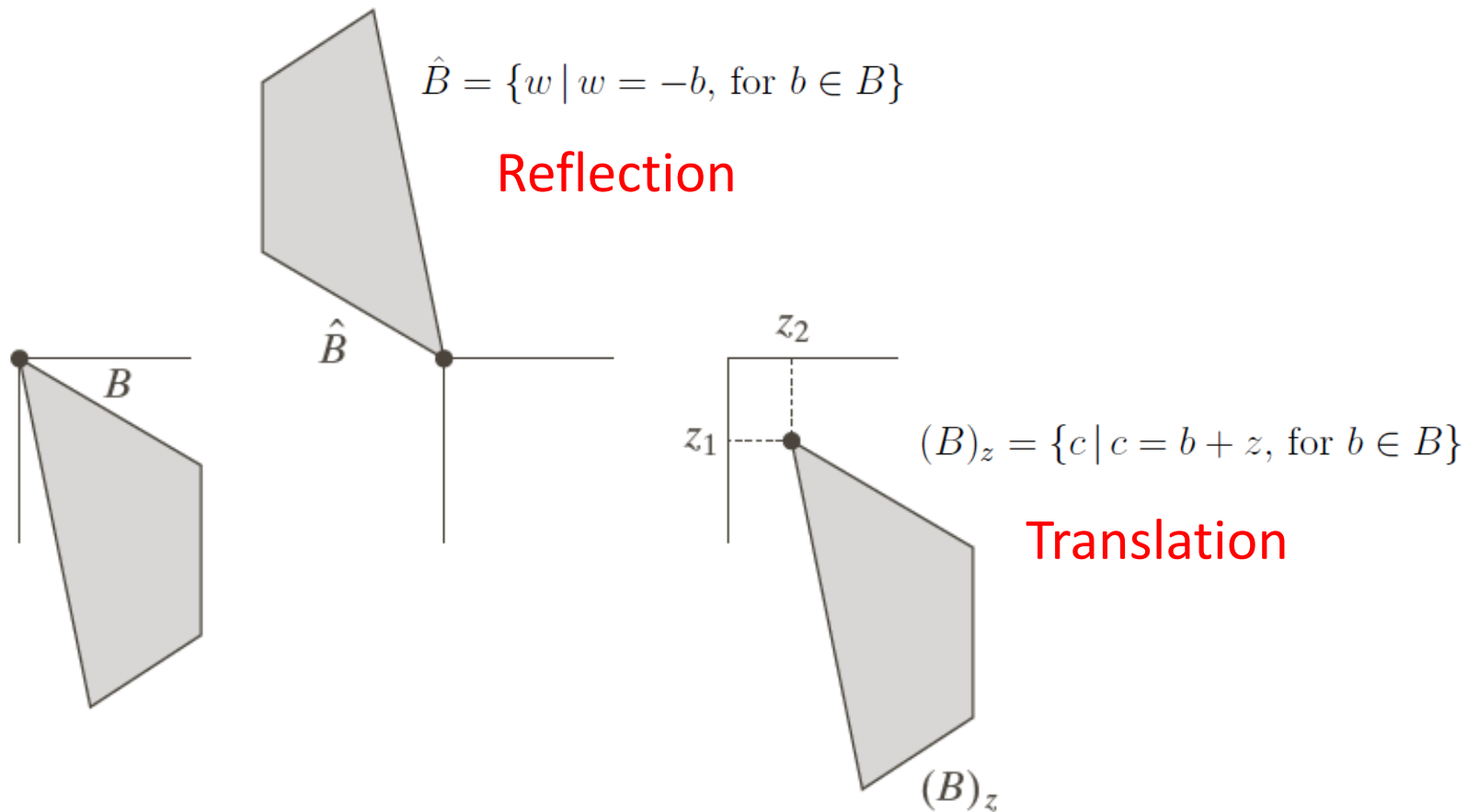
CSE 166

Lecture 14

Announcements

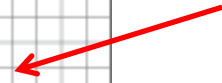
- Assignment 5 is due today, 11:59 PM
- Assignment 6 will be released today
 - Due May 23, 11:59 PM
- Reading
 - Chapter 9: Morphological image processing
 - Sections 9.1, 9.2, 9.3, and 9.5 (through subsection connected components)

Reflection and translation

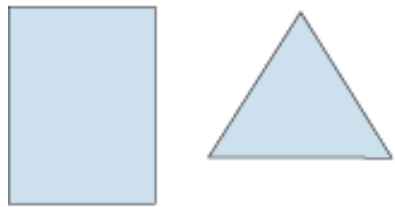


Sets of pixels: objects and structuring elements (SEs)

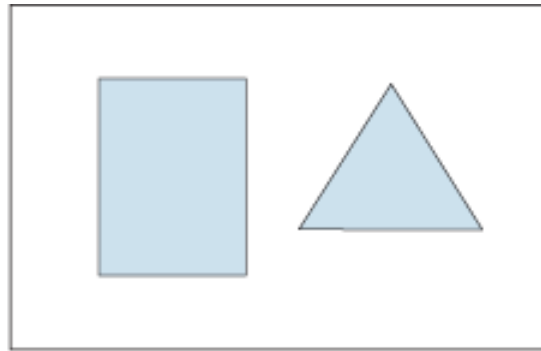
Border of
background
pixels
around
objects



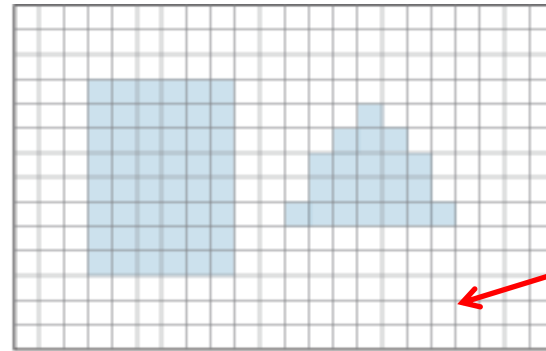
Tight border
around SE



Objects represented
as sets



Objects represented as
a graphical image



Digital image



Structuring element
represented as a set

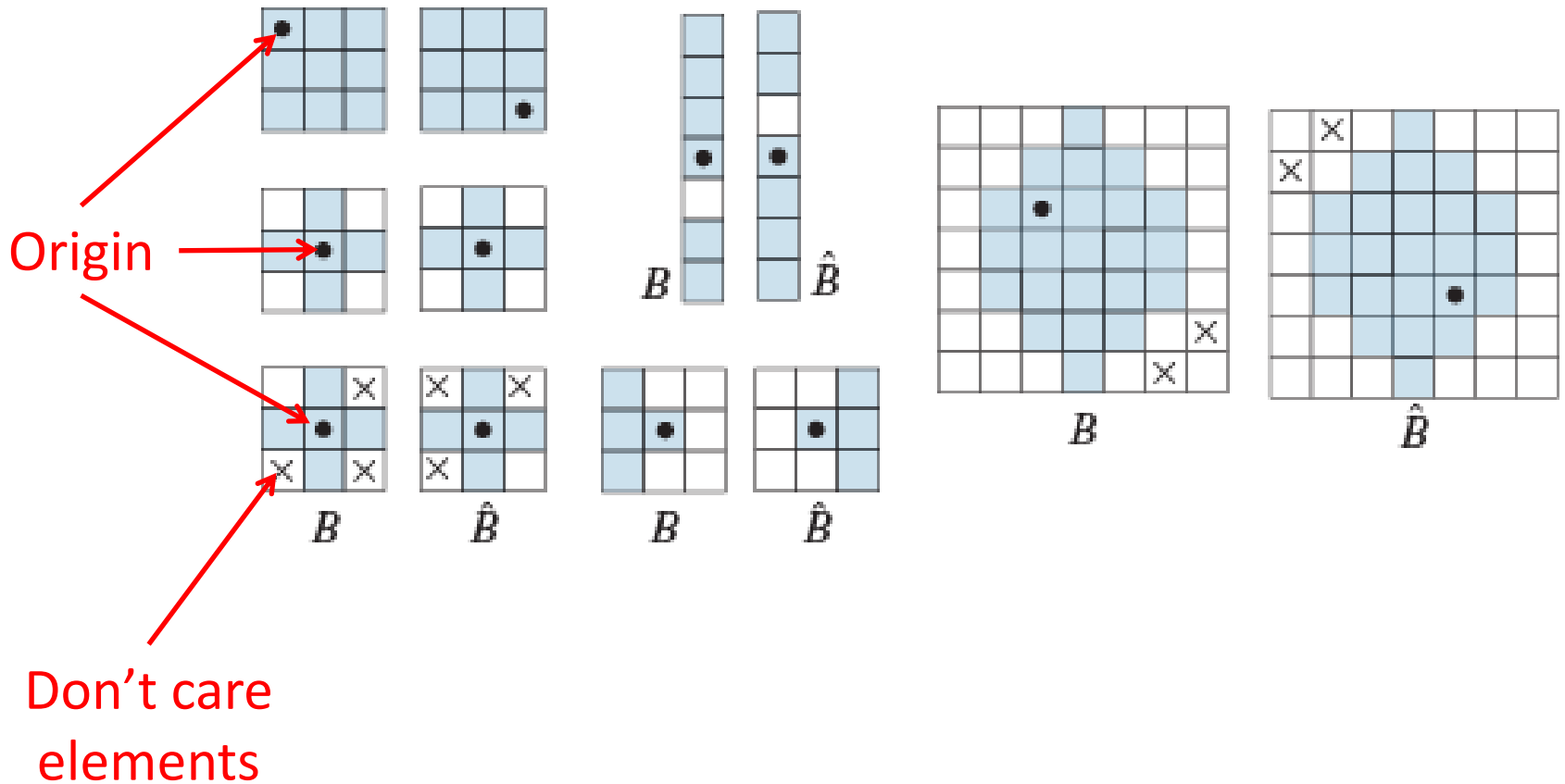


Structuring element
represented as a graphical image



Digital
structuring element

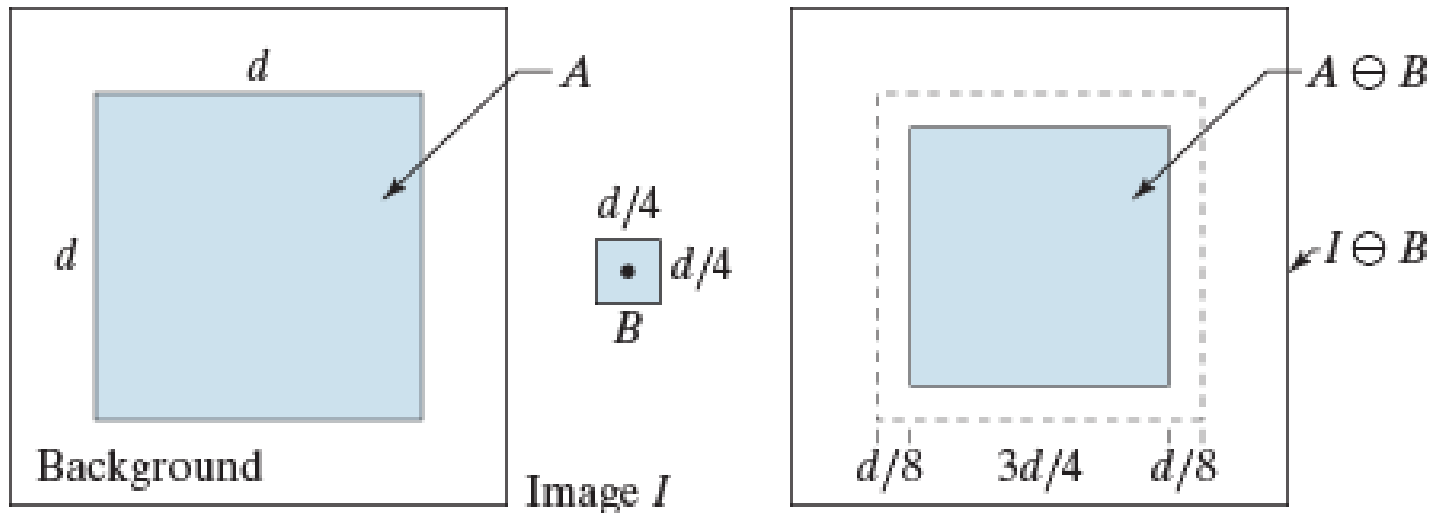
Reflection about the origin



Erosion

Example: square SE

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



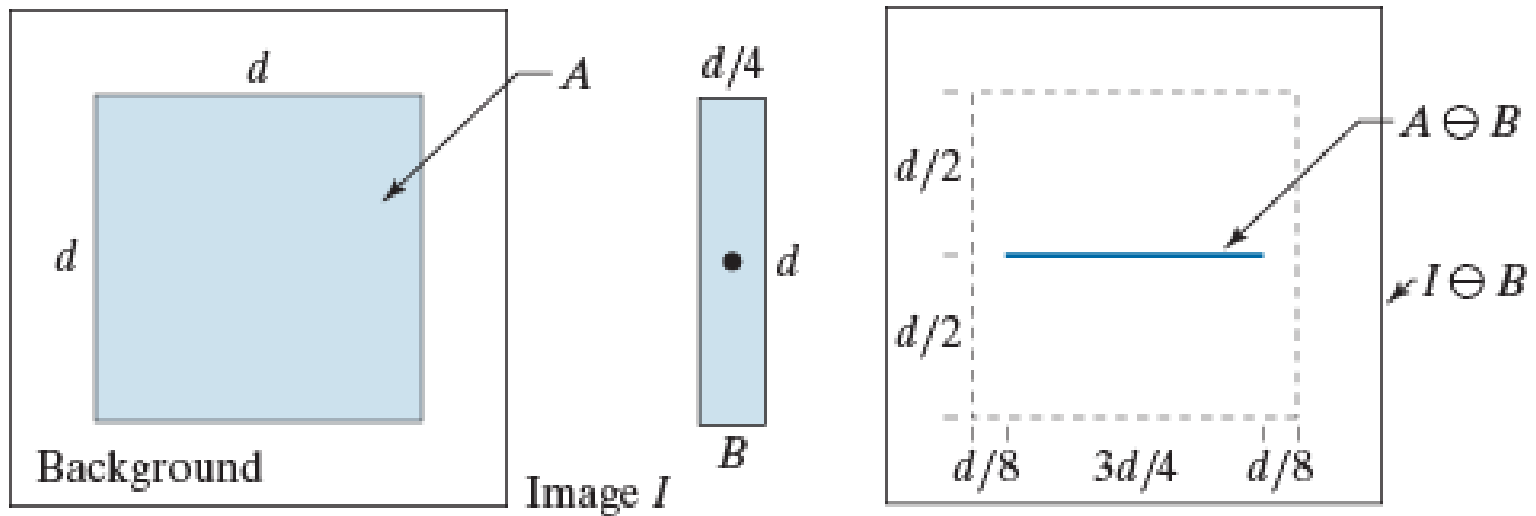
$$I \ominus B = \{z \mid (B)_z \subseteq A \text{ and } A \in I\} \cup \{A^c \mid A^c \subseteq I\}$$

Complement of A
(i.e., set of elements not in A)

Erosion

Example: elongated SE

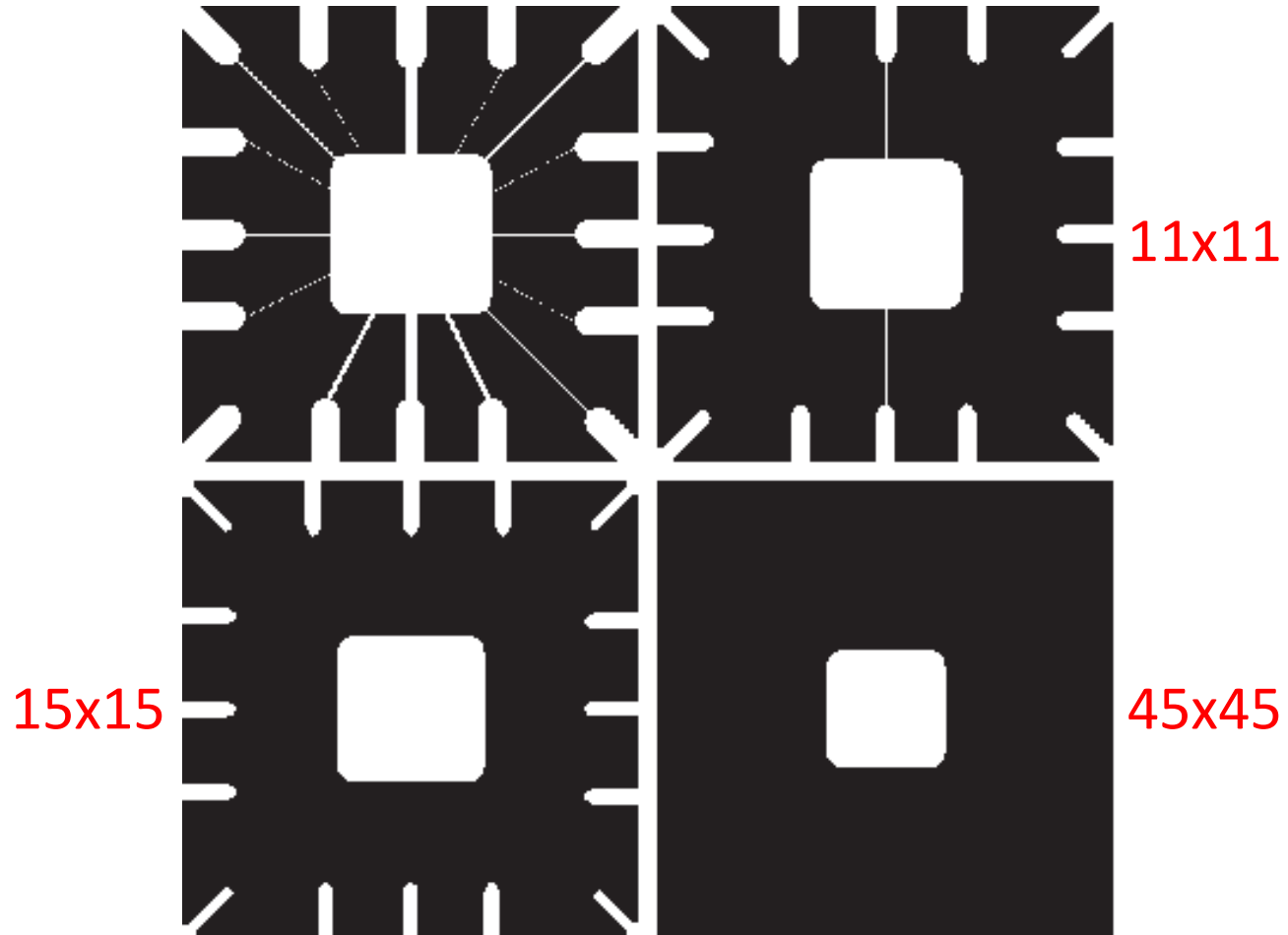
$$A \ominus B = \{z \mid (B)_z \subseteq A\}$$



$$I \ominus B = \{z \mid (B)_z \subseteq A \text{ and } A \in I\} \cup \{A^c \mid A^c \subseteq I\}$$

Erosion

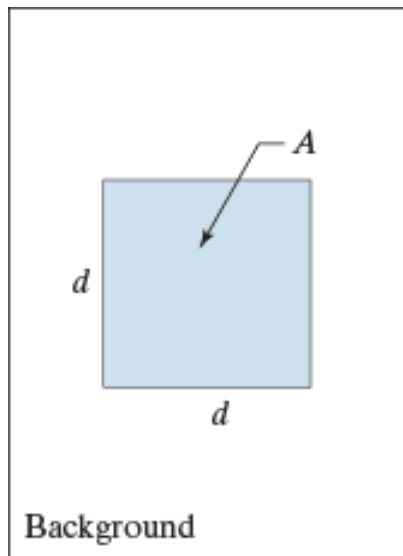
Shrinks



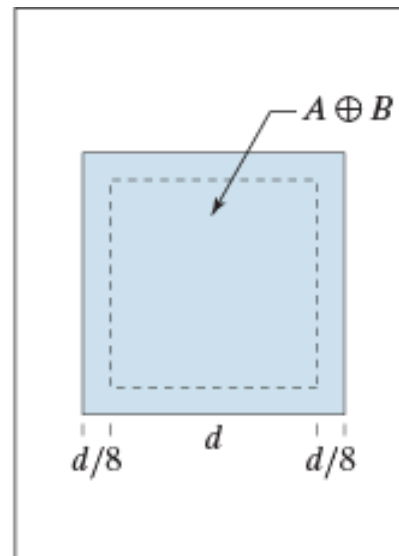
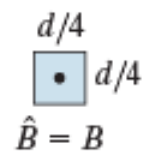
Dilation

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

Examples

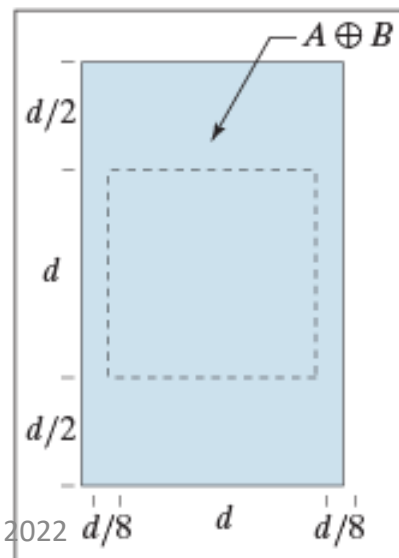


Image, I



$I \oplus B$

Square SE



$I \oplus B$

Elongated SE

Dilation

Expands

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.

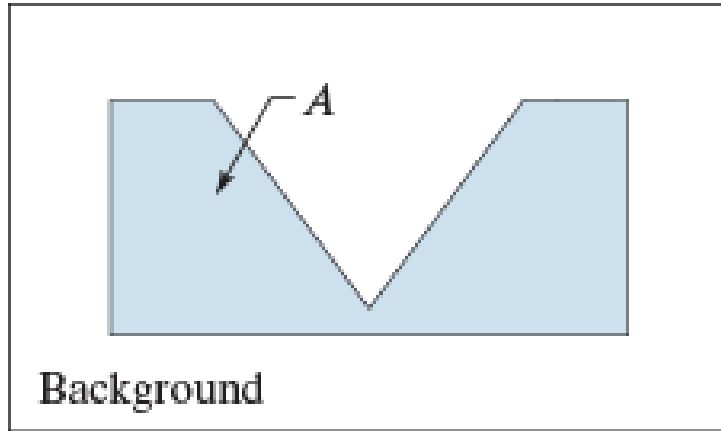


Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.



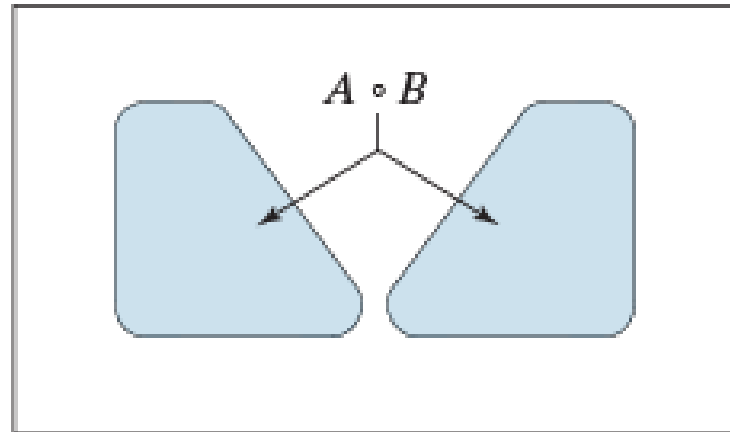
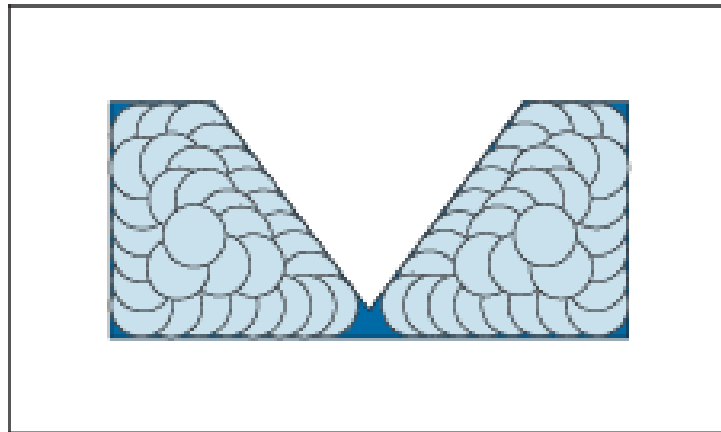
1	1	1
1	1	1
1	1	1

Opening



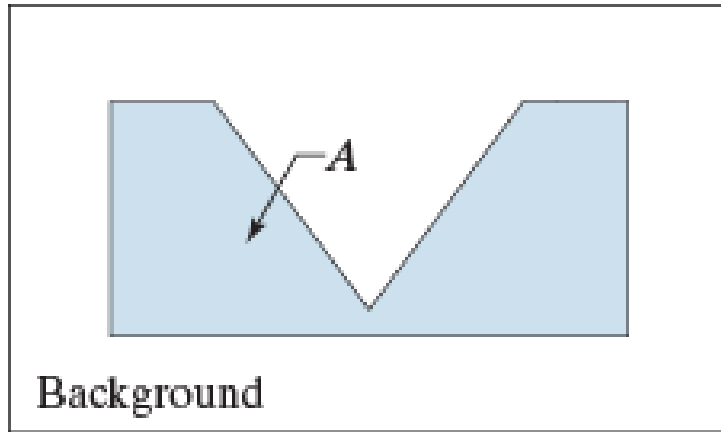
Image, I

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



Structuring element rolls along **inner** boundary

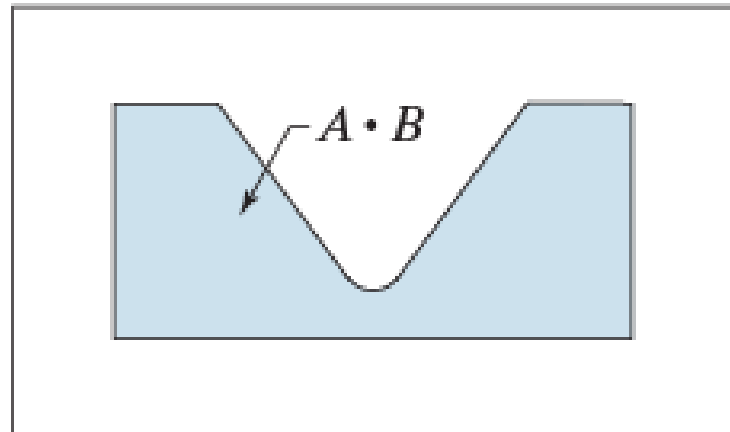
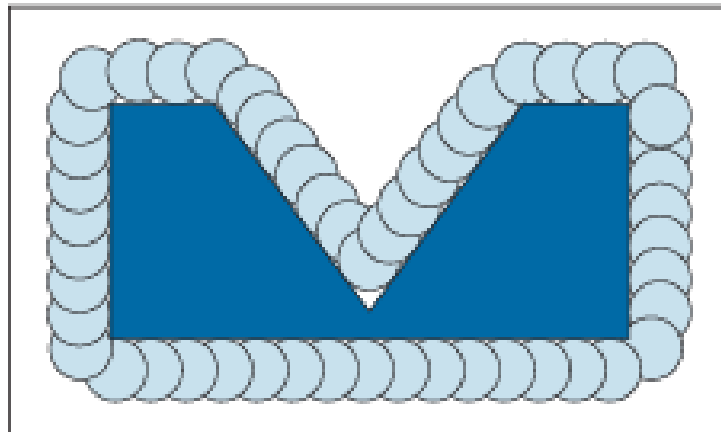
Closing



Image, I

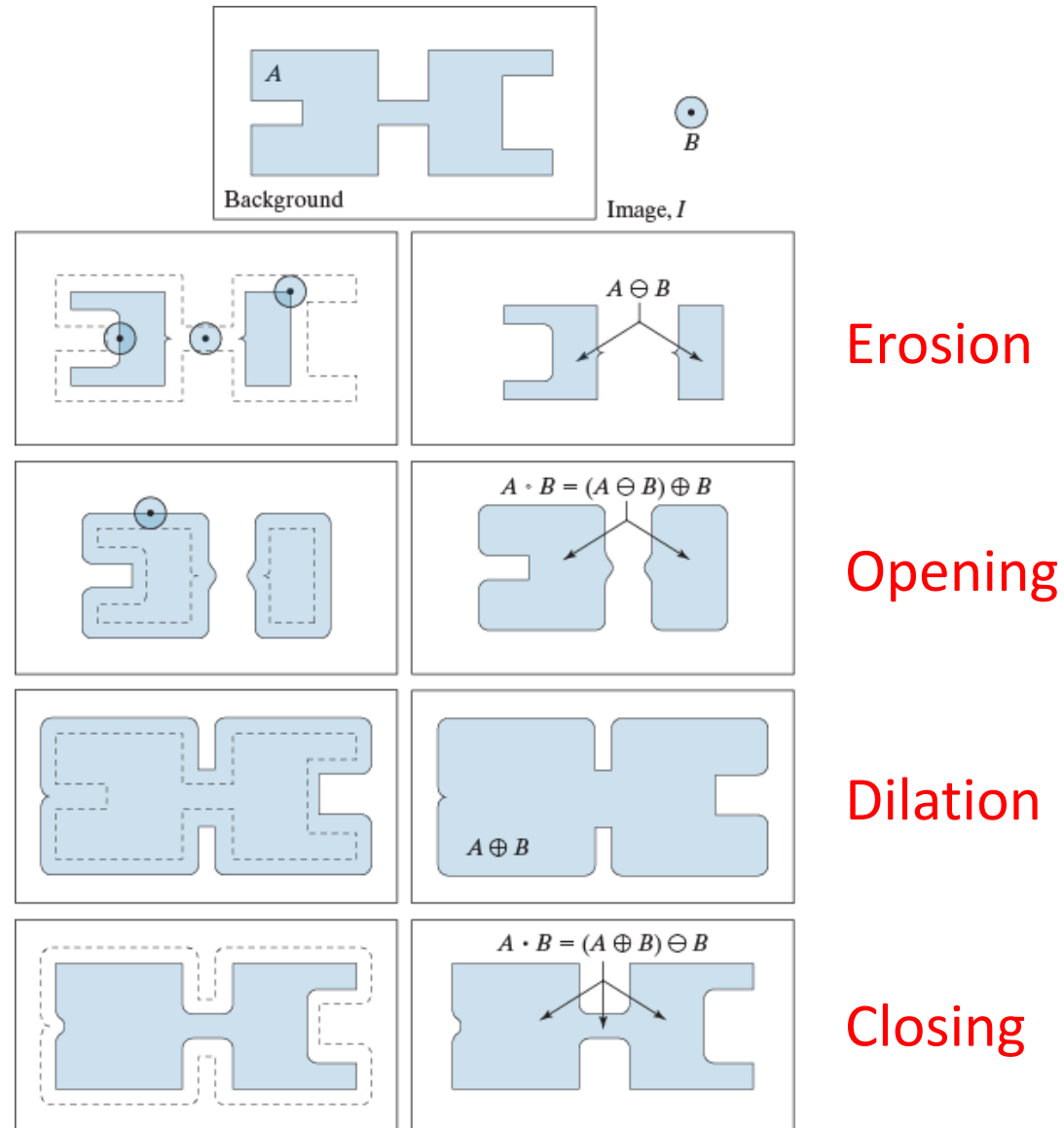


$$A \bullet B = (A \oplus B) \ominus B$$

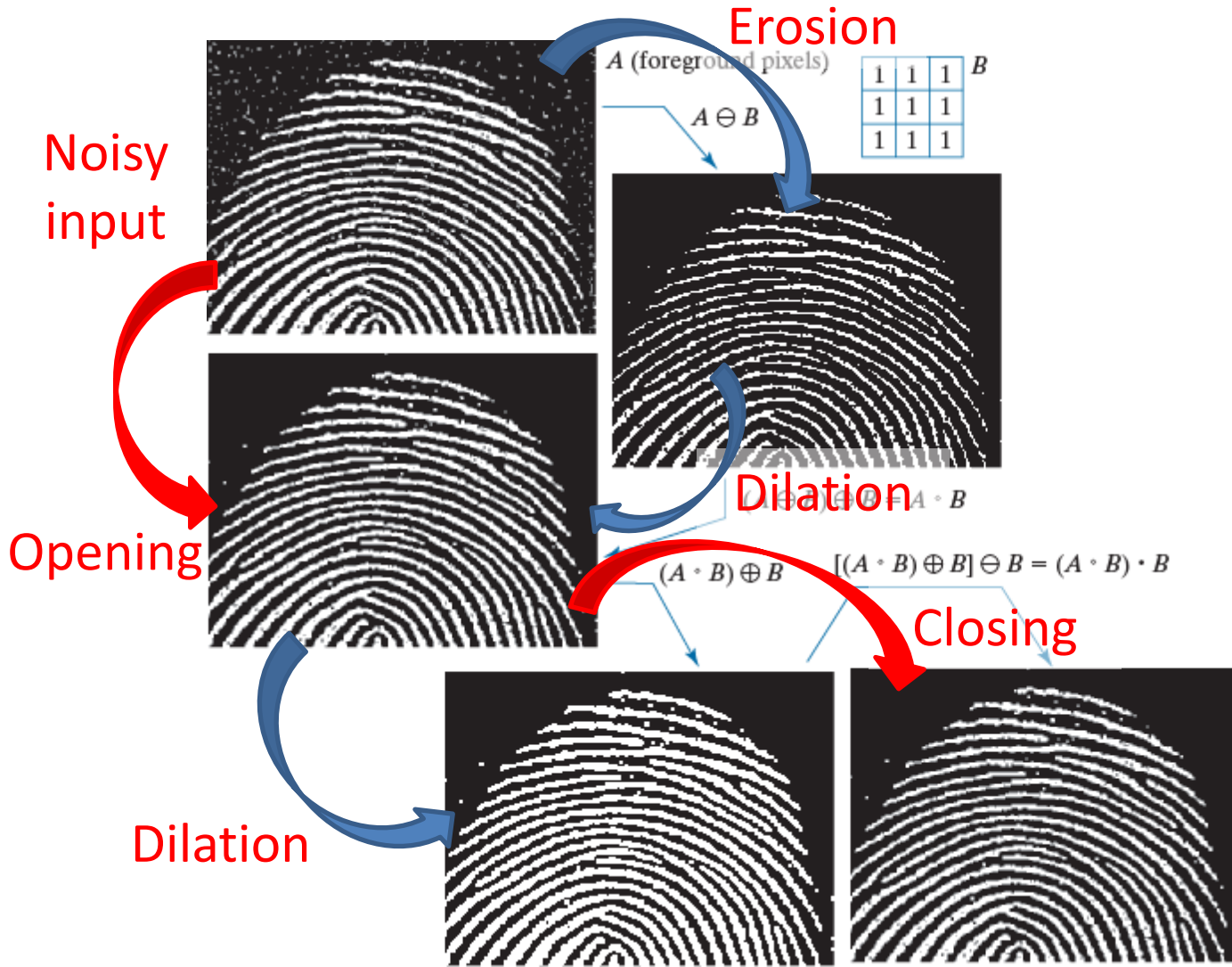


Structuring element rolls along **outer** boundary

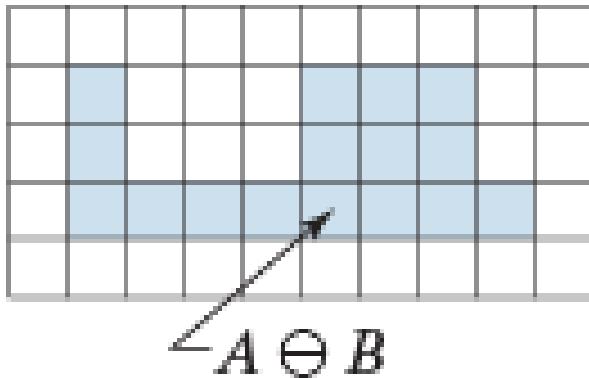
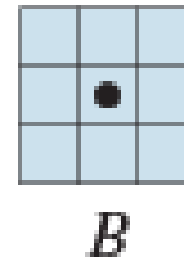
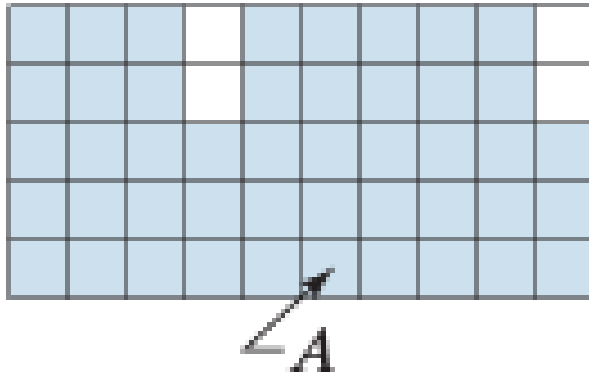
Opening and closing



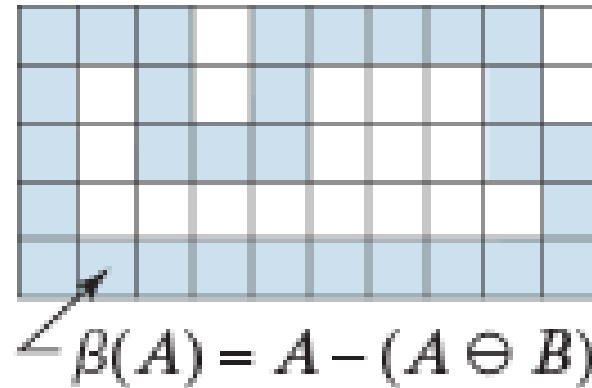
Morphological image processing



Boundary extraction

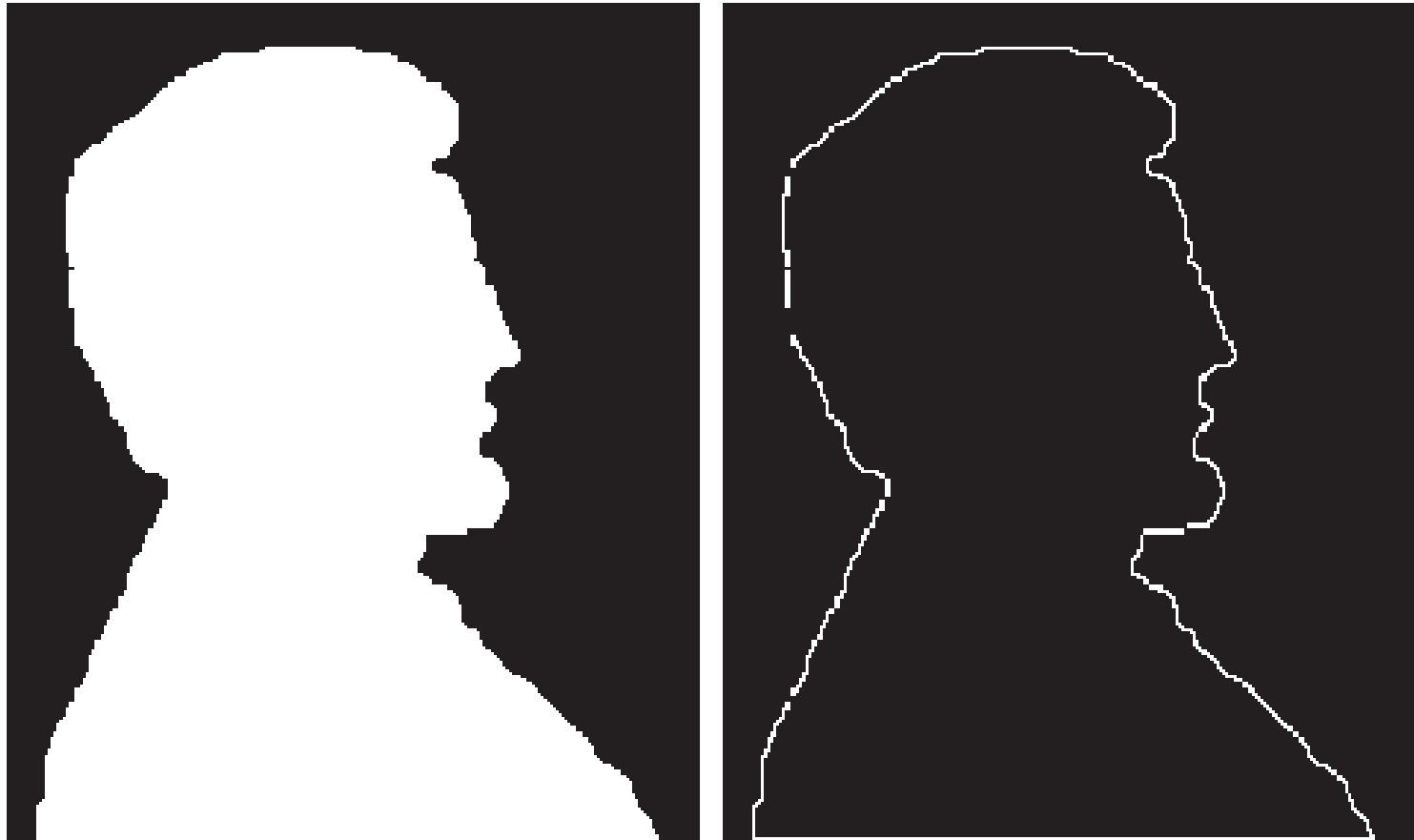


Erosion



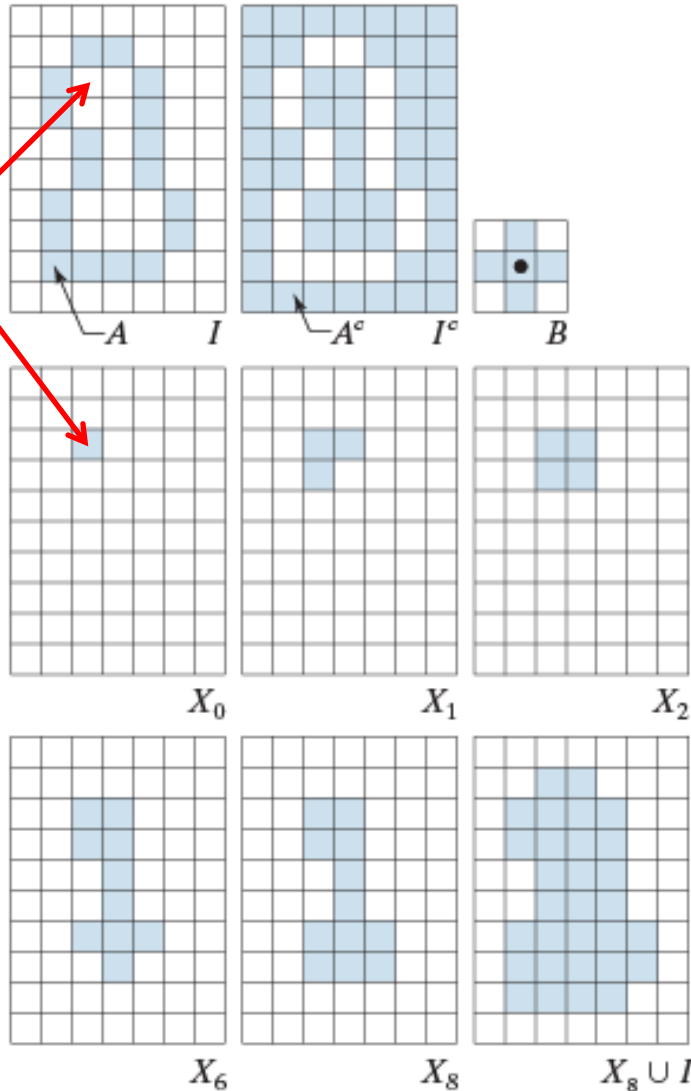
Set difference

Boundary extraction



Hole filling

Given point
in hole

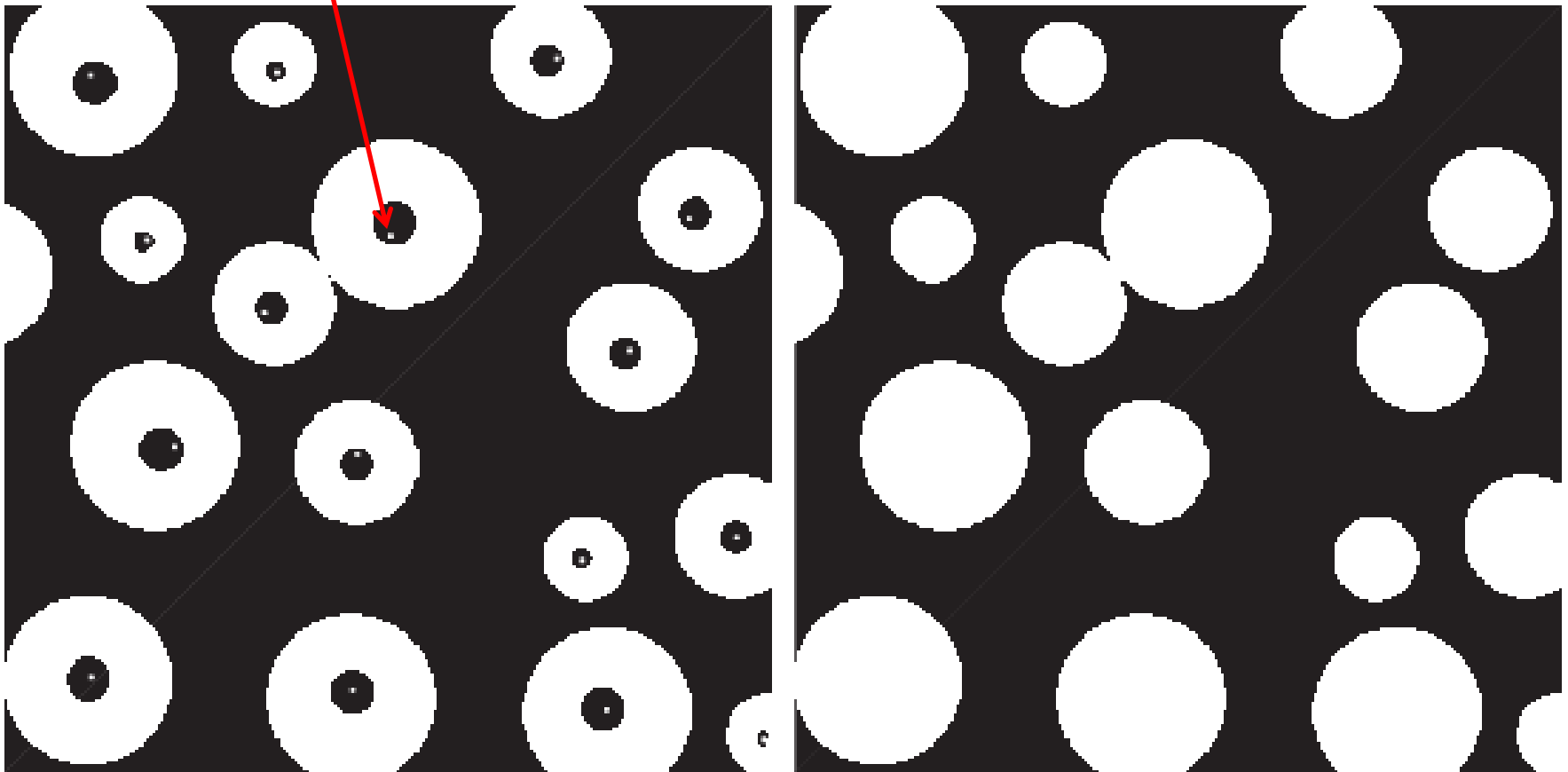


$$X_k = (X_{k-1} \oplus B) \cap A^c \quad k = 1, 2, \dots$$

Hole filling

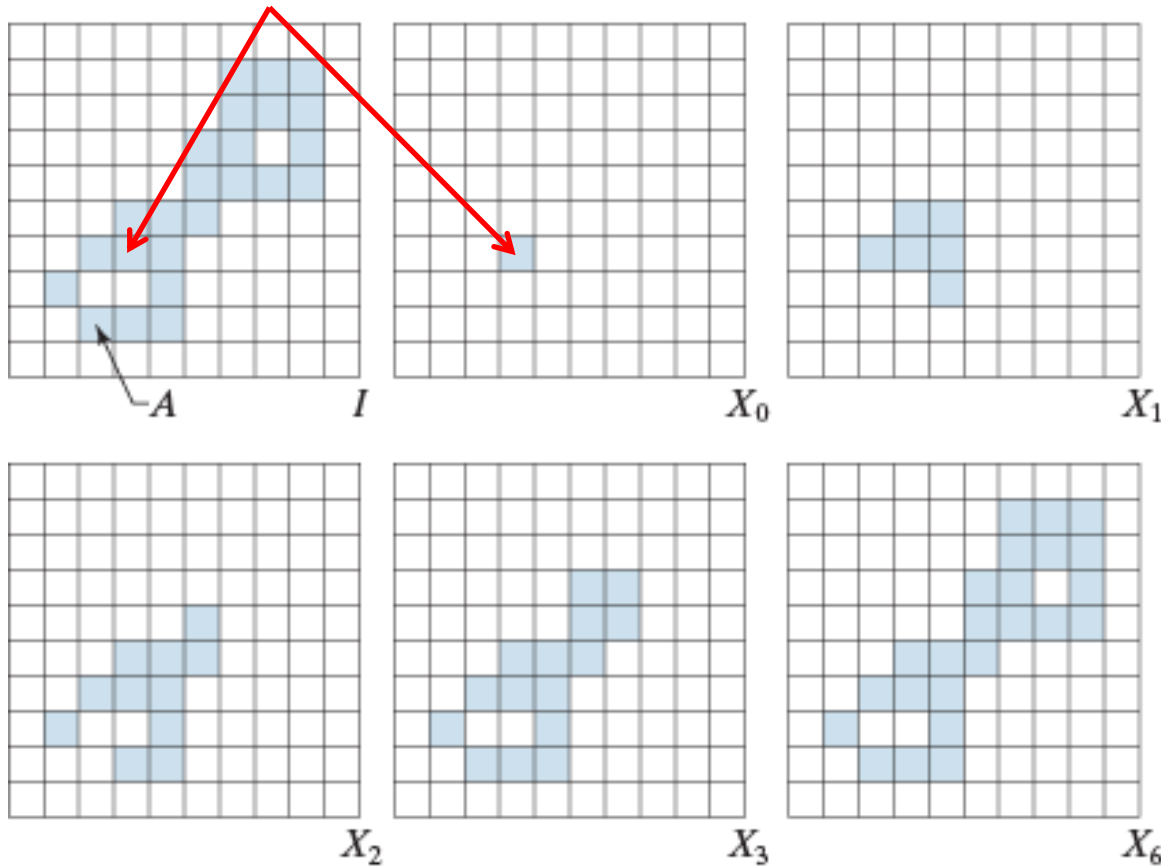
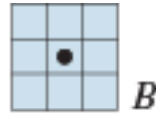
Given points in holes

All holes filled



Connected components

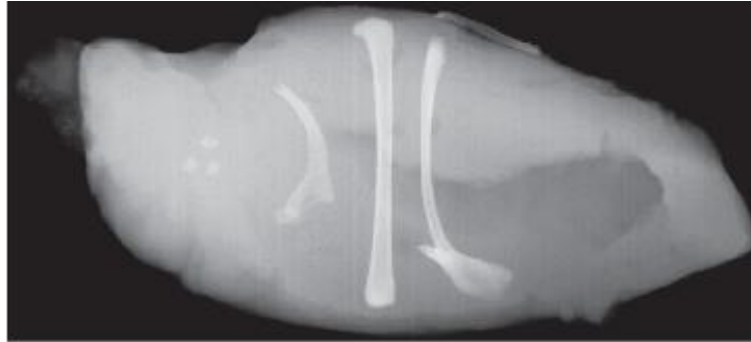
Given point
in A



$$X_k = (X_{k-1} \oplus B) \cap A \quad k = 1, 2, \dots$$

Connected components

X-ray image



Threshold
(negative)



Connected component	No. of pixels in connected comp
01	11
02	9
03	9
04	39
05	133
06	1
07	1
08	743
09	7
10	11
11	11
12	9
13	9
14	674
15	85

15
connected
components

Next Lecture

- Image segmentation
- Reading
 - Chapter 10: Image segmentation I: edge detection, thresholding, and region detection
 - Sections 10.1, 10.2, and 10.3