Lecture 17-Morphological Operations

(Chapter 9.1-9.5)

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Course piazza link:
piazza.com/shanghaitech.edu.cn/spring2021/cs270spring2021

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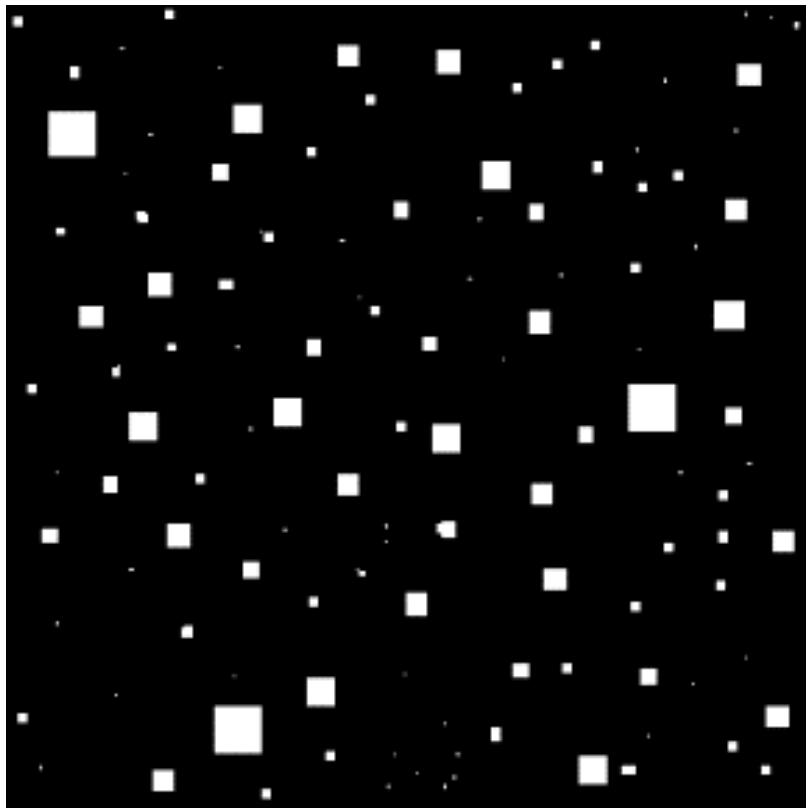
Outline

This lecture will cover：

- Morphology Image Processing （形态学图像处理）
  - Morphological operation.
  - Morphological algorithms.

Problem try to solve

- **Imperfect from image segmentation.**

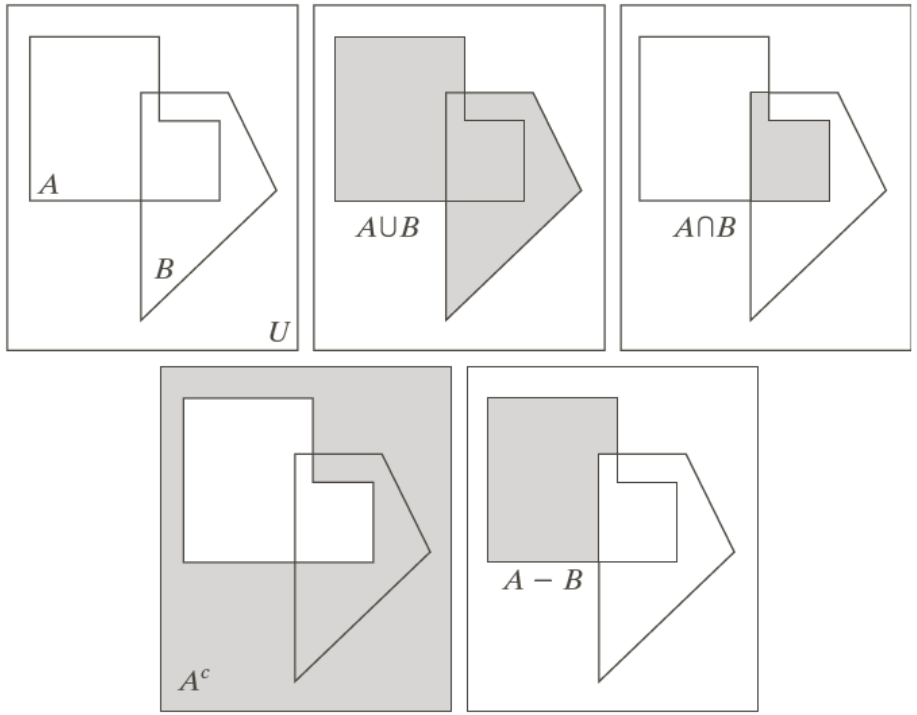


Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.

Preliminaries ---Set Operation

A digital image $f(x, y)$ can be considered as a set A, if $w(x, y)$ in 2D integer space Z^2, then

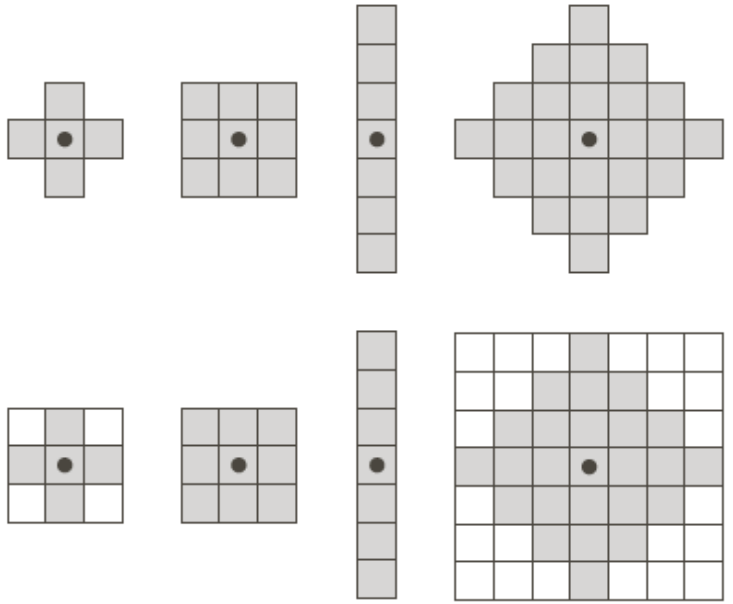
- $w \in A$: w is an element of A.
- $w \notin A$: w is not an element of A.
- $B = \{w|condition\}$: all elements which meet the specific condition.
  - $A \cup B = \{w|w \in A \ or \ w \in B\}$: union (并集)
  - $A \cap B = \{w|w \in A \ and \ w \in B\}$: intersection (交集)
  - $\mathrm{A}^C = \{w|w \notin A\}$: complement (补集)
  - $A - B = \{w|w \in A \ and \ w \notin B\}$: difference (差集)



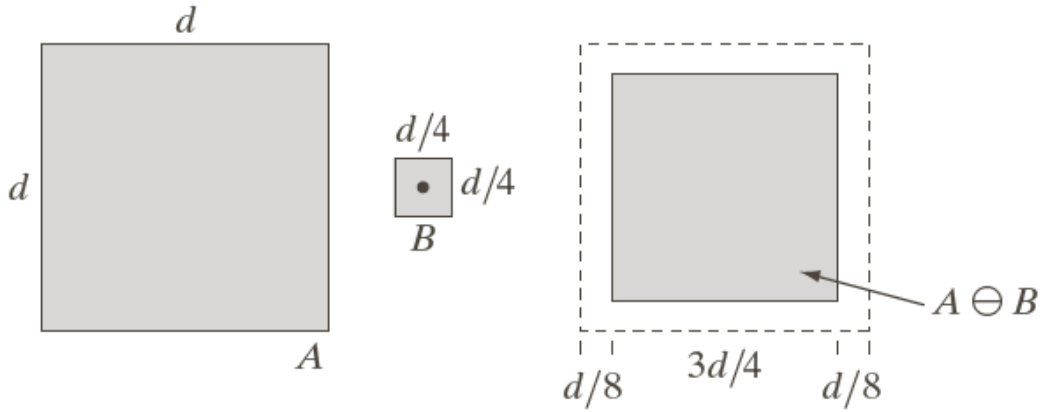
Structure element (结构元)

- **Structuring Element (SE) ---** small sets or sub-images used to probe an image under study for properties of interest.

- **SE Selection**
  - Simpler than the image
  - With boundary
  - Convex
- **Structures**
  - Origin
  - Rectangular



Erosion (腐蚀)



➢**Definition：**

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

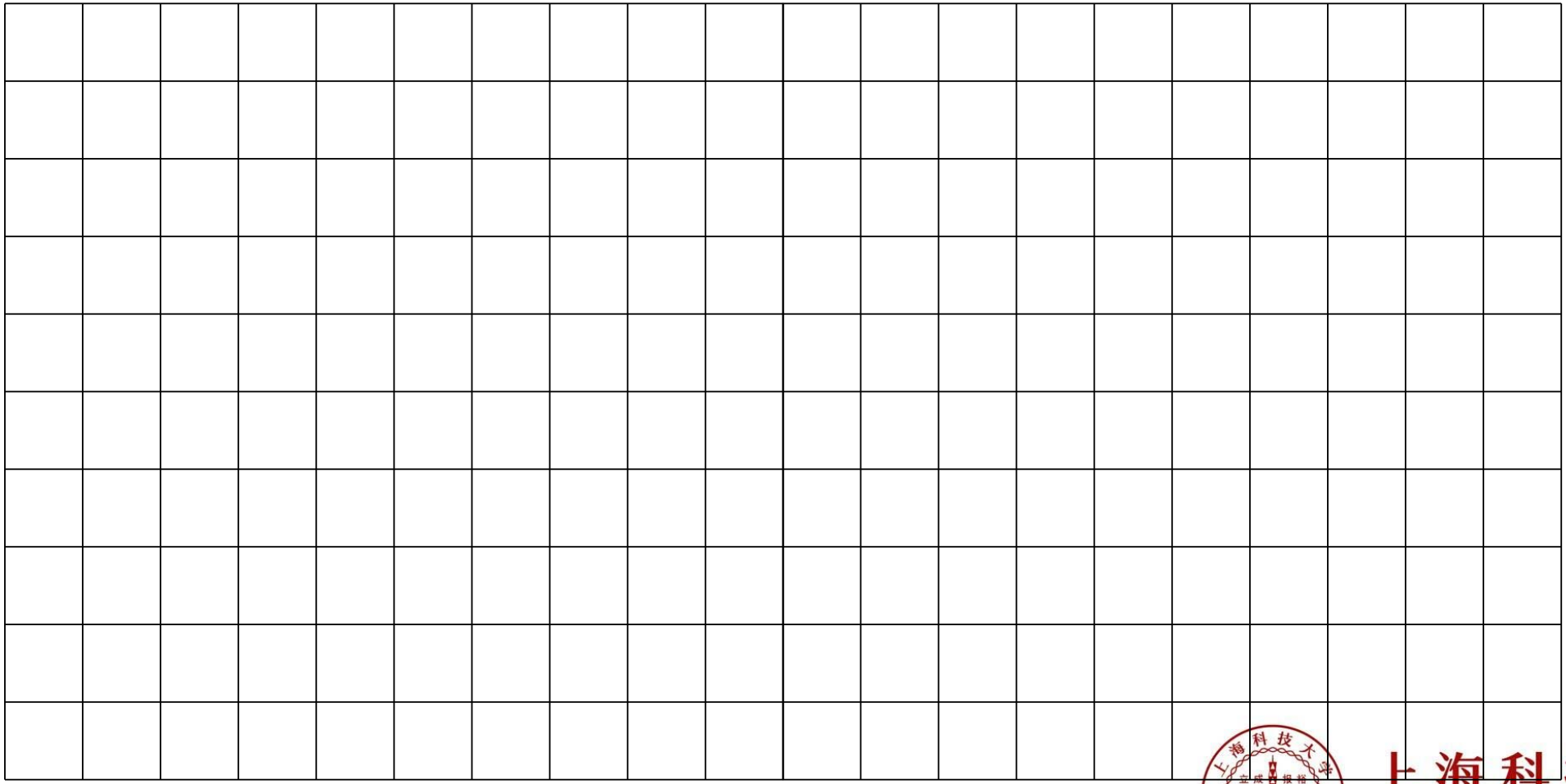
or

$$A \ominus B = \{z \mid (B)_z \cap A^c = \emptyset\}$$

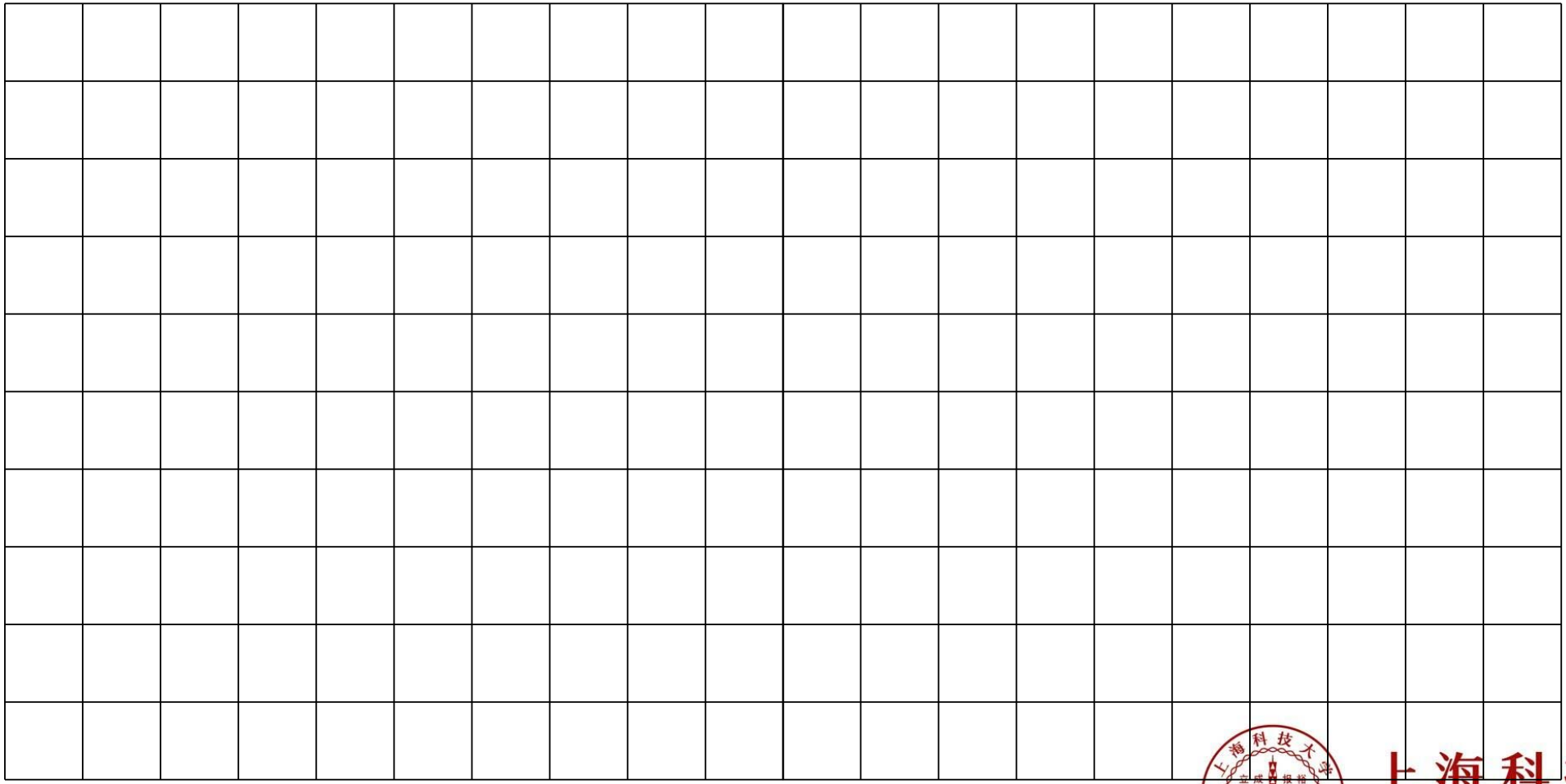
➢**Erosion will do:**

- removes thin lines
- isolate dots
- leaves gross details
- “Peeling away” layers
- Is always a sub-set of A

Erosion (腐蚀)



Erosion (腐蚀)



Dilation (膨胀)

- **Definition**

$A \oplus B = \{z | \widehat{B_z} \cap A \subseteq A\}$ or

$A \oplus B = \left\{z \middle| \widehat{B_z} \cap A \subseteq \emptyset\right\}$

Dilation will do:

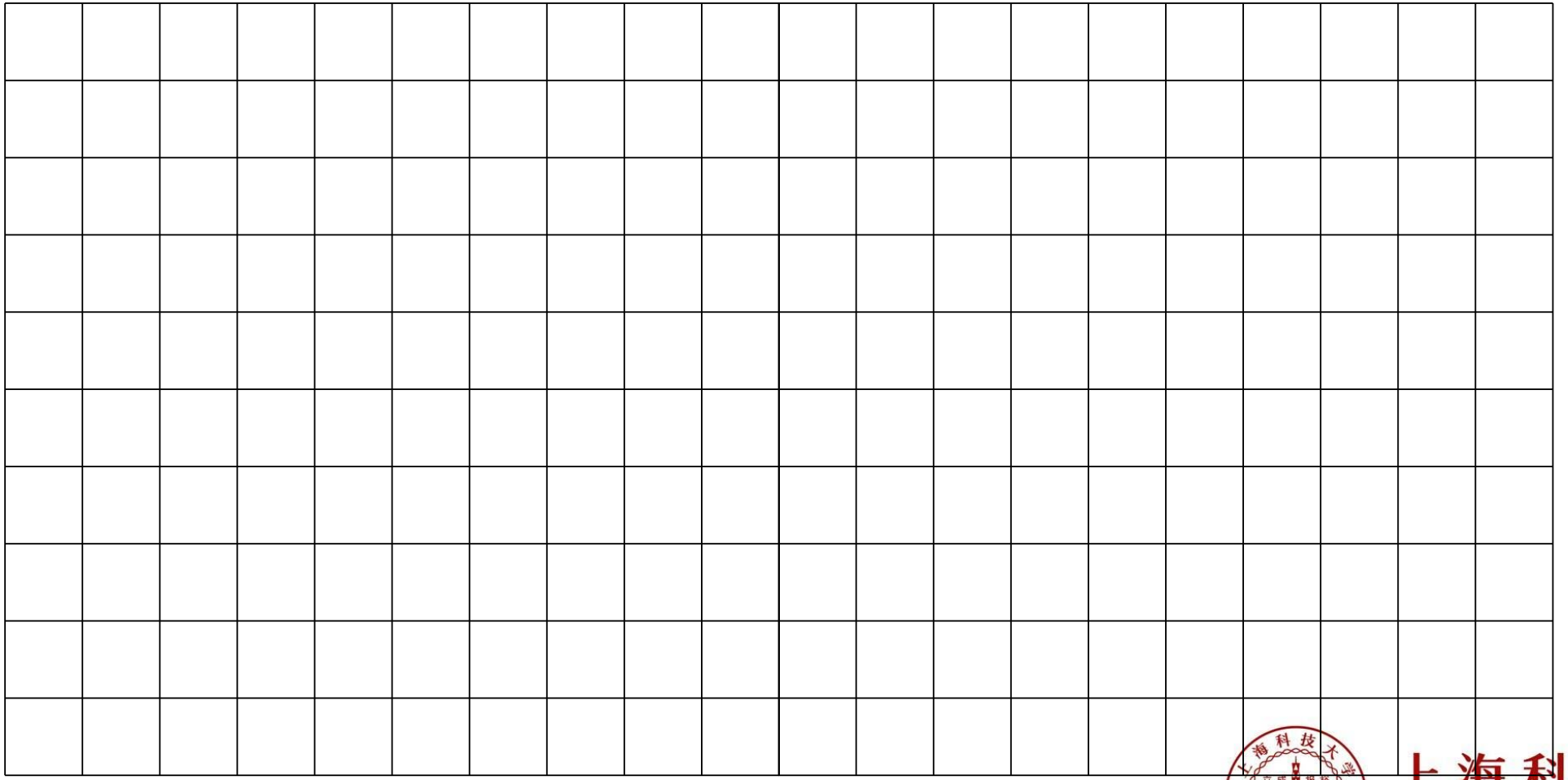
Fatten up. Kind of opposite of

Erosion.

Bridge gaps, fill holes, wighout change

overall size of object.

Dilation (膨胀)



Opening (开操作)

- **Definition:**

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

  or

  $A \circ B = \bigcup \{ (B)_z \mid (B)_z \subseteq A \}$

- **Erode then dilate: break narrow bridges, eliminate thin structures**
- **Matlab Function:** J = imopen(I,SE)
- **Properties:**

  ① $A \circ B$ is a subset (subimage) of A

  ② If C is a subset of D, the $C \circ B$ is a subset of $D \circ B$

  ③ $(A \circ B) \circ B = A \circ B$

Closing (闭操作)

- **Definition:**

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

- **Dilate, then erode: fuse narrow breaks, eliminate small holes**
- **Matlab Function:** J = imclose(I,SE)
- **Properties:**

① A is a subset (subimage) of $\mathrm{A} \bullet \mathrm{B}$

② If C is a subset of D, the $\mathrm{C} \bullet \mathrm{B}$ is a subset of $\mathrm{D} \bullet \mathrm{B}$

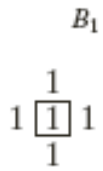
③ $(\mathrm{A} \bullet \mathrm{B}) \bullet \mathrm{B} = \mathrm{A} \bullet \mathrm{B}$

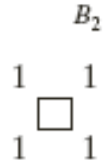
Opening & Closing (开操作和闭操作)

- **Opening（开操作）**
  - Smooth the contour of an object
  - Break narrow bridges.
  - Eliminate thin structures.
- **Closing（闭操作）**
  - Smooth the contour of an object
  - Fuse narrow breaks and long thin gulfs
  - Eliminate small holes
  - Fill gaps in the contour

The Hit-or-Miss Transformation (击中或击不中变换)

$$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)$$





The Hit-or-Miss Transformation (击中或击不中变换)

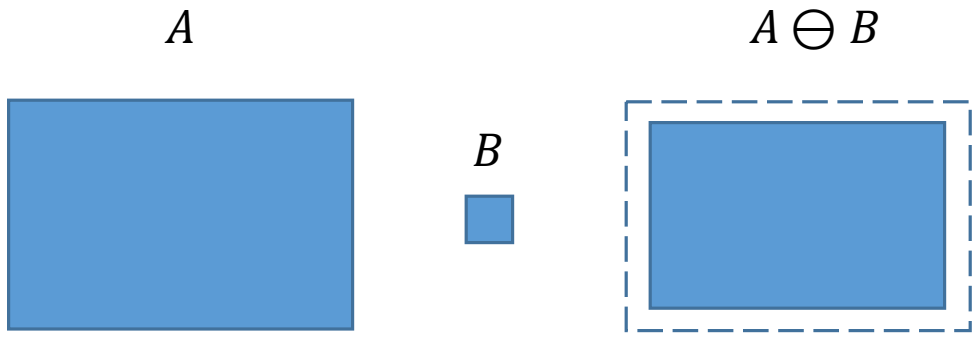
$$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)$$

- A method to find the location of a shape B_1 in an image A.
  - Erosion of $A \ominus B_1$ gives all places where B_1 fits in A.
- So also require the boundary around the shape, B_2 to be empty.
  - Erosion of $A^c \ominus B_2$ gives all places where B_2 fits in empty places of A.
- Then take the intersection:

$$A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)$$

Boundary Extraction (边界提取)

Morphological algorithm: $\beta(A) = A - (A \ominus B)$



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

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Hole Filling (孔洞填充)

- Let A be the set of 8-connected boundary points of a region
- Start with a point inside the region
- Repeatedly dilate
- At each step, the points corresponding to the region boundary are set to zero：

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

- Stop when no more changes

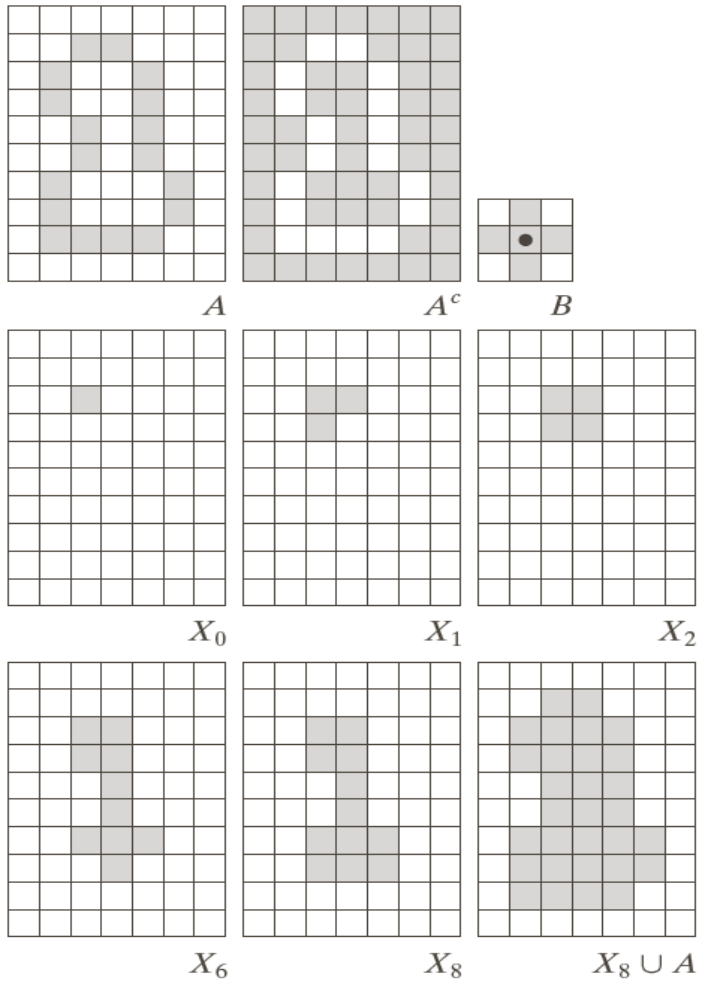

Figure 9.5 Region filling

Take home message

- **Morphological Language：Set theory (集合)**
- **Morphological operations take a set of pixels:**
  - Key element: “structure element”.
  - Insensitive to noise.
  - Smooth edge
  - **Key operations**
  - HMT (Hit or Miss Transformation)(击中与否变换)
  - Dilation (膨胀）and Erosion (腐蚀)