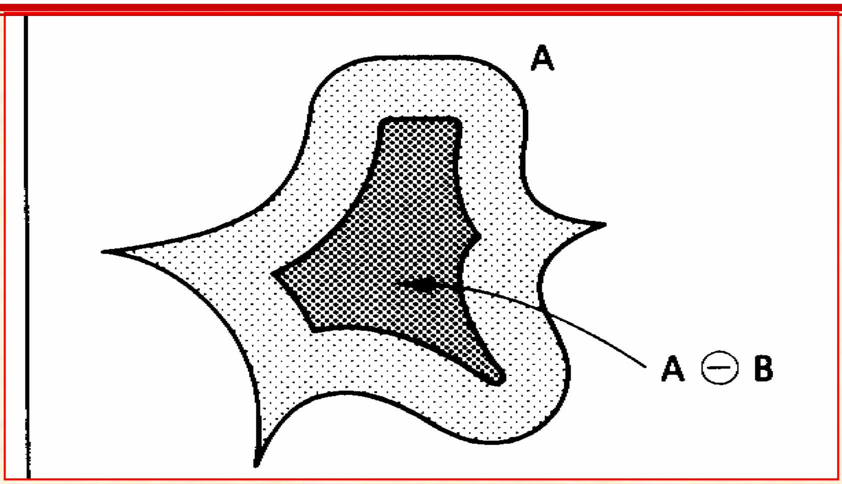
MORPHOLOGY *(SHAPE PROCESSING)*

The term **morphology** denotes a branch of biology that deals with the form (shape) and structure of living organisms and their tissues.

Mathematical morphology is a branch of image processing an analysis which uses concepts from algebra (set theory, lattices) and geometry (translation, distance, convexity).



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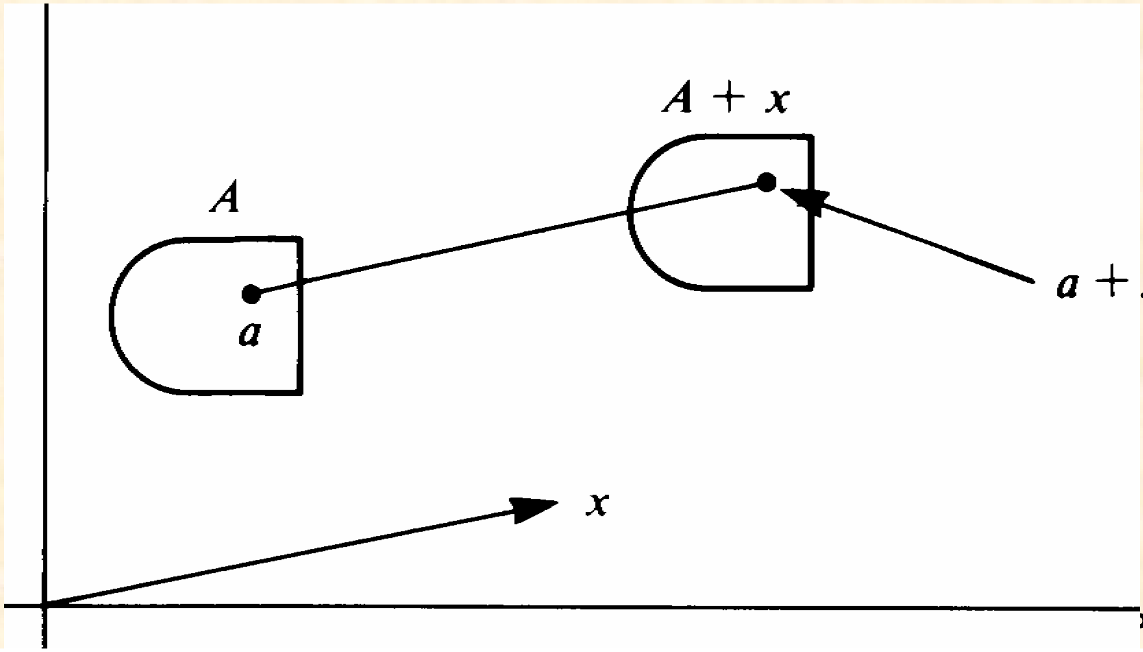
Translation

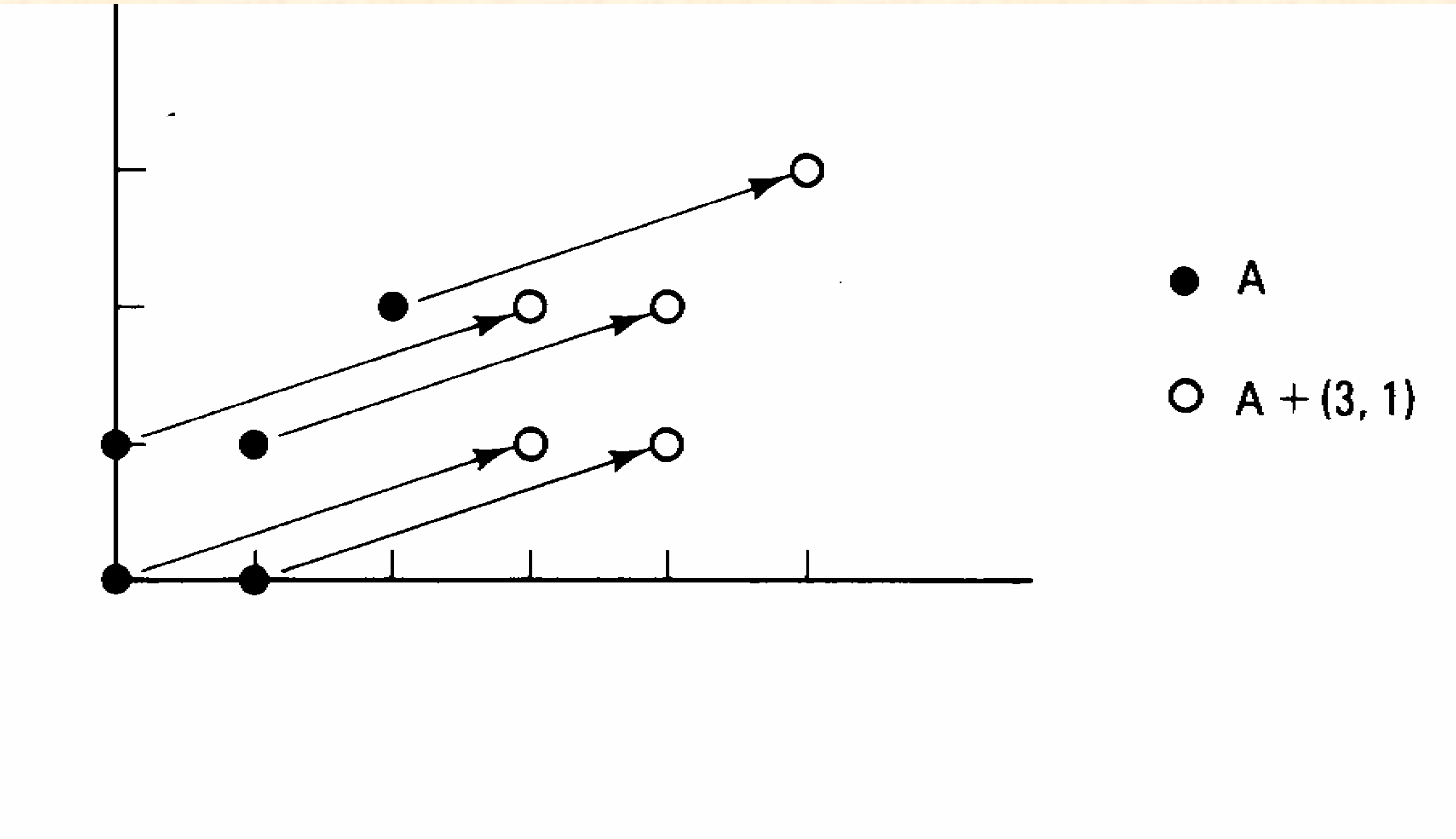
The_**translation** of *A* by $x=(x_1,x_2)$, denoted by $(A)_X$, is defined by:

$$(A)_x = \{c \mid c = a + x, for\, a \in A\}$$



Translation of a discrete image

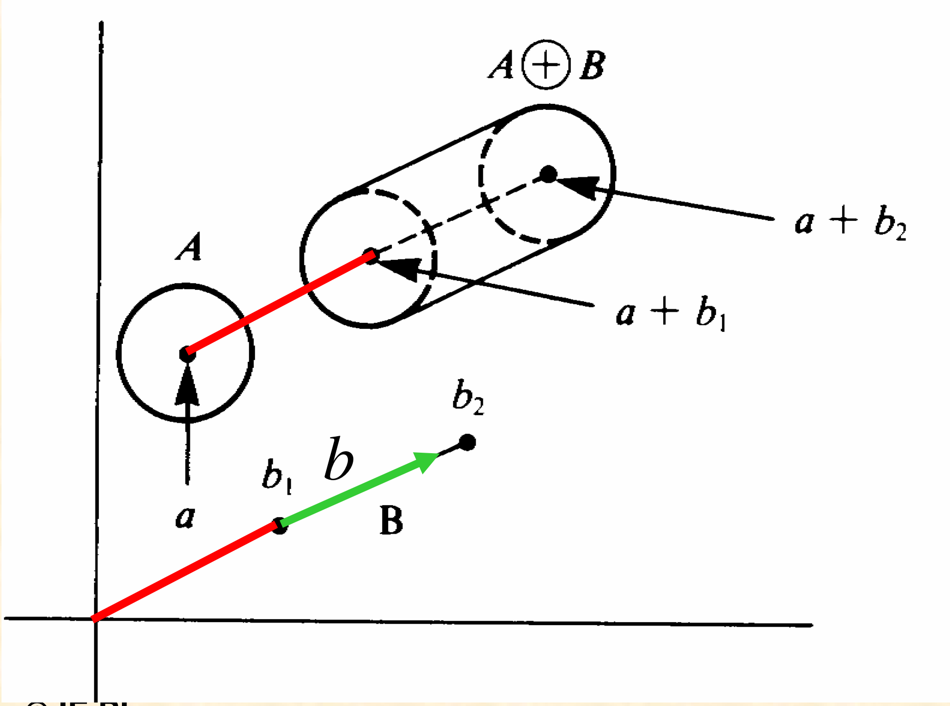
x=[3,1]



Dilation

Let A and B be the sets in R^2, the dilation of A by B is defined as:

$$A \oplus B = \bigcup_{b \in B} (A + b)$$



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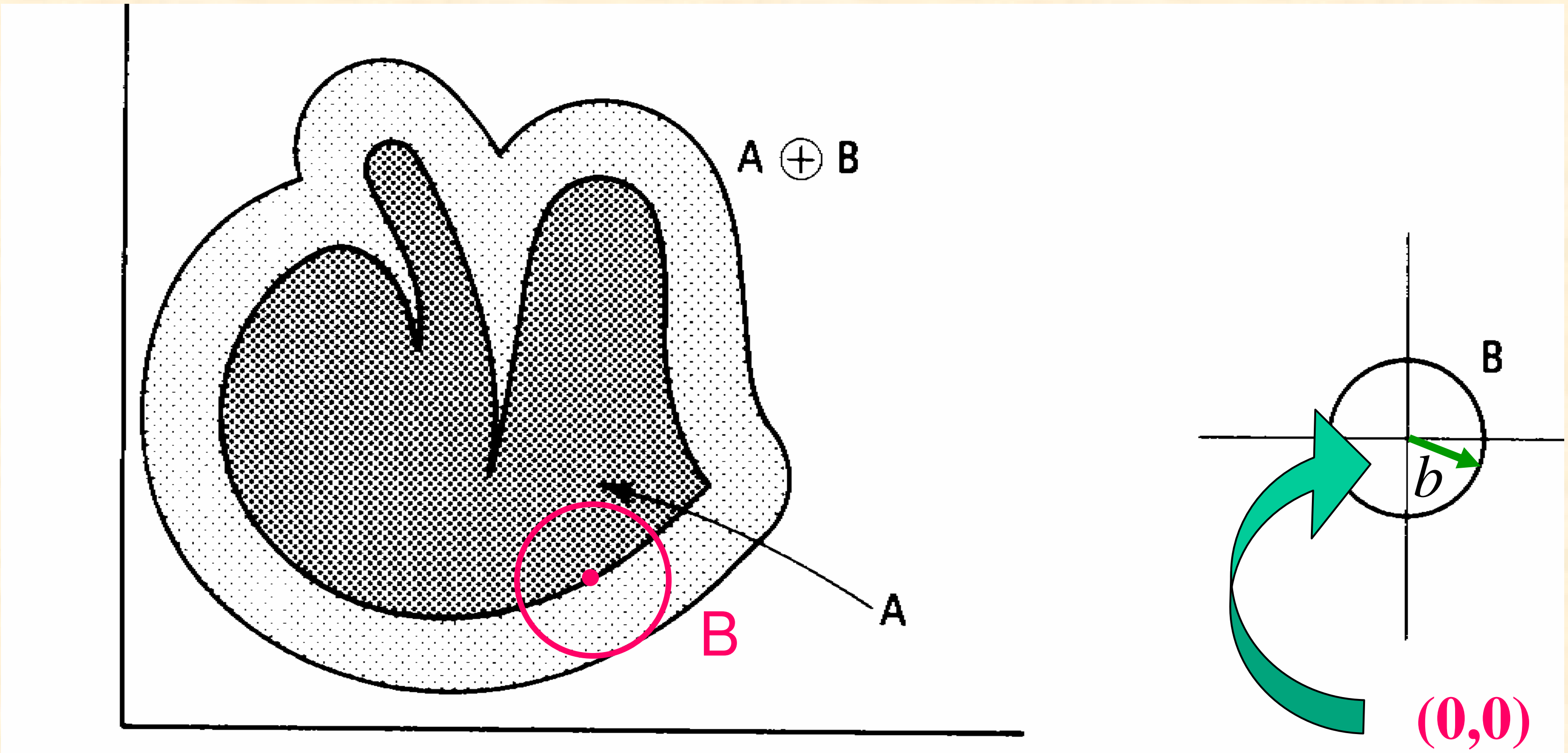
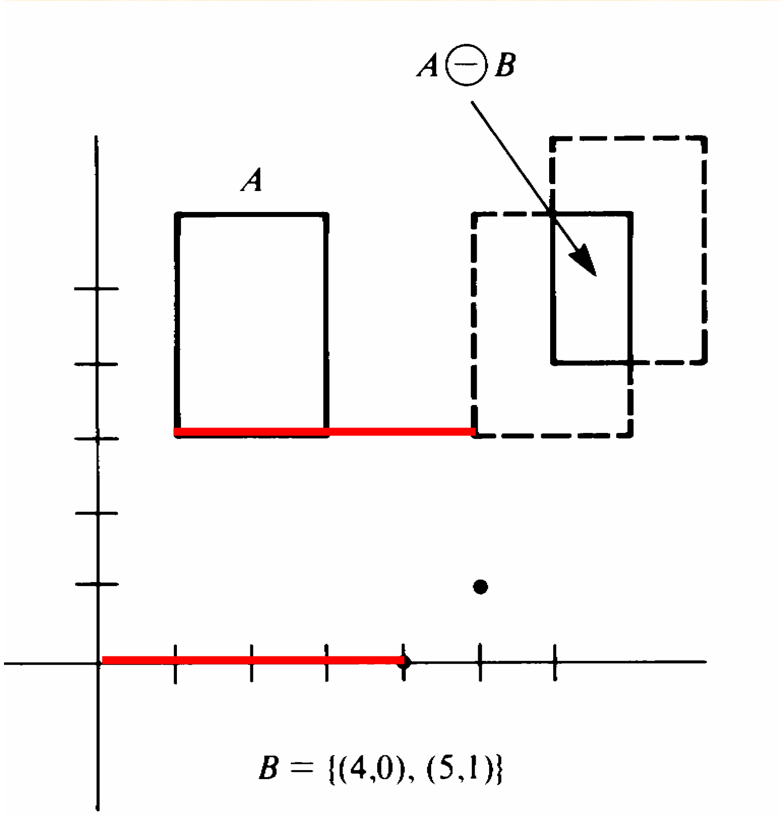
Dilation - example



Erosion

Let *A* and *B* be the sets in R^2, the erosion of A by B is defined as:



$$A \otimes B = \bigcap_{b \in B} (A + b)$$

The structuring element is located in the centre of the Cartesian system !

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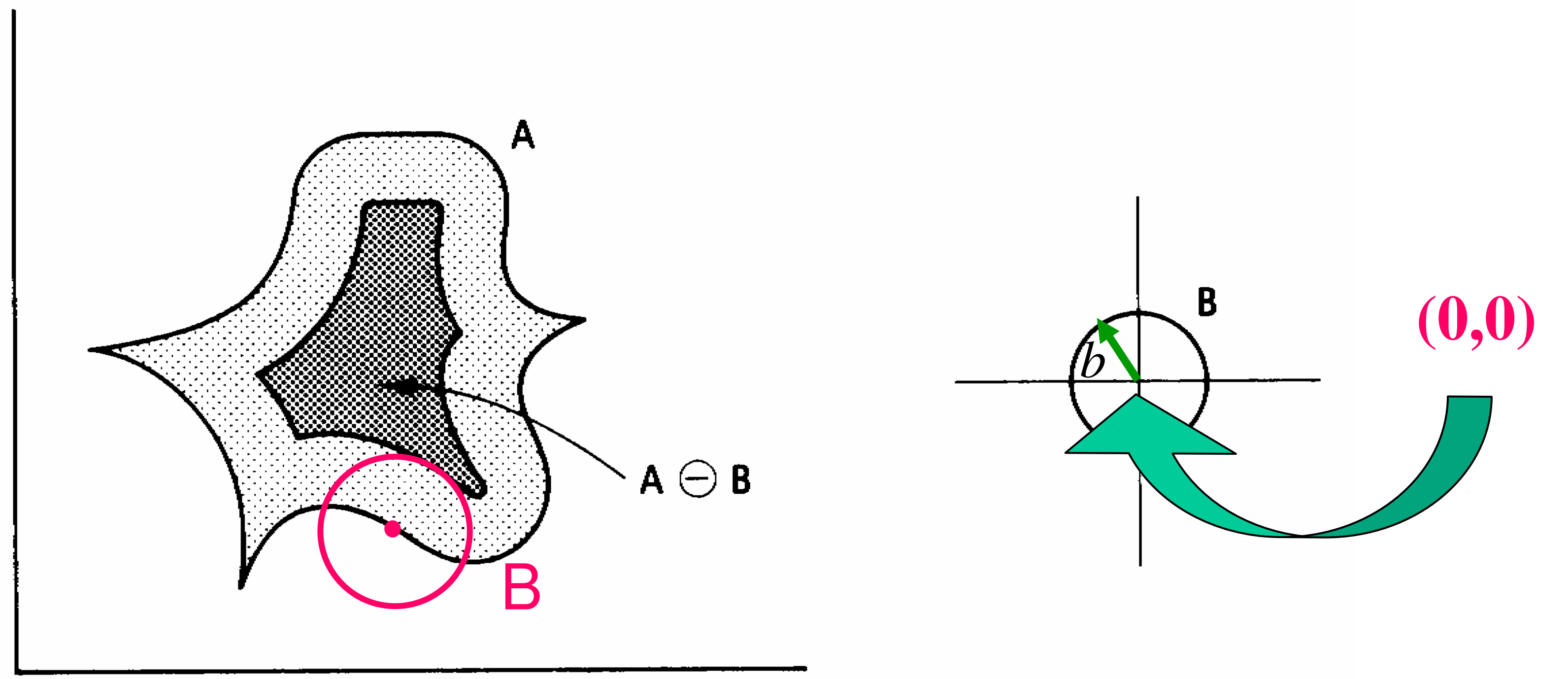
Erosion - example



Opening and closing

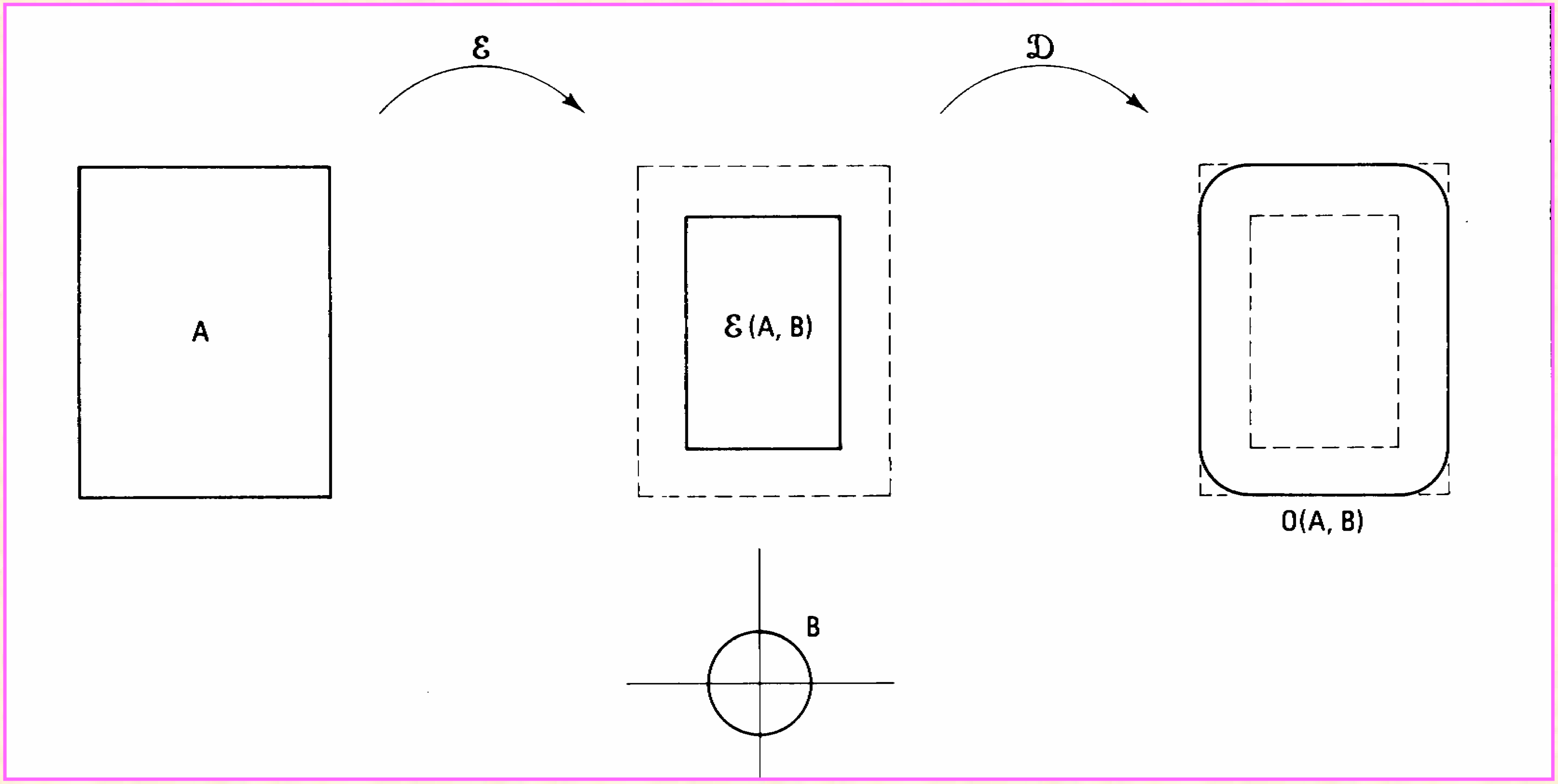
The **opening** of set *A* by structuring element *B* is defined as:

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

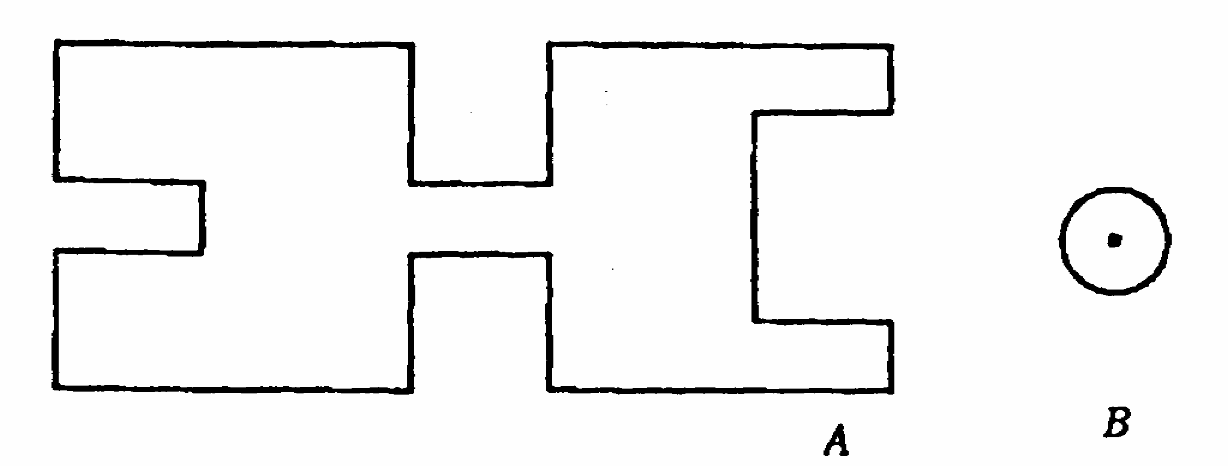
The **closing** of set *A* by structuring element *B* is defined as:

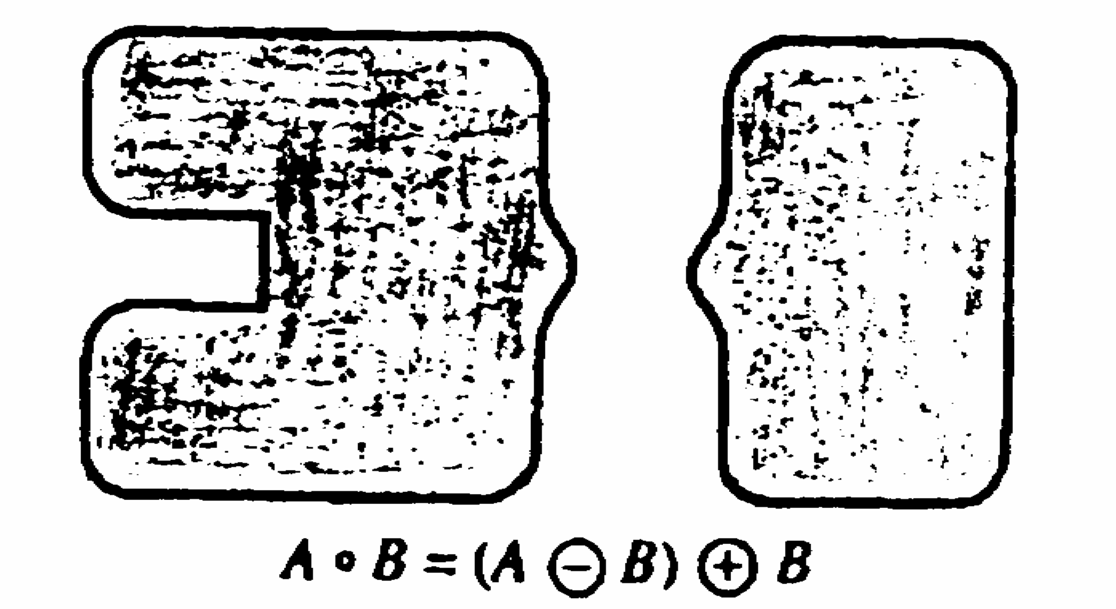
$$A \bullet B = (A \oplus B) \otimes B$$

Opening - example

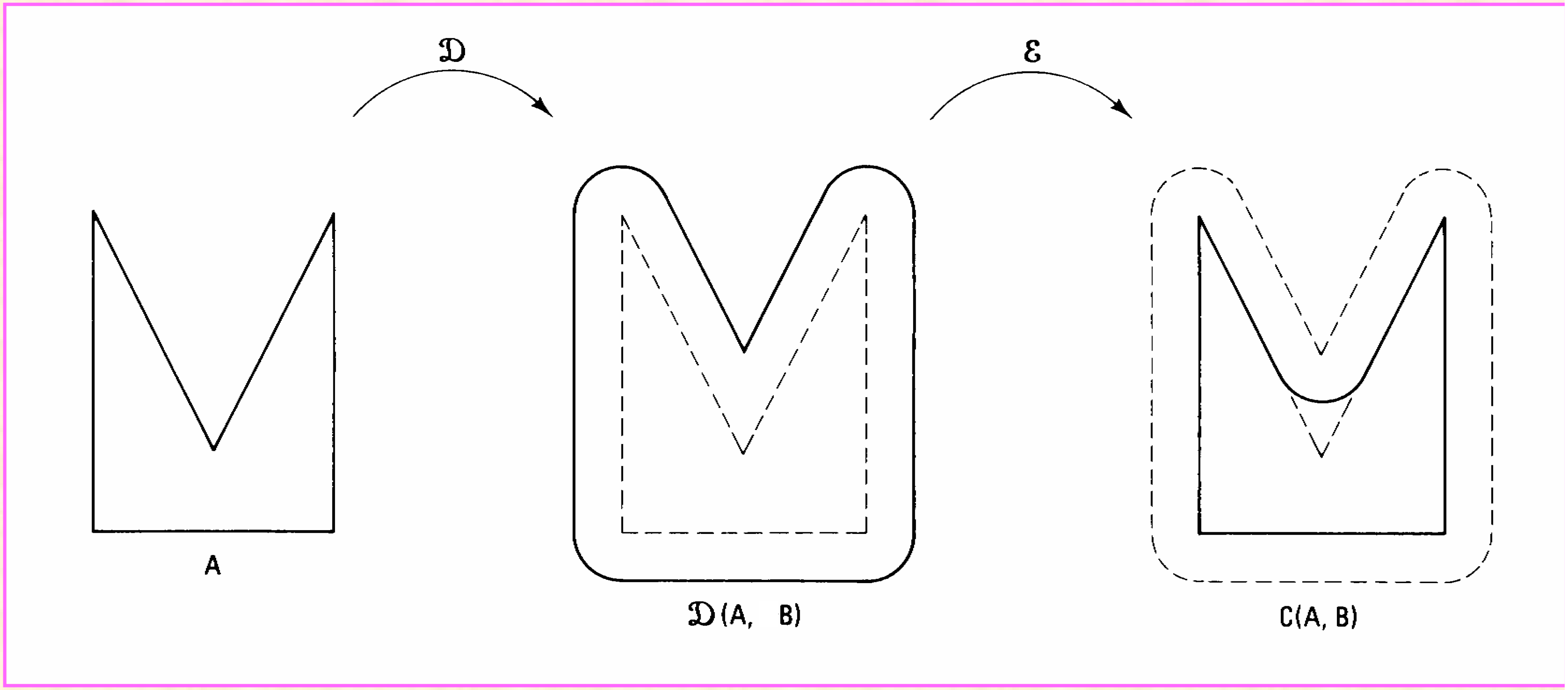


Opening - example

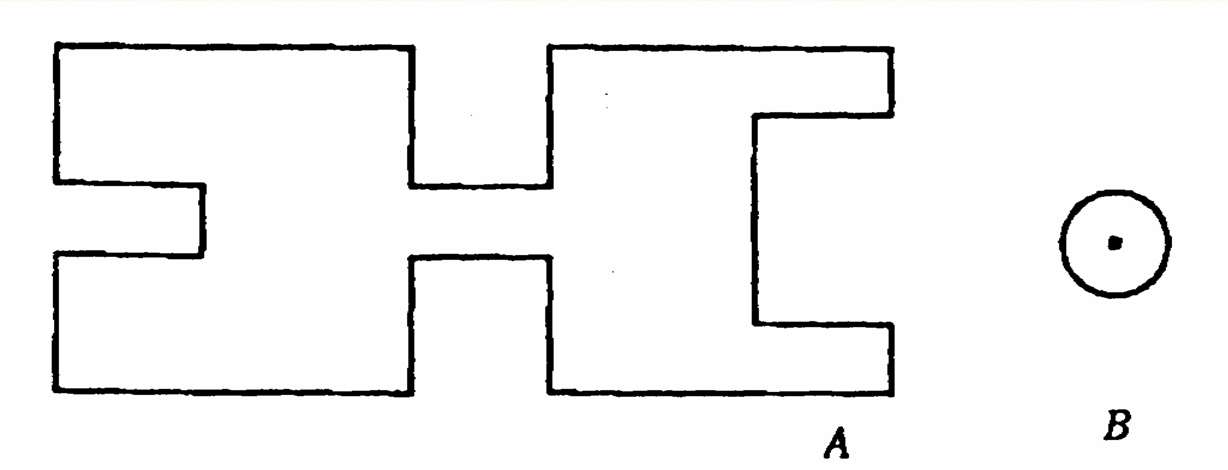


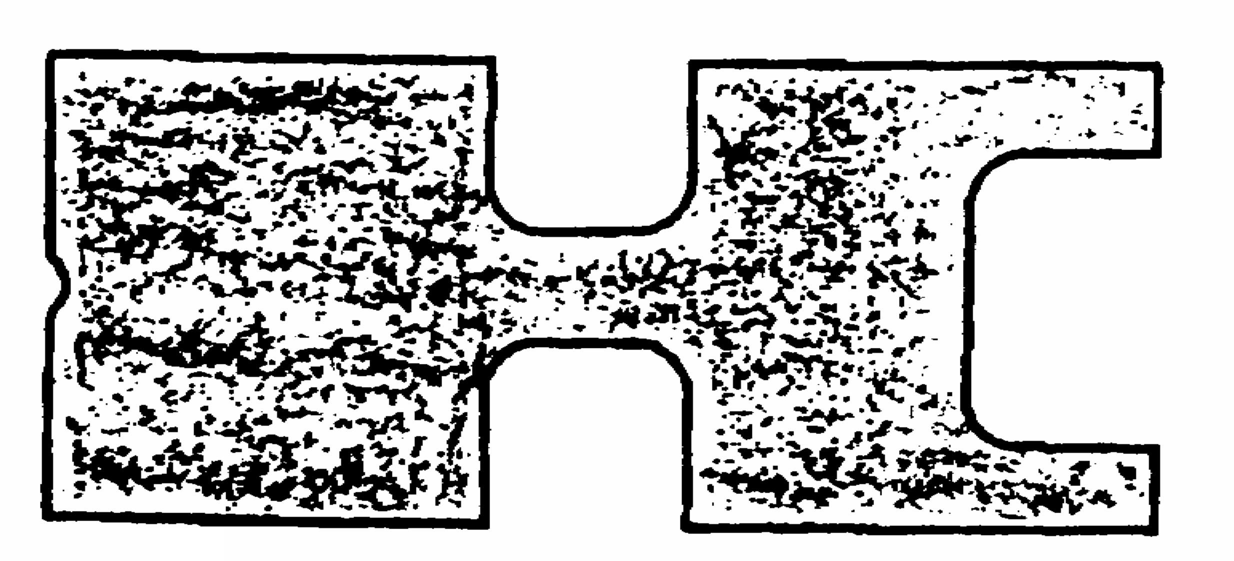


Closing - example



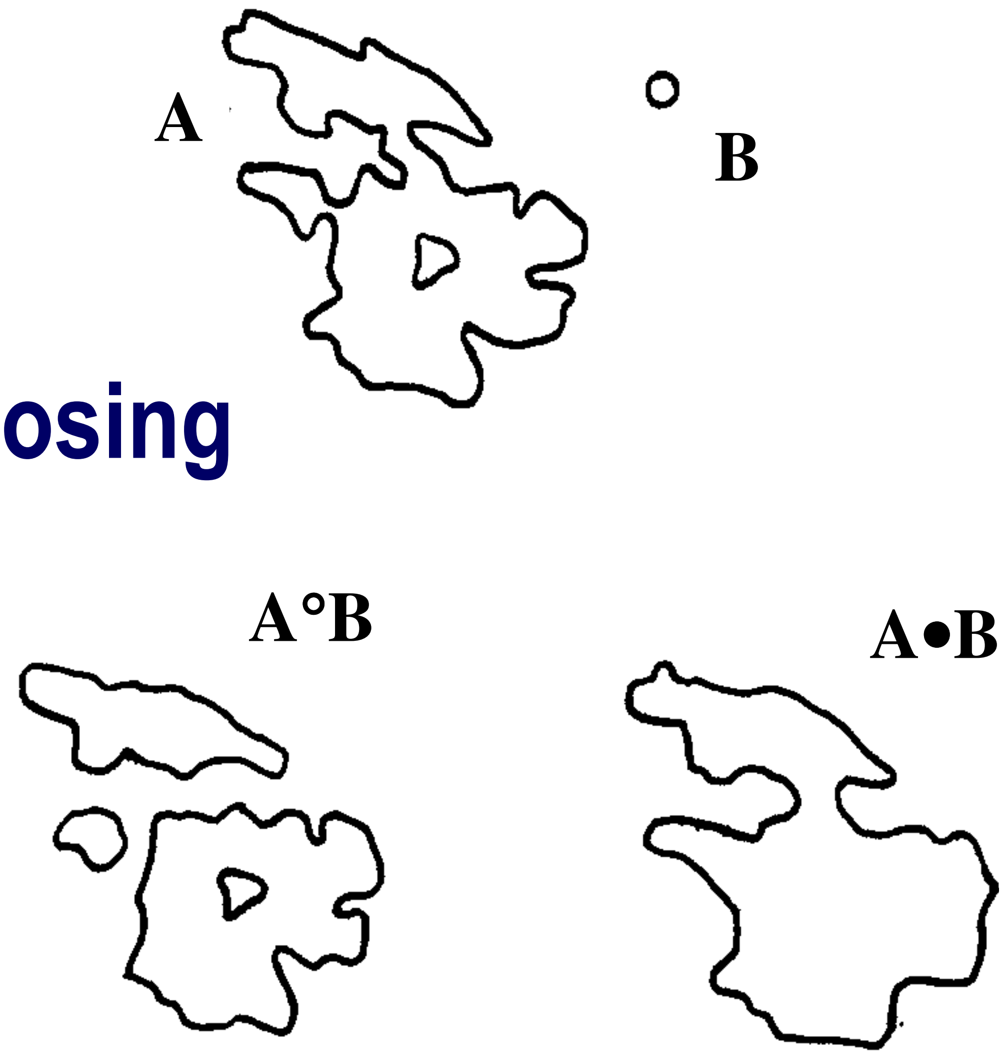
Closing - example





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

Opening and closing



Erosion and dilation alternative definitions

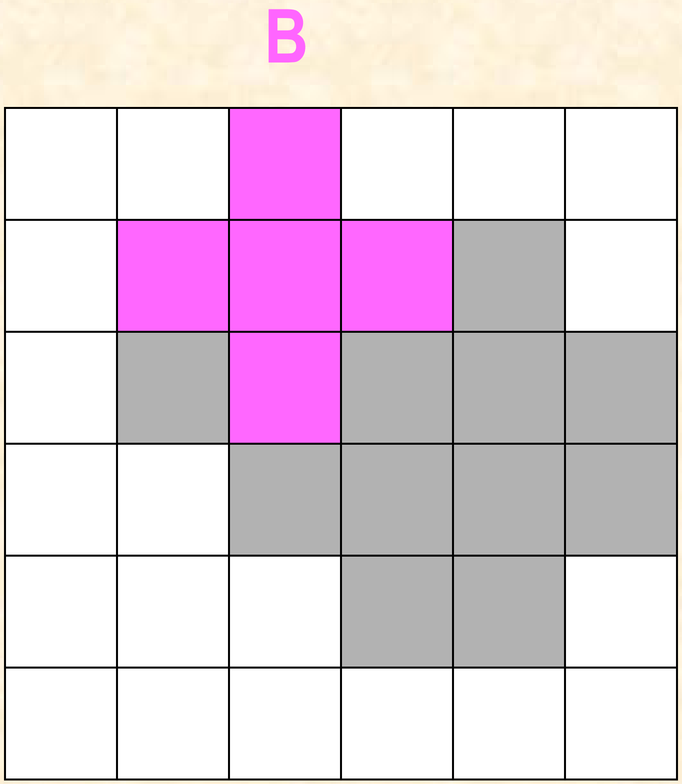
Erosion:

$$A \otimes B = \{x, y : B_{xy} \subseteq A\}$$

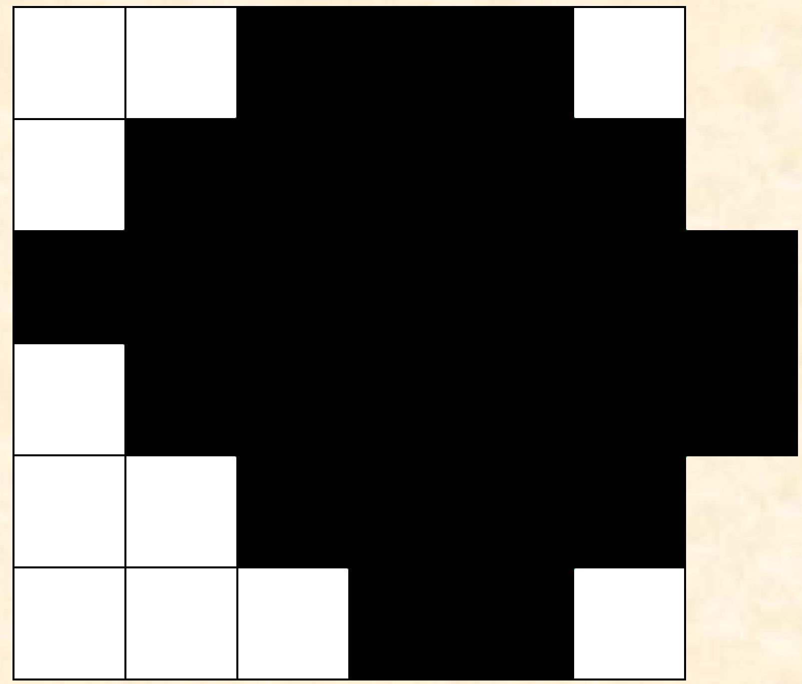
Dilation:

$$A \oplus B = \{x, y : B_{xy} \cap A \neq \varnothing\}$$

Dilation - example



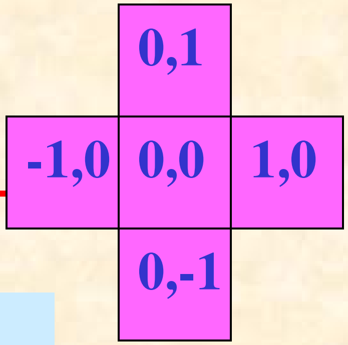
Source image



Output image

$$A \oplus B = \{ x, y : B_{xy} \cap A \neq \varnothing \}$$

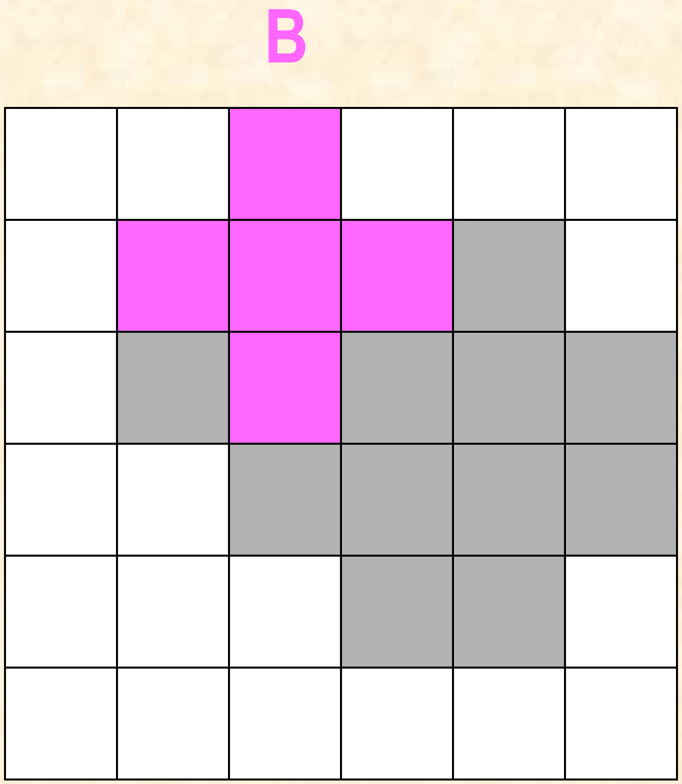
Dilation - algorithm



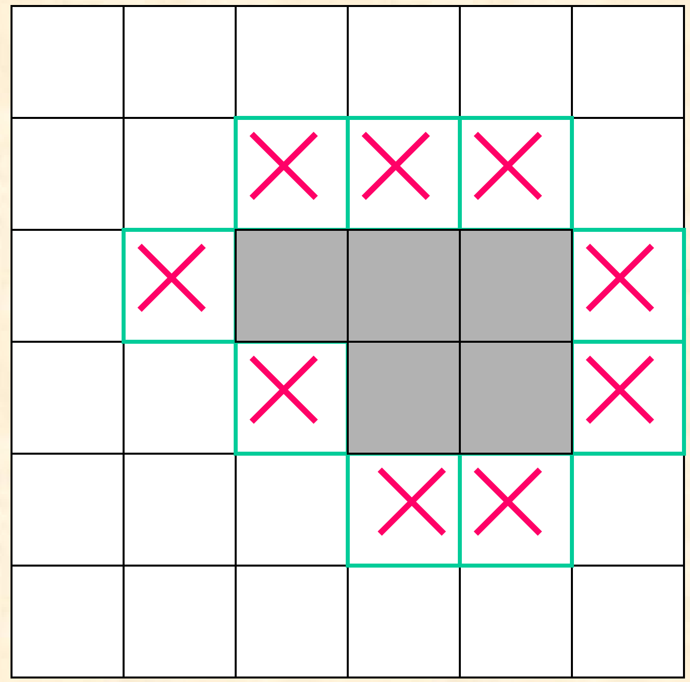

```
El_Size=5;
Sx : array[1..El_Size]of byte = (0, -1, 0, 1, 0);
Sy : array[1..El_Size]of byte = (1, 0, 0, 0, -1);
{ f(i,j) - source image, g(i,j) - output image }
...
g(i,j):=255;
for  i:=0 to N-1 do for j:=0 to N-1 do
if f(i,j)<>255 {background brightness} then
        for k:=1 to El_Size do g(i+Sx[k], j+Sy[k])=0
...
```

The size of the resulting image is larger !!!

Erosion - example



Source image



Output image

$$A \otimes B = \{ x, y : B_{xy} \subseteq A \}$$

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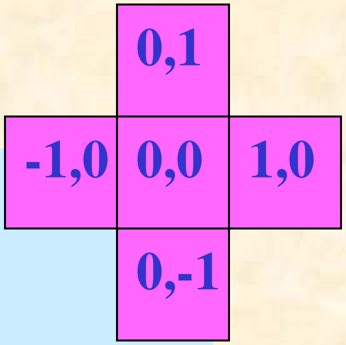
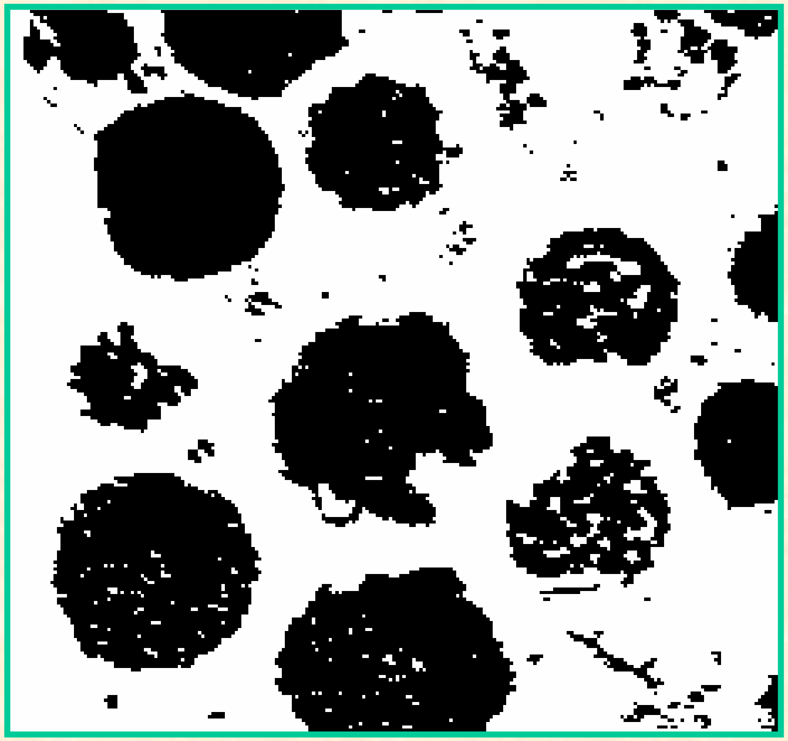
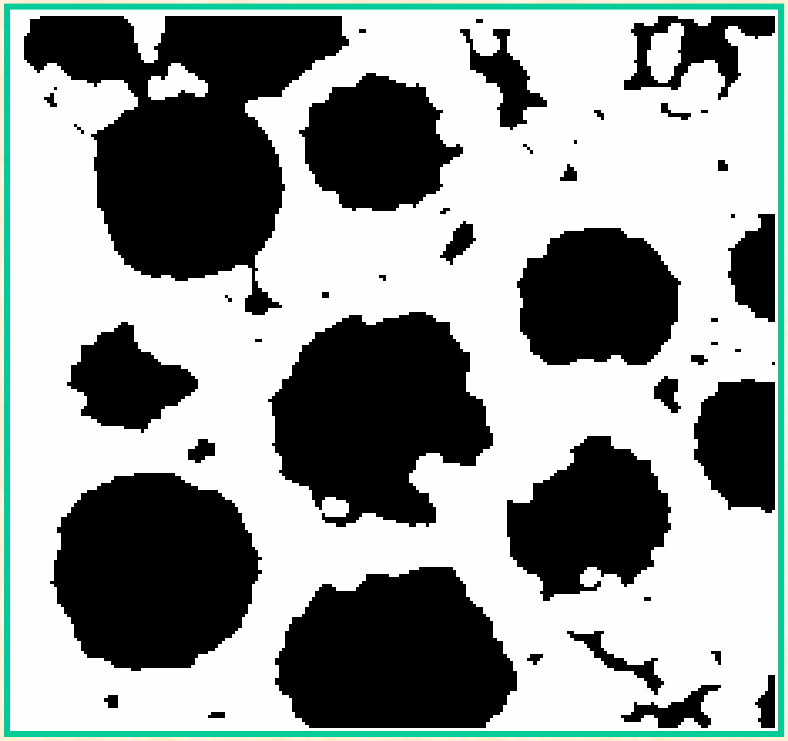
Erosion - algorithm



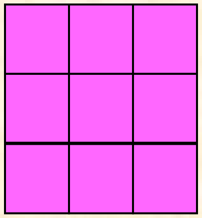

```
El_Size=5;
Sx : array[1..El_Size]of byte = (0, -1, 0, 1, 0);
Sy : array[1..El_Size]of byte = (1, 0, 0, 0, -1);
...
g(i,j):=255;
for  i:=0 to N-1 do for j:=0 to N-1 do
  if f(i,j)<>255 {background brightness} then
  begin
    inside =true;
    for k:=1 to El_Size do if f(i+Sx[k], j+Sy[k])=255 then
                        inside=false;
    if inside then g(i,j)=0;
  end;
...
```

Example of image closing





Structuring element:



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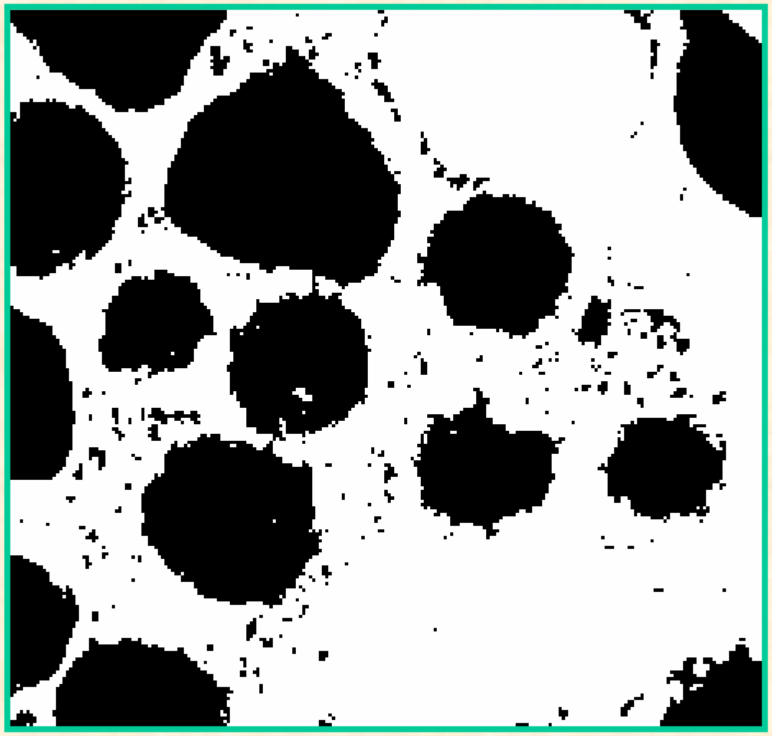
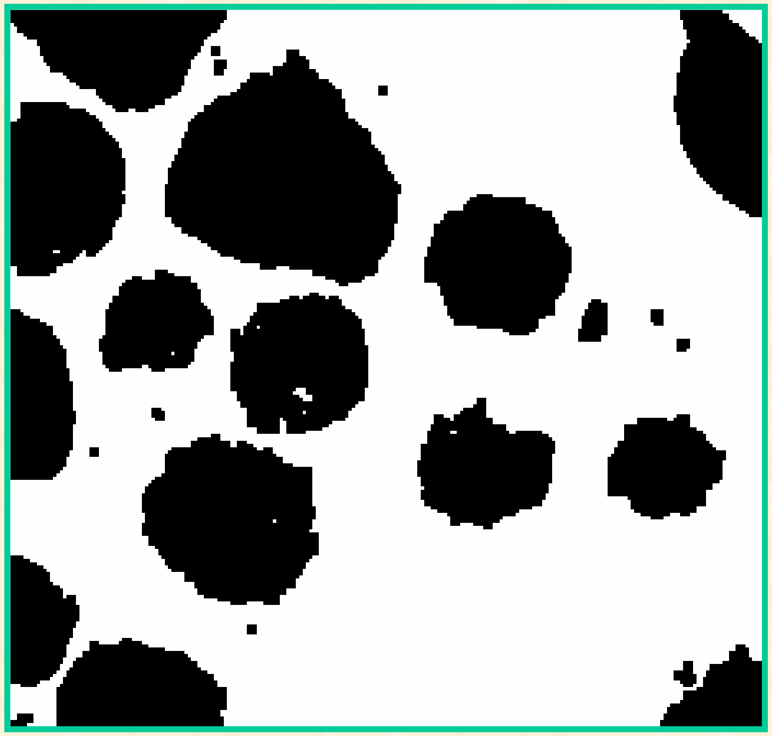
Example of image opening





Structuring element:

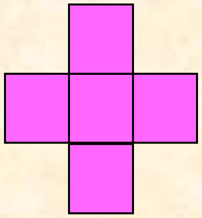


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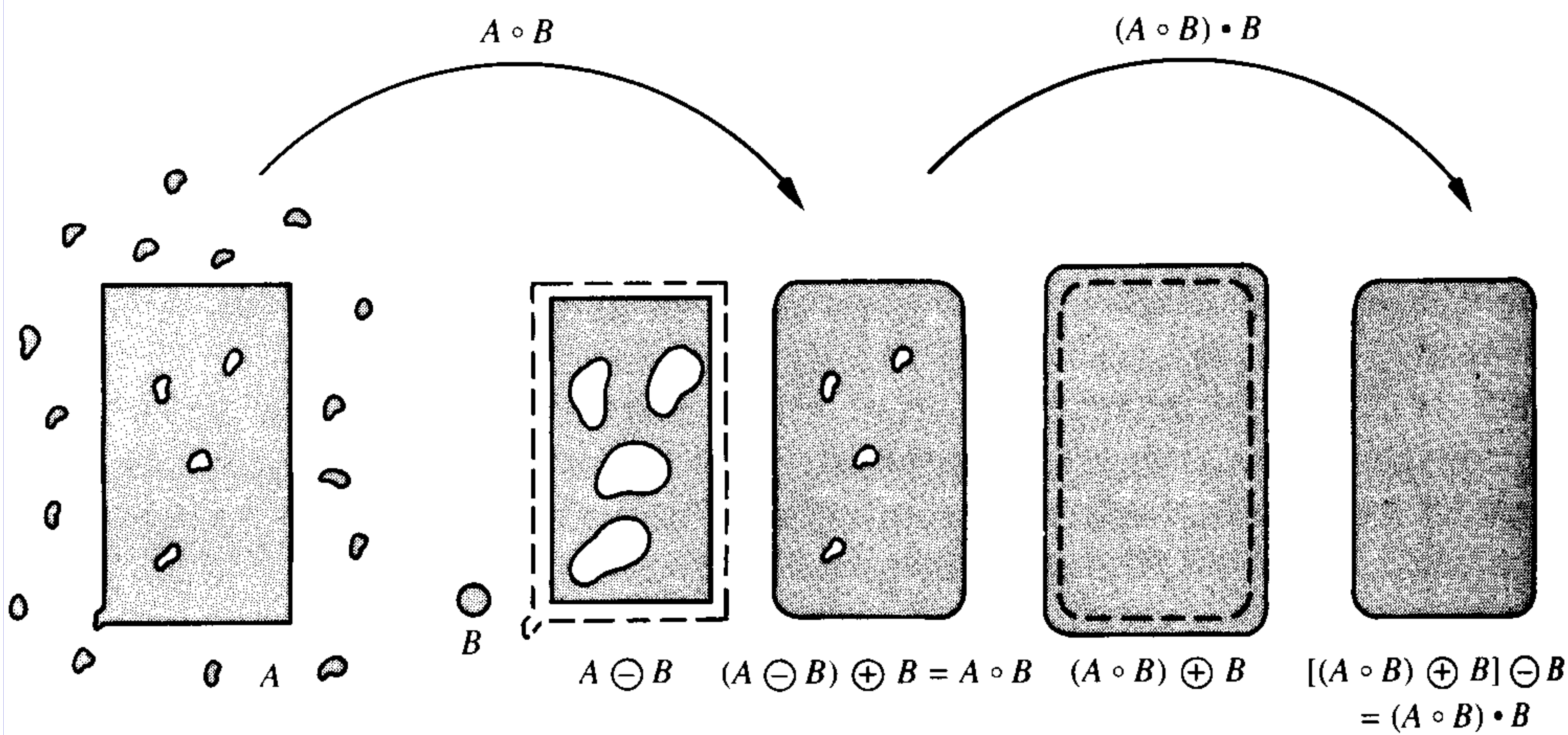
Image processing using morphology



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