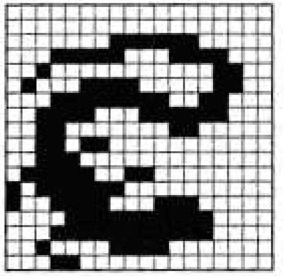
PRELUCRARI PE IMAGINI BINARE (ALB/NEGRU)



Imagine binara?

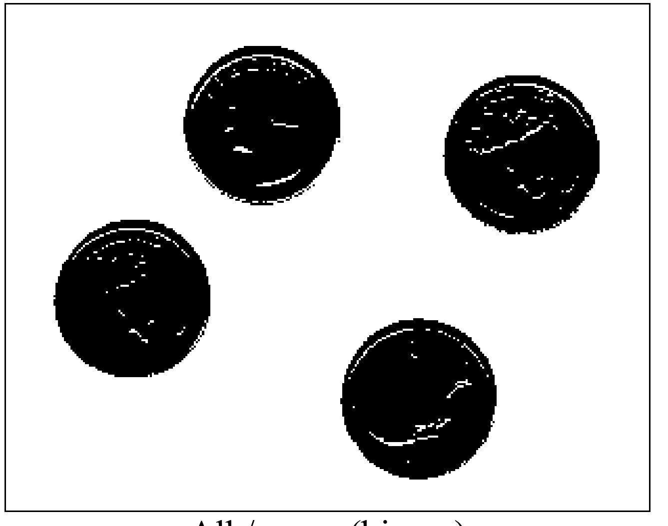
2 nuante:

alb ("0") – pixelii de fond (I(x,y)= 255 pt. imagini indexate cu 8 biti/pixel)
negru ("1") – pixelii apartinand obiectelor (I(x,y)= 0 pt. imagini indezate cu 8 biti/pixel)

Notatii:

$$b(x,y)=\begin{cases}1 & pixel\_obiect\\ 0 & pixel\_fond\end{cases} \quad \Rightarrow \quad \text{eticheta pixelului de la locatia (x,y)}$$

Grayscale



Alb/negru (binara)

Transformarea grayscale ⇒ alb/negru: binarizare (thresholding)

$$Dst(x,y)=\begin{cases}0 & (black='1') \quad , \quad if \quad Src(x,y) < threshold\\ 255 & (white='0') \quad , \quad if \quad Src(x.y) \geq threshold\end{cases}$$

OPERATII MORFOLOGICE

Morfologie := [moprphos = forma] forma si structura organismelor vii

Morfologie matematica ⇒ unelte pentru modificarea formei sau extragere de componente, reprezentarea si descrierea formei unei regiuni / obiect (contur, skeleton).

Teorie mulţimilor (set-urilor) ⇒ Limbajul folosit in morfologia matematica

Fie A o **mulţime** din Z^2. Dacă a = (a_1,a_2) este un element din A:

$a \in A$.

Similar, daca a **nu** este un element din A:

$a \notin A$.

Mulţimea fără nici un element: Ø.

Notaţie: { … }

Elementele mulţimilor pe care le consideram: pixeli *b(x,y)* ai obiectelor imagini binare

Relaţii / operaţii pe mulţimi

1. Incluziunea

$A \subseteq B$

2. Reuniunea

$C = A \cup B$

3. Intersecţia

$D = A \cap B$

4. Mulţimi disjuncte (mutual exclusive)

$A \cap B = \emptyset$.

5. Complementul

$A^C = \{w \mid w \notin A\}$

6. Diferenţa

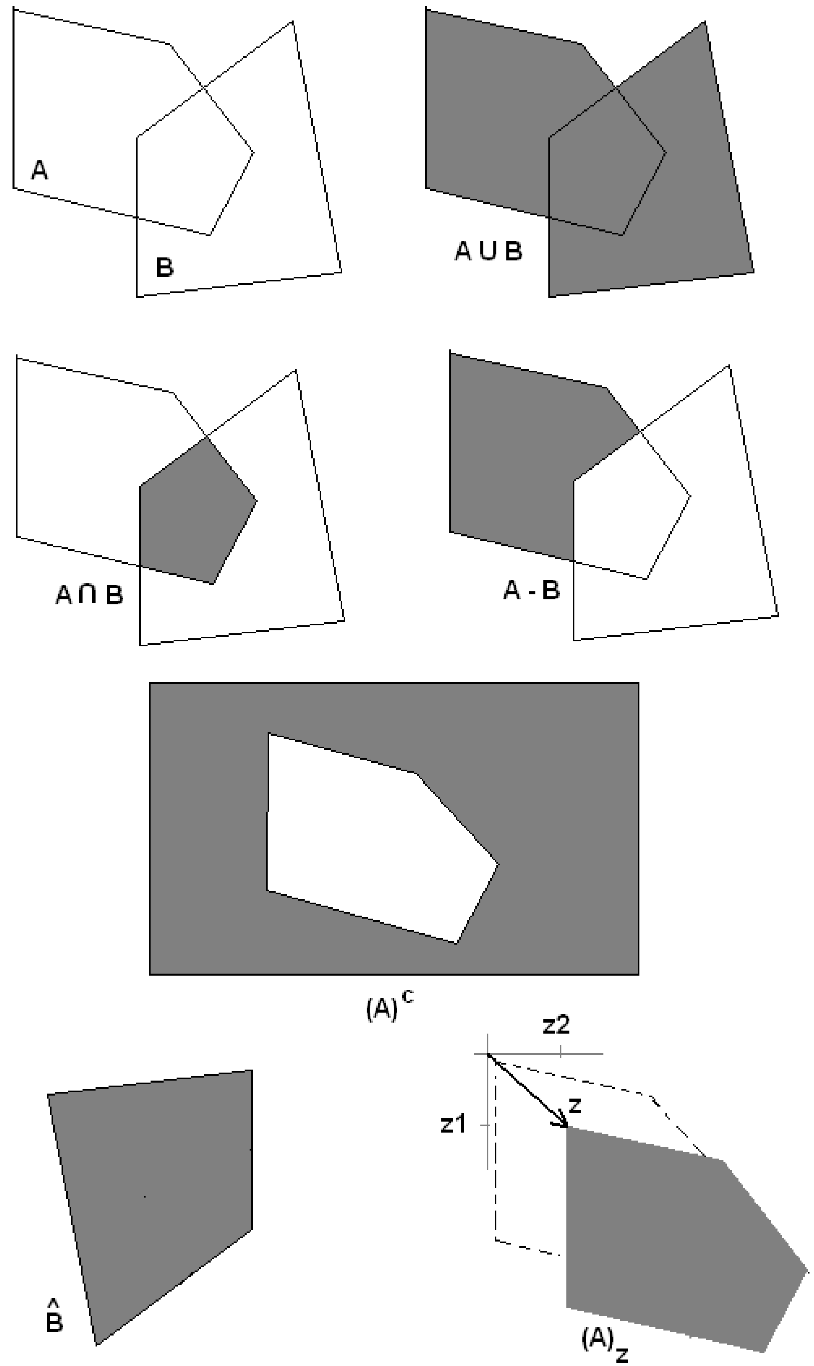
$A - B = \{w \mid w \in A, w \notin B\} = A \cap B^C$

7. Reflexia (flip orizontal + vertical)

$\hat{B} = \{w \mid w = -b, \text{ for } b \in B\}$

8. Translaţia (setului *A* cu *z=(z₁,z₂)*)

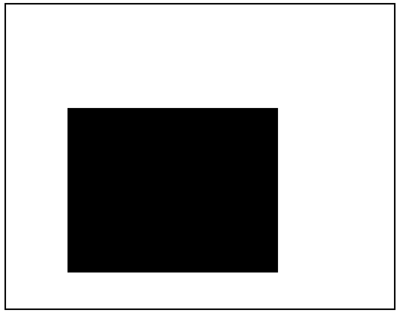
$(A)_Z = \{c \mid c = a + z, \text{ for } a \in A\}$



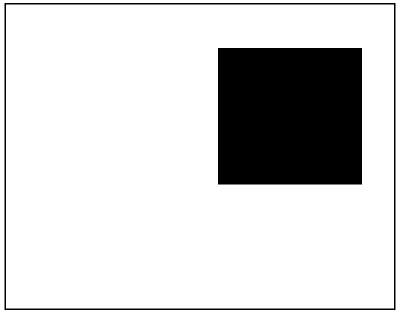
Operaţii logice / aritmetice aplicate pe imagini binare

- Unare: imagine op operand_scalar
- Binare: imagine1 op imagine2
- Realizate la nivel de pixel

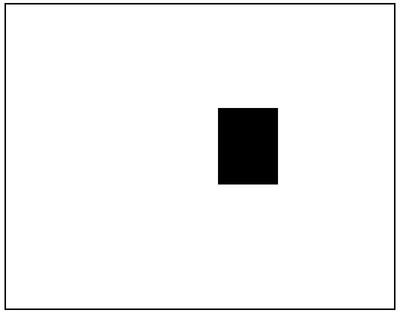
Operaţii logice: AND, OR, and NOT (COMPLEMENT) + orice alte combinaţii



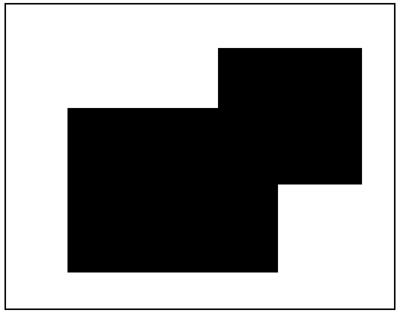
A



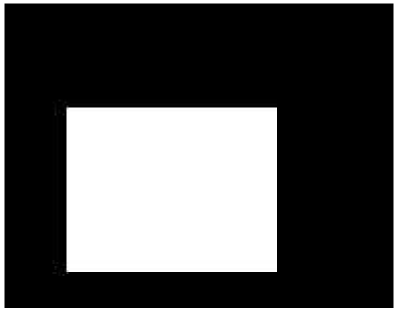
B



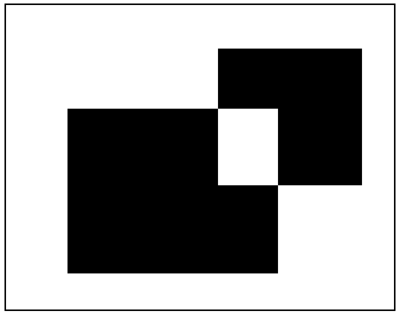
A and B



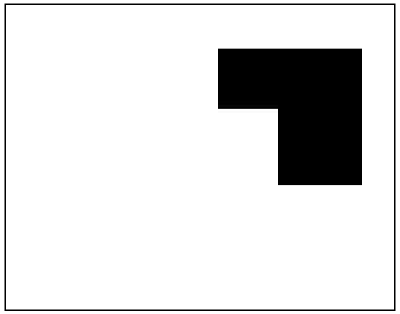
A or B



not (A) = A^C



A xor B



not(A) and B = B-A

DILATAREA SI EROZIUNEA

Dilatarea si eroziunea - cele doua primitive de baza ale operaţiilor morfologice!

A, B $\subset$ Z^2

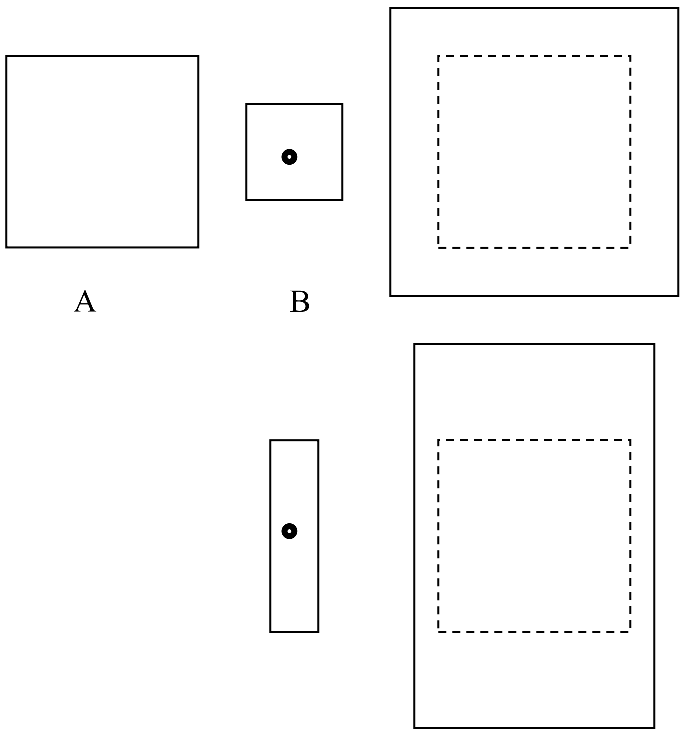
DILATAREA

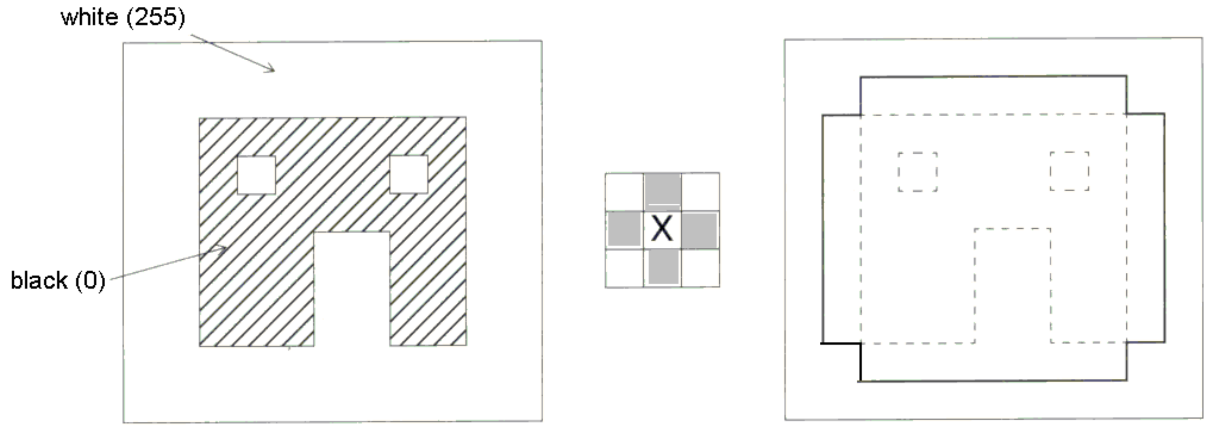
Dilatarea A cu B

$$A \oplus B = \{z \mid (\hat{B})_z \cap A \neq \emptyset\} \quad \text{sau} \quad A \oplus B = \{z \mid [(\hat{B})_z \cap A] \subseteq A\}$$

B – element structural

:





a. Original image. b. Structural element; x = origin. c. Image after dilation; original in dashes.

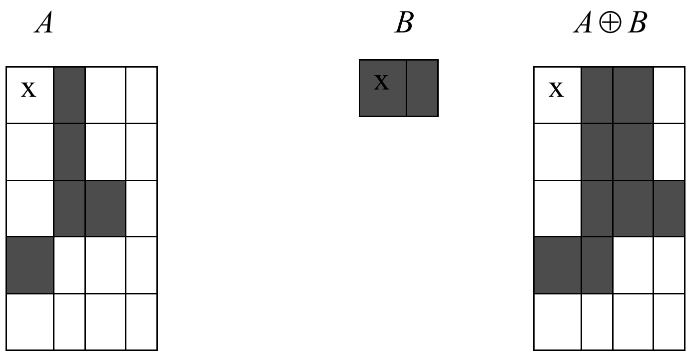
Alta definiţie pt. dilatare

$a=(a_1, a_2, \ldots, a_N)$ şi $b=(b_1, b_2, \ldots, b_M)$.

$$A \oplus B=\{z \in Z^2 | z=a+b \text{ pt. un } a \in A \text{ şi } b \in B\}$$

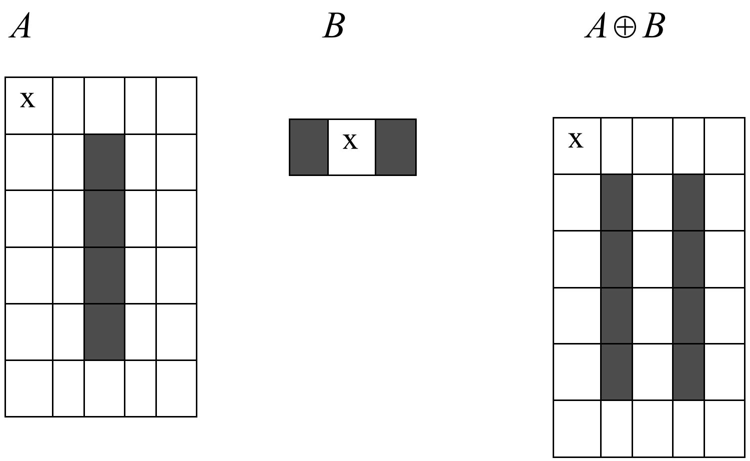
Ex: $A=\{(0,1), (1,1), (2,1), (2,2), (3,0)\}$;

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



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

Ex: $A=\{(1,2), (2,2), (3,2), (4,2)\}$; $B=\{(0,-1), (0,1)\}$



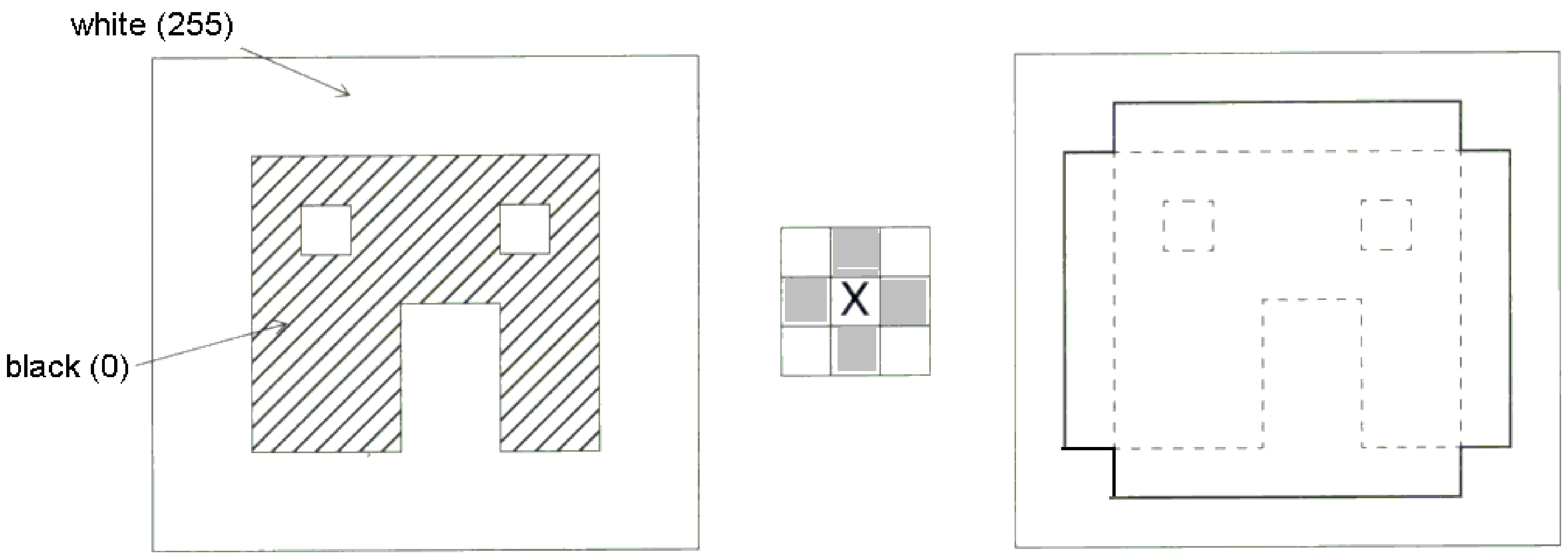
$A \oplus B =\{(1,1), (2,1), (3,1), (4,1), (1,3), (2,3), (3,3), (4,3)\}$

Modalitate practica de aplicare (laborator)

Se aplica elementul structural peste imaginea sursa

1. Daca originea elementului structural coincide cu un pixel ‚0' (alb) din imaginea sursa nu fac nimic (trec la pixelul următor)

2. Daca originea elementului structural coincide cu un pixel ‚1' negru (din imaginea sursa) realizez OR logic intre pixelii corespunzători elementului structural si pixelii corespunzători din imaginea sursa (asemănător convoluţiei – operaţia este OR logic si nu înmulţire aritmetica !!!)



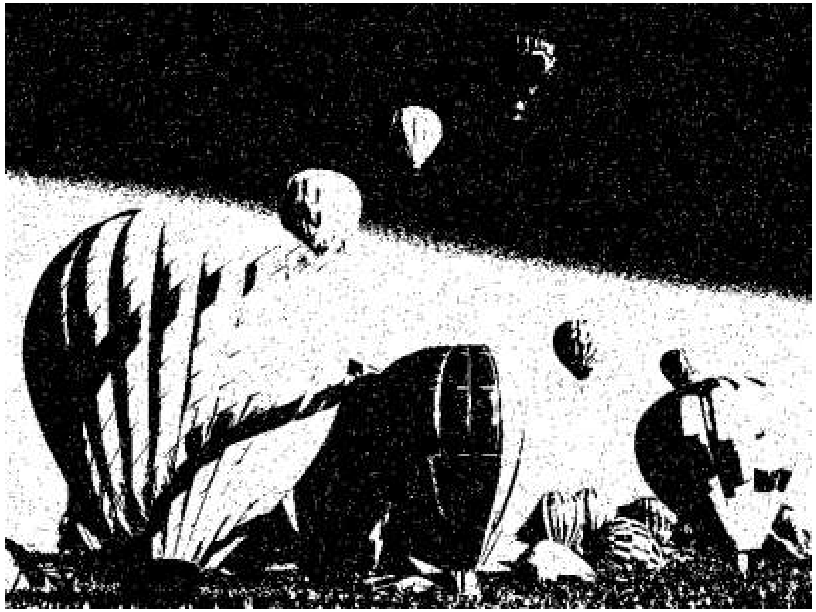
a. Original image.

b. Structural element; x = origin.

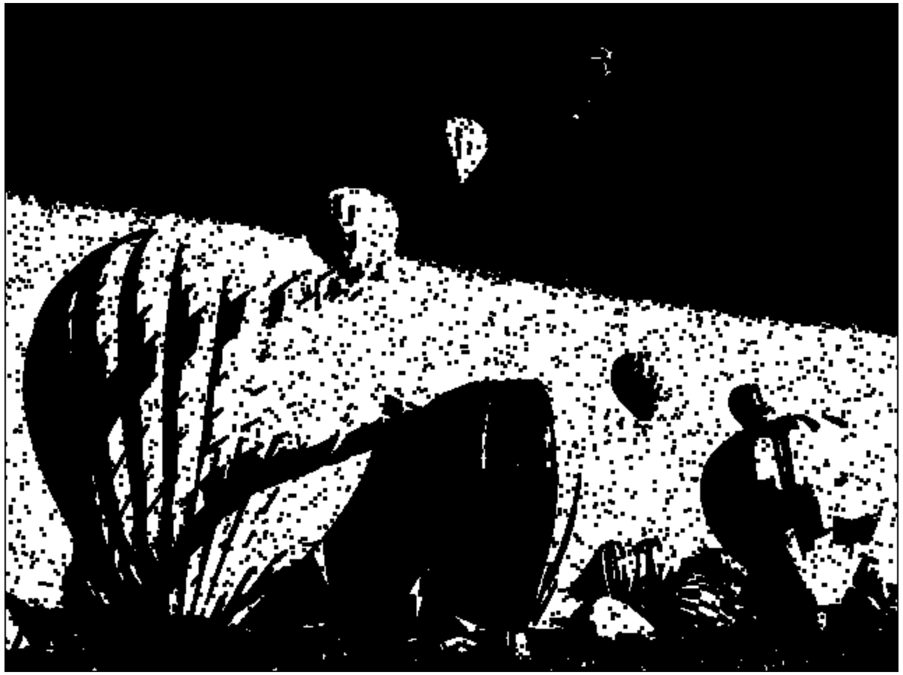
c. Image after dilation; original in dashes.

Aplicaţii: Umplere goluri, unire legaturi slabe intre obiecte (istmuri)

binarizare ⇒



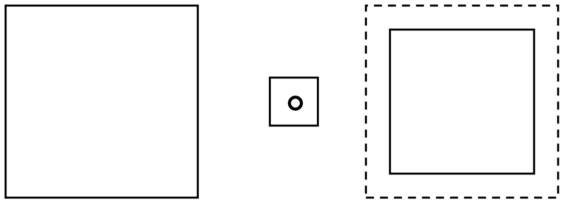
dilatare (obiect = negru) ⇒

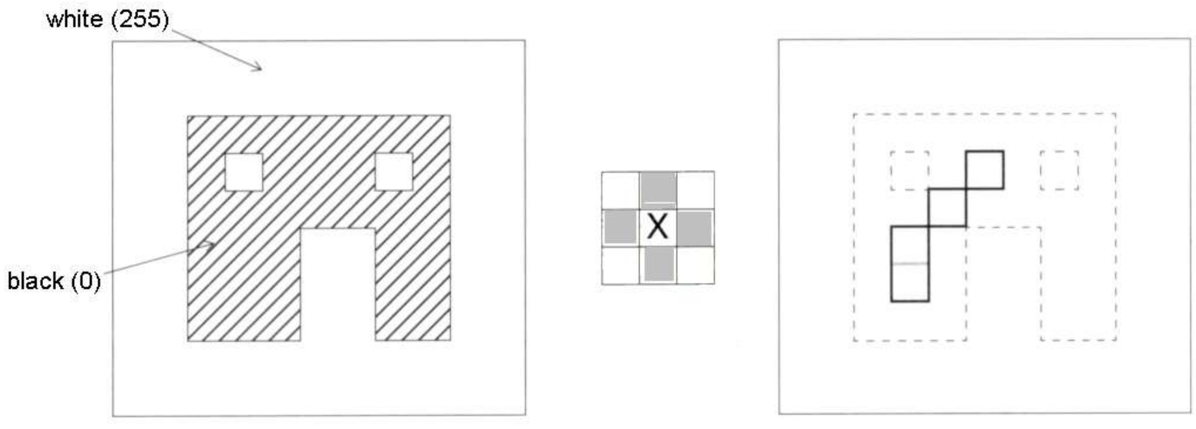


EROZIUNEA

Eroziunea *A* cu *B*

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





a. Original image.
b. Structural element; x = origin
c. Image after erosion; original in dashes.

Alta definiţie pt. eroziune

Eroziunea ↔ dilatare (duale /complementare)

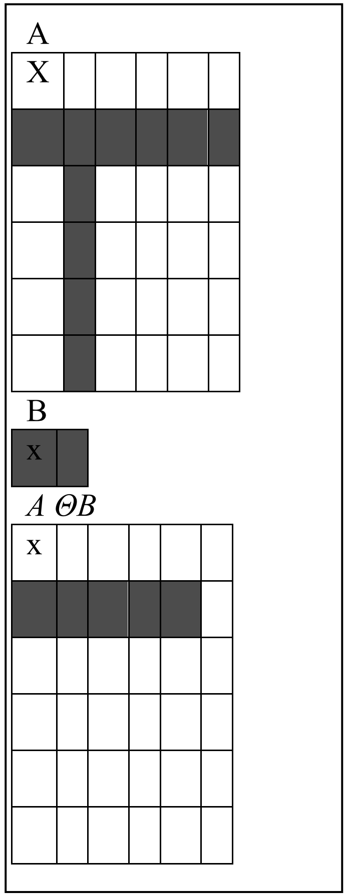
$a=(a_1, a_2, \ldots, a_N)$ şi $b=(b_1, b_2, \ldots, b_N)$.

$$A \ominus B = \{x \in Z^2 \mid x+b \in A \text{ pt. orice } b \in B\}$$

Ex1: 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 ΘB={(1,0), (1,1), (1,2), (1,3), (1,4)}

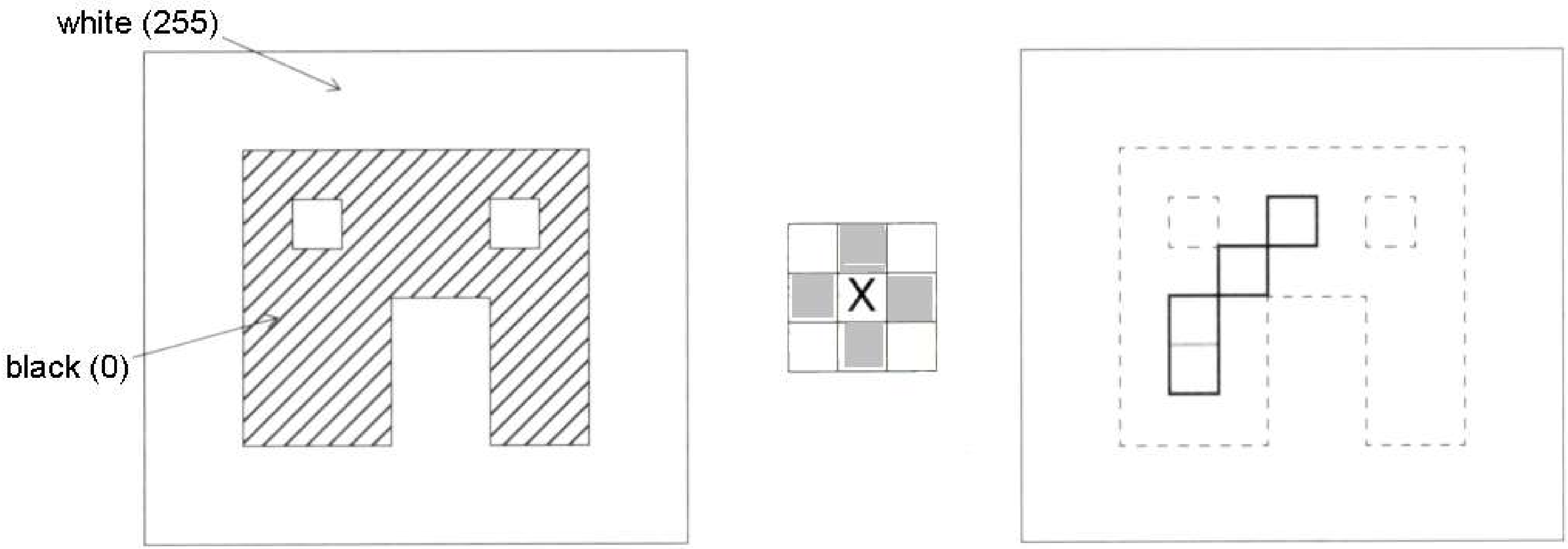


Modalitate practica de aplicare (laborator)

Se aplica elementul structural peste imaginea sursa

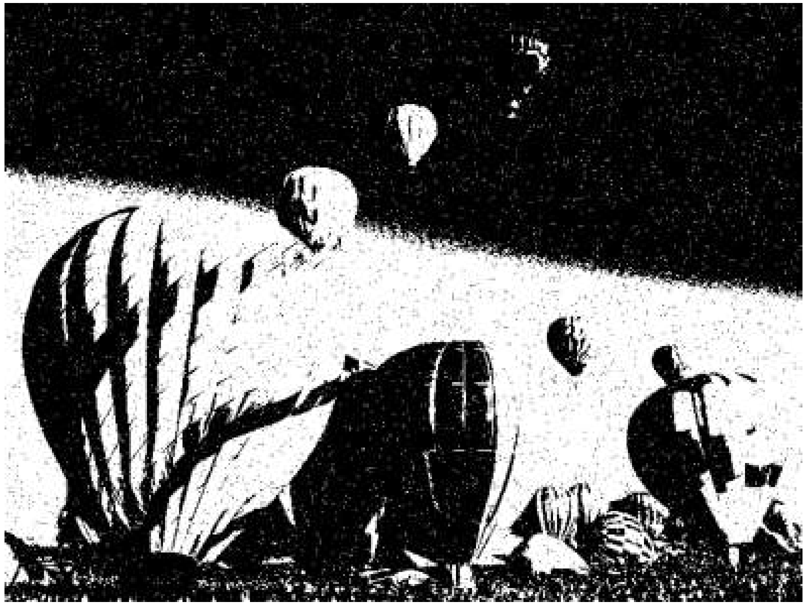
1. Daca originea elementului structural (B) coincide cu un pixel 0 din imaginea sursa nu fac nimic (trec la pixelul următor)

2. Daca originea elementului structural (B) coincide cu un pixel 1 din imaginea sursa (pixel curent) si oricare (exista cel putin unul) dintre pixelii de 1 din elementul structural se extinde in afara obiectului (A) atunci schimb valoarea pixelului curent din imaginea sursa in 0.



a. Original image. b. Structural element; x = origin c. Image after erosion; original in dashes.

Aplicaţii: Eliminare obiecte mici (zgomote), spargere legaturi slabe intre obiecte (istmuri)



eroziune (negru)⇒

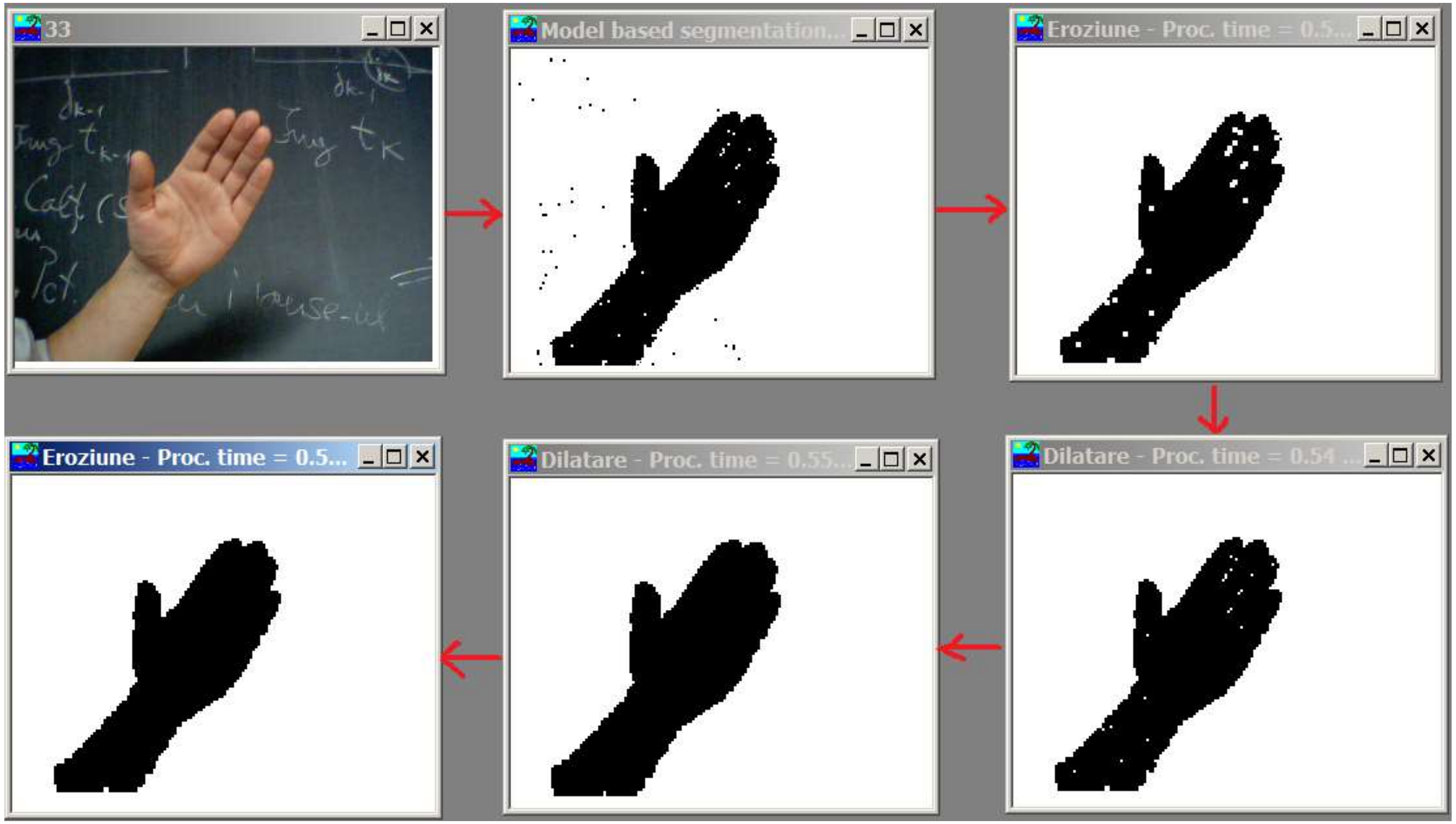
Imagine originala

Imagine rezultat după eroziune

Exemplu de aplicare tipica a operatiilor morfologice in segmentarea imaginilor:

Dorim sa segmentam mana care apare in imaginea de mai jos. Realizam o clasificare a pixelilor bazata pe un model de culoare a pielii (invatat anterior) ⇒ o imagine cu „defecte/zgomote" (erori de clasificare a pixelilor) ": pixeli albi in zona obiect si pixeli negrii in zona de fond.

- Aplicam o eroziune pt. a scapa de pixelii de „zgomot" din zona de fond (dreapta sus)
- Aplicam 2x dilatari pt. a scapa de „golurile" din zona obiect (dreapta jos)
- Aplicam o eroziune pt. a reduce obiectul la aria initiala / reala (stanga jos)



DESCHIDERE SI INCHIDERE

Deschidere

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

Aplicaţii: netezire contur, eliminare obiecte mici, spargere legaturi slabe intre obiecte (istmuri)

Închidere

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

Aplicaţii: netezire contur, eliminare goluri mici din obiecte, unire legaturi slabe intre obiecte (istmuri)

Deschidere

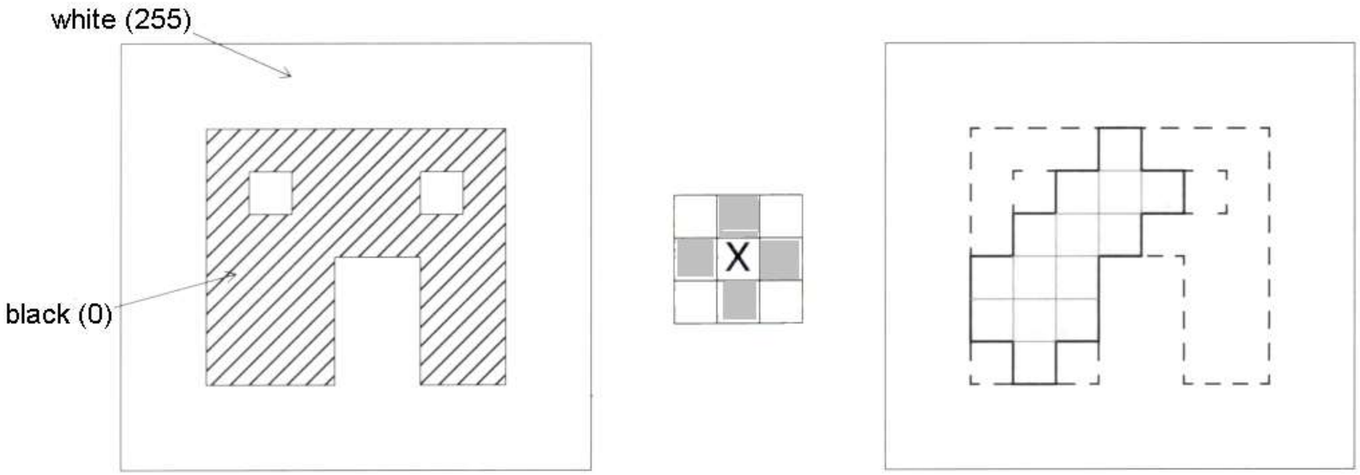
Imagine rezultat după deschidere (obiect = negru)

Închidere

Imagine rezultat după închidere (obiect = negru)

Exemple:

Deschidere

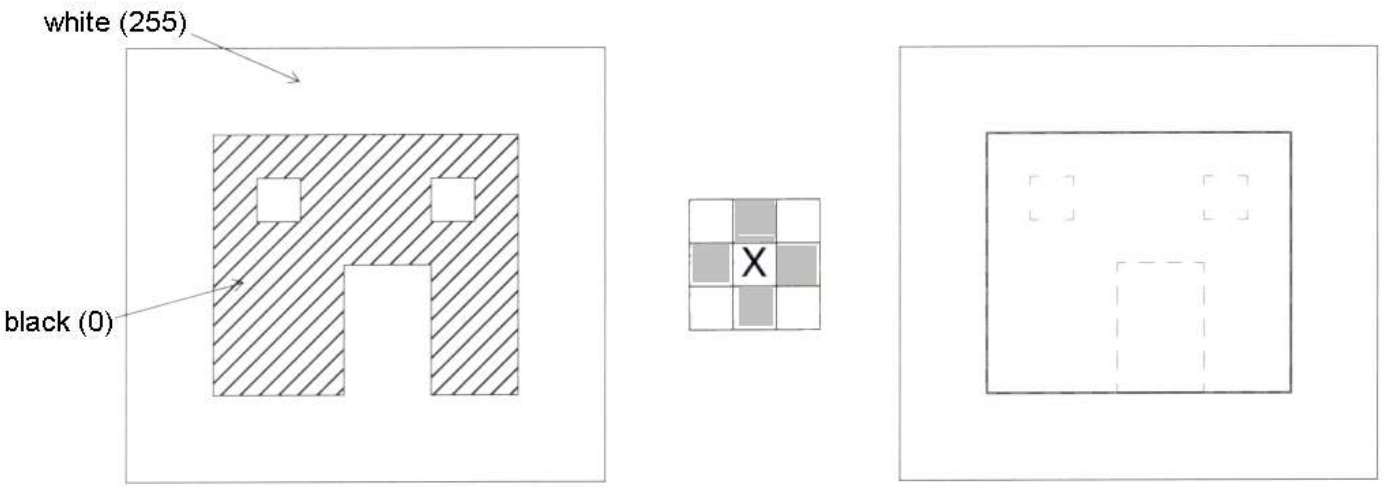


a. Original image.

b. Structural element; x = origin.

c. Image after opening; erosion followed by dilation.

Închidere



a. Original image.

b. Structural element; x = origin.

c. Image after closing; dilation followed by erosion; original in dashes.

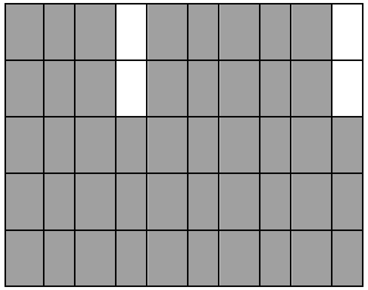
Proprietati (ale operatorilor morfologici)

1. $A \oplus B = B \oplus A$
2. $(A \ominus B)^C = A^C \oplus B$
3. $A \circ B \subseteq A$
4. $C \subseteq D \Rightarrow C \circ B \subseteq D \circ B$
5. $(A \circ B) \circ B = A \circ B$ (IDEMPOTENŢĂ)
6. $A \subseteq A \bullet B$
7. $C \subseteq D \Rightarrow C \bullet B \subseteq D \bullet B$
8. $(A \bullet B) \bullet B = A \bullet B$ (IDEMPOTENŢĂ)

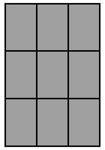
Aplicatii ale operatiilor morfologice de baza

EXTRAGERE CONTUR

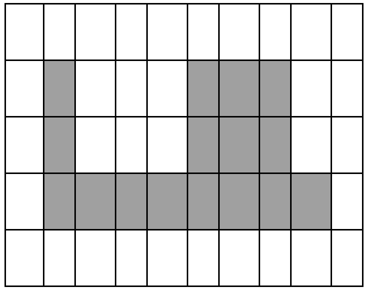
$\beta^{i}(A)=A-(A\Theta B)$ (contur interior)



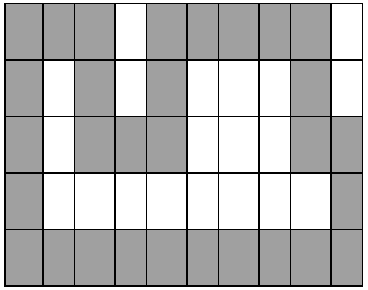
A



B



$A\,\Theta B$



$\beta^{i}(A)$

$\beta^{e}(A)=(A\oplus B)-A$ (contur exterior)

UMPLERE REGIUNI

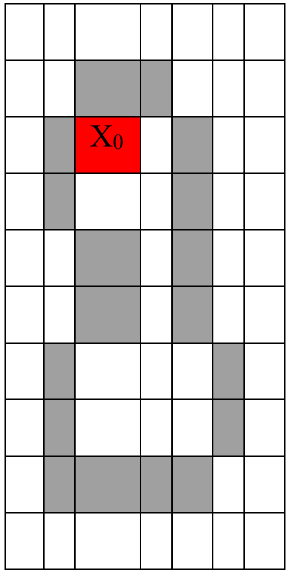
- p in interiorul conturului A (care se doreşte a fi umplut in interior cu „1")

1. X_0 = p, (p='1')

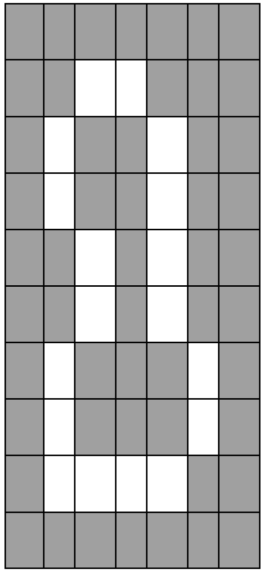
2. $X_k=(X_{k-1}\oplus B)\cap A^C \quad k=1,2,3,$

3. *Daca* $X_k=X_{k-1}\Rightarrow$ stop. Altfel repeta 2.

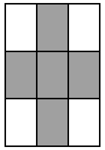
Obiectul final (umplut): $A\cup X_k$



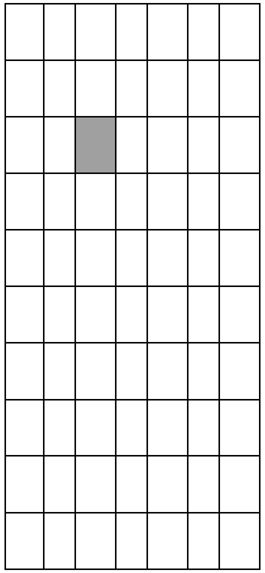
A



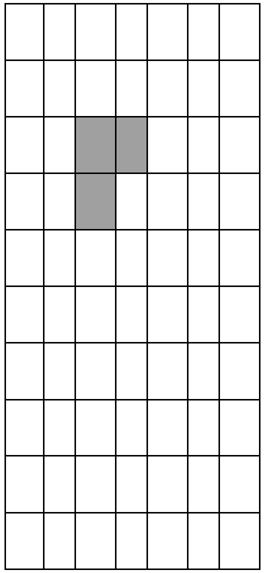
$\mathbf{A^C}$



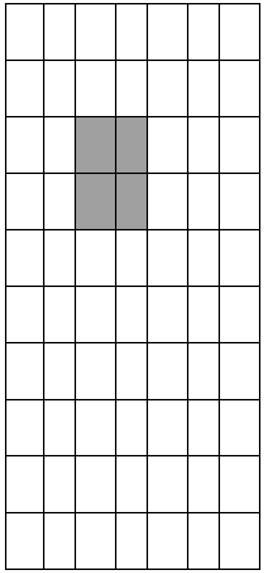
B



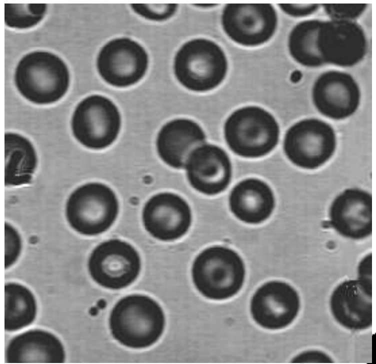
$\mathbf{X_0}$

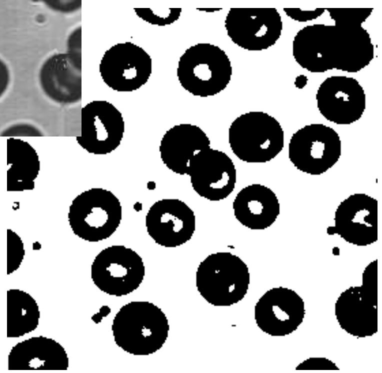


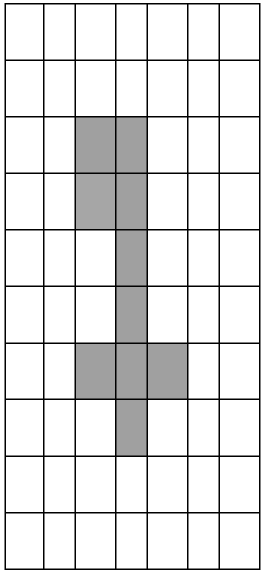
$\mathbf{X_1}$



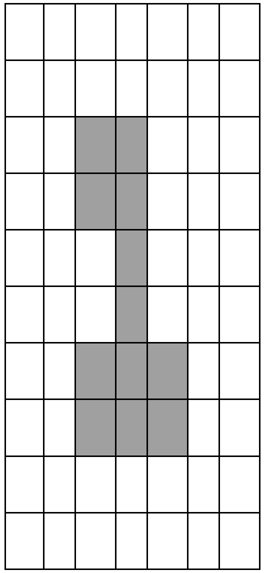
$\mathbf{X_2}$



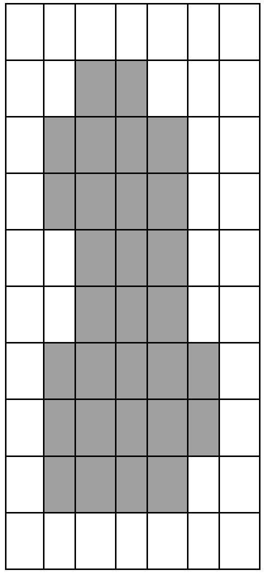




$\mathbf{X_6}$



$\mathbf{X_7}$



$\mathbf{X_7} \cup A$

EXTRAGERE COMPONENTE CONEXE (ETICHETARE)

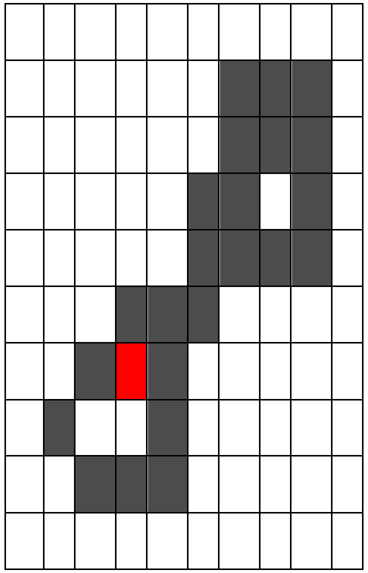
$A = \{ Y_1, Y_2, ... Y_n\}$, Y_i – componente conexe

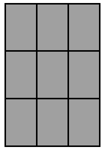
$Y \subseteq A$

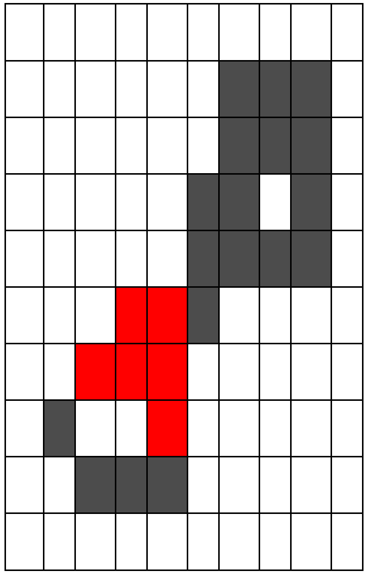
1. $p \in Y$. $X_0 = p$

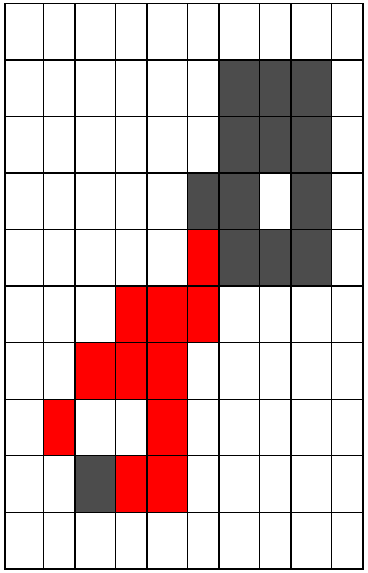
2. $X_k = (X_{k-1} \oplus B) \cap A \quad k=1,2,3,...$

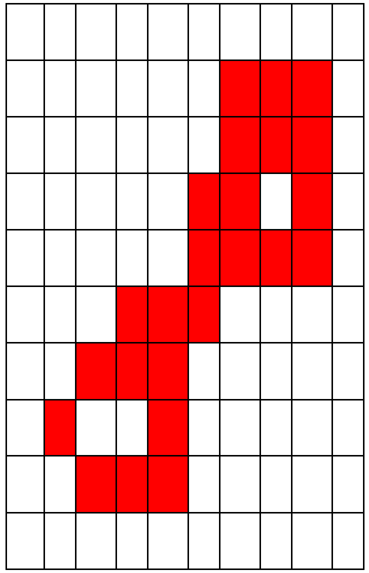
3. Dc. $X_k = X_{k-1} \Rightarrow$ stop ($Y = X_k$). Altfel repeta 2.











Y, p **B** **X_1** **X_2** **X_3 = Y**

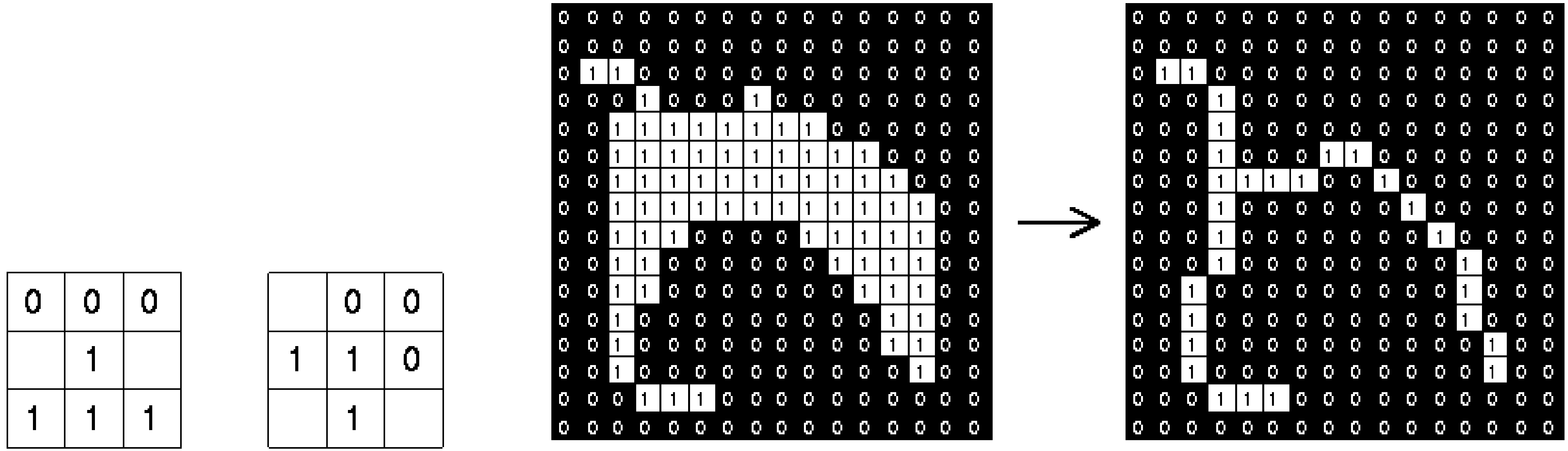
TRANSFORMATA „HIT-AND-MISS”

Se foloseşte la selecţia unor seturi de pixeli cu proprietăţi geometrice specifice: colturi, puncte izolate, puncte de contur, *template matching* (obiecte cu o anumită formă), subţiere, îngroşare etc.

Transformat hit & miss a unui set A cu elementele structurale *(J,K)*:

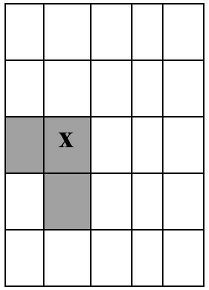
$$A \otimes (J,K) = (A \Theta J) \cap (A^C \Theta K).$$

Ex. 1: Thinning (subţiere)

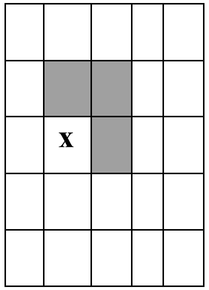


J **K** **A** **A⊗(J,K)**

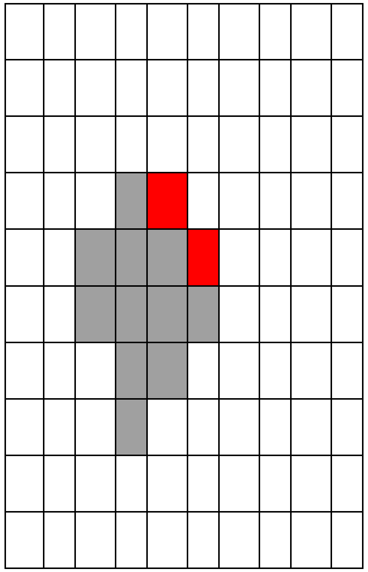
Ex.2: Detecţie colţuri



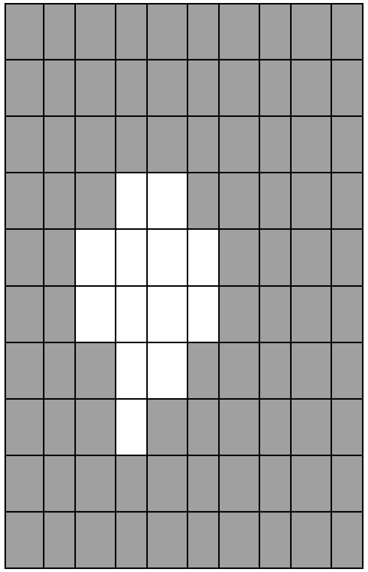
J



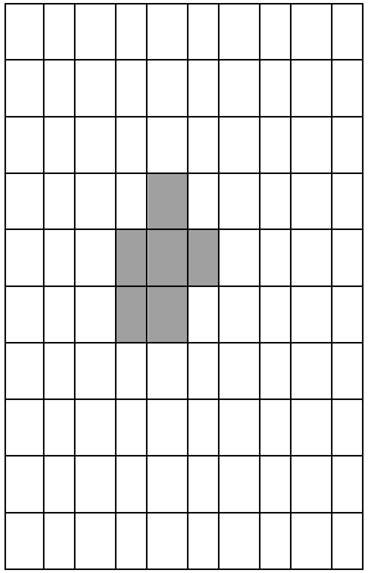
K



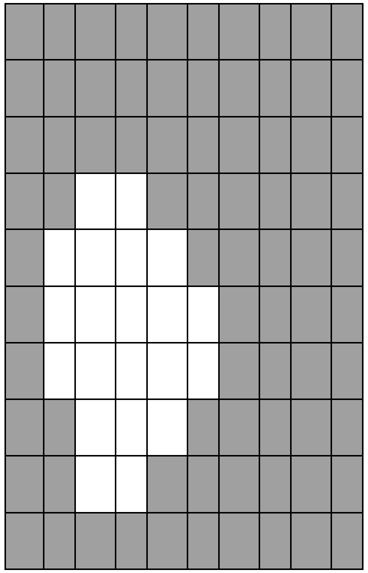
A



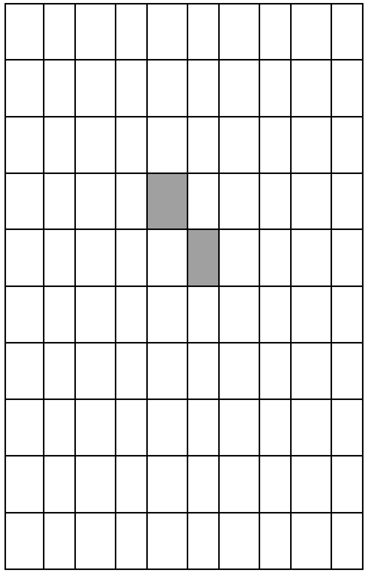
A^C



$(A \Theta J)$

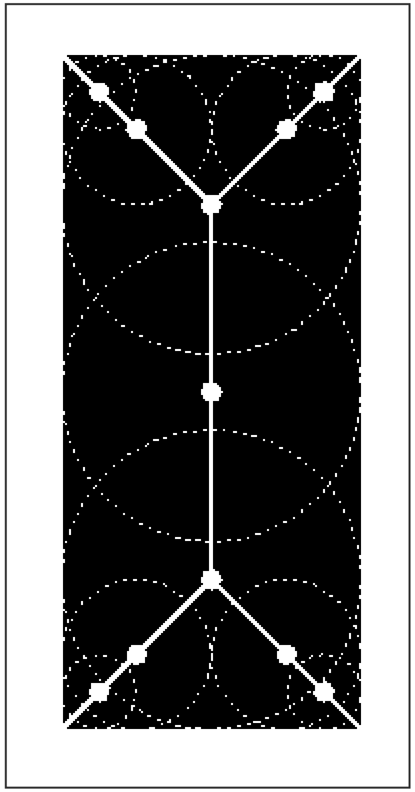


$(A^C \Theta K)$



$A \otimes (J,K) = (A \Theta J) \cap (A^C \Theta K)$

SKELETIZAREA



‚Skeletonul' setului A:

$$S(A) = \bigcup_{k=0}^{K} S_k(A)$$

$$S_k(A) = (A \Theta kB) - (A \Theta kB) \circ B$$

$$A \Theta kB = (...(A \Theta B) \Theta B) ....) \Theta B$$

$$K = \max\{k \mid (A \Theta kB) \neq \Phi$$

Reconstrucţia setului A:

$$A = \bigcup_{k=0}^{K} (S_k(A) \oplus kB)$$

K – trebuie sa fie cunoscut

Referinţe:

[1] Robert M. Haralick, Linda G. Shapiro, *Computer and Robot Vision*, Addison-Wesley Publishing Company, 1993

[2] Rafael C. Gonzalez, *Digital Image Processing*, Prentice-Hall, 2002