C07 - Prāguire: Thresholding
(C08 - Operații morfologice)

Grayscale [0, 255] → BW  0 (obiect) sau invers
                              1 (fundal)

(I > 128) → TRUE: albi, $I(x, y) > 128$
               negru, altfel

Th($I$) : Threshold          Histograma
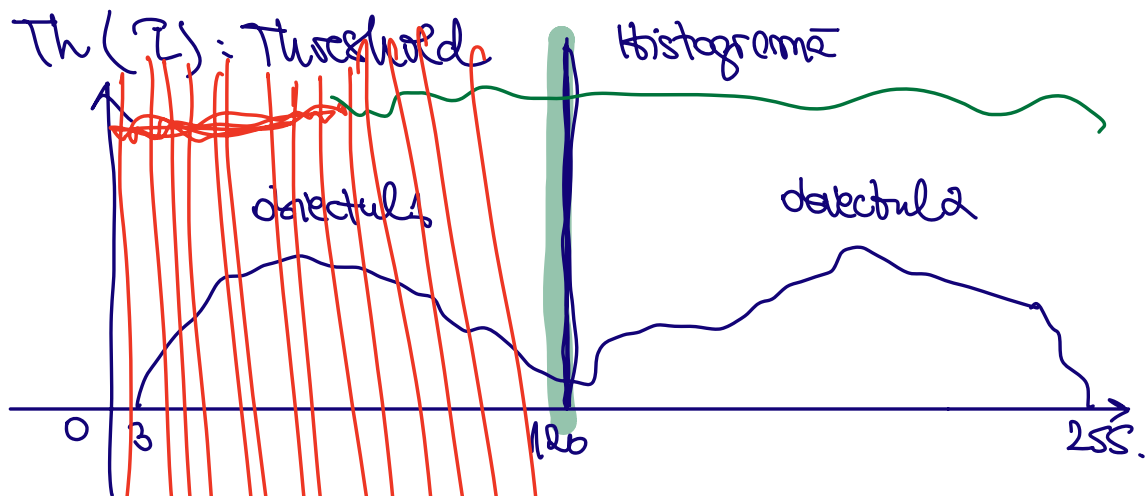


Algoritmul de prāguire Otsu / Otsu's Thresholding alg.
2 clase ┬ obiectului / culoare închisă
        └ fundalului / culoare deschisă

CLUSTERING: inter-cluster variation / inter class variation
            intra-cluster variation / intra class variation

Otsu se minimizeaza varianța intra clasă ⟺
       cu maximizarea varianței inter clasă



inter-clasă
mare
varianța inter-clasă

varianța intra clasă
puncte rostainse în jurul

medie

$$Var = \frac{\Sigma(x-\mu)^2}{\underset{esential}{n-1}} \left( \simeq \frac{\Sigma(x-\mu)^2}{n} \right)$$

abaterea populatie $= \sqrt{\frac{\Sigma(x_i-\mu)^2}{n}} = \sigma$

$$\boxed{\sigma^2_{inter} = P_1(\mu_1 - \mu_{Global})^2 + P_2(\mu_2 - \mu_{Global})^2}$$

$P_1 = $ probabilitatea pixelilor din clasa 1 (obiect)

30 pixeli albi (1), 6 pixeli negri (0), total 36.

$P_1 = \frac{30}{36}$.  $P_2 = \frac{6}{36}$.    $P_2 = W_{Background}$)  $P_1 = W_F$ foreground

$\mu_{Global} = \mu = $ media tuturor pixelilor (intensitate)

$\mu_F - \mu_1 - $ medie pixelilor ~~fundal~~ obiect

$\mu_B - \mu_2 - $ medie pixelilor fundal

$$\sigma^2_{inter} = W_B\left(\mu_B - \mu_{Glob}\right)^2 + W_F\left(\mu_F - \mu_{Glob}\right)^2$$

$$= W_B \cdot \sigma^2_B + W_F \cdot \sigma^2_F$$

minimizeaza

$T = 3$.  $I(x,y) < T$ obiect/0
          $\geq T$ fundalului/1

$W_B$

$\mu_B$

intensitate

$\mu_{Global} = \frac{8 \, pxc \cdot 0 + 7 \, pxc \cdot 1 + 2 \, pxc \cdot 2 + 6 \, pxc \cdot 3 + 9 \, pxc \cdot 4 + 4 \, pxc \cdot 5}{36}$

$= \frac{7 + 4 + 18 + 36 + 20}{36} = \frac{36 + 39}{36} = \frac{75}{36}$

$W_F$

$\mu_F$

$$\boxed{\sigma^2_{inter} = W_F \cdot \sigma^2_F + W_B \cdot \sigma^2_B \qquad \sigma^2_F = \Sigma\left(x_i^F - \mu_F\right)^2 \quad \sigma^2_B = \Sigma\left(x_i^F - \mu_B\right)^2}$$

$$W_B = \frac{nr\ de\ pixeli\ Backgr.}{nr.\ total} = \frac{8+7+2}{36} = 0.4722$$

$$W_F = \frac{nr.\ de\ pixeli\ foregr.}{nr.\ total} = \frac{19}{36} = 0.5278 = \Big] = +1.$$

$$\sigma_B^2 = \frac{\sum(X_i - X_B)^2}{nr.\ pixeli\ B} \overset{8buc.}{=} \frac{(0-0.6471)^2 + 7buc.(1-0.6471)^2 + 2buc.(2-0.6471)^2}{17}$$

$$= 0.4637$$

$$\sigma_F^2 =$$

$$\mu_B = \frac{8buc.0 + 7buc.1 + 2buc.2}{17} = \frac{7+4}{17} = \frac{11}{17} = 0.6471$$

$$\mu_F = \frac{6buc.3 + 9buc.4 + 4buc.5}{19} = \frac{18+36+20}{19} = \frac{74}{19} = 3.8947$$

$$\sigma_F^2 = \frac{6\cdot buc(3-3.8947)^2 + 9buc(4-3.8947)^2 + 4buc.(5-8.8947)}{19}$$

$$= 0.5152$$

$$\sigma_{inter}^2 = 0.4782 \cdot 0.4637 + 0.5278 \cdot 0.5152 = 0.4909$$

$T = 0.$    $I < T,\ obiect\ maimic\ \Big]$   $\mu_F$
           $\geq =,\ fundal\ tot$      $\mu_B$
                             $\sigma_F$
                             $W_B$
                             $\sigma_{inter}^2$

$T = 1$

imbinarize $(I)$

$\longrightarrow\ ||\ \longrightarrow\ (I, "global"):$ Threshold Otsu calculează
                            prag GLOBAL

<u>Prag local/adaptativ</u>
imbinarize $(I, "adaptiv")$
se imparte imaginea în blocuri: 6x6
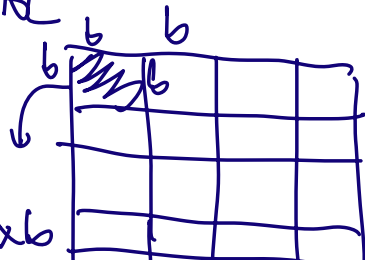
În fiecare bloc se calc. pragul Otsu propriu

$$0 \quad\quad 0.5 \quad\quad 1$$
$$0 \quad\quad 128 \quad\quad 255$$
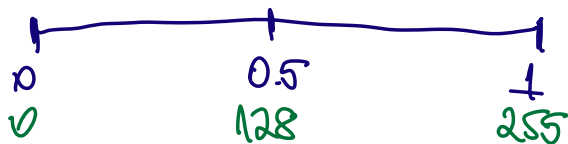
$$0.51372 \cdot 255 = 131.$$

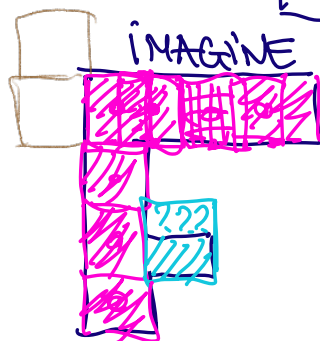## C08 — Operații morfologice

Se aplică pe imagini BW.
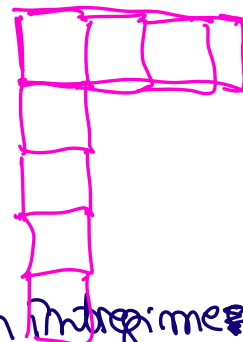
imerode — ERODE / EROZIUNE

imdilate — DILATE / DILATARE

imopen — EROZIUNE, apoi DILATARE
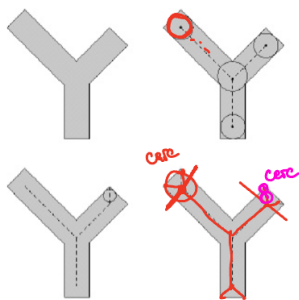
imclose — DILATARE apoi EROZIUNE

element structural ○ cerc/disk



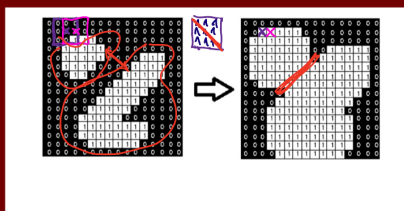IMAGINE                EL. STRUCTURAL

EROZIUNE: el. structural parcurge img., în întregime este în interiorul obiectului se păstrează pixelul central



### Exemplu dilatare

■ Același element de structură de $3 \times 3$

# Exemplu dilatare



(a)

A

(f)
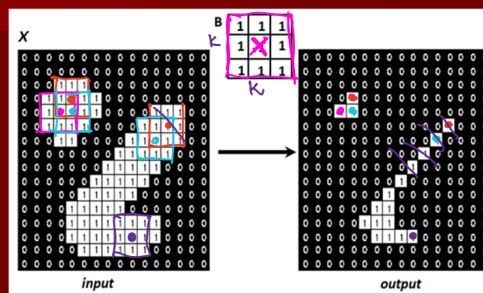
(g)

$A \oplus B$

# Exemplu eroziune



input

output
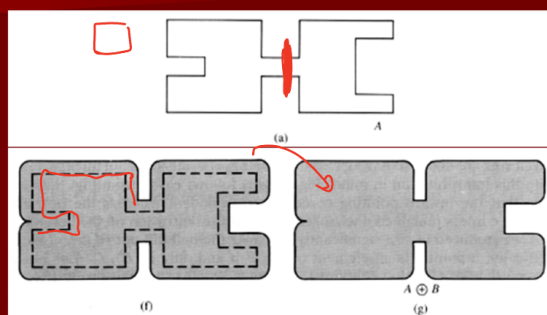
**Figure 2. Effect of erosion using a 3X3 square structural element B.**