UNIUNEA EUROPEANĂ

GUVERNUL ROMÂNIEI

Instrumente Structurale
2007-2013

Platformă de e-learning și curriculă e-content pentru învățământul superior tehnic

AEACD

6. Algoritmi generali de binarizare. P-tile thresholding. Optimal thresholding

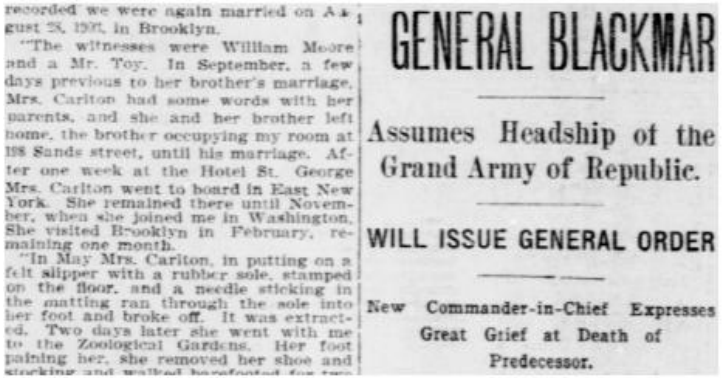
Algoritmi generali de binzarizare

- Se pot aplica pe orice tip de document
- Asa cum am spus mai devreme algoritmii de binarizare clasifica pixelii in doua categori:
  - Prima formata din pixelii cu o **proprietate masurabila** ce are valoarea sub un anumit prag

  si
  - a doua formata din pixelii pentru care aceasta **proprietate** are o valoare egala sau mai mare decat acest prag
- Acestia creaza o imagine binara
- **Alegerea pragului este o operatie critica!!!**

Algoritmi generali de binarizare (2)

- Desi poate parea o operatie simpla **pragul** (**threshold**) determinat poate avea o valoare prea mica sau prea mare


recorded we were again married on August 28, 1906, in Brooklyn.
"The witnesses were William Moore and a Mr. Toy. In September, a few days previous to her brother's marriage, Mrs. Carlton had some words with her parents, and she and her brother left home, the brother occupying my room at 198 Sands street, until his marriage. After one week at the Hotel St. George Mrs. Carlton went to board in East New York. She remained there until November, when she joined me in Washington. She visited Brooklyn in February, remaining one month.
"In May Mrs. Carlton, in putting on a felt slipper with a rubber sole, stamped on the floor, and a needle sticking in the matting ran through the sole into her foot and broke off. It was extracted. Two days later she went with me to the Zoological Gardens. Her foot paining her, she removed her shoe and

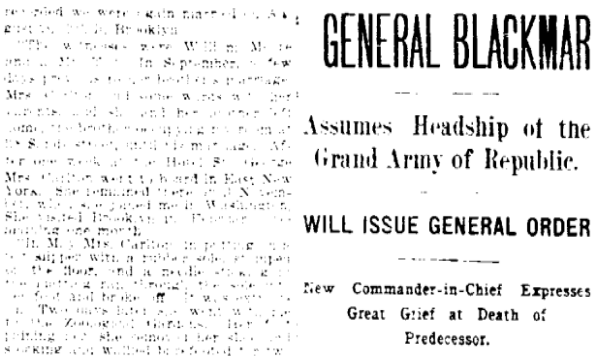
GENERAL BLACKMAR

Assumes Headship of the Grand Army of Republic.

WILL ISSUE GENERAL ORDER

New Commander-in-Chief Expresses Great Grief at Death of Predecessor.

Imagine grayscale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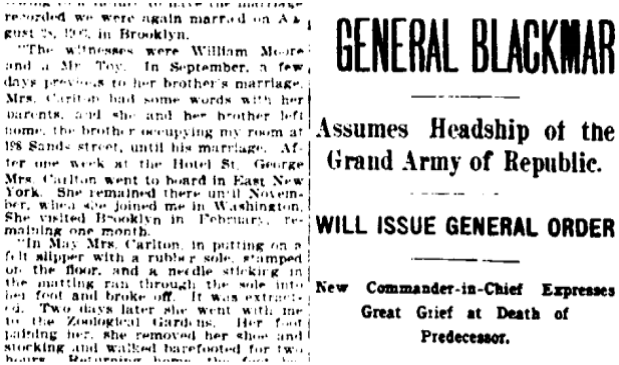
Valoarea pragului este prea mica

Rezultat obtinut dupa ce am crescut valoarea pragului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Algoritmi generali de binarizare (3)

- O posibila clasificare a algoritmilor de binarizare este :
  - P-tile thresholding
  - Optimal thresholding
  - Mixture modelling
  - Adaptive thresholding
  - Mode method

- Toate metodele enuntate mai sus sunt automate

AGB – P-tile thresholding

- Se bazeaza pe informatia obtinuta in mod apriori: obiectul este mai luminos/intunecat decat background-ul si ocupa un procent cunoscut **1/p** din aria totala a imaginii

- Setam un prag corespunzator unei valori a intensitatii culorii care satisface conditia ca **1/p** din pixeli sa se gasesca sub aceasta valoare

AGB – P-tile thresholding (2)

- Folosim histograma cumulativa:

$$c(g) = \sum_{k=0}^{g} h(k)$$

$$h(k) = \frac{n_k}{n}$$

- Pragul T verifica ecuatia :
  - pentru obiecte cu luminozitatea scazuta (dark foreground)

$$c(T) = \frac{1}{p}$$

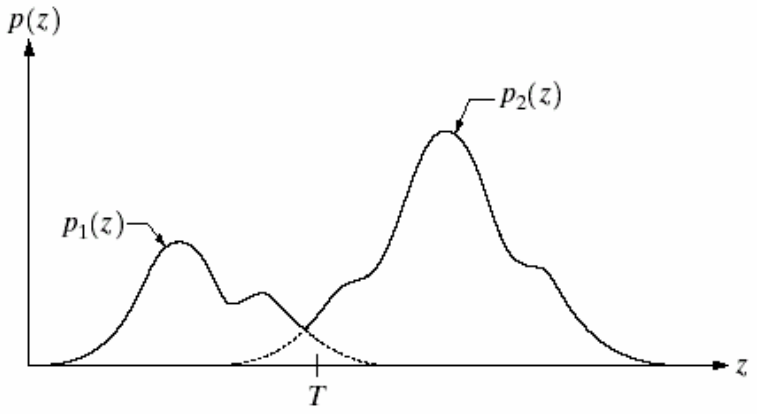
  - pentru obiecte cu luminozitatea ridicata (bright foreground)

$$c(T) = 1 - \frac{1}{p}$$

AGB – Optimal thresholding

- **Idea**: histograma unei imagini este suma a doua distributii care se suprapun
- **Pragul optim** (**optimal threshold**): punctele din aceste distributii care se suprapun (corespund probabilitatii minime dintre maximele celor doua distributii)
- **Problema**: distributiile sunt necunoscute

FIGURE 10.32
Gray-level probability density functions of two regions in an image.



Imagine preluata:
http://cs.joensuu.fi/pages/koles/image/Segmentation.pdf

AGB – Optimal thresholding (2)

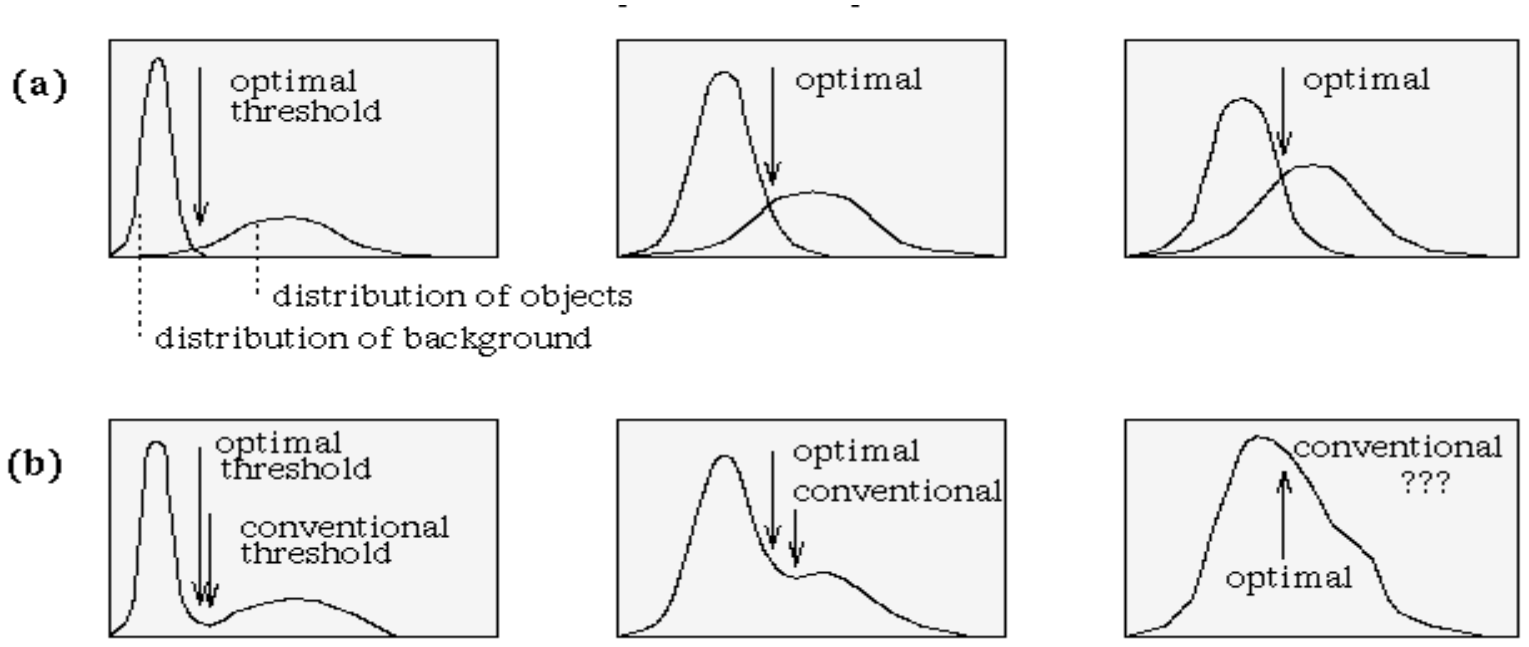


Figure 5.4 *Grey level histograms approximated by two normal distributions; the threshold is set to give minimum probability of segmentation error: (a) Probability distributions of background and objects, (b) corresponding histograms and optimal threshold.*

Imagine preluata:
http://www.ece.uvic.ca/~aalbu/computer%20vision%202009/Lecture%209.%20Segmentation-Thresholding.pdf

AGB – Optimal thresholding (3)

- Optimal thresholding folosind clusterizare
  - Cel mai simplu caz: segmentarea in doua clase (foreground/background)
  - Pixelii ce au intensitatea culorii apartinand uneia sau alteia dintre clase formeaza clusterele noastre
  - Dorim sa gasim un prag astfel incat fiecare pixel din fiecare cluster este mai aproape ca intensitate de media tuturor pixelilor din acel cluster decat de media pixelilor din celalalt cluster

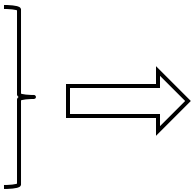
AGB – Optimal thresholding (4)

- Selectia iterativa a pragului optim
  1. Initial estimam o valoare pentru prag T
  2. Segmentam imaginea folosind T. Aceasta va produce doua grupuri de pixeli: G1 – cu nivelul de gri mai mare decat T si G2 – cu nivelul de gri mai mic decat T
  3. Se calculeaza media valorilor de gri a pixelilor din regiunile G1 si G2: μ_1 si μ_2
  4. Se calculeaza un nou prag T: $T = \frac{\mu_1 + \mu_2}{2}$
  5. Repeta pasii de la 2 la 4 pana cand diferenta dintre valorile lui T la iteratii succesive este mai mica decat o valoare predefinita

Optimal thresholding -Metoda Otsu

- Otsu este un algoritm global de binarizare ce foloseste clusterizarea

- Metode de evaluare a calitatii clustere-lor
  - entropy
  - purity
  - intra-cluster cohesion
  - inter-cluster separation



variance σ^2

(variabile aleatoare)

Metoda Otsu (2)

- Se cauta o valoare de prag t, astfel incat varianta in cadrul claselor să fie minima.
- $\sigma^2_w(t) = \sigma^2_w(t) + \sigma^2_b(t)$

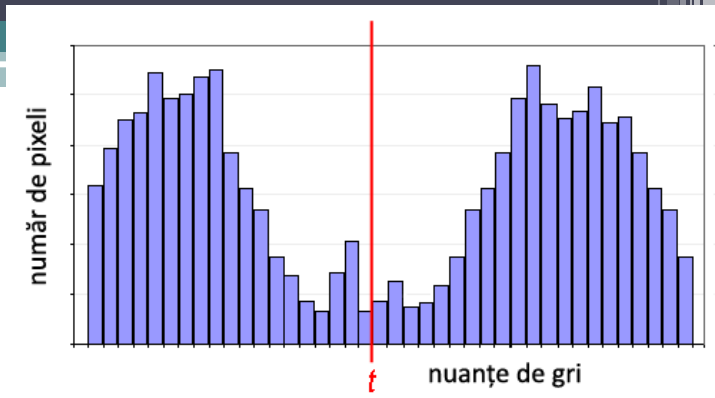
- $\omega_w(t)$ – probabilitatea ca un pixel sa fie alb
- $\omega_b(t)$ – probabilitatea ca un pixel sa fie negru
- Ponderile:

$$\omega_b(t) = \sum_{i=1}^{t} p_i, \quad \omega_w(t) = \sum_{i=t+1}^{n} p_i$$

$$P = \begin{pmatrix} 1 & 2 & 3 & \dots & n \\ p_1 & p_2 & p_3 & \dots & p_n \end{pmatrix}$$

$$\sum_{i=1}^{n} p_i = 1$$

Metoda Otsu (3)



- Media claselor:

$$\mu_w(t) = \sum_{i=1}^{t} \frac{i \cdot p_i}{\omega_a(t)} \qquad \mu_b(t) = \sum_{i=t+1}^{n} \frac{i \cdot p_i}{\omega_b(t)}$$

- Varianta totala
  - $\sigma^2(t) = \sigma^2_w(t) + \sigma^2_b(t)$
  - $\sigma^2(t) = \sigma^2$
  - (varianta totala nu depinde de t)
- a minimiza $\sigma^2_w(t)$ ≡ a maximiza $\sigma^2_b(t)$

- $\sigma^2_b(t) = \omega_w(t) \cdot \omega_b(t) \cdot [\mu_w(t) - \mu_b(t)]^2$

Metoda Otsu (4)

- Algoritmul:
  a. calculeaza histograma
  b. $\omega_a(0) = 0,\ \omega_n(0) = 0$
  c. for t = 1 .. n
     a. recalculeaza $\omega_a(t), \omega_n(t)$
     b. recalculeaza $\mu_a(t), \mu_n(t)$
     c. calculeaza $\sigma^2_b(t)$
  d. t cautat este cel care corespunde valorii maxime $\sigma^2_b(t)$

Metoda Otsu (5)

- Avantaje
  - Destul de rapid
  - Usor de implementat
  - Rezultate foarte bune daca cele doua clase au dimensiuni comparabile

- Dezavantaje
  - Sensibil la dimensiunea obiectului
    - dimensiunea obiectului din foreground este mult mai mare sau mai mică decat background-ul
    - Otsu 2D
  - Sensibil daca parti ale obiectului au nuanta apropiata de culoarea background-ului
    - pixeli clasificati incorect
    - Recursive Otsu

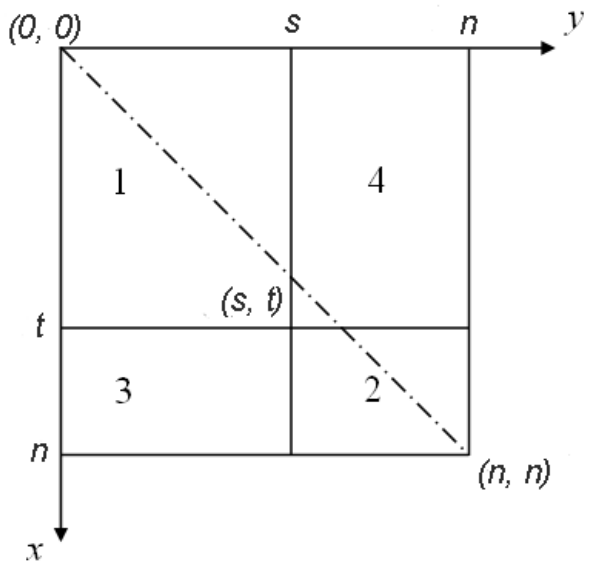
Metoda Otsu (6)

Imagine grayscale

Imagine binara

Metoda Otsu (7)

- Otsu 2D
  - pentru fiecare pixel se calculează şi o medie a nivelelor de gri ale vecinilor
  - Prag format din o pereche *(s, t)*



- Recursive Otsu
  - se aplică succesiv
  - rezultatele sunt suprapuse