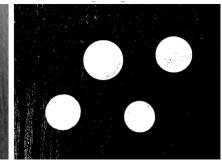
Segmentation by thresholding

Three points from the topic:





- 1. What do we mean by image segmentation in general and by thresholding in particular?
 - ✓ Finding regions in the image that share similar features. Thresholding only look at intensity level and divide in forground/background based on that alone. (How to find threshold? Have looked at P-tile method and Ridler-Calvard so far)
- How does the much used Otsus method work?
- 3. Why would we need adaptive thresholding?

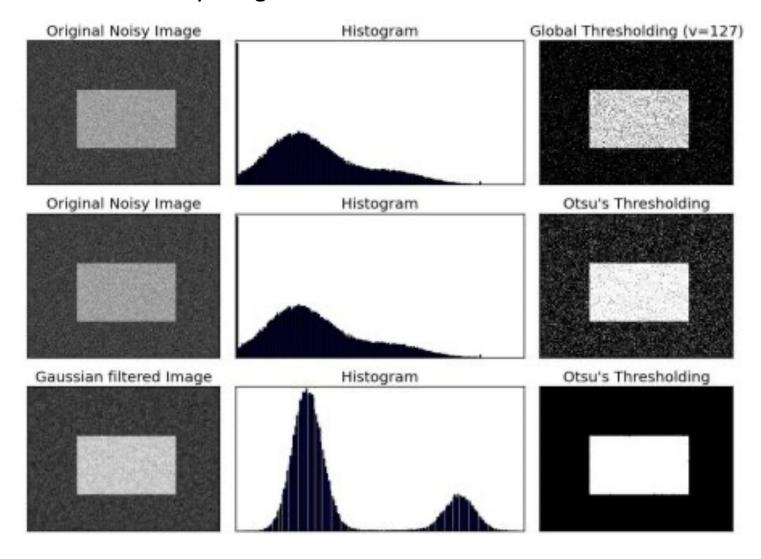
How to find the threshold(s)? Otsus method

- More used : Otsus method. Expect the background and foreground to have different μ AND different σ)
- Minimize within-class variance, $\sigma_w^2(t)$ AND maximize between-class variance, $\sigma_h^2(t)$, as function of threshold t.
- $oldsymbol{\sigma}$ Can be shown: $\sigma^2 = \sigma_w^2(t) + \sigma_b^2(t)$

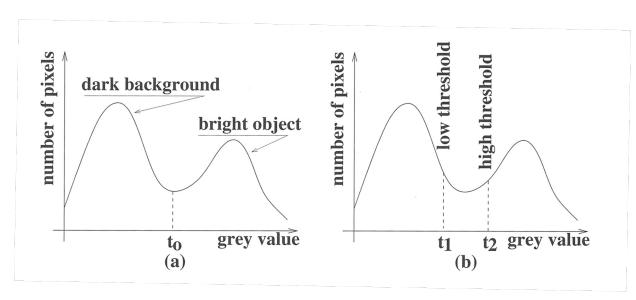
-> enough to look at one of them. We can maximize the between-class variance.

Otsus method – find threshold

Noisy images should be smoothed first



Hysteresis thresholding



For all pixel positions (x,y) in image f(x,y)

If f(x,y) < t1: background If f(x,y) > t2: object

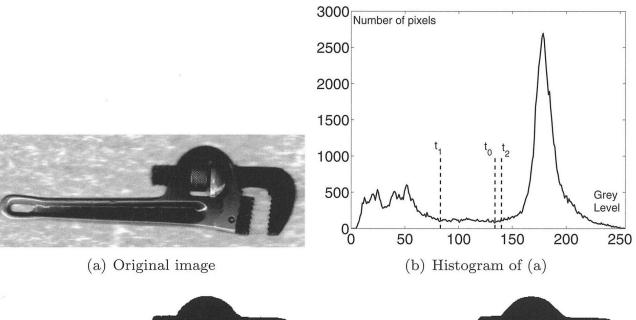
If t1 < f(x,y) < t2: look at neighbourhood (Nb).

- 1) If any of the pixels in the Nb is object-> let pixel be object
- OR count how many pixels in Nb that is object/ background -> majority decision.

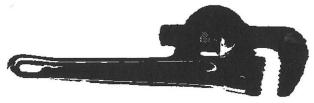
If the "valley" is not sharply defined we can use *hysteresis thresholding* or double thresholding.

- The highest threshold is used to define the central part of the object.
- The lowest threshold is used in conjunction with spatial proximity (neighboring pixels) together with a rule for labeling as an object or background.

Hysteresis Thresholding



Simple thresholding versus hysteresis thresholding.

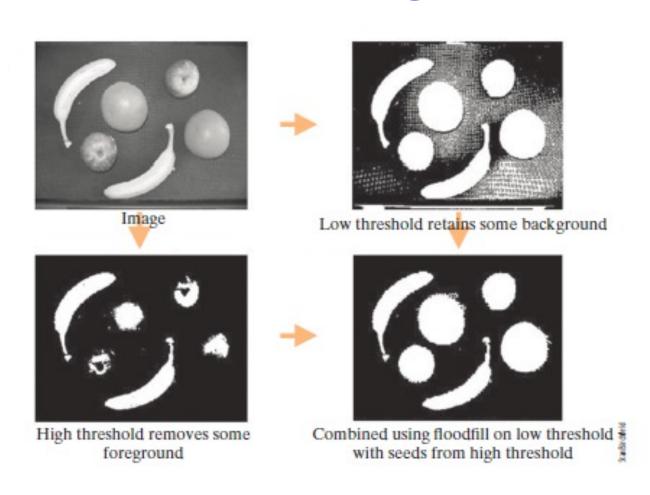


(c) Thresholded with $t_0 = 134$



(d) Thresholded with $t_1 = 83$ and $t_2 = 140$

Hysteresis Thresholding



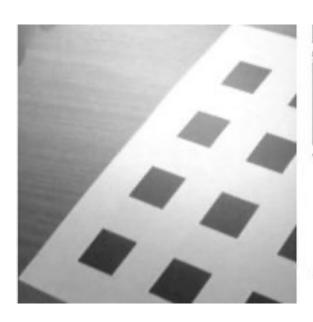
Thresholding - summary

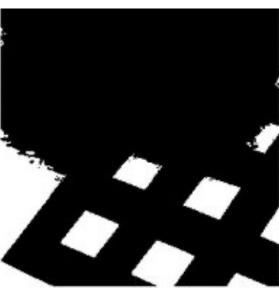
- Histogram based thresholding finding a valley
- Using knowledge about fraction of pixels in object. For example know physical size of object, physical distance, and pixel resolution (p-tile method)
- Ridler-Calvards method
- Otsu's method
- Hysteresis thresholding (T1,T2)

It is all **global** thresholding

Doesn't always work. (Uneven illumination, shadows ..)

Uneven illumination causes problems





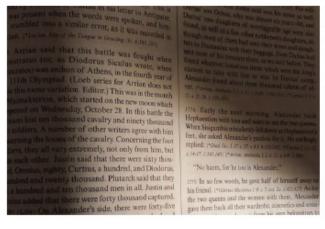


Adaptive thresholding

 Uneven illumination can be supressed firstly, thereafter global thresholding can be applied.

OR:

Adaptive / local thresholding



was present when the words were spoken, and himian life as a similar error, as it was recorded in ign. 1*Least. Siy of the Yongse is Greating (6) 6-18: Lea

Arrian said that this battle was fought when ostratus (or, as Diodorus Siculus wrote, when ocrates) was archon of Athens, in the fourth year of 111th Olympiad. (Loeb series for Arrian does not on this name variation. Editor.) This was in the month Maimakterion, which started on the new moon which pened on Wednesday, October 28. In this battle the sians fost ten thousand cavalry and ninety thousand soldiers. A number of other writers agree with him cerning the losses of the cavalry. Concerning the foot fiers, they all vary extremely, not only from him, but m each other. Justin said that there were sixty thoud. Orosius, eighty, Curtius, a hundred, and Diodorus, undred and twenty thousand. Plutarch said that they a hundred and ten thousand men in all. Justin and sius added that there were forty thousand captured. 10] [L'w] On Alexander's side, there were forty-five

Danigat son Ochia, who was always as years of a set. Deritat two Ochia, who was always as years of a set as well. Deritat two daughters of marrangerish gar were also flound, as well as a few other noblement daughters, at ten though roots of them had sent their whose and daughters to Darnascus with their bagagar. Even Darias had sent most of his treasure there, as we said before. They found whatever learnings items which were the king's custom to take with him to the Darias' camp, Alexander found about three thousand takents of silver. Person. Askens. 12 - 81 - 90.0 Mel 2001 (19 month) 10. A. 2001. 1331.279

"No harm, for he too is Alexander."

1713. In so few words, he gave half of himself away to his friend. (**Sairia Manisas.) 4 c 2 cc 2a d. 415.477. As for the two queens and the worden with them, Alexander gave them back all their wardrobe, committies and orma-

Adaptive/local thresholding by global method

- Divide image in (large) overlapping blocks, use «global thresholding method» in each block, for example Otsus method.
- Interpolate thresholding values to make smooth thresholding transitions between blocks -> t(x,y)



Otsus global thresholding



Local Otsu's thresholding, blocksize 30x30



Adaptive/local thresholding — other

- Find local mean M(x,y) for every pixel by convolution (gauss, box)
- Find local variance S(x,y)
- Can have different sized neighborhoods and filters.
- Threshold t(x,y) can be based on local means and/or local std.dev. Ex:

cv2.threshold cv2.adaptiveThreshold



Global Thresholding (v = 127)

4 7 9

5 8

9 3

7

Adaptive Mean Thresholding



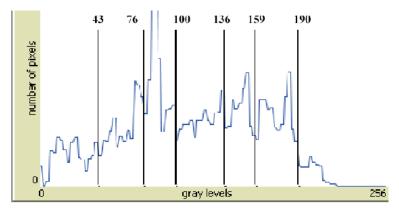
From: opencv.org

Multilevel thresholding

- Otsus method can straight forward be extended to multiple levels. One threshold gives two regions, two threshold gives three regions etc. Otsu still maximize the between class variance, testing the different thresholds.
- Other methods exist.

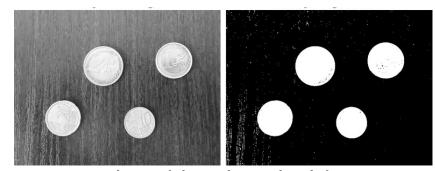






Segmentation by thresholding

Three points from the topic:



- 1. What do we mean by image segmentation in general and by thresholding in particular?
 - ✓ Finding regions in the image that share similar features. Thresholding only look at intensity level and divide in forground/background based on that alone.
- 2. How does the much used Otsus method work?
 - ✓ Find threshold that maximize between class variance
- 3. Why would we need adaptive thresholding?
 - ✓ Shadows and uneven illumination for example makes one single threshold for the entire image not very good.