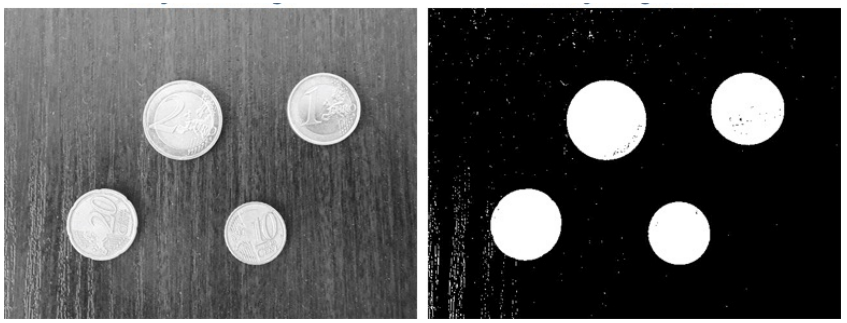
Segmentation by thresholding



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)
2. How does the much used Otsus method work?
3. Why would we need adaptive thresholding?

How to find the threshold(s)? Otsus method

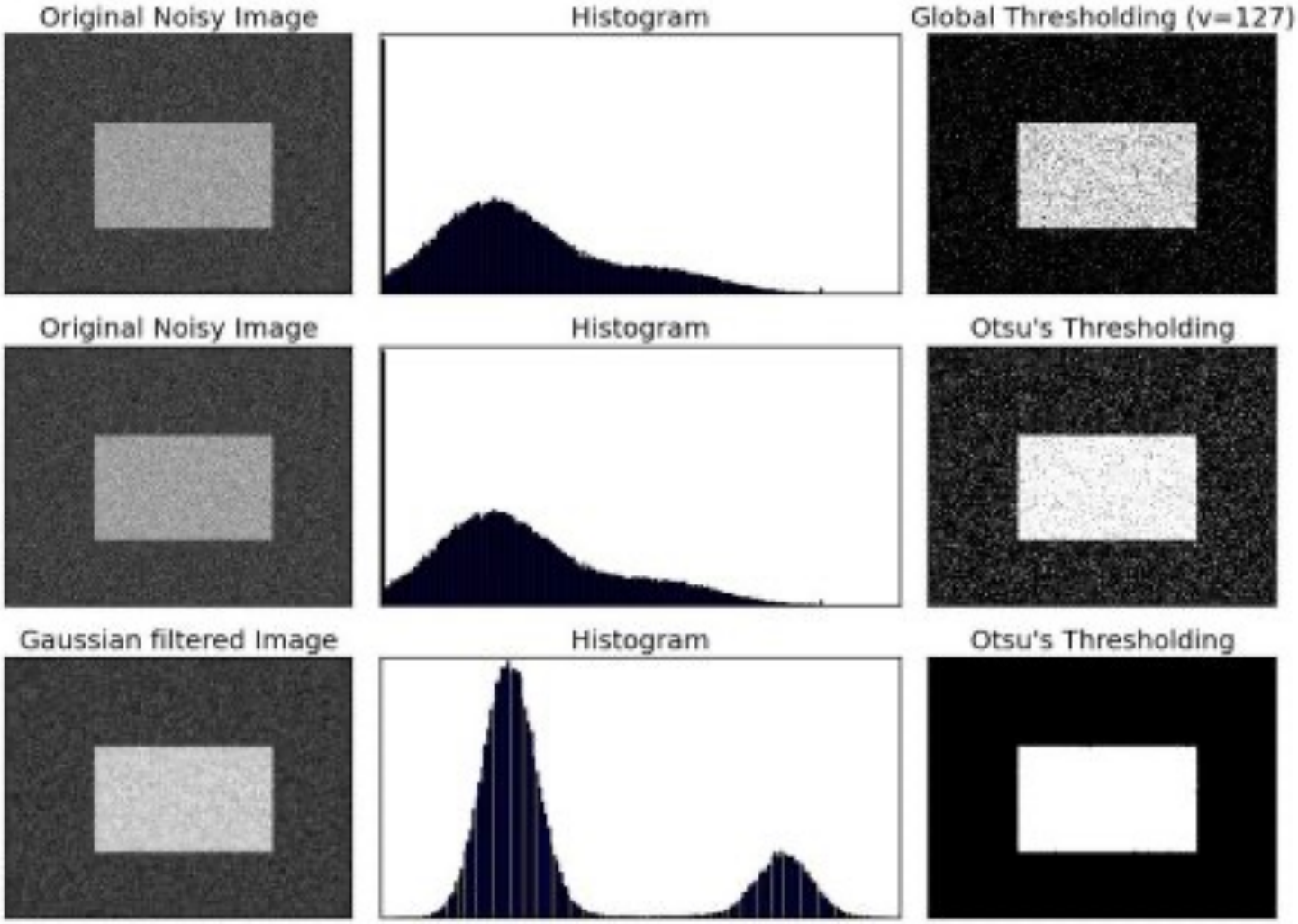
- More used : Otsus method. Expect the background and foreground to have different μ AND different σ)
- Minimize within-class variance, $\sigma_w^2(t)$ AND maximize between-class variance, $\sigma_b^2(t)$, as function of threshold t.

- Can be shown: $\boxed{\sigma^2 = \sigma_w^2(t) + \sigma_b^2(t)}$

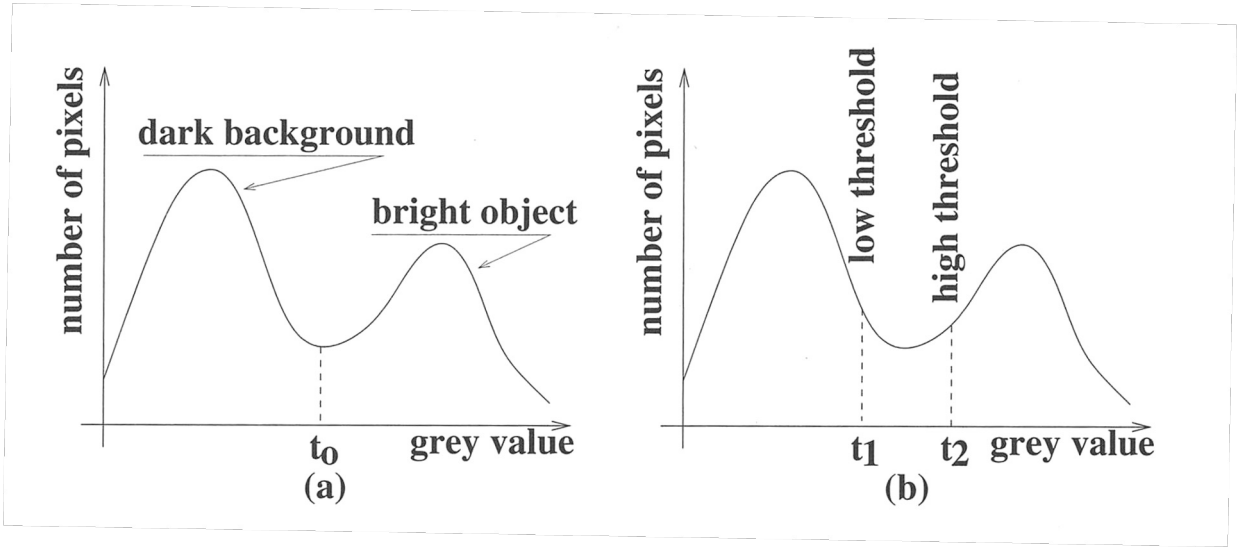
-> enough to look at one of them. We can maximize the between-class variance.

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

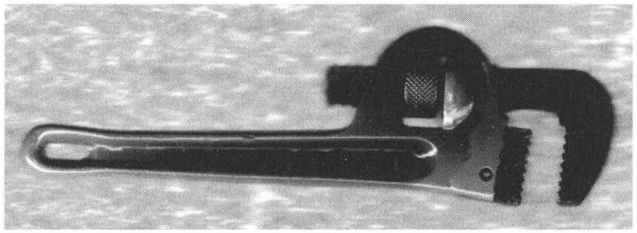
If $t1 < f(x,y) < t2$: look at neighbourhood (Nb).

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

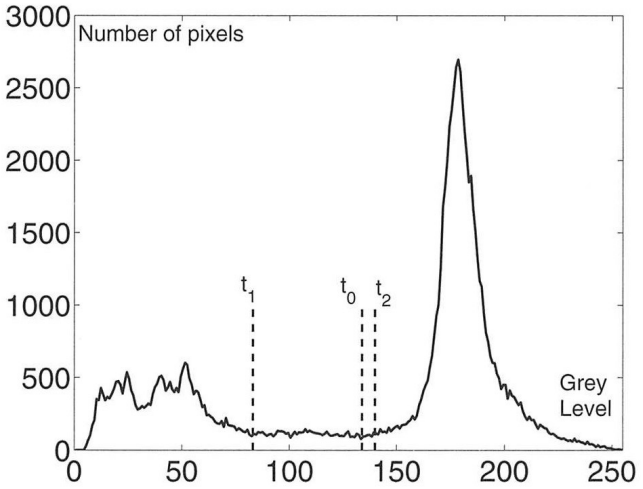
If the "valley" is not sharply defined we can use ***hysteresis thresholding*** or double thresholding.

- 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.

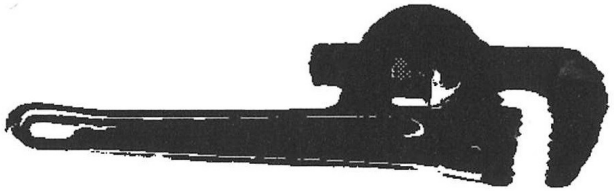
Hysteresis Thresholding



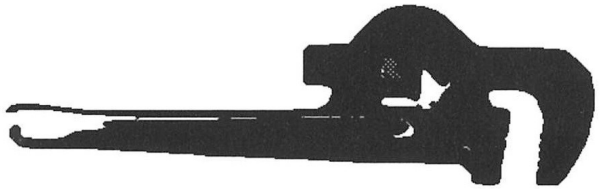
(a) Original image



(b) Histogram of (a)



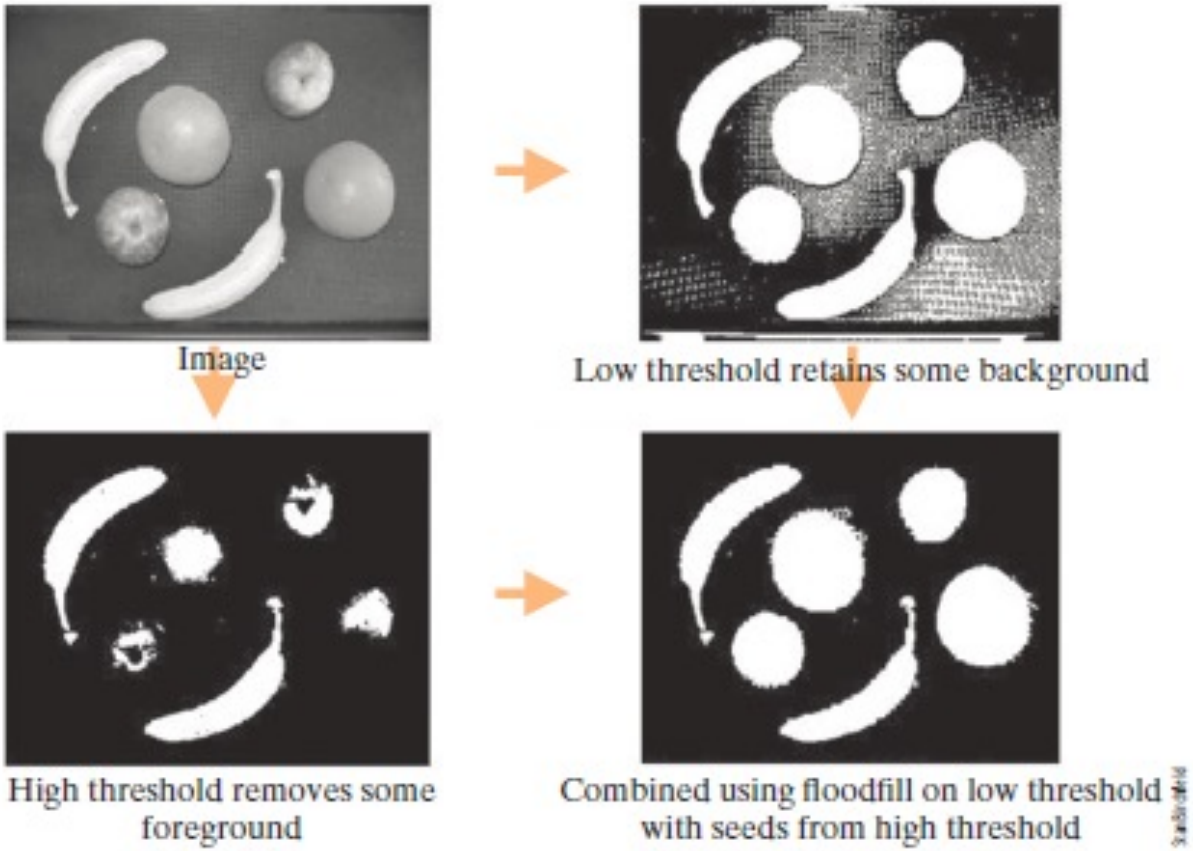
(c) Thresholded with $t_0 = 134$



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

Simple thresholding versus hysteresis thresholding.

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 ..)

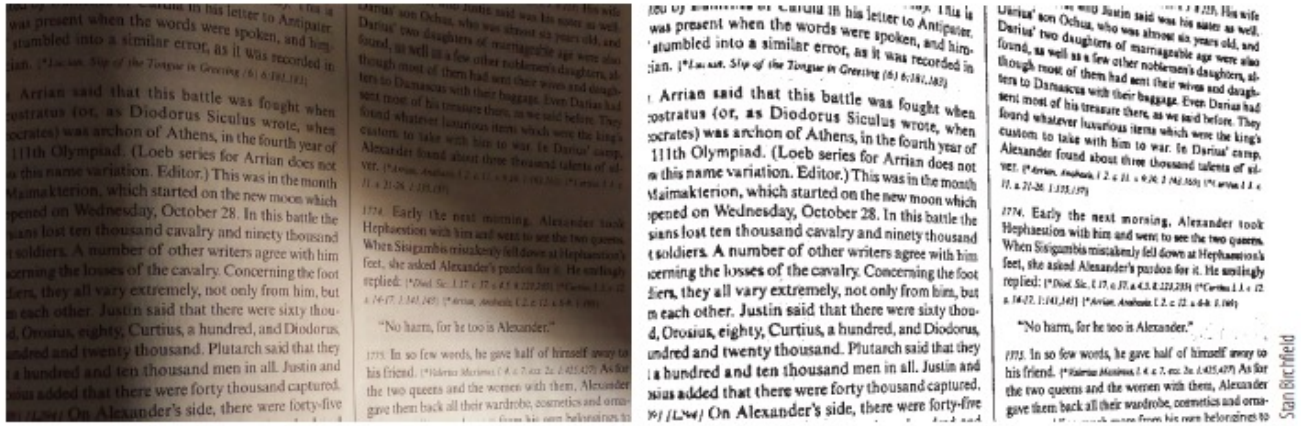
Uneven illumination causes problems

Adaptive thresholding

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

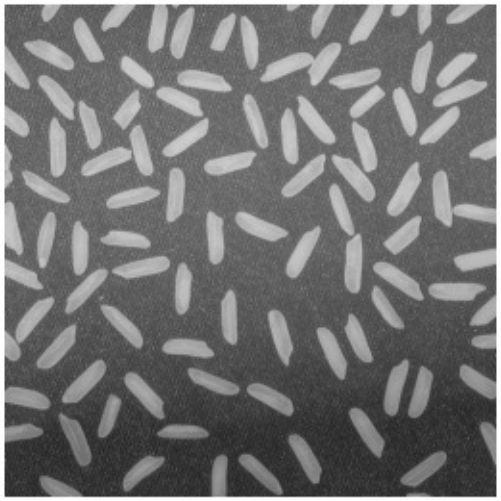
  OR:

- Adaptive / local thresholding



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)



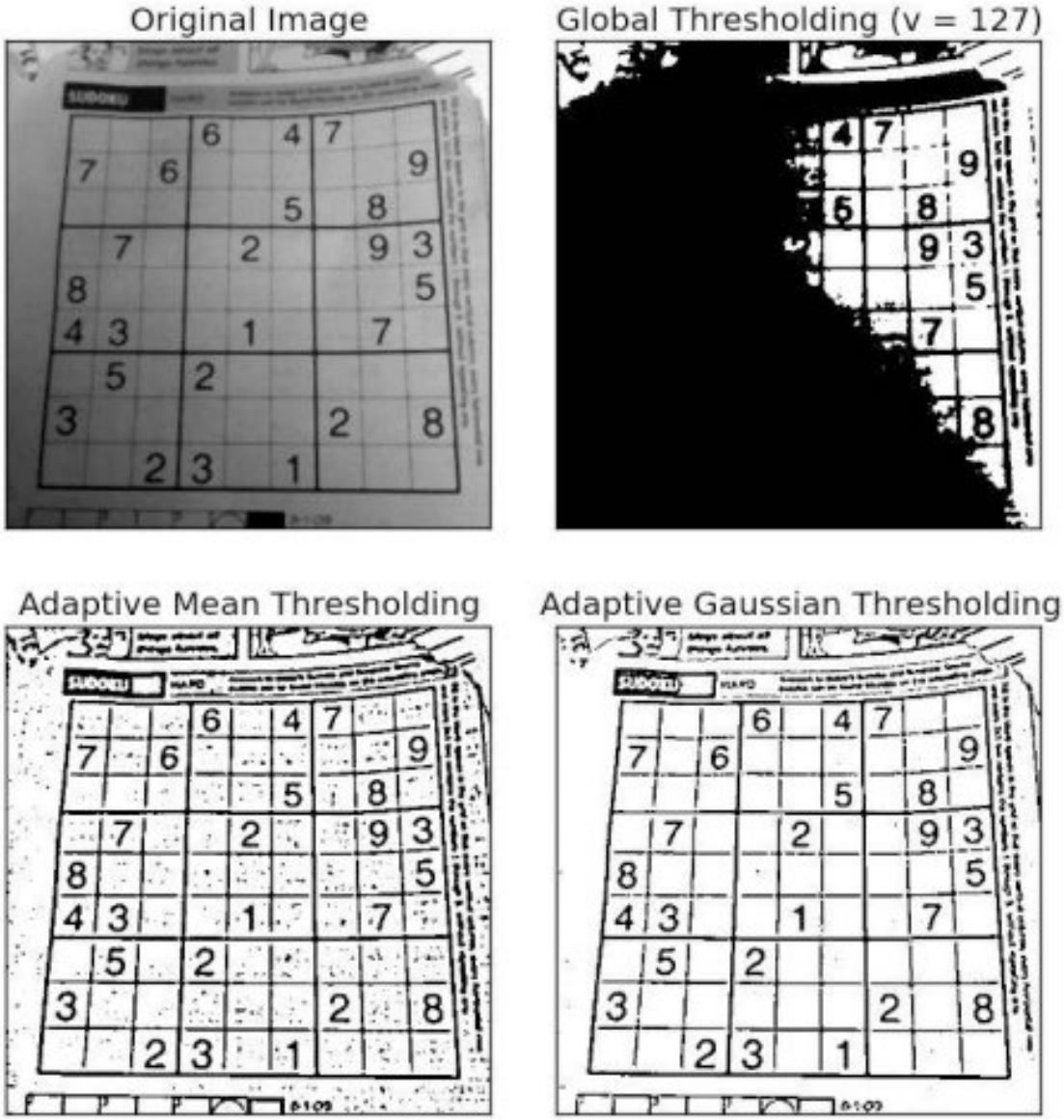
Otsus global thresholding

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:

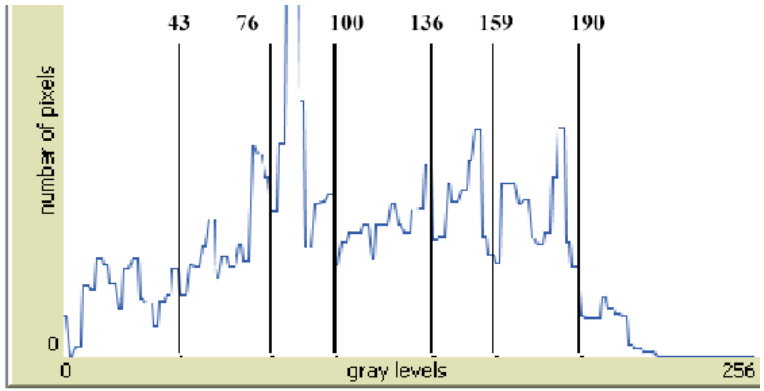
cv2.threshold
cv2.adaptiveThreshold



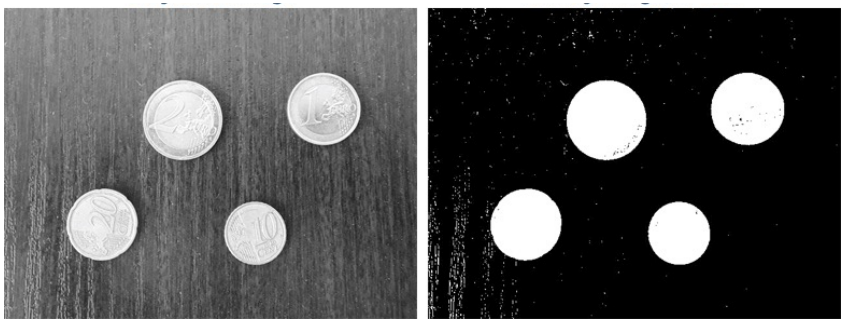
From: opencv.org

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.