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Laboratory – Otsu's Algorithm

1 Introduction

Thresholding is a task that must be conducted frequently. The threshold level must be adjusted meaningfully. Meaningfullnes depends on the particular image. Hence, an algorithm that suggests a good threshold is an asset. Otsu's Algorithm does exactly this. The Goal ist that you implement Otsu's Algorithm and reproduce the thresholding results shown in the lecture (Slide 15) for the image `polymersome_cells_10_36.png`.

2 Tasks

2.1 Basic thresholding

Start from scratch, or if you prefer, use the file `otsu_skeleton.py` and implement the basic thresholding algorithm in a method `basic_thresholding()`, where you

a) estimate T , e.g. middle point between maxima or average gray level

b) segment image using T into G1 ($\leq$ T) und G2 ($>$ T)

c) compute average intensity value m_1 and m_2 for pixels in G1 resp. G2

d) evaluate $T_{n+1} = \frac{1}{2}(m_1 + m_2)$

e) repeat steps b)-d) until $|T_{n+1} - T_n| < \epsilon$

Experiment with the initial estimate for T: converge from left, from right, compare the outcome.

2.2 Implement Otsu's Algorithm

Implement the method `my_otsu()` according to the equation:

$$\sigma_B^2 = \frac{[P_1 \cdot m_G - m]^2}{P_1 \cdot (1 - P_1)}$$

and

$$\hat{k} = \arg\max_k \left\{\sigma_B^2(k)\right\}$$

with

$$m(k) := \sum_{i=0}^{k-1} i \cdot p(i),$$

$$m_G := \sum_{i=0}^{L-1} i \cdot p(i)$$

and

$$P_1(k) := \sum_{i=0}^{k-1} p(i).$$

2.3 Apply Otsu's Algorithm

Reproduce the results shown in the lecture (Slide 15) for the image `thGonz.tif`. Generate the binarized image, the histogram and visualize the Within-Class-Variance $\sigma_B^2(k)$ for each k.

3 Optional Tasks

3.1 Separability Measure Implementation

Extend the method `my_otsu()` so that it returns the separability measure $\eta(\hat{k})$. Use the definitions

$$\eta(k) := \frac{\sigma_B^2(k)}{\sigma_G^2}$$

and

$$\sigma_G^2 := \sum_{i=0}^{L-1} p(i) \cdot (i - m_G)^2$$

3.2 Compare Separability Measure

Evaluate the separatability measure for the `thGonz.tif` and a the almost binary image `binary_test_image.pn`

For which one of the two images is it simpler to find an appropriate threshold level: (a) according to your intuition and (b) according to the separability measure η?