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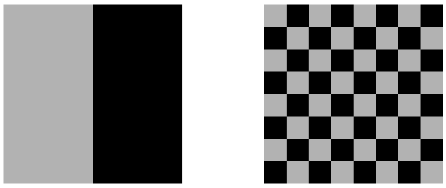
Exercise: Segmentation

Exercise 1. Histogramm and Filtering

Given are the two following very different images, both images have the same gray scale histogram:



Both images are now filtered with a 3×3 average mask. For border handling the image is replicated. Consider if the two histograms are still the same after the filtering.

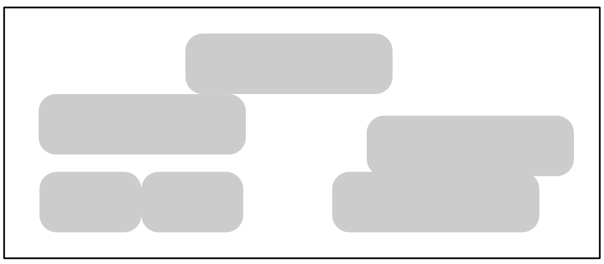
Exercise 2. Hystersis-Thresholding

Given is the image on the right. Apply hysteresis thresholding with $T_L \geq 4$ and $T_H \geq 7$ and use a neighborhood of 8. Iterate as long until no more pixels can be added.

9	5	1	0	2
5	1	1	2	1
9	5	6	8	7
2	2	7	1	0
3	1	7	1	1
3	9	3	5	0

Exercise 3. Thresholding and Watersheds

The image below shows six objects that are only recognized as three objects when thresholding is applied. For a better segmentation the Watershed method shall be applied. The locations for the water inlets in the basins are to be be obtained with the help of the distance transformation.



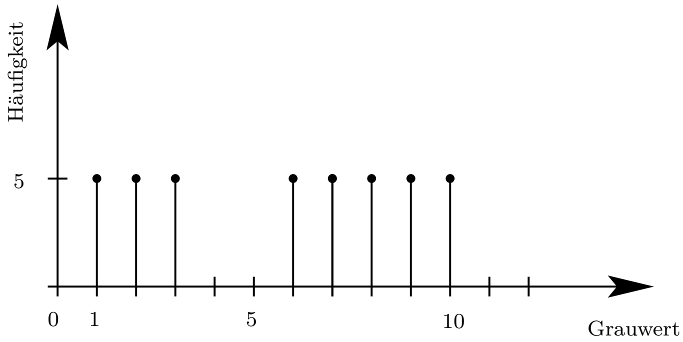
a) Draw the approximative inlet locations resulting from the distance transformation by hand.

b) Draw the segment boundaries resulting from watersheding.

c) How could you describe the boundaries of the watershed algorithm?

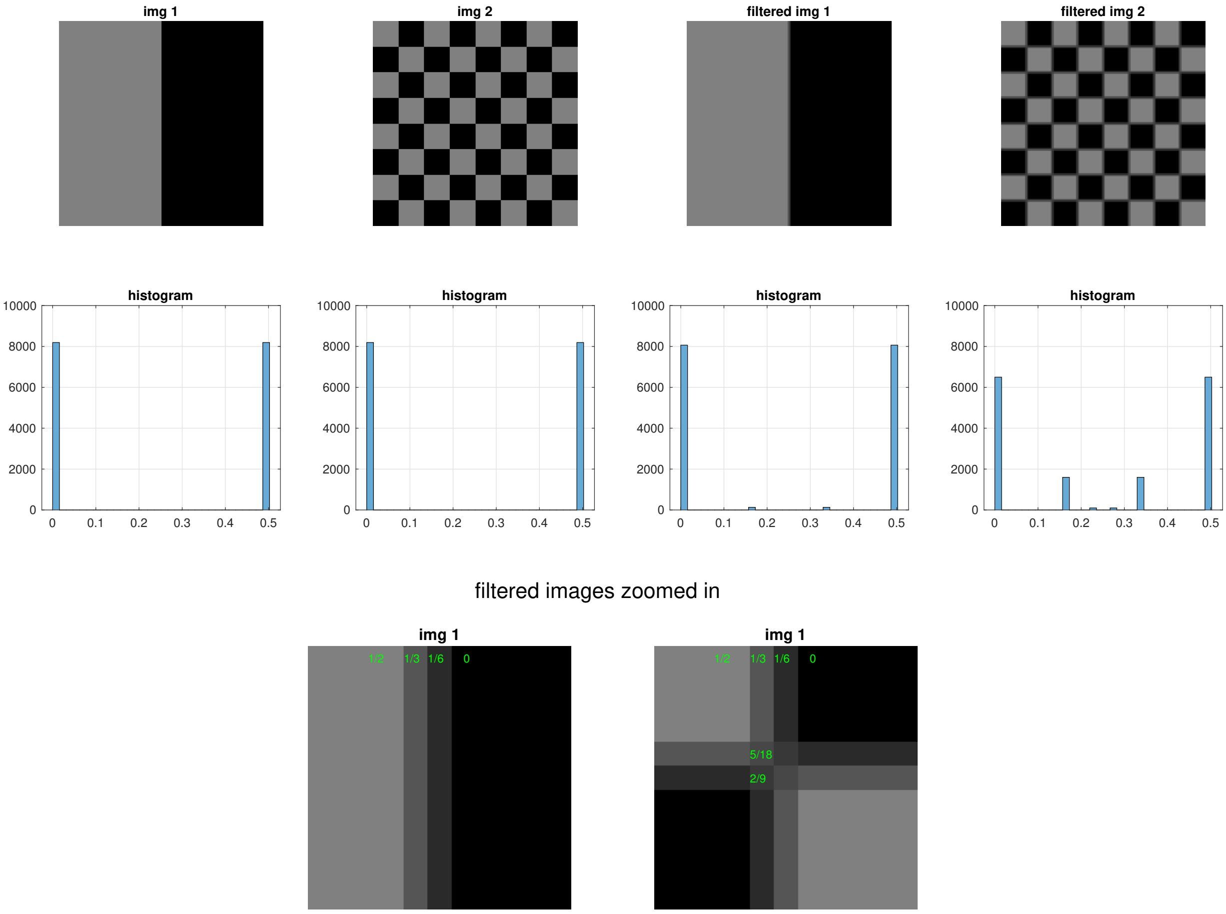
Exercise 4. K-Means Clustering

Given is the highly simplified histogram of a gray scale image:

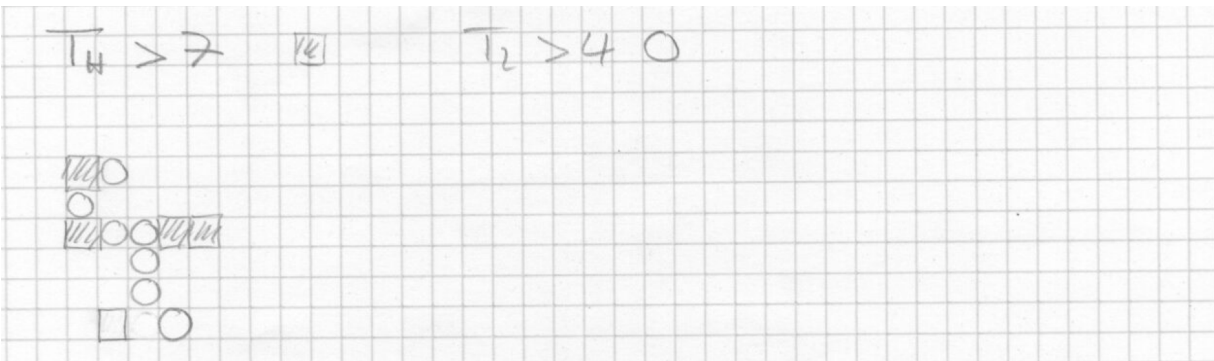


The gray values $m_{i,1}$ and $m_{i,2}$ are the two cluster centers from the K-Means algorithm for two clusters or $K = 2$ after its i-th iteration. Based on the initial values $m_{0,0} = 6$ and and $m_{0,1} = 7$, determine the cluster centers for $i = 1$ and $i = 2$.

Solution 1. The filtering causes that new gray values are crated. Two new values $\left(\frac{1}{3} \text{ and } \frac{1}{6}\right)$ lie between black and the current gray value. The longer the borders are on the image, between gray and black, the more pixels will hold one of the two new gray values created by the filtering. This border length is different on both images, precisely it is longer on the chessboard image. Thus, the histrogramms of the filtered images will change. Furthermore, two more values $\left(\frac{2}{9}\text{and}\frac{5}{18}\right)$ are created at the corner points of the chess board, creating new non-empty bins in the histogram.

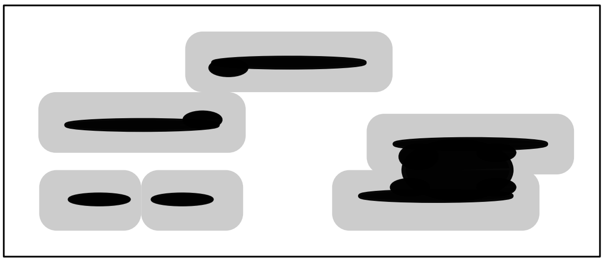


Solution 2.

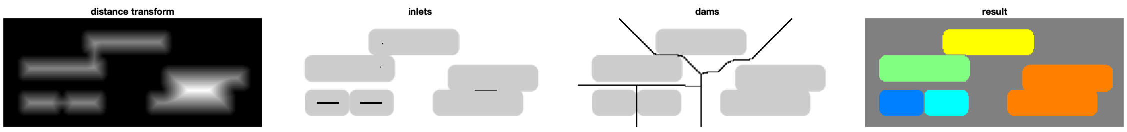


Solution 3.

a) The following figure shows the inlet locations in black. All black points have the same distance to the edge.



The following figure shows the computed output:



b) The two small objects are perfectly separated. The two objects on the top left are separated almost perfectly. The two objects on the bottom right cannot be separated.

c) the areas where the individual objects touch must not be too large.

Solution 4.

i = 1: The cluster $C_{0,0}$ contains those gray values that are closer to $m_{0,0}$ than to $m_{0,1}$: $C_{0,0} = \{1, 2, 3, 6\}$. The cluster $C_{0,1}$ contains those gray values that are closer to $m_{0,1}$: $C_{0,1} = \{7, 8, 9, 10\}$. From this, the new cluster mean values follow:

$$m_{1,0} = \frac{(6+3+2+1)}{4} = 3$$

$$m_{1,1} = \frac{(7+8+9+10)}{4} = 8.5$$

i = 2: The clusters are formed according to the cluster means of the last iteration. The new cluster mean values are:

$$m_{2,0} = \frac{(1+2+3)}{3} = 2$$

$$m_{2,1} = \frac{(6+7+8+9+10)}{4} = 8$$