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Problem Sheet 2

Problem 1 (First week)
To get familiar with basic morphological operations, we consider morphological contrast enhancement. (scikit image, open cv or similar may be used when appropriate.)
In order to enhance contrast, frequently the (linear) Laplace filter L is used in the following way:

$$S = I - c\ L_{\text{lin}}(I),$$

i.e., the contrast enhanced output is obtained by subtracting the discrete Laplacian of the image $L_{\text{lin}}(I) = I * L_{\text{lin}}$ times a positive parameter c from the image I.
In analogy, we here consider the morphological Laplacian L within

$$S = I - c\ L(I).$$

Another morphological operator for this task is based on the tophat transform: the white tophat is added to the image, whereas the black tophat is subtracted from the image. In formulae, the operator reads:

$$I - c\ WTH(I) + c\ BTH(I) = (1 + 2c)\ I - c(O_A(I) + C_A(I)).$$

a) Implement the three means for contrast enhancement discussed above.

b) Find suitable parameters c by considering different test images. Compare the results by visual inspection. (There could be two images coming with the sheet which you might consider as useful.)

c) *Optional:* Sometimes it can be useful to smooth the image beforehand. Please explain why. Incorporate smoothing in your setup and show its results. (A possibility for morphological smoothing in considered in Problem 2 on this sheet.)

Problem 2
Morphological smoothing by reconstruction for grayscale images (scikit image, open cv or similar may be used when appropriate.)
We start to consider reconstruction by dilation as a basic operation.

a) Implement a (naive variant of) reconstruction by dilation (potentially following the defintion given in the lecture notes.

b) Familiarize yourself with the implementation used in scikit image. (As a service, the papers are attached).

c) Compare runtimes. (Either take a set of existing images and compare, or generate a set of artificial test images of – potentially increasing size to study the influence of the image size)

Now we use reconstruction by dilation as a basic operation to define morphological smoothing by reconstruction.

d) Realize functions performing opening by reconstruction and closing by reconstruction. Use them to implement smoothing by reconstruction as concatenation of opening by reconstruction and closing by reconstruction, and vice versa.

e) Compare the results of opening by reconstruction and closing by reconstruction with opening and closing: Investigate the different results of visually comparing suitable images. Compare the runtimes. Comment on both aspects.

f) Compare the results of the smoothing by reconstruction algorithms with basic morphological smoothing: Investigate the different results of visually comparing suitable images. Compare the runtimes. Comment on both aspects.

Problem 3

Watershed transform (scikit image, open cv or similar may be used when appropriate.)

a) As a test image, generate a binary image with three overlapping circles. Apply the watershed transform to the negative distance map to segment the three circles.

b) Apply the strategy of using the inverse distance map as segmentation map to segment the images "pills" and "cells" attached. (Use a suitable thresholding to obtain a binary image.) Investigate the effect of smoothing the distance map. Maybe filling holes can be useful. (E.g., for filling holes, consider the situation where the foreground is bright. Then reconstruction by erosion starting from a marker initialized with the image gray values at the image boundary and the maximal gray value (or 255) else produces an image with filled inner holes. If you apply this procedure to a binary image you get the connected component touching the boundary which could also be realized by other procedures.)

Next we use the gradient map as a segmentation map. We consider the image "pears."

c) Apply the watershed transform to the smoothed gradient map (Gaussian smoothing) and observe the resulting oversegmentation.

d) Now we are going to apply the watershed transform with markers to the smoothed gradient map. We distinguish foreground and background markers (note that the algorithm does not distinguish them.) (i) To get foreground markers, use morphological smoothing of the image with a structuring element of larger radius (compare last sheet) and then compute the regional maxima. Use these regional maxima as markers. Instead of computing the regional maxima, also try thresholding after smoothing as an alternative and use the result as foreground markers. Now, smooth the shape of the candidates and erode them to get markers. (ii) To get background markers, compute the SKIZ of the foreground markers. (Hint: What is the relation between the SKIZ and the Watershed transform applied to the corresponding binary image?). (iii) Apply the Watershed transform with the foreground markers obtained using regional maxima/thresholding with/without background markers (four cases) and compare the results.

e) Apply the described procedure to the image "hist" and try to get good segmentation results. (Vary the smoothing parameters and do not forget to observe that the objects are dark when looking for regional maxima.)