02, Assignment Rectangles and Sampling

Assignment 2, 25 points in total; 16.6% of the total score of the practical part.

This assignment consists of four (4) parts. You follow the steps as presented in the assignment and compile the results in a report. The report therefore consists of part 1 – 4, and in the report for each part answers to the questions should be presented. These are tables, graphs and explanations. You can also add images that result from processing. Make sure you present the images in a concise manner so that they do demonstrate the effect that you observed after processing. Strictly adhere to the order of this assignment.

In this assignment we work on the assessment of a measurement under various conditions of noise and how filters influence the noise.

All images for this assignment are in "tiff" format. There are 3 sets of images. The standard images, i.e. series A: *rect1a, rect2a*, *rect3a* and *rect4a,* each contain a set of rectangles of certain size. These are very limited in their intensity distribution and this limitation can be investigated by checking the histogram.

The original standard images series A {*rect1a, rect2a*, *rect3a* and *rect4a*} have been processed with noise to series B {*rect1b, rect2b*, *rect3b rect4b*} and C {*rect1c, rect2c*, *rect3c, rect4c*}. The noise level series B and C differs.

Part 2.1

Segmentation by thresholding will be a very straightforward operation in order to get binary objects that we can measure. A value can be obtained by the histogram as well as through threshold values that are derived from the image data, i.e., isodata-threshold.

It is possible that the sampling process has introduced an error in the shape of these objects. This can be observed by the fact that the identical original objects do not at all seem the same when digitized. The differences in the objects can be expressed through measurements.

1. (1) Compute the histogram of each of the images of series A, and plot them as 4 different graphs.
2. (2) Measure the size (area) of each of the objects, and calculate the average and the average and the standard deviation of the sizes of the objects in each image.
3. (2) Measure the length of the perimeter of each of the objects and calculate the average and standard deviation of the perimeter length of the objects in each image.

Part 2.2

The relative error diminishes with increasing size. This effect on the relative error can be shown by plotting the **square root of the mean** of the size of the objects against the coefficient of variation: $cv = \frac{\sigma}{\mu}$,

i.e., standard deviation over the mean. The resulting graph shows the relative discretization error.

4. (2) Assemble the results of your measurements of q2 (area), for all objects, in a table including average and standard deviation per object.
   Use pyplot to produce a graph for the relative discretization error for area.
5. (2) Assemble the results of your measurements of q3 (perimeter), for all objects, in a table including average and standard deviation per object.
   Use pyplot to produce a graph for the relative discretization error for perimeter.
6. (1) Explain the differences in the outcome of the area plot and the perimeter plot.

Part 2.3

Noise complicates measurements in images and in order to investigate that we use series B and C. The noise level in the images of series B {*rect1b, rect2b*, *rect3b rect4b*} is similar and the same holds for the images in series C {*rect1c, rect2c*, *rect3c, rect4c*}.

7. (1) Compute and plot the histograms for series B and C; in like manner to question 1.
8. (2) Find a suitable manner to suppress the noise so that the measurement can be done accurately. Choose two methods (filters) and two (2) different parameters, i.e., kernel sizes, for these filters. Apply these systematically to series **B** and **C**. Indicate the filter parameters with your results.
9. (3) Repeat the measurements of 2) and 3) of part 2.1 and put them in a table. Produce the plots for the different sets of filters and parameters in similar fashion to 4) and 5) of part 2.2.
10. (2) Explain the influence of the noise on the measurement, given that the original series contains no noise and the deviation is only due to discretization.
11. (2) Explain the plots in the light of the sampling theorem.

Part 2.4

As the images are corrupted with noise, we want to relate the effect that we observe expressed in terms of noise. To that end we compute the signal to noise ratio. This is expressed as:

$$SNR = \frac{\mu}{\sigma},$$

in other words, the average divided by the standard deviation.

12. (2) For the three series available, compute the SNR of all images, i.e. series A, B and C; and put the results in a table. In addition, compute the results of the SNR after application of the noise suppression filter to these series. From the results motivate the filter and parameters that performed best.
13. (3) Relate the SNR per image to the measurement in that image. As we consider the image as a whole, the sum of the measurements per image should be taken. Produce a plot SNR against the log (measurement). Explain the observations from the plots.

All the results should be elaborated in the report – including tables, graphs and images, with the code as separate appendix to the report. For graphs you can use pyplot. Please be aware that the images and graphs in the report have sufficient contrast. The report must be submitted as a pdf file.