T-61.5100 Digital image processing, autumn 2014
Soft deadline: **Oct 16, 2014**
Hard deadline: **Jan 12, 2015**

Course assignment 1

This course assignment is a mandatory part of the course T-61.5100 Digital image processing. This assignment can, in principle, be done with any programming language that can open and manipulate images. However, the traditional choice is to use Matlab in the Aalto IT Services computer classrooms, since one can then access the Image Processing Toolbox (IPT), which makes image processing operations easier. If you wish to do the assignment on your own computer, it is also possible to use Octave, a free software alternative to Matlab. This requires that you are knowledgeable in installing and configuring software on your own computer. Some instructions on Octave usage can be found on the course web page. All examples and problems in this course should work in both Matlab and Octave.

For tips how to use Matlab or Octave for image processing see examples from previous computer assignments on the course web page.

The problem

This assignment considers noise reduction using spatial filtering. On the left side in Figure 1 is a noisy image (`city_noise.png`) and on the right side the original image without noise (`city_orig.png`). The images can be found from the course assignment page ("Assignments" page in Noppa). The noisy image contains impulsive noise (top part) and additive white gaussian noise (right side). This means that the top right corner has both types of noise, the top left corner only impulsive ("salt & pepper") noise and bottom right corner only gaussian noise.

Calculate the mean-square error *separately for each* of the three noisy parts of the image. The general formula is:

$$E = \frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} \left(I_o(x,y) - I_f(x,y) \right)^2 , \tag{1}$$

where I_o is the original image and I_f is the noisy image. In this case however you need to sum over the approriate parts of the image, i.e. top-left corner, top-right corner and bottom-right corner, separately – not the entire image.

city_noise.png

city_orig.png

Figure 1: The noisy image on the left and the original on the right.

Tip: In Matlab or Octave you can easily get the different parts of the image by using matrix indexing. A simple trick makes this really easy:

```
% height and width of image
[H,W] = size(I);

% W2 is half of the width, H2 is half height
W2=ceil(W/2); H2=ceil(H/2);

% set nice names for the index ranges
left=1:W2; right=W2+1:W;
top=1:H2;  bottom=H2+1:H;
```

Now you can get for example the top right corner of image `I` as `I(top,right)`, because `top` are the indices for the top half of rows and `right` are the indices for the rightmost half of columns.

Now the task is to try to reduce the noise in the image. Try a median filter and an arithmetic mean filter. In addition to these filters, try at least one other filter from Chapter 5.3 in the textbook. Then, calculate the mean-square error (separately on each part of the image) after each filtering method and use this to compare the methods. How well do the different methods work for different types of noise? Compare and discuss the results both numerically and visually.

Finally, show "the best possible" filtered image, where each image part has been filtered with the filter that produces the minimum mean-square error for that part. Show also the respective error image (i.e. the difference image between the original and the corrected image). Remember to scale the error image properly so that it is visually clear!

How to report

A written report must be returned, containing all your Matlab or Octave code, all the resulting images, and a clear explanation of exactly what was done and what were the results. Collaboration between students is good, but *each student must write his or her individual course assignment report*, making it clear that the student has understood the assignment and its solution.

The course assignment is graded as passed or failed, and a short description of what needs to be improved will be given for those graded as failed. A corrected version of a failed report must then be returned within one week after receiving the assistants comments. If you return your report by the soft deadline (**Oct 16, 2014**) and pass on the first try (i.e. without corrections needed) you will get an additional point in the exam. In any case you must complete all three assignments by the hard deadline of **Jan 12, 2015** in order to pass the course.

The written report should be returned electronically as an e-mail attachment PDF file to the assistant (ville.viitaniemi@aalto.fi) The file should be named after your student number, e.g. `dip_assignment1_12345X.pdf`. If you have not received a reply within two working days it might be a good idea to inquire from the assistant, since the e-mail might have gotten stuck in the "spam" mail filter, or otherwise lost among the myriad of mails the assistant receives every day. *Please state your name and student number clearly in the e-mail and the report itself.*