TNM087 – Image Processing and Analysis
Lab 2 –Spatial Filtering

TASK 1 Preparation

Lowpass filtering and derivative operators

The preparation task consists of a few simple problems that should be solved using Matlab. Your answers (in Swedish or English) should be written in the document *Lab_2.1_Preparation_Answers.docx*, where you also insert the required images. To save the images you can use the MATLAB functions `imwrite` or `imsave`. Make sure to save the images in an uncompressed format, such as **.tif** or **.png**.
Don't scale the images when inserting them in the word document. Before submitting the answer document on Lisam, first save the document as **.pdf**!

For the preparation tasks you do not need to submit your m-file. However, it is strongly recommended that you save your experiments in an m-file, in case you need to go back and correct anything later. Sometimes, you can also re-use your code in later tasks.

In this task, you are supposed to do a number of spatial filtering tests on a given grayscale test image named *TestPattern.tif*. Start reading this image into MATLAB and scale it on $[0, 1]$. (Use for example $imread$ followed by $im2double$ in MATLAB).

There are a number of MATLAB functions that can be used to filter an image, for example, $filter2$, $conv2$, and $imfilter$. **See the lecture notes for Chapter 3** to learn the differences between these functions and how they work.

1) Testing different box filters:

Problem 1) Filter the test image (*TestPattern.tif*) with a box kernel of size 9×9. We call the resulting image $Image1$. Insert your result in the answer document. (**HINT:** In the lecture notes you find how to create a box kernel)

Problem 2) Filter the test image with a box kernel of size 21×21. We call the resulting image $Image2$. Insert your result in the answer document.

Problem 3) Obviously, $Image2$ is much more blurred than $Image1$. Does this mean that the 21×21 box filter has a lower or higher cutoff frequency than the 9×9 box filter kernel? Explain why!

As can be seen in $Image2$, the filtering has introduced visible dark borders in the filtered result.

Problem 4) What is the reason for these dark borders? (**HINT:** discussed in the lecture)

Problem 5) Filter the test image again with a box kernel of size 21×21. Use an appropriate MATLAB function and padding to avoid the dark borders. We call the resulting image $Image3$. Insert your result in the answer document. (**HINT:** MATLAB function $imfilter$, described in the lecture notes for Chapter 3 (page 43), is an appropriate function to be used)

Problem 6) Now, make a highpass filter of the 21×21 box filter (which obviously is a lowpass filter). Filter now the test image with your highpass filter kernel. Use an appropriate MATLAB function and filtering to avoid the dark borders. We call the resulting image $Image4$. Insert your result in the answer document.

Problem 7) Why is $Image4$ so dark? What should the average value of the pixel values in $Image4$ be? And why? (**HINT:** discussed in the lecture and also in one of the class ("lektion") assignments)

Problem 8) Add $Image4$ to the original test image, and call the result $Image5$. This operation is called unsharp masking. Insert your result in the answer document.

2) Testing Sobel filters and gradient:

The following two Sobel filter kernels are commonly used to perform the first derivative in the x and y direction, respectively. If you use these kernels as they are, then you should use **correlation** to perform filtering. You can therefore use the MATLAB function $filter2$ (the function $imfilter$ can also be used).

$$Sob_x = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \qquad Sob_y = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

Problem 9) Filter the test image, i.e. *TestPattern.tif*, with Sob_x. We call the resulting image $Image6$. Insert your result in the answer document.

Problem 10) Filter the test image with Sob_y. We call the resulting image $Image7$. Insert your result in the answer document.

The length of the gradient vector is: $M(x,y) = \|\nabla f\| = \sqrt{g_x^2 + g_y^2}$, which is an image of the same size as the original image. $M(x,y)$ is commonly called the gradient image. Remember that, the operation to find the square (and square root) of these matrices has to be performed **elementwise**.

Problem 11) Find the gradient of the test image by using your results in Problem 9 and 10. Call the resulting image $Image8$. Insert your result in the answer document.