# 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)** Apply a $9 \times 9$ box filter to the test image (*TestPattern.tif*) using either the Matlab function $filter2$ or $conv2$. The resulting filtered image will be referred to as $Image1$. Insert the resulting image into the answer document. **HINT:** Refer to the lecture notes for Chapter 3 (page 31) for instructions on how to create a box filter kernel.

**Problem 2)** Filter the test image with a box kernel of size $21 \times 21$. The resulting filtered image will be referred to as $Image2$. Insert the resulting image into the answer document.

**Problem 3)** Apply a Gaussian filter with a kernel size of $29 \times 29$ and a standard deviation of $4.8$ to the test image. The resulting filtered image will be referred to as $Image3$. Insert the resulting image into the answer document. **HINT:** Refer to the lecture notes for Chapter 3 (page 33) for instructions on how to create a Gaussian filter kernel.

**Problem 4)** Which of the three filter kernels in problems 1, 2, and 3 represents the lowest and highest cut-off frequencies? Explain why. **HINT:** Use the amount of blurring observed in each result as an indicator of the cut-off frequencies.

As observed in the filtered images, the application of filtering has introduced visible dark borders in the results due to the use of zero-padding.

**Problem 5)** Provide a detailed explanation of why zero-padding leads to dark borders and how the width of these borders is connected to the size of the filter kernel.

**Problem 6)** Re-filter the test image using a box kernel of size $21 \times 21$. Utilize an appropriate MATLAB function and padding method to prevent the occurrence of dark borders. The resulting filtered image will be referred to as $Image4$. Insert the resulting image into the answer document. **HINT:** The appropriate MATLAB function and padding methods can be found in the lecture notes for Chapter 3 (pages 38-43).

**Problem 7)** Next, construct a high-pass filter kernel using the $21 \times 21$ box filter, which is inherently a low-pass filter. For detailed guidance, refer to the lecture notes in Chapter 3, pages 64-66. Apply your high-pass filter kernel to the test image. Use an appropriate MATLAB function and padding method to avoid dark borders. The resulting filtered image will be referred to as $Image5$. Insert the resulting image into the answer document.

**Problem 8)** As is typical with the results obtained from applying high-pass filter kernels, $Image5$ appears quite dark. Explain the reason for this phenomenon. Additionally, what should the average value of the pixel values in $Image5$ be, and why? **HINT:** Examine the sum of the pixel values in your high-pass filter kernel and discuss how this affects the average value of the filtered image. Refer to assignments 12 and especially 13 in "Lektion 2" for further insight.

**Problem 9)** Add $Image5$ to the original test image and label the resulting image as $Image6$. This operation is known as unsharp masking. Include your result in the answer document.

## 2) Testing Sobel filters and gradient:

The following two Sobel filter kernels are commonly employed to compute the first derivative in the $x$ and $y$ directions, respectively. When using these kernels as they are, it is important to apply correlation for filtering. Consequently, you can utilize the MATLAB function $filter2$ (the $imfilter$ function 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 10)** Filter the test image, *TestPattern.tif* using $Sob_x$. Label the resulting image as $Image7$ and include it in your answer document.

**Problem 11)** Filter the test image using $Sob_y$. Label the resulting image as $Image8$ and include it in your answer document.

The length of the gradient vector is defined as: $M(x,y) = \|\nabla f\| = \sqrt{g_x^2 + g_y^2}$. This results in an image, $M(x,y)$, that has the same dimensions as the original image and is commonly referred to as the gradient image. Please remember that the operations for squaring and taking the square root of these matrices must be performed **elementwise**.

**Problem 12)** Calculate the gradient of the test image using your results from Problems 10 and 11. Label the resulting image as $Image9$ and include it in your answer document.