EEE 391: Basics of Signals and Systems
Fall 2024-2025
Matlab Assignment 2

Image signals is a particular signal type. Colorful image signals are represented by 3D matrices where each pixel is represented by three channels corresponding to red, green, and blue (RGB) colors. The mixture of these three colors can represent all other colors. On the other hand, 2D images are called grayscale images. This assignment focuses on implementing some image processing techniques on grayscale images.

Question 1

Image processing operations can be characterized by filter matrices. Performing convolution operation between the input image and an appropriate filter matrix gives the filtered image. In this assignment, we work on 2D images. Hence, the convolution operation can be written as

$$Y[i,j] = \sum_m \sum_n X[m,n]H[i-m, j-n]$$

where X is a 2D input image, H is a 2D filter and Y is a 2D output image. MATLAB has a built-in function named "conv2" to perform such convolution. However, you will not use this function for your operations. Instead, you need to implement it by yourself to learn it better. This can be done via nested loops or matrix operations. You can check the correctness of your function by comparing your outputs with the built-in function.

Part 1

Download the image provided on Moodle named "flower.jpg". Read it by using the Matlab command: I = imread("flower.jpg"). The given image is colorful. Hence, we need to convert it to grayscale by using the "rgb2gray" built-in function. Then, use the command: A = mat2gray(I) to convert matrix I to matrix J whose values are between 0 and 1 where 0 represents black and 1 represents white. Intermediate values are gray scale values.

In this part, you will implement various smoothing filters. Construct three NxN matrices whose elements are $1/N^2$ for $N = 3$, $N = 10$ and $N = 50$. Perform convolution using these matrices and display your output images using "imshow" function. Compare your results with the output images of the built-in "conv2" function. Explain the operation performed on each pixel in the convolution with these filters. Compare the output figures. What is the effect of increasing N?

Part 2

In this part, you will add noise to the given input image. Create a matrix whose size is equal to the input image. Use a Gaussian random number generator with mean value of 0 and a standard deviation of 0.5 to fill the entries of this matrix. Multiply the generated matrix by 0.2 to scale it down. Add this matrix to input image and display the noisy image.

Apply smoothing filters with $N = 3$, $N = 10$ and $N = 50$ and display the images. Compare the results and comment on the effect of the filters. Do they reduce the noise? How is this effected by changing the value of N? Is there an undesirable side effect on the image? What do you think is the best choice of N here?

Question 2

Download the images named "image1.png" and "image2.png" from Moodle. Read them using "imread" command. Before applying convolution, we need to convert these matrices to double-precision which can be done via "im2double" command. Afterwards, multiply the corresponding matrices of image 1 and image 2 with constants 10 and 5, respectively. Then, add them up. Filter the resulting matrix with the $10x10$ smoothing filter you implemented in Question 1. Display the result.

On the other hand, again multiply the matrices of image 1 and image 2 with 10 and 5, respectively. Then, filter each of these two modified images with the $10x10$ smoothing filter separately without summing them up. You need to have two filtered images at this point. Sum the corresponding matrices of these two filtered images and display the result.

Compare the two displayed images. What do you observe? Explain the reasoning behind your observation.

Question 3

Download the images named "Text.png" and "letter_t.png" from Moodle. Read them using "imread" command. This time images are given as logical matrices. We need to convert them to double to be able to perform convolution. This can be done via "im2double" command.

Write a code that finds how many times the letter "t" appears in the horizontal part of the text of the given image using the two images and your convolution function (You do not

have to identify "t" letters written in the vertical text). You need to perform some preprocessing before convolving these two images. The output matrix of the convolution operation should have the same number of peaks with the number of letter "t" in the horizontal part of the text of the given image i.e. 5 . To identify peaks, you can rescale the elements of the output matrix of the convolution operation between 0 and 1 using "rescale" command. Then, apply a proper threshold, say 95%, to the resulting matrix's elements.

Answer the questions below.

(i) What preprocessing did you perform? Why?

(ii) Explain your procedure.

(iii) What is the name of the application you performed in this part?