

# Assignment 1

Digital Signals Analysis and Applications - IEC239

Deadline at 11:55pm on 23<sup>rd</sup> January, 2017

## PROBLEM 1

Let,

$$x[n] = \begin{cases} 1, & \text{if } 0 \leq n \leq 9 \\ 0, & \text{elsewhere} \end{cases} \quad \text{and} \quad h[n] = \begin{cases} 1, & \text{if } 0 \leq n \leq N \\ 0, & \text{elsewhere} \end{cases}$$

where  $N \leq 9$ . Determine the value of  $N$ , given that  $y[n] = x[n] \star h[n]$  and

$$y[4] = 5, \quad y[14] = 0$$

## PROBLEM 2

Create a matrix of size 3x3 which when convolved with Figure 1 results in a white line where the white meets the black. Now do the following and give report on what you see:

1. convolve cameraman.tif with the matrix you made previously
2. convolve cameraman.tif with the transpose of the matrix you made previously

Instructions to create Figure 1

- Should be a 500x500 matrix
- Rows 0 to 250 should all have values 0
- Rows 251 to 500 should all have values 255

Note: Do not use loops for the creation of Figure 1 nor for convolution, use matlab functions. Lookup `imshow()`, `imread()`. Sample input and output are attached. The image on the left is the input and the on the right is the output.

Hint: First try to create a 3x1 matrix then extend it to 3x3.

## PROBLEM 3

Given a pair of sequences, use discrete convolution to find the response from the following two signals:

$$x[n] = [\dots 0 \ 0 \ 1 \ 1 \ 1 \ 0 \ 0 \dots] \quad \text{and} \quad y[n] = [\dots 0 \ 1 \ 2 \ 3 \ 2 \ 1 \ 0 \dots]$$

1. Compute the convolution by hand and in MALTAB.
2. Using a suitable command, plot all the signals and impulse response.

Hint: Use subplot.

#### PROBLEM 4

An algorithm for the calculation of the square root of a number  $\alpha$  is given by

$$y[n] = x[n] - y^2[n-1] + y[n-1]$$

where  $x[n] = \alpha u[n]$  with  $0 \leq \alpha \leq 1$ . If  $x[n]$  and  $y[n]$  are considered input and output of a discrete-time system, is the system linear or non linear? Is it time invariant? As  $n \rightarrow \infty$ , show that  $y[n] \rightarrow \sqrt{\alpha}$ . Note that  $y[-1]$  is a suitable approximation to  $\sqrt{\alpha}$ .

#### PROBLEM 5

An image of size (Width, Height, Channels) is convolved with  $\mathbf{N}$  filters of size (F,F,Channels). The convolution is done with a step size of  $\mathbf{S}$  units, and the input is also padded with a zero padding of  $\mathbf{Z}$ . The convolution always happens in such a way that the filter is always contained in the image.

- a) Predict the dimensions of the output of this convolution.
- b) How many additions and multiplications are involved in this convolution?

#### PROBLEM 6

You are at the Kumbh Mela, which is billed as the world's largest religious gathering, with around 30 million people. You are trying to find your long lost friend Shyam in the Mela. Fortunately, with the help of cutting edge surveillance systems, the organizers at the Mela have helped you get an image of Shyam (shyam.jpg). Shyam is somewhere in this photo (kumbhmela.jpg). Spot Him!

#### PROBLEM 7

1. Read a wav file in MATLAB. It is originally sampled at 44.1kHz and has digitized at 24 bits. Play the sound. Also, record your own voice for this question.
2. Subsample to 24kHz, 16kHz, 8kHz and 4kHz. Play the sound.
3. Simulate it in three different environments using the concepts and examples considered in the class. You can download impulse response characterizing the system (environment) from the internet (use freely available resources like <http://www.openairlib.net/auralizationdb>).

**Write a report for all the results and comparisons.**