DIGITAL SIGNAL PROCESSING LAB

(EL-302)

LABORATORY MANUAL

ENGR. Muhammad Ibrar Khan

Discrete Time Systems

(LAB # 03)

Student Name: ____

Roll No: ______________ Section: ___

Date performed: ___________, 2019

NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES, ISLAMABAD

Prepared by: Engr. Muhammad Asim
Last Edited by: Engr. Muhammad Asim, Feb 02, 2016
Verified by: Dr. Shahzad Saleem

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Lab # 03: Discrete Time Systems

Learning Objectives

A. Introduction
B. Linear Convolution methods
C. Moving Average Filter:
D. Computing Impulse response
E. Illustration of Filtering Concept

Equipment Required

1. PC
2. MATLAB

1. Introduction

Mathematically, a discrete-time system is described as an operator T[.] that takes a sequence x(n) called excitation and transforms it into another sequence y(n) (called response). Discrete time systems can be classified into two categories

i) LTI systems ii) NON-LTI systems.

A discrete system T[.] is a linear operator L[.] if and only if L[.] satisfies the principle of superposition, namely

$L[a_1x_1(n) + a_2x_2(n)] = a_1L[x_1(n)] + a_2Lx_2(n)]$ and

A discrete system is time-invariant if Shifting the input only causes the same shift in the output. A system is said to be bounded-input bounded-output(BIBO) stable if every bounded input produces a bounded output.

$$|x(n)| < \infty \Rightarrow |y(n)| < \infty, \forall x, y$$

An LTI system is BIBO stable if and only if its impulse response is absolutely summable.

$$\text{BIBO Stability} \Longleftrightarrow \sum_{-\infty}^{\infty} |h(n)| < \infty$$

A system is said to be causal if the ouput at index n_0 depends only on the input up to and including the index n_0; that is output does not depend on the future values of the input. An LTI system is causal if and only if the impulse response is

$$h(n) = 0, \quad n < 0$$

2. Linear Convolution methods

Convolution is a formal mathematical operation, just as multiplication, addition, and integration. Addition takes two numbers and produces a third number, while convolution takes two signals and produces a third signal. It has many applications in numerous areas of signal processing. The most popular application is the determination of the output signal of a linear time-invariant system by convolving the input signal with the impulse response of the system.

The linear convolution of two discrete-time signals x(n) and h(n) is defined by

$$y(n) = x(n) * h(n) = \sum_{k=-\infty}^{\infty} x(k)\,h(n-k)$$

In matlab, there are basically three built in commands to compute the convolution which are

1) “filter” 2) “conv” 3) “toeplitz”

We can also write our manual code to compute the convolution of two discrete time signals.

Task 01:

1) Generate the following two sequences.

$$x[n] = \begin{cases} 1, & 0 < n < 5 \\ 0, & \text{otherwise} \end{cases}$$

$$h[n] = \begin{cases} (1/2)^n, & 0 < n < 6 \\ 0, & \text{otherwise} \end{cases}$$

2) Find y[n] using the “conv” command and plot input and output sequences and label them properly.

Task 02:

Find y[n] using the “conv” command and plot input and output sequences and label them properly.

Task 03:

1) Find y[n] using the “toeplitz” command and plot input and output sequences and label them properly.
2) Which of the above method is preferable?

3. Moving Average Filter

M-point Moving average filter is defined by following equation

$$y[n] = \frac{1}{M}\sum_{k=0}^{M-1} x[n-k]$$

The above given filter is LTI causal system.

Task 04:

1) Generate a sinusoidal signal x[n] which should be combination/sum of a low and high frequency i.e. low frequency=0.05and high frequency=0.47. $0 \leq n \leq 100$
2) Implement moving average filter with M=2,4,10 on the above generated signal. Hint: You can use “filter” command.
3) Display input and output signals and properly label the plots.
4) Which component of the input x[n] is suppressed by the discrete-time system simulated by this program?

4. Computing Impulse Response

In signal processing, the impulse response, or impulse responsefunction (IRF), of a dynamic system is its output when presented with a brief input signal, called an impulse.We have a built in command in matlab to compute the impulse response i.e. “impz”. We can compute manually the impulse response when given system input-output relation equation is non-recursive. For example the impulse response of following system equation

$$y[n] = 0.5x[n] + 2x[n-1] + x[n-3] + 3x[n-4]$$

is given by

$$h[n] = \{0.5, 2, 0, 1, 3\}$$

Task 05:

1) Compute the impulse response of the system whose input-output relation is given by

$$y[n]-0.4\, y[n-1]+0.75\, y[n-2] = 2.2403\, x[n]+2.4908\, x[n-1]+2.2403\, x[n-2]$$

2) Plot the impulse response and label it properly. Use the “impz” command.

5. Illustration of the Filtering Concept

Task 06:

1) Generate the following sequence

$$x[n] = \cos\left(\frac{20\pi n}{256}\right) + \cos\left(\frac{200\pi n}{256}\right), with \quad 0 \le n < 299$$

2) Compute the outputs of above inputs using two systems

System No. 1

$$y[n] = 0.5x[n] + 0.27x[n-1] + 0.77x[n-2]$$

System No. 2

$$y[n] = 0.45x[n] + 0.5x[n-1] + 0.45x[n-2] + 0.53y[n-1] - 0.46y[n-2]$$

3) In this question both filters are lowpass filters butwith different attenuation in the stopband, especially at the frequencies of the input signal. Which filter has better characteristics for suppression of the high-frequency component of the input signal x[n]?

Student's feedback: Purpose of feedback is to know the strengths and weaknesses of the system for future improvements. This feedback is for the 'current lab session'. Circle your choice:

[-3 = Extremely Poor, -2 = Very Poor, -1 = Poor, 0 = Average, 1 = Good, 2 = Very Good, 3 = Excellent]:

The following table should describe your experience with:

S#	**Field**	**Rating**	**Describe in words if required**
1	Overall Session	-3 | -2 | -1 | 0 | 1 | 2 | 3	
2	Lab Instructor	-3 | -2 | -1 | 0 | 1 | 2 | 3	
3	Lab Staff	-3 | -2 | -1 | 0 | 1 | 2 | 3	
4	Equipment	-3 | -2 | -1 | 0 | 1 | 2 | 3	
5	Atmosphere	-3 | -2 | -1 | 0 | 1 | 2 | 3	

Any other valuable feedback: ____

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Student's Signature: ______________________________

MARKS AWARDED	**Attitude**	**Neatness**	**Correctness of results**	**Initiative**	**Originality**	**Conclusion**	**TOTAL**
TOTAL	**10**	**10**	**10**	**20**	**20**	**30**	**100**
EARNED							

Lab Instructor's Comments:____

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Lab Instructor's Signature: ______________________________