Independent University, Bangladesh

Department of Electrical and Electronic Engineering

BAETE Accredited

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Section: 2

Course Title	: Digital Signal Processing LAB
Course Code	: EEE 321L / ETE 324L (New); ECR 305L (Old)
Instructor	: Dr. Kh Shahriya Zaman
Experiment No.	**: 05**
Experiment Name	**: Study on cross correlation, autocorrelation, and impulse response.**

Objectives:

1. To understand the cross correlation & autocorrelation of 2 signals.
2. To understand the impulse response of a system by applying a discrete signal.

Theory

Cross correlation: Correlation is an operation used in many applications in digital signal processing. It is a measure of degree to which two sequences are similar. Given two real-valued sequences ***x(n)*** and ***y(n)*** of finite energy, the cross correlation of ***x(n)*** and ***y(n)*** is a sequence $r_{xy}(l)$ is defined by:

$$r_{xy}(l) = \sum_{n=-\infty}^{\infty} x(n)y(n-l)$$

Auto correlation: Autocorrelation represents the degree of similarity between a given time series and a lagged version of itself over successive time intervals. Autocorrelation measures the relationship between a variable's current value and its past values:

$$r_{xx}(l) = \sum_{n=-\infty}^{\infty} x(n)x(n-l)$$

Or

$$r_{yy}(l) = \sum_{n=-\infty}^{\infty} y(n)y(n-l)$$

Convolution: An LTI system is completely characterized in the time domain by the impulse response ***h(n)*** as:

$$x(n) \rightarrow \boxed{h(n)} \rightarrow y(n) = h(n) * x(n)$$

The convolution operation mentioned above is used to describe the response of an LTI system. In DSP, it is an important operation and has many other uses.

Moving average: The moving average filter is a simple Low filter commonly used for smoothing an array of sampled signal. It takes input points, computes the average of those -points and produces a single output point.

Moving average for 3 points is:

$$y(n) = \frac{1}{3}[x(n+1) + x(n) + x(n-1)]$$

Lab-Work:

1.Perform the cross correlation of the following 2 sequences using xcorr(x,y) function:

$x(n) = \{1,2,4\}$ $y(n) = \{1,1,1,1\}$

```
%Hemal Sharma
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x = [1,2,4];
y = [1,1,1,1];
z = xcorr(x,y);
subplot(1,3,1)
stem(x)
title("x")
subplot(1,3,2)
stem(y)
title('y')
subplot(1,3,3)
stem(z)
title("xcorr")
```

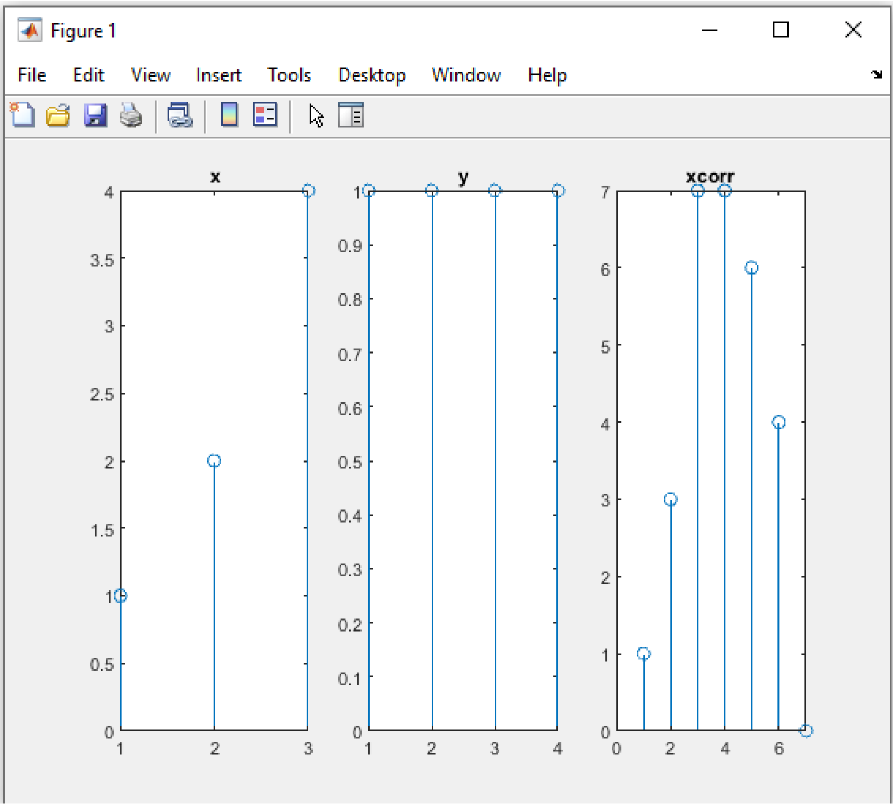

2. Perform the autocorrelation of the following signal using xcorr(x) function:

$x(n) = \{1,2,1,1\}$

```
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x= [1,2,1,1];
z = xcorr(x,x);
stem(z)
```

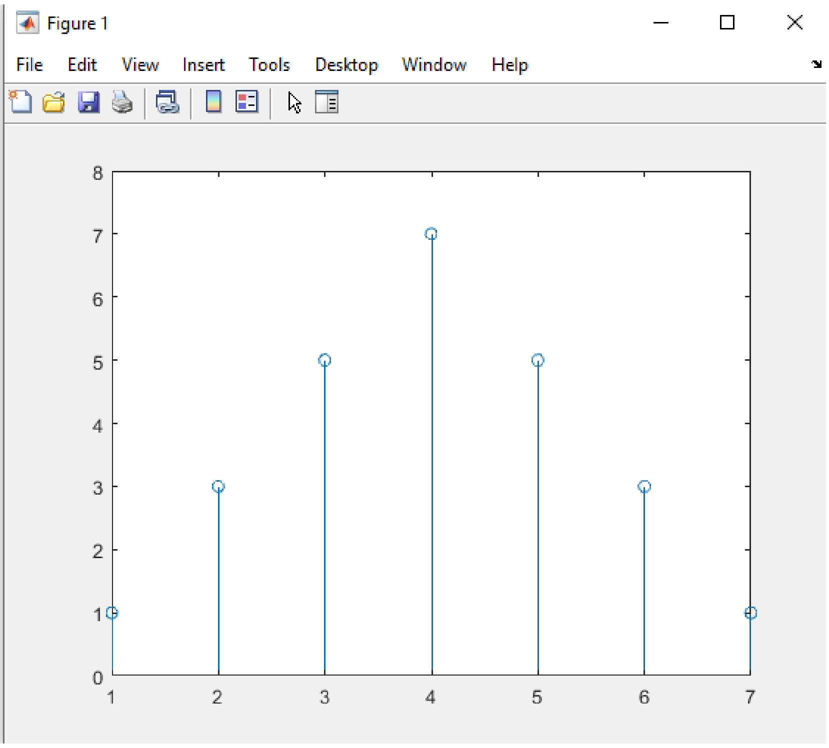

3. Consider a discrete signal x(n) = u(n) – u(n–10) be an input to an LTI system with impulse response h(n) = u(n). Determine the output signal y(n) using conv(x,h). Also plot x(n), h(n) and y(n) using MATLAB.

```
%Hemal Sharma
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n = -15:15;
x = stepseq(0,-15,15)-stepseq(10,-15,15);
h = stepseq(0,-15,15);
z = conv(x,h);
subplot(3,1,1)
stem(n,x)
title("x(n)")
subplot(3,1,2)
stem(n,h)
title("h(n)")
subplot(3,1,3)
stem(z)
title("y(n)")
```
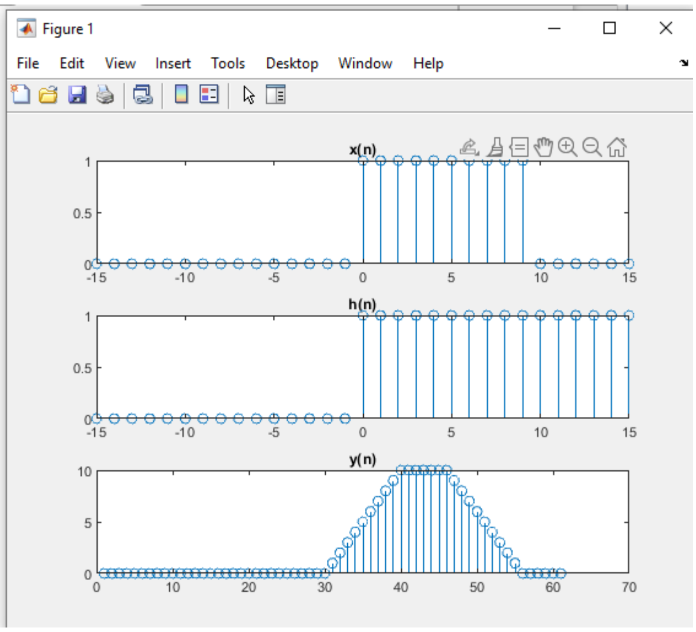
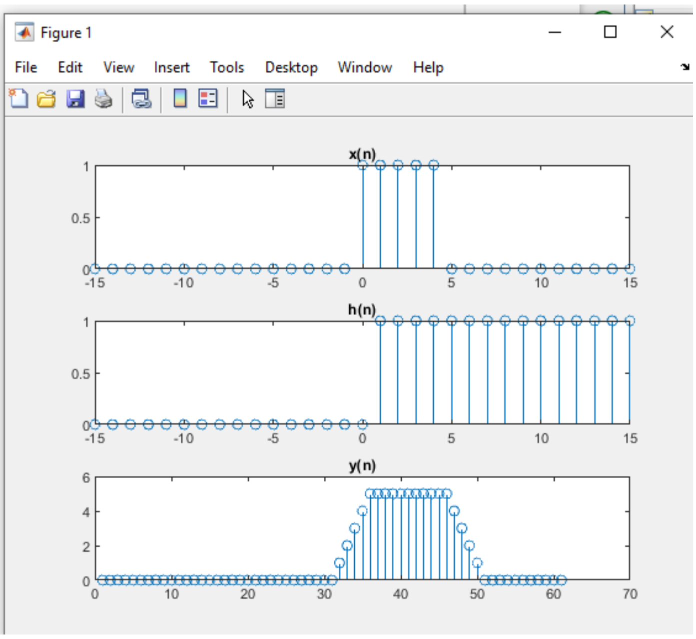



Lab Assignment-5:

1. Consider a discrete signal x(n) = u(n) – u(n–5) be an input to an LTI system with impulse response h(n) = u(n-1). Determine the output signal y(n) using conv(x,h). Also plot x(n), h(n) and y(n) using MATLAB.

```
%Hemal Sharma
%ID: 2221855

n = -15:15;
x = stepseq(0,-15,15)-stepseq(5,-15,15);
h = stepseq(1,-15,15);
z = conv(x,h);
subplot(3,1,1)
stem(n,x)
title("x(n)")
subplot(3,1,2)
stem(n,h)
title("h(n)")
subplot(3,1,3)
stem(z)
title("y(n)")
```



2. Develop a MATLAB function to perform the moving average of a sequence.

```
%Hemal Sharma
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function [z] = movavg(x,m)
    z = movmean(x,m);
end
```

```
%Hemal Sharma
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n = -2*pi:0.1:2*pi;
noise = sin(50*n);
signal = sin(n);
x = signal + noise;
y = movavg(x,3);
subplot(3,1,1)
plot(n,signal)
title('Signal')
subplot(3,1,2)
plot(n,x)
title('x')
subplot(3,1,3)
plot(y)
title('Moving Average')
```