DEPARTMENT OF
ROBOTICS AND MECHATRONICS ENGINEERING

LAB REPORT

DIGITAL SIGNAL PROCESSING (CSE-401)

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Submitted To:
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Experiment no. 3

Name of the experiment

Convolution of a digital signal with a given filter signal.

Objectives

- To learn how to use linear filters.

- To understand the basics of convolution.

- implementing linear convolution using MATLAB

Theory

In mathematics convolution is a mathematical operation on two functions (f and g) to produce a third function that expresses how the shape of one is modified by the other.

An input signal, x[n], enters a linear system with an impulse response, h[n], resulting in an output signal, y[n]. In equation form: $y[n] = x[n] * h[n]$. Expressed in words, the input signal convolved with the impulse response is equal to the output signal.

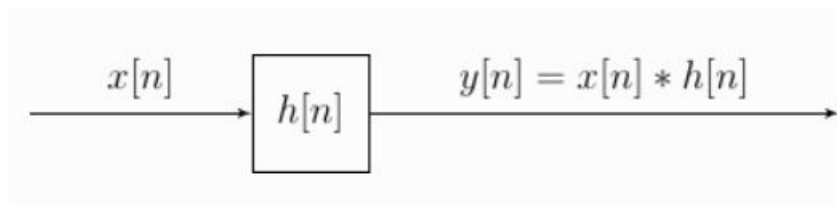$$x[n] \quad \boxed{h[n]} \quad y[n] = x[n] * h[n]$$

Figure 1: Convolution Block Diagram

The mathematical definition of convolution is:

$$y[n] = x[n] * h[n] = \sum_{m=-\infty}^{\infty} x[m]h[n-m]$$

To perform discrete time linear convolotions we need to follow the following steps:

- Select the filter signal and flip the signal

- Pad the signal to be convolved, with zeros to sufficient lengths

- Align the right most element of the filter with the left most element of the signal to be convolved.

- Perform cross multiplication.

- Apply 1 unit right shift on the filter signal.

- Perform previous two steps until no element of the original signal is left.

Implementation Code

<div align="center">main.m</div>

```
1  clc; clear; close all;
2  h = [ 1 2 1 -1 ]; ho = 2;
3  x = [ 1 2 3 1 ];  xo = 1;
4
5  [out,outOrigin] = convolution(x,h,xo,ho);
```

Functions Used:

<div align="center">convolution.m</div>

```
1  function [out,outOrigin] = convolution(input, h, ino
      , ho)
2      hneg = fliplr(h);
3      L = size(input,2);
4      ho = L-ho+1;
5      X = zeros(1, 3*L);
6      H=X;
7      out = X;
8      H=hneg;
9      for i =L+1:2*L
10         X(i) = input(i-L);
11     end
12     for i =1:size(X,2)
13         out(1,i) = Ws(X,H);
14         H = rightShift(H);
15     end
16     out = out(2:size(out,2)-L);
17     outOrigin = L-ho;
18 end
```

rightShift.m

```matlab
function [outSignal] =  rightShift(inSignal,inOrigin
    )
    l = size(inSignal,2);
    outSignal = zeros(1,l);

    for i = 2:l
        outSignal(i) = inSignal(i-1);
    end
end
```

Ws.m

```matlab
function out = Ws(a,b)
    s=0;
    for j = 1:size(b,2)
        s = s+ a(1,j)*b(1,j);
    end
    out=s;
end
```