DIGITAL SIGNAL PROCESSING LAB

Debagnik Kar

Roll: 1804373, ETC -06, EC - 3096

Index Page

Experiment No.	Aim of the Experiment	Page No.	Date of Experiment	Date of Submission
01	To write a function for finding circular convolution and correlation. Prove that autocorrelation is an even function and Rxy(n) = Ryx(-n)	2-6	23/12/2020	25/12/2020
02	To solve a given differential equation to find it's impulse and step responses. Plot the response and verify the solution			
03	To find the DTFT of an arbitrary sequence and prove the convolution property			
04	To write a function to find DFT and IDFT and use it to find circular and linear convolution of given sequences.			
05	To perform sectional convolution using overlap add and overlap save method.			
06	To design FIR LPF, HPF and BPF using windowing techniques.			
07	To Study various parameters required for designing an IIR filter and design LPF, HPF and BPF Butterworth filters for specific cut-off frequencies.			
08	To study up sampling and down sampling of the sequences and study the frequency response			
09	Open Ended – I			
10	Open Ended - II			

Experiment Number	01
Date of Experiment	23/12/2020
Date of Submission	25/12/2020
Name of the Student	Debagnik Kar
Roll Number	1804373
Section	ETC - 06

Aim of The Experiment :-

To write a function for finding circular convolution and correlation. Prove that autocorrelation is an even function and $R_{xy}(n) = R_{yx}(-n)$

Software Required :-

- MATLAB R2018a

Theory :-

Convolution is a mathematical operation on two functions (*f* and *g*) that produces a third function (*f***g*) that expresses how the shape of one is modified by the other. The term convolution refers to both the result function and to the process of computing it. It is defined as the integral of the product of the two functions after one is reversed and shifted.

Cross-correlation is a measure of similarity of two series as a function of the displacement of one relative to the other. This is also known as a sliding dot product or sliding inner-product.

Autocorrelation, also known as serial correlation, is the correlation of a signal with a delayed copy of itself as a function of delay. Informally, it is the similarity between observations as a function of the time lag between them. The analysis of autocorrelation is a mathematical tool for finding repeating patterns

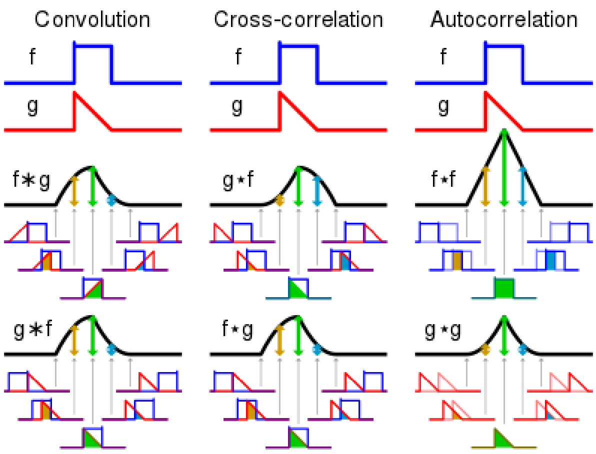

Fig:1.1: Visual comparison of convolution, cross-correlation, and autocorrelation. (Source: By Cmglee - WikiMedia)

Code :-

<<<File: main.m comment: Driver and plotter program>>>

```
% main.m Driver and plotting program
% Coded by Debagnik Kar 1804373
% Used sequences h = [0,5,3,1,6,8,9,2,4,7]; x =
[0,1,2,3,4,5,6,7,8,9]
close all
clear all
clc
x=input('Enter the first sequence : ')
h=input('Enter the second sequence: ')

N = max(length(x),length(h))
cc = circonv(x,h,N)
lc = linearconv(x,h)
[t1,rxh] = corel(x,h)
[t2,rhx] = corel(h,x)
[t3,rxx] = corel(x,x)
subplot 421
stem(x,'filled','r')
title('First Input Sequence')
xlabel('Samples')
ylabel('Amplitude')
grid on
subplot 422
stem(h,'filled','k')
title('Second Input Sequence')
xlabel('Samples')
ylabel('Amplitude')
grid on
subplot 423
stem(cc,'filled','g')
title('Circular Convolution')
xlabel('Samples')
ylabel('Amplitude')
grid on
subplot 424
stem(lc,'filled','c')
xlabel('Samples')
ylabel('Amplitude')
title('Linear Convolution')
grid on
subplot 425
stem(t2,rxh,'filled','b')
title('Cross Correlation Rxh Sequence')
xlabel('Samples')
ylabel('Amplitude')
grid on
subplot 426
stem(t2,rhx,'filled','m')
```

```
title('Cross Correlation Rhx Sequence')
xlabel('Samples')
ylabel('Amplitude')
grid on
subplot 414
stem(t3,rxx,'filled','y')
title('Auto Correlation Rxx Sequence')
xlabel('Samples')
ylabel('Amplitude')
grid on
```

<<< File: circonv.m comment: Circular convolution function script>>>

```
% Expt_1 Functional dependency
% Circular Convolution Coded by Debagnik Kar 1804373
function[y]= circonv(x,h,N)
    N1=length(x)
    N2=length(h)
    if(N2>N1)
        x4=[x,zeros(1,N-N1)]
        x5=h
    elseif(N2==N1)
        x4=x
        x5=h
    else
        x4=x
        x5=[h,zeros(1,N-N2)]
    end
    y=zeros(1,N);
    for m=0:N-1
        y(m+1)=0;
        for n=0:N-1
            j=mod(m-n,N);
            y(m+1)=y(m+1)+x4(n+1).*x5(j+1);
        end
    end
end
```

<<<File: linearconv.m Comment: Linear convolution function dependency>>>

```
% Expt_1 Functional dependency
% Linear Convolution Coded by Debagnik Kar 1804373
function[y] = linearconv(x,h)
    m = length(x)
    n = length(h)
    N = m+n-1
    y = zeros(1,N)
    h = [h,zeros(1,N)]
    x = [x,zeros(1,N)]
    y = cconv(x,h,N)
end
```

<<<File: corel.m Comment: Correlation function dependency>>>

```
% Expt1 function dependency
% Correleation fuction coded by Debagnik Kar 1804373
function[t,y] = corel(x,h)
    n = length(x)
    m = length(h)
    N = n+m-1
    h = fliplr(h)
    x = [x, zeros(1, n)]
    h = [h, zeros(1, m)]
    y = circonv(x,h,N)
    t = -(N-1)/2:(N-1)/2
end
```

Graph/Output :-

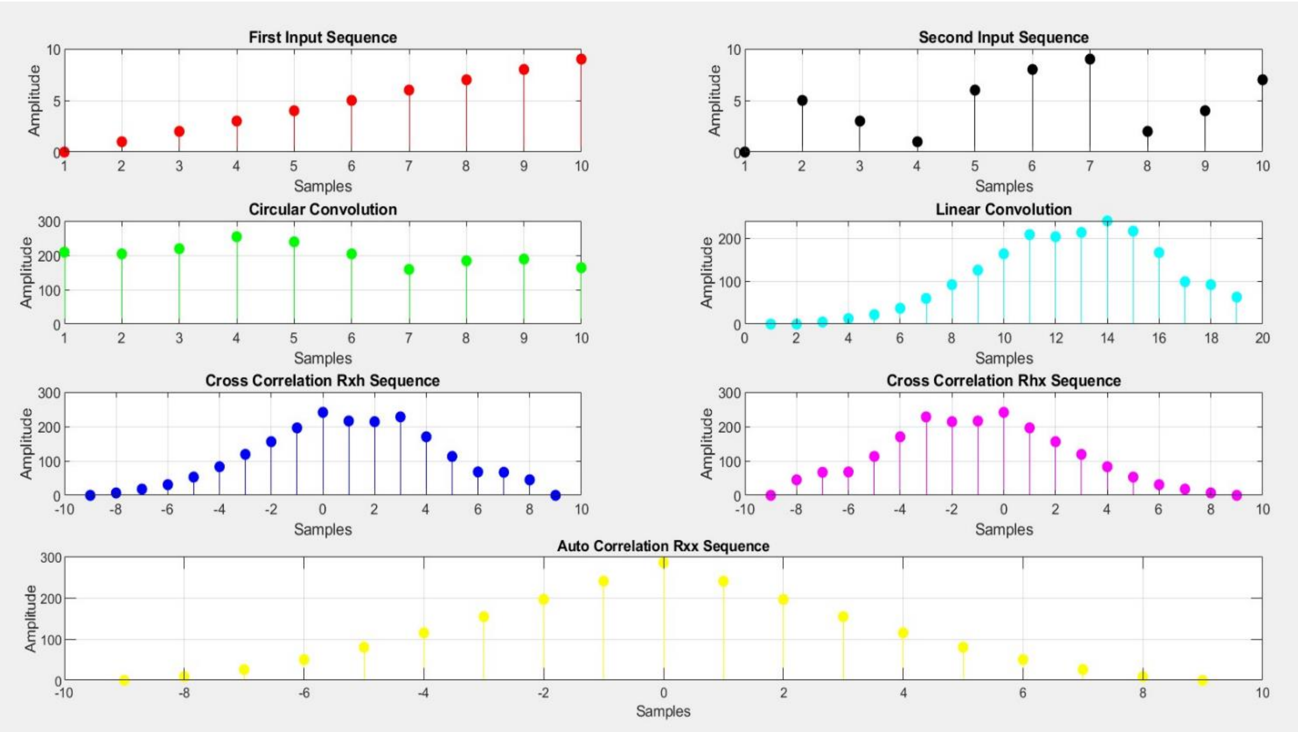

Fig 1.2: code output

Discussion/Inference of the experiment :-

From the graph generated by the above code we can see that

$R_{xh}(-8) = 7 = R_{hx}(8)$

$R_{xh}(-3) = 119 = R_{hx}(3)$

$R_{xh}(3) = 228 = R_{hx}(-3)$

$R_{xh}(8) = 45 = R_{hx}(-8)$

Cross-correlation $R_{x,h}$ graph is the mirror image of Cross Correlation $R_{h,x}$ graph therefore,

$\mathbf{R_{x,h}(n) = R_{h,x}(-n)}$.

From the Auto-Correlation graph we get

$R_{xx}(-8) = 9 = R_{xx}(8)$

$R_{xx}(-4) = 115 = R_{xx}(4)$

$R_{xx}(2) = 196 = R_{xx}(-2)$

$R_{xx}(6) = 50 = R_{xx}(-6)$

Here in this this graph at any point n, **$R_{xx}(n) = R_{xx}(-n)$, which means that the function is even**

Conclusion :-

In this experiment, a function for finding circular convolution linear convolution and correlation was successfully written and visualized using MATLAB scripts. It is also proved that autocorrelation is an even function and $R_{xh}(n) = R_{hx}(-n)$. It is concluded that the experiment is successful