DIGITAL SIGNAL
PROCESSING LAB

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Experiment Number	01
Date of Experiment	23/12/2020
Date of Submission	25/12/2020
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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
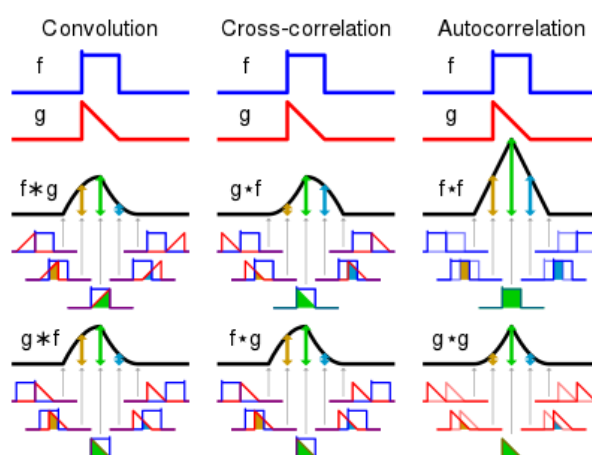

Fig:1.1: Visual comparison of convolution, cross-correlation, and autocorrelation. (Source: By Cmglee - WikiMedia)

Code :-

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

```matlab
% 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')
```

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```matlab
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>>>

```matlab
% 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>>>

```matlab
% 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
```

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

```matlab
% 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
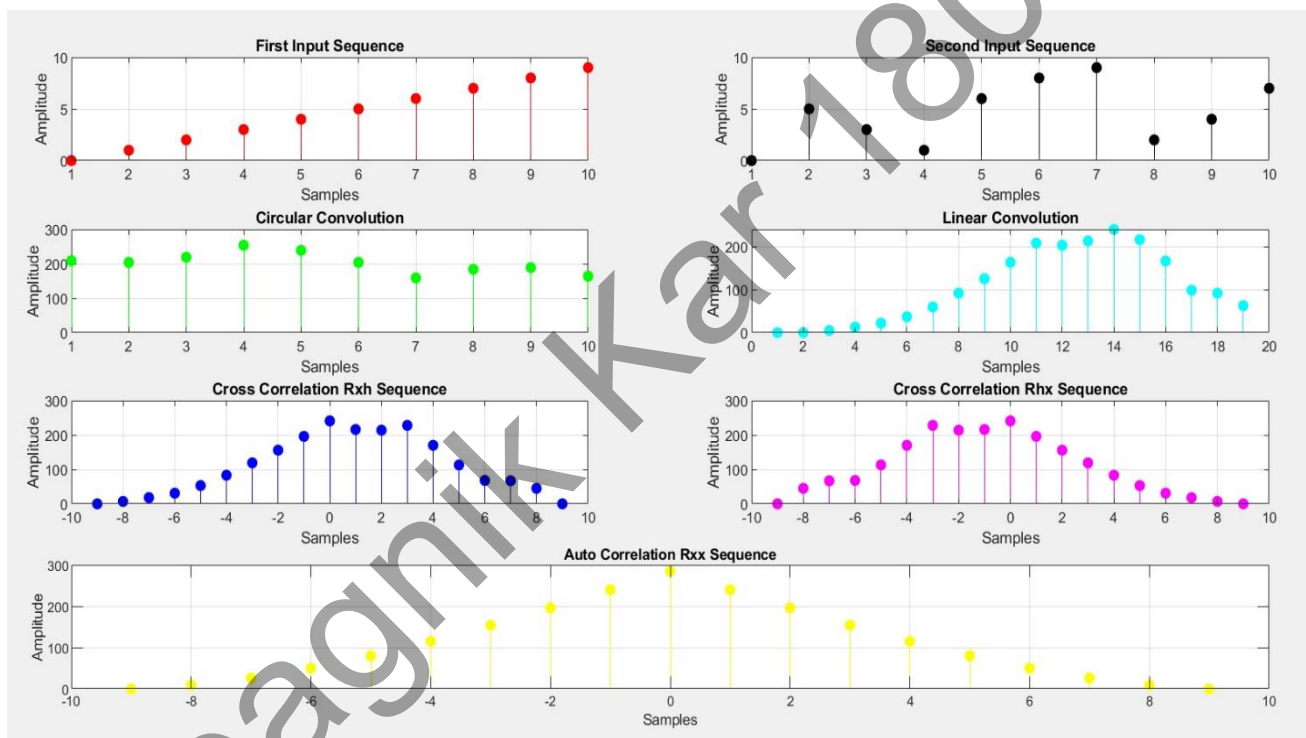```

## **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,

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

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