Rajshahi University of Engineering & Technology

Department : Electrical & Computer Engineering

Course No: ECE 4124

Course Name: Digital Signal Processing Sessional

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Experiment No: 3
Experiment Date: 15.5.23
Experiment Name: Study about auto correlation and cross correlation.

Theory:

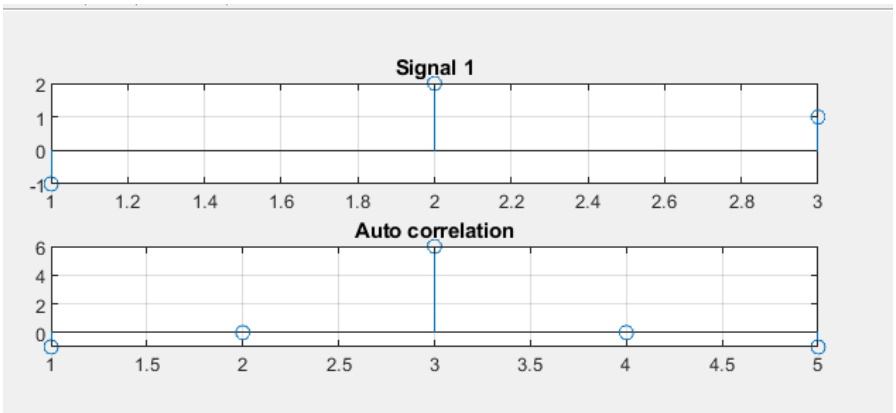
Autocorrelation, sometimes known as serial correlation in the discrete time case, is the correlation of a signal with a delayed copy of itself as a function of delay. Informally, it is the similarity between observations of a random variable as a function of the time lag between them. **Cross-correlation** is a measure of similarity of two series as a function of the displacement of one relative to the other.

Code:

With built in function:
Auto Correlation:

```
clc;
clear all;
close all;
x = input('Enter x: ');
a = xcorr(x)
subplot(4,1,1);
stem(x)
title('Signal 1');
grid on;
subplot(4,1,2);
stem(a)
title('Auto correlation');
grid on;
```

Output signal:



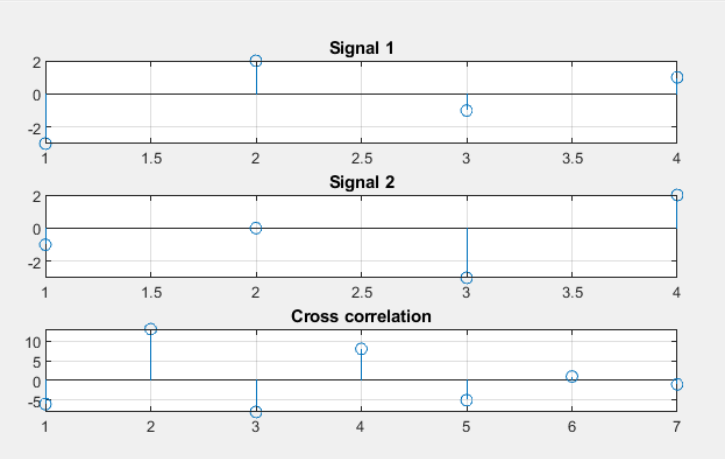
Output:

```
Enter x: [-1 2 1]

a =

   -1.0000         0    6.0000         0   -1.0000

>>
```

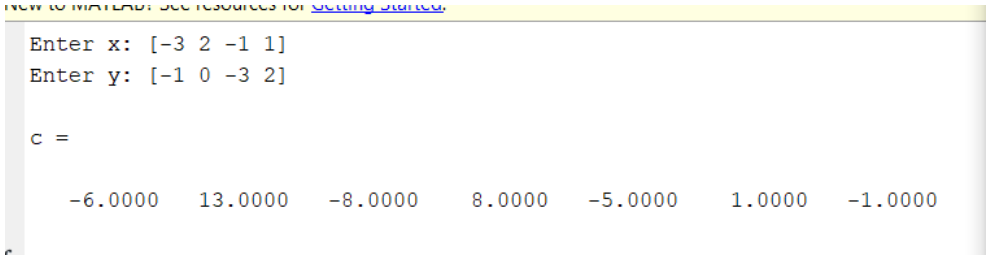
Cross Correlation:

```
clc;
clear all;
close all;
x = input('Enter x: ');
y = input('Enter y: ');
c = xcorr(x,y)

subplot(4,1,1);
stem(x)
title('Signal 1');
grid on;

subplot(4,1,2);
stem(y)
title('Signal 2');
grid on;

subplot(4,1,3);
stem(c)
title('Cross correlation');
grid on;
```

Output signal:



Output:



```
Enter x: [-3 2 -1 1]
Enter y: [-1 0 -3 2]

c =

   -6.0000   13.0000   -8.0000    8.0000   -5.0000    1.0000   -1.0000
```

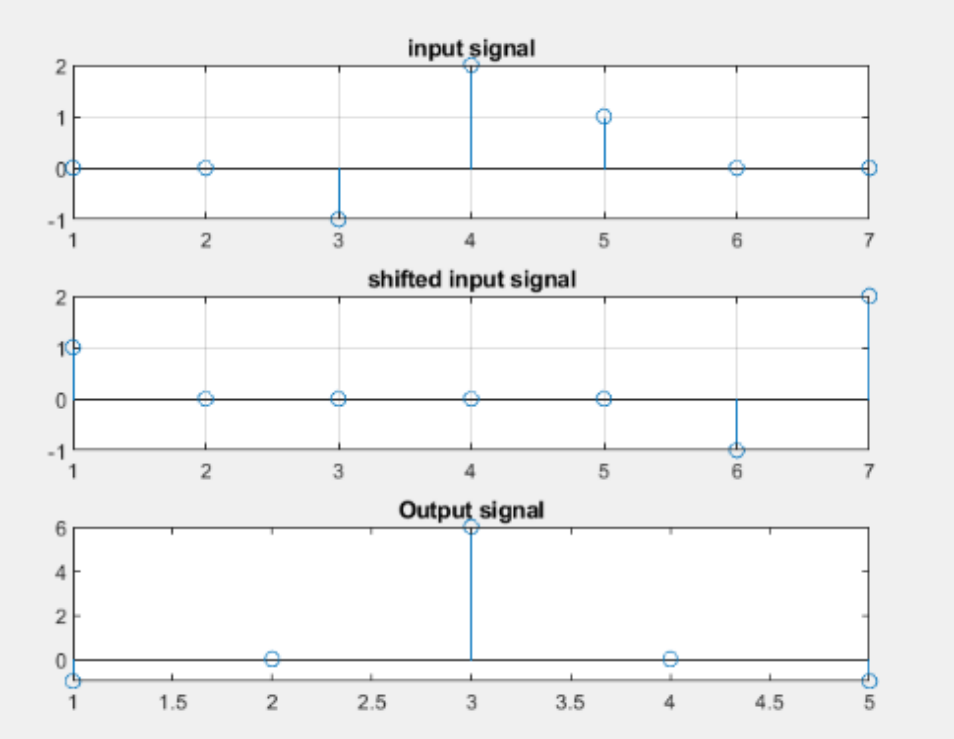
Without built in function:
Auto Correlation:

```
clc
clear all;
close all;
L=input('input L: ');
x=input('input matrix x: ');
N=L+L-1;
N1=L-1;
x1 = [zeros(1, N1) x zeros(1, N1)];
x2 = [x zeros(1, N1) zeros(1, N1)];
y=[zeros(1,N)];
L1=length(x1);
sum=0;
for i=1:N
    sum=0;
    for j=1:L1
        sum=sum+( x1(j)*x2(j) );
    end
    y(i)=sum;
    x2=circshift(x2,1);
end
y
%plotting
subplot(3,1,1)
stem(x1);
title('input signal')
grid
subplot(3,1,2)
stem(x2);
title('shifted input signal')
grid
subplot(3,1,3)
stem(y);
title('Output signal')
```

Output:

```
input L: 3
input matrix x: [-1 2 1]

y =

    -1     0     6     0    -1
```

Output signal:



Delay time of shifted signal:

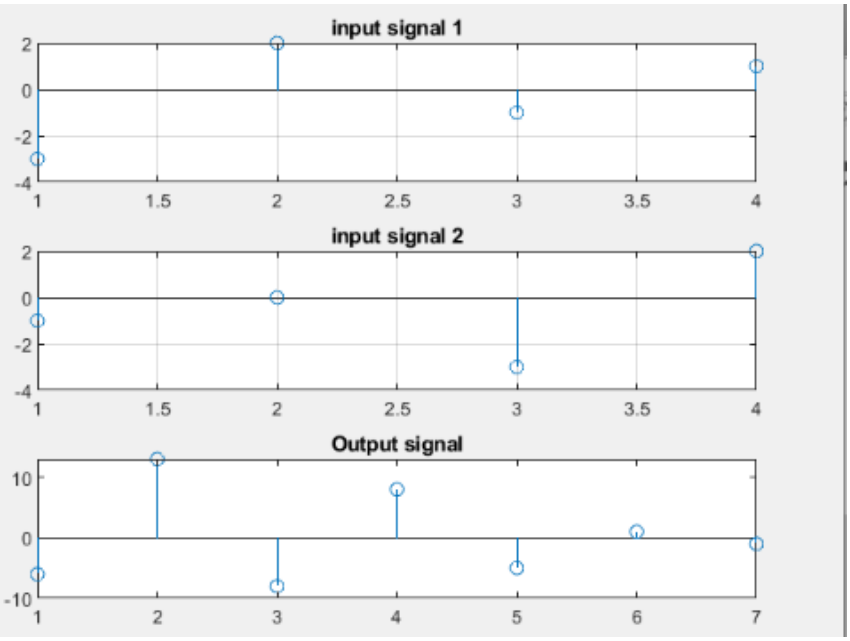
From the graph we can see that at time, t=3 sec the signal output is maximum. The result obtained is shown in Figure, which clearly exhibits a peak at time t = 3. This means that the received signal matches with the test signal the best when the test signal is shifted by 3 units along the time-axis.

Cross Correlation:

Code:

```
clc
clear all;
close all;
x=input('input matrix x: ');
x4=input('input matrix y: ');
if length(x) > length(x4)
    x4 = [x4 zeros(1, length(x) - length(x4))];
else
    x = [x zeros(1, length(x4) - length(x))];
end
L=length(x4);
M= length(x);
N=L+M-1;
N1=L-1;
x1 = [zeros(1, N1) x zeros(1, N1)];
x2 = [x4 zeros(1, N1) zeros(1, N1)];
y=[zeros(1,N)];
L1=length(x1);
sum=0;
for i=1:N
    sum=0;
    for j=1:L1
        sum=sum+( x1(j)*x2(j) );
    end
    y(i)=sum;
    x2=circshift(x2,1);
end
y
% [-3 2 -1 1]
%[-1 0 -3 2]
%plot
subplot(3,1,1)
stem(x);
title('input signal 1')
grid
subplot(3,1,2)
stem(x4);
title('input signal 2')
grid
subplot(3,1,3)
stem(y);
title('Output signal')
```

Output signal:



Output:

```
New to MATLAB? See resources for Getting Started.

input matrix x: [-3 2 -1 1]
input matrix y: [-1 0 -3 2]

y =

    -6    13    -8     8    -5     1    -1

fx >>
```

Conclusion:

The desired output has been achieved successfully.