Rajshahi University of Engineering & Technology

Department of Electrical & Computer Engineering

LAB REPORT

Course No: ECE 4124

Course Title: Digital Signal Processing Sessional

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Experiment No. 03

Experiment Name: Study Auto-Correlation and Cross-Correlation in MATLAB

Theory:

Auto-correlation and cross-correlation are essential tools for analyzing time series data in various fields, such as signal processing, econometrics, and finance. Auto-correlation function measures how similar a signal is to a delayed version of itself and is used to identify repeating patterns or periodicity in the signal. It can also be used to estimate the parameters of a time series model, such as the order of a moving average or autoregressive process. The autocorrelation function of a discrete-time signal x(n) is described mathematically as:

$Rxx(m) = \Sigma [x(n) * x(n - m)]$; in the autocorrelation function Rxx(m) is a measure of the similarity between the signal x(n) and a delayed version of itself. On the other hand, cross-correlation is useful for measuring the similarity of two signals, even when they are not periodic. It can be used to identify the time delay between two signals or to detect a specific signal in noise. Cross-correlation is also used in time delay estimation, speech recognition, and image processing, among other applications. The cross-correlation function is defined mathematically as follows:

$Rxy(m) = \Sigma [x(n) * y(n - m)]$; in the cross-correlation function Rxy(m) measures the similarity of two signals x(n) and y(n) when one is delayed by m samples. In both cases, the correlation score ranges from -1 to 1. A positive score indicates a direct correlation between the signals, while a negative score implies an inverse correlation. A score of 0 means that there is no correlation between the signals. Overall, auto-correlation and cross-correlation are powerful techniques for analyzing time series data, providing insights into the underlying patterns and relationships between signals. They are widely used in various fields and are essential tools for data analysts and researchers.

Software used : MATLAB

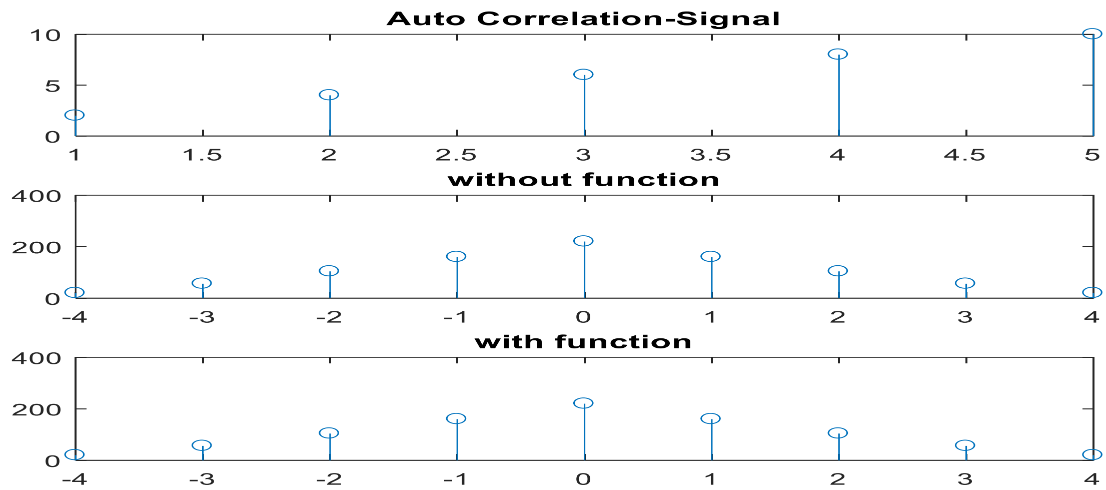
Code: Auto Correlation

```
clc
clear all;

x=input('Enter the Array:');
n1=input('Sample Range:');
h=fliplr(x);
n2=-fliplr(n1);
z=[];

for i=1:length(x)
 g=h.*x(i);
 z=[z;g];
end

[r c]=size(z);
k=r+c;
t=2;
y=[];
cd=0;

while(t<=k)
 for i=1:r
 for j=1:c
 if((i+j)==t)
 cd=cd+z(i,j);
 end
 end
 end
 t=t+1;
 y=[y cd];
 cd=0;
end

subplot(3,1,1);
stem(x);
title('Auto Correlation-Signal');

subplot(3,1,2);
nl=min(n1)+min(n2);
nh=max(n1)+max(n2);
t=nl:1:nh;
stem(t,y);
title('without function');

subplot(3,1,3);
z=xcorr(x,x);
stem(t,z);
title('with function');
```

Input:

```
Enter the Array:[2 4 6 8 10]
Sample Range:[0 4]
```

Output:



Code: Cross-correlation

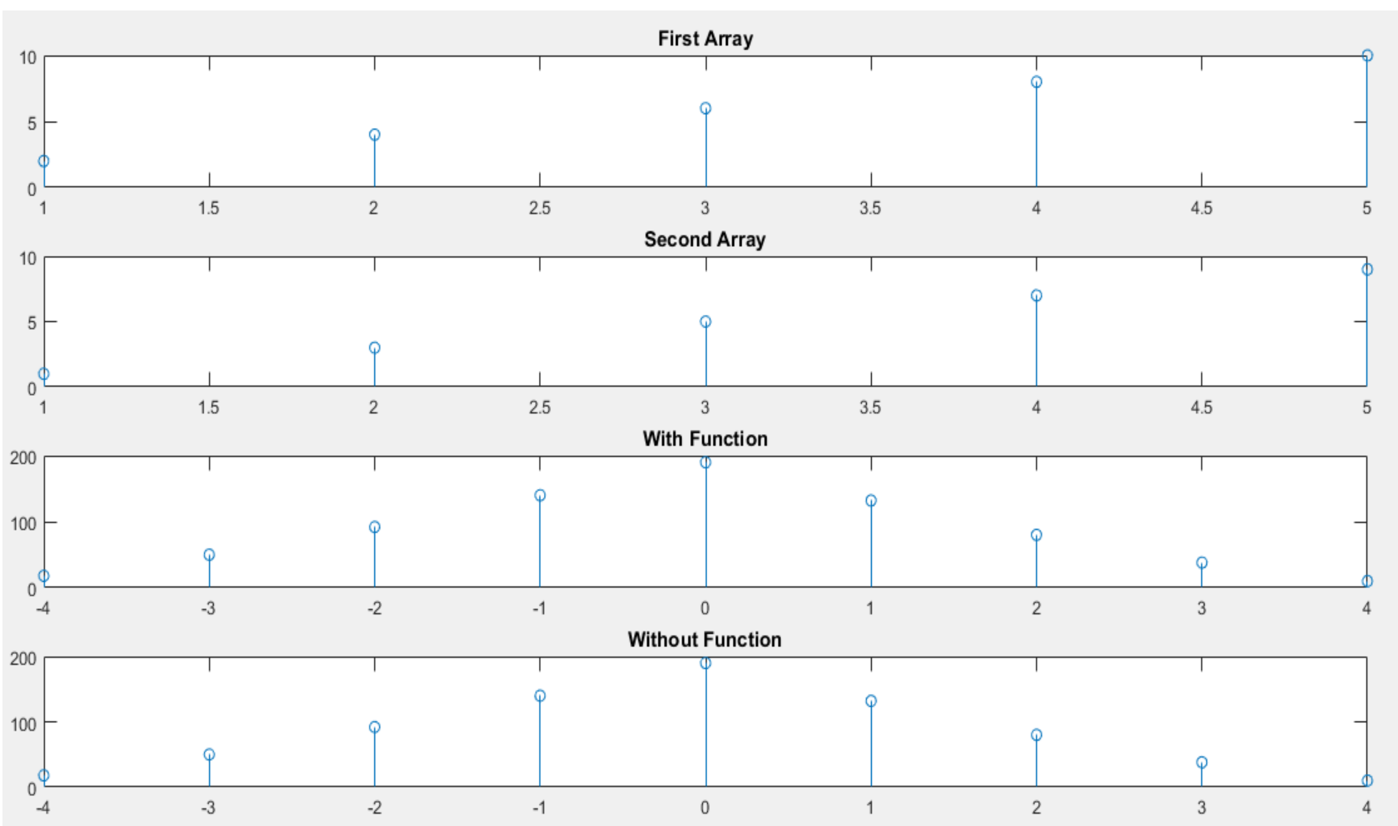
```
clc
clear all;

x=input('Enter the first Array:');
n1=input('Sample Range:');
h=input('Enter the second Array:');
n2=input('Sample Range:');
n2=-fliplr(n2);
z=[];
w=fliplr(h);

for i=1:length(x)
 g=w.*x(i);
 z=[z;g];
end

[r c]=size(z);
k=r+c;
t=2;
y=[];
cd=0;

while(t<=k)
 for i=1:r
 for j=1:c
 if((i+j)==t)
 cd=cd+z(i,j);
 end
 end
 end
 t=t+1;
 y=[y cd];
 cd=0;
```

```
end

subplot(4,1,1);
stem(x);
title('First Array');

subplot(4,1,2);
stem(h);
title('Second Array');

subplot(4,1,4);
nl=min(n1)+min(n2);
nh=max(n1)+max(n2);
t=nl:1:nh;
stem(t,y);
title('Without Function');

subplot(4,1,3);
p=xcorr(x,h);
stem(t,p);
title('With Function');
```

Input:

```
Enter the first Array:[2 4 6 8 10]
Sample Range:[0 4]
Enter the second Array:[1 3 5 7 9]
Sample Range:[0 4]
```

Output:



Discussion :

In this lab experiment, we focused on understanding the concepts of auto-correlation and cross-correlation in time series analysis. We started by defining what these terms mean and how they are used to analyze signals. Auto-correlation measures the similarity between a signal and its shifted version, while cross-correlation measures the similarity between two distinct signals. We then performed tests using MATLAB to demonstrate the features of these functions. We generated two signals with known properties, such as a sine wave and a square wave, using the sin and square functions in MATLAB. We then computed the auto-correlation of each signal using the autocorr function and the cross-correlation of the two signals using the xcorr function. The output of these functions was a plot of the correlation function over a range of lag values .By analyzing the plots, we were able to observe the correlation patterns of the signals. In the auto-correlation plot, we identified the periodicity of the signal, which helped us to identify the underlying pattern of the signal. In the cross-correlation plot, we observed the time delay between the two signals, which helped us to identify the relationship between the two signals.

Conclusion:

Through this experiment, we gained practical understanding of how auto-correlation and cross-correlation can be used in signal processing and time series analysis. We also learned how to use MATLAB functions to compute these correlations and analyze the results. We discussed the theoretical properties of auto-correlation and cross-correlation and their limitations, such as their sensitivity to noise and the assumptions of linearity and stationarity. Overall, this lab experiment provided us with a deeper understanding of these essential tools for analyzing time series data.