Department of Electrical & Computer Engineering

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: The two forms of correlation used to evaluate time series data are auto-correlation and cross-correlation.

The correlation of a signal with a delayed version of itself is referred to as auto-correlation. In other words, auto-correlation assesses the similarity between a signal and its shifted counterpart. It quantifies the link between a signal and its own historical values.

The autocorrelation function of a discrete-time signal x(n) is described mathematically as:

$R_{xx}(m) = \Sigma [x(n) * x(n - m)]$; in the autocorrelation function $R_{xx}(m)$ is a measure of the similarity between the signal x(n) and a delayed version of itself.

Cross-correlation, on the other hand, calculates the similarity of two signals as a function of a time delay given to one of them. It quantifies the link between two distinct signals. In signal processing and time series analysis, cross-correlation is frequently used to compare two signals and evaluate their degree of similarity.

The cross-correlation function is defined mathematically as follows:

$R_{xy}(m) = \Sigma [x(n) * y(n - m)]$; in the cross-correlation function $R_{xy}(m)$ measures the similarity of two signals x(n) and y(n) when one is delayed by m samples.

In both cases, correlation is a measure of the linear relationship between two signals, with values ranging from -1 to 1. A number of 1 indicates a perfect positive correlation, while a value of -1 shows a perfect negative correlation. A score of 0 implies that there is no correlation between the signals.

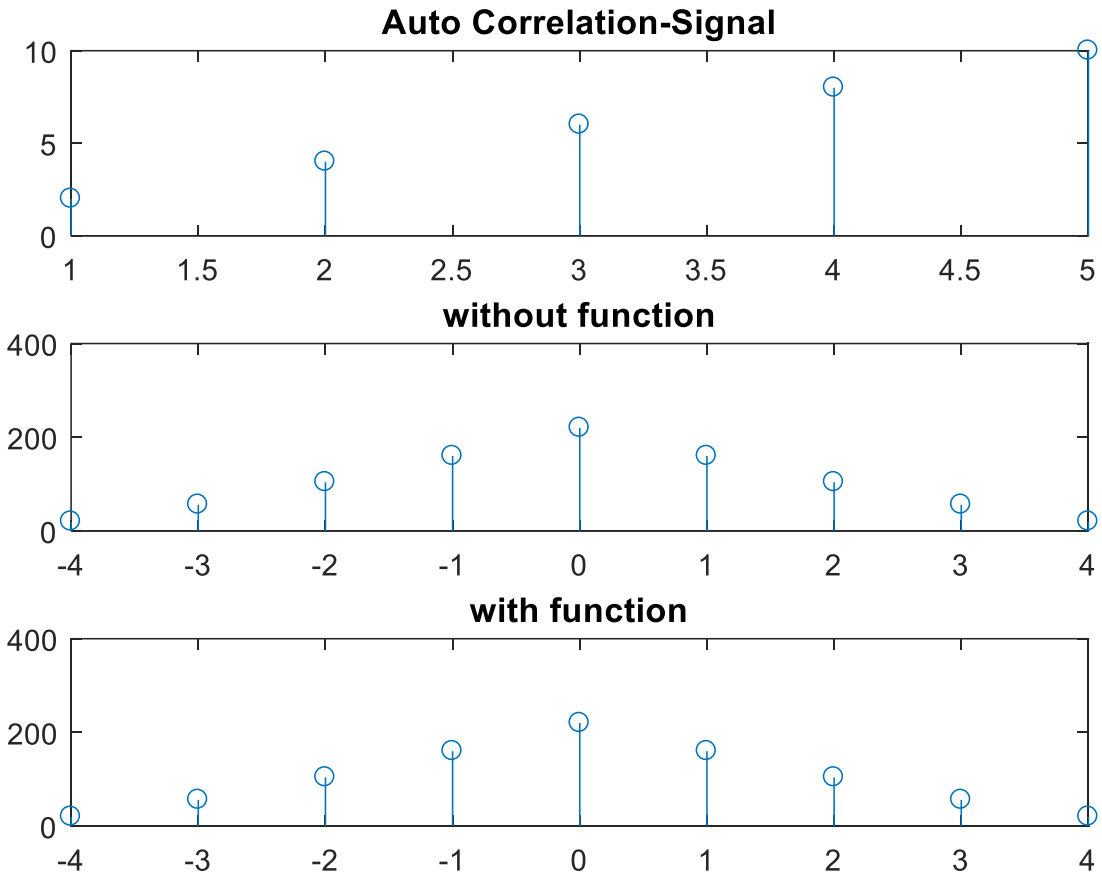
Code: Auto Correlation

```
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:


Auto Correlation-Signal
10
5
0
1
1.5
2
2.5
3
3.5
4
4.5
5
without function
400
200
0
-4
-3
-2
-1
0
1
2
3
4
with function
400
200
0
-4
-3
-2
-1
0
1
2
3
4

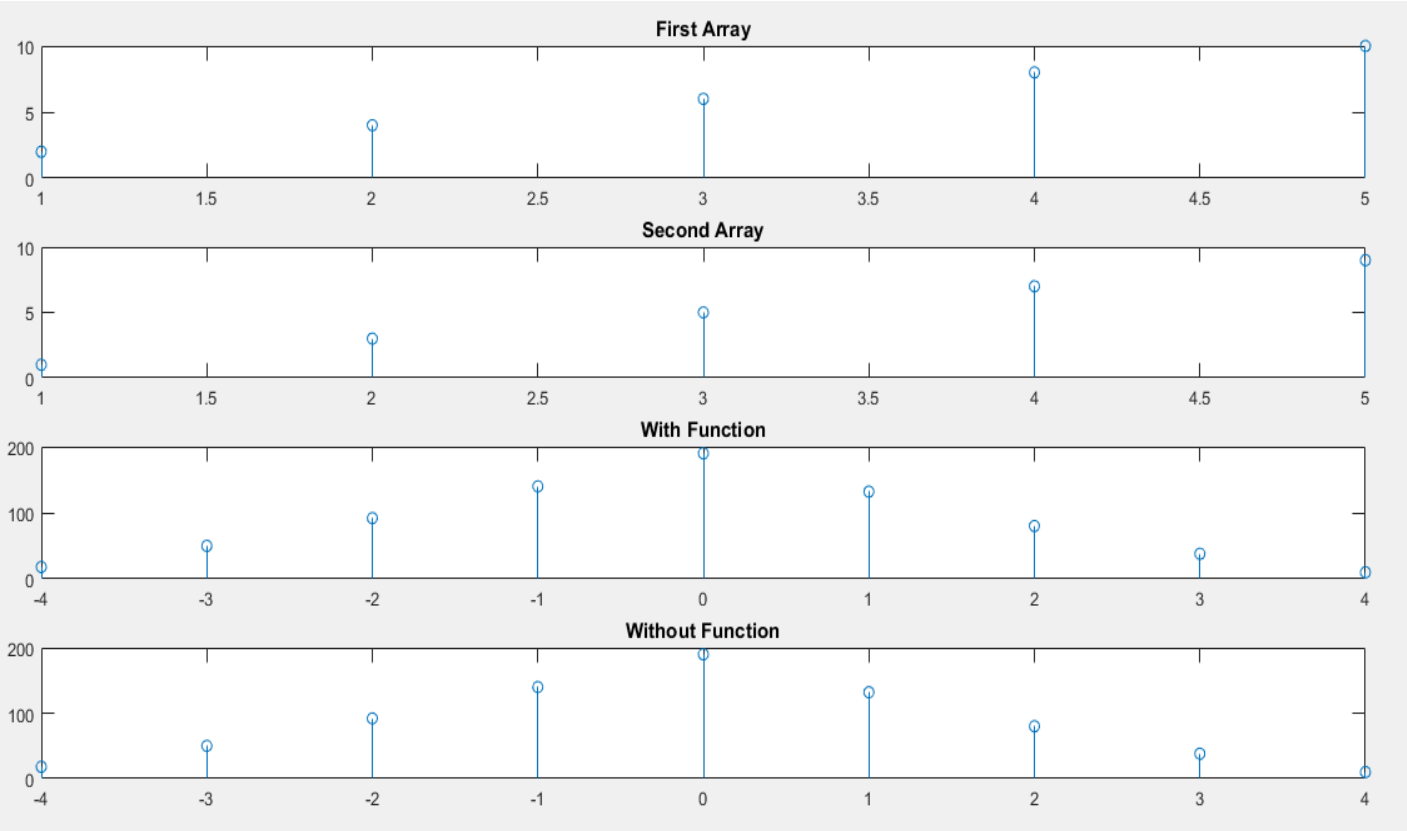
Code: Cross-correlation

```
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 and Conclusion:

We studied the concepts of auto-correlation and cross-correlation in time series analysis in this lab experiment. We then conducted tests to demonstrate the features of these functions in MATLAB.