"Heaven's light is our guide"

RAJSHAHI UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Electrical & Computer Engineering

Course No: ECE 4124

Course Title: Digital Signal Processing Sessional

Experiment No: 02

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Experiment No: 02

Experiment Name: Study of

1. Circular convolution of two signals
2. Take two signal and plot their summation and subtraction
3. Plot shapes of trapezoid

Theory

Convolution is a mathematical tool to combining two signals to form a third signal. Therefore, in signals and systems, the convolution is very important because it relates the input signal and the impulse response of the system to produce the output signal from the system. In other words, the convolution is used to express the input and output relationship of an LTI system. The convolution of two functions in real space is the same as the product of their respective Fourier transforms in Fourier space.

The Circular Convolution can be performed using two methods: concentric circle method and matrix multiplication method. Assuming x1(n) and x2(n) as two finite sequences of length N. Now let us consider X1(K) and X2(K) as the inverse DFTs of sequences x1(n) and x2(n). The DFT for the sequences is [1]

$$X_1(K) = \sum_{n=0}^{N-1} x_1(n) e^{\frac{\text{j2IIkm}}{N}}, k = 0,1,2, \ldots N-1$$

$$X_2 K = \sum_{n=0}^{N-1} x_2(n) e^{\frac{\text{j2IIkm}}{N}}, k = 0,1,2, \ldots N-1$$

Let x3(n) be one more sequence with DFT X3(K). The relation between the three finite duration sequences is given as

$$X_3 K = X_1 K \times X_2 K$$

After taking inverse discrete Fourier transform of above sequences we have

$$x_3 n = \frac{1}{N} \sum_{n=0}^{N-1} X_3(K) e^{\frac{\text{j2IIkm}}{N}}$$

The above equation can also be written as

$$x_3(n) = \sum_{m=0}^{N-1} x_1(m)x_2[(n-m)N], m = 0,1,2,\ldots,N-1$$

[1] https://www.goseeko.com/blog/what-is-circular-convolution/

Code: (Circular convolution)

```
clc;
clear all;

x1=input('enter x1: ');
x2=input('enter x2: ');

n1=length(x1);
n2=length(x2);

N=max(n1,n2);
N3=n1-n2;

if(N3>0)
x2=[x2,zeros(1,N3)];
else
x1=[x1,zeros(1,-N3)];
end

for n=1:N
a(n)=0;
for i=1:N
    j=n-i+1;
    if(j<=0)
        j=N+j;
    end
    a(n)=[a(n)+(x1(i)*x2(j))];
end
end

disp('Result: ');
a
hold on;

figure(1)
subplot(4,1,1);
plot(x1);
title('X1 signal');
grid on;

subplot(4,1,2);
plot(x2);
```

```
title('X2 signal');
grid on;

subplot(4,1,3);
stem(a);
title('circular convoluted discrete signal');
grid on;

subplot(4,1,4);
plot(a);
title('circular convoluted continuous signal');
grid on;
```

Input

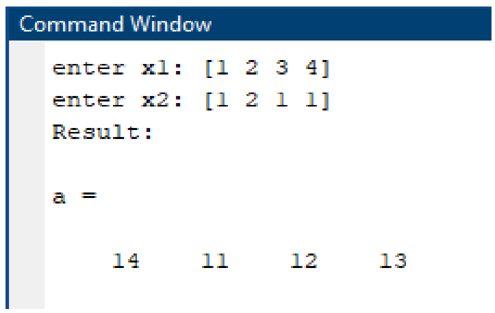

Figure 2.1: Input of two signals

Output:

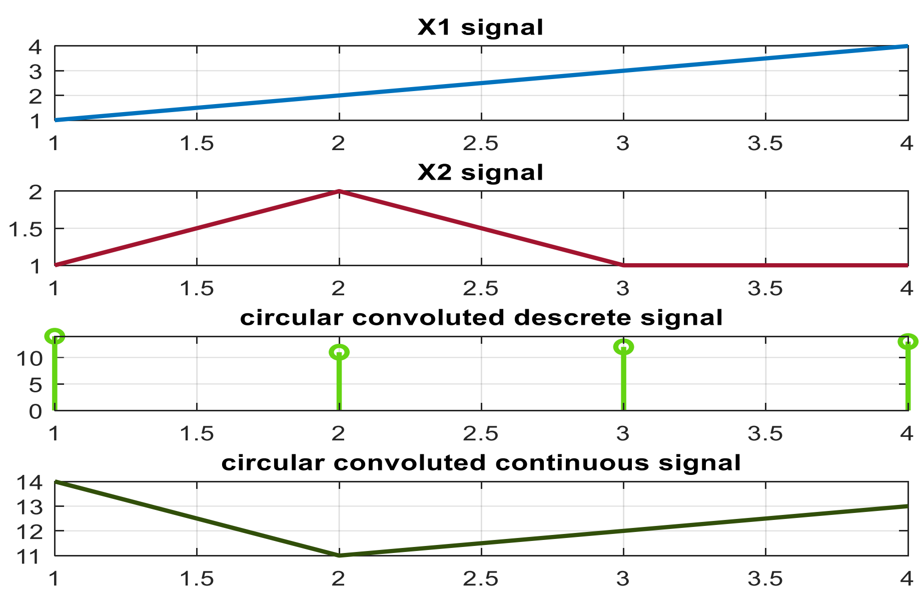

Figure 2.2: Output of circular convolution

Code: (Summation and subtraction)

```
clc;
clear all;
n1=[0,0,0,2,2,2,1,1,1,0,2];
n2=[2,2,0,1,1,1,0,0,0,0,3];
sum =n1+n2;
sub= n1-n2;

figure(2)
subplot(4,1,1);
plot(n1);
title('n1 signal');
grid on;

subplot(4,1,2);
plot(n2);
title('n2 signal');
grid on;

subplot(4,1,3);
plot(sum);
title('sum of signal');
grid on;

subplot(4,1,4);
plot(sub);
title('sub of signal');
grid on;
```

Output:

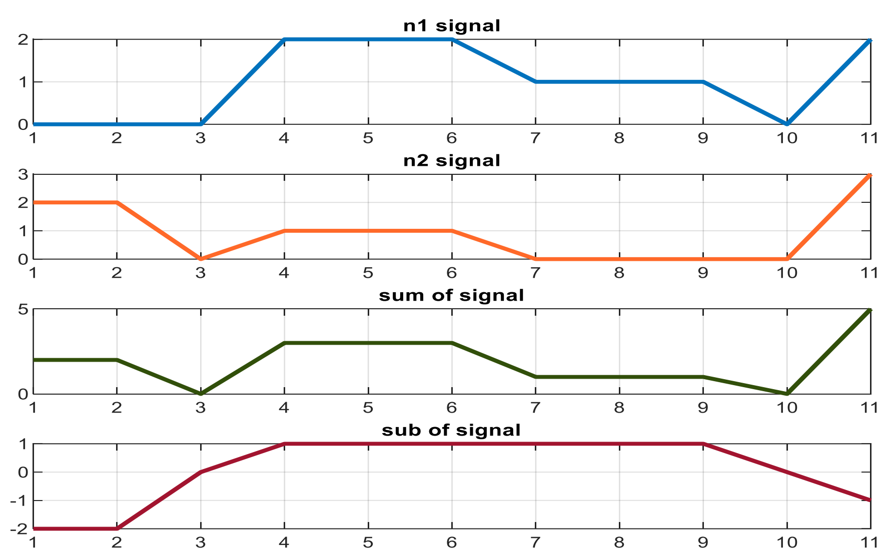

Figure 2.3: Output of summation and subtraction of two signals

Code: (Plot shape 1)

```
clc;
clear all;
u= @(t) t>=0;
x= @(t) t.*u(t)-(t-1).*u(t-1)+(t-2).*u(t-2)-(t-3).*u(t-3)-(t-4).*u(t-4)+(t-5).*u(t-5)-(t-6).*u(t-6)+(t-7).*u(t-7);
t= -1:.001:8;

figure(1)
plot(t,x(t),'r');
xlabel('x axis');
ylabel('y axis');
title('shape');
grid on;
ylim([-1 3.5]);
```

Output

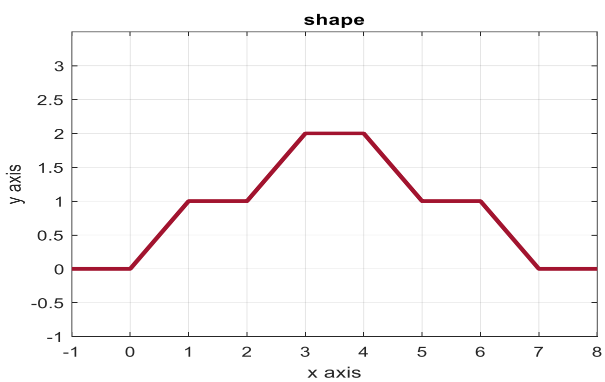

Figure 2.4: output of a double trapezoidal shape

Code: (Plot shape 2)

```
clc;
clear all;
u= @(t) t>=0;
x= @(t) t.*u(t)-(t-1).*u(t-1)-(t-4).*u(t-4)+(t-5).*u(t-5);
t= -2:.001:7;

figure(1)
plot(t,x(t),'r');
grid on;
ylim([-1 2]);
```

Output:

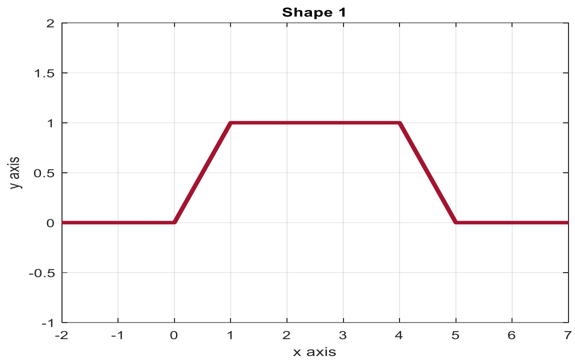

Figure 2.5: Output of a trapezoidal shape

Discussion

The code was executed successfully and no errors were found. Form this experiment, we had learned about determining circular convolution of two signals without using conv function in MATALB software. Also, we have learned about summation and subtraction of two signals and plotting different shapes of trapezoid.

References:

[1] https://www.goseeko.com/blog/what-is-circular-convolution/