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Topic : **Discrete Convolution**

Aim : The aim of this experiment is to study mathematical operations such as:
1. Linear Convolution,
2. Circular Convolution
3. Linear Convolution using Circular Convolution

Linear convolution

Problem Definition :
Find Linear Convolution of L point sequence x[n] and M point sequence h[n].

Experimentation : Case 1: m = 5, x[n] = [3,6,8,9,11] , n = 3, h[n] = [1,2,3]

```
Enter the length of x[n] M= 5
Enter the values of x[n]=
3 6 8 9 11

Enter the length of h[n] N= 3
Enter the values of h[n]=
1 2 3

The Value of output y[0]=3:
The Value of output y[1]=12:
The Value of output y[2]=29:
The Value of output y[3]=43:
The Value of output y[4]=53:
The Value of output y[5]=49:
The Value of output y[6]=33:
```

Analysis:

 Here Length of x[n] (L) = 5 Length of h[n] (M) = 3
I analyze that : If the input signal are causal then the output of linear convolution of both the signal is also causal Length of linear convoluted output signal is (l+m-1) Where l=length of first input signal m=length of second signal
 Length of output signal y[n] = L + M -1 = 5 + 3 - 1 = 8 -1 = 7 Since the input signal is causal then n=1,2,3,4…. In each iteration for n output signal y[n] is generated
We conclude the following:
- Length of Linear Convolution output signal (y[n]) = Length of first input signal (x[n]) + Length of second input signal (h[n]) – 1
- Adding zeros at the end of the input signal does NOT change the output for Linear Convolution, i.e. Linear Convolution always gives a unique answer.
- In Linear convolution, if both the input signals are causal, then the resultant output signal is also causal.

Circular Convolution

Problem Definition:
Find Circular Convolution of L point sequence x[n] and M point sequence h[n].
Experimentation Case 1: x[n] = {3,6,8,9,11} h[n] = {1,2,3}

 Output:

```
Enter the length of x[n] L = : 5
Enter the values of x[n] : 3 6 8 9 11
Enter the length of h[n] M = : 3
Enter the values of h[n] : 1 2 3


 x[n] =   3.00    6.00    8.00    9.00    11.00

 h[n] =   1.00    2.00    3.00    0.00    0.00

 y[n] =   52.00    45.00    29.00    43.00    53.00
```

Analysis
Given Two signals are:
Length of x[n] (L) = 5 x[n] = {3,6,8,9,11}

Length of h[n] (M) = 3 h[n] = {1,2,3}

In case of circular Convolution ,the length of the both the input signal has to be same we take the length as follow: N=max(L,M) Now we add zero padding to the smaller input signal Therefore h[n]={1,2,3,0,0} Length of y[n] = 5
Output for Linear convolution for the same input signals is:
y[n] = {3,12,29,43,53,49,33}
Output for Circular convolution for the same input signals is:
y[n] = {52.00,45.00,29.00,43.00,53.00} I noticed that {29,43,53} is common in both the signal
We conclude the following:
- Length of Linear Convolution output signal (y[n]) = Length of first input signal (x[n]) + Length of second input signal (h[n]) - 1
- Length of Circular Convolution gives max(length signal1,length of signal2)

Linear Convolution using Circular Convolution

Problem Definition: Find Linear Convolution using Circular Convolution of L point sequence x[n] and M point sequence h[n].

Experimentation
Case 1: Length of input signals is Equal to the length of output signal of Simple Linear Convolution Two signals are: x[n] = {3,6,8,9,11} Length of x[n] (L) = 5 h[n] = {1,2,3} Length of h[n] (M) = 3
In Linear Convolution length of output signal y[n] = L + M -1 = 5 + 3 - 1 = 8-1 =7
In circular convolution the length of the output signal is the maximum of the length of the input signal whereas in linear convolution the length of the output signal is given by(L+M-1) To obtain linear convolution using circular convolution the length of the input signal has to the length of the output of the lInear convolution i.e.(L+M-1) So to do that the we have to do zero padding in input signal till the length to the output of Linear convolution Since length of x[n] = 5, to make its length = 10, we will pad signal x[n] with 10-5 = 5 zeros. Similarly length of h[n] = 3, to make its length = 10, we will pad signal x[n] with 10-3 = 7 zeros. Therefore final x[n] = [3,6,8,9,11, 0, 0, 0] Therefore final h[n] = [1,2,3, 0, 0, 0,0,0] And, L = M = 10

Output:

```
Enter the length of x[n] L = : 5
Enter the values of x[n] : 3 6 8 9 11
Enter the length of h[n] M = : 3
Enter the values of h[n] : 1 2 3


 x[n] =   3.00    6.00    8.00    9.00    11.00    0.00    0.00

 h[n] =   1.00    2.00    3.00    0.00    0.00    0.00    0.00

 y[n] =   3.00    12.00    29.00    43.00    53.00    49.00    33.00
```

Case 2: Length of input signals is GREATER than the length of output signal of Simple Linear Convolution

For Case 2, we will add two extra zeros to the already padded input signals to get length greater than the length of the output signal of Linear Convolution.

```
Enter the length of x[n] L = : 10
Enter the values of x[n] : 3 6 8 9 11 0 0  0 0 0
Enter the length of h[n] M = : 10
Enter the values of h[n] : 1 2 3 0 0 0 0 0 0 0


 x[n] =   3.00    6.00    8.00    9.00    11.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
  0.00    0.00    0.00

 h[n] =   1.00    2.00    3.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
 0.00    0.00    0.00

 y[n] =   3.00    12.00    29.00    43.00    53.00    49.00    33.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0
.00    0.00    0.00    0.00
```

Analysis:

Final Length of x[n] (L) = 10

Final Length of h[n] (M) = 10

Final Length of y[n] = 10

To generate linear convolution using Circular convolution n>= (L+M-1) L+M-1=7 …….(for Linear Convolution) I have taken n=10 .

so it will always generate a linearly convoluted signal using circular Convolution. In Circular Convolution length of output signal is same as the length of input signal Here length of the input signal is 10.

We can see that this y[n] is the same as the one that we got by doing Linear Convolution in the first case.

We will get the same y[n] if we add extra zeros to make the length greater than L+ M -1 of original signals = 10. So if we make length of x[n] = 10 and Length of h[n] = 10, we will get the same output signal y[n] with some extra Zeros

We conclude the following: ● We will get correct output only when length of input signals with padding is greater than or equal to the length of output signal of simple Linear Convolution ● Length of output signal (y[n]) >= Original Length of first input signal (x[n]) + Original Length of second input signal (h[n]) – 1

Conclusion :

1.Length of Linear Convolution output signal (y[n]) = Length of first input signal (x[n]) + Length of second input signal (h[n]) – 1

2.Length of Circular Convolution gives max(length signal1,length of signal2)

3.Length of output signal (y[n]) >= Original Length of first input signal (x[n]) + Original Length of second input signal (h[n]) – 1.For n<(l+m-1) there is aliasing in circular convolution