CIRCULAR CONVOLUTION

OBJECTIVE:

To understand the concept of circular convolution and find the circularly convolved sequences for a few inputs using Scilab.

PRE-SESSION WORK:

Is there any relation between linear convolution and circular convolution?

Let c(n) be the result of the linear convolution of x(n) and y(n), which are given below.

x(n) = -1, 2, 1, 4 for n = 0, 1, 2, 3 respectively
0 for other values of n.
y(n) = 3, 5, 2 for n = 0, 1, 2 respectively and
0 for other values of n.
Then,
c(n) = -3, 1, 15, 13, 18, -8 for n = 0, 1, 2, 3, 4, 5 respectively
0 for other values of n.

Now let us find out the circular convolution, cir_c(n), of x(n) and y(n). Zero padding y(n) to equate the length of the two sequences results into y(n) = 3, 5, 2, 0.

cir_c(0) = -3 + 0 + 2 + 20 =

If y(n) is periodic then linear convolution c(n) will be equal to cir_c(n) as shown below.

.... -4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7....... (n)**
.... 3	5	2	0	3	5	2	0	3	5	2	0....... (y(n))
.... 0	0	0	0	-1	2	1	4	0	0	0	0....... (x(n))
..........3	0	2	5	3	0	2	5	3	0	2	5....... (y(-n))

c(0) = -3 + 0 + 2 + 20 =19

.... 0	0	0	0	-1	2	1	4	0	0	0	0....... (x(n))
.... 5	3	0	2	5	3	0	2	5	3	0	2....... (y(-n+1))

c(1) = -5 + 6 + 0 + 8 = 9

Proceeding in the same way we get c(3) = 11, c(4) = 21. Which shows that c(n) = cir_c(n).

Mention any one context where we come across the circular convolution in DSP.

We know that linear convolution in time domain results in multiplication in frequency domain and vice versa. Let X(k) and H(k) denote the DFTs of x(n), h(n) respectively. IDFT of Y(k), where Y(k) = (X(k)H(k)), is circular convolution of x(n) and h(n) not their linear convolution. So to avoid aliasing x(n), h(n) are zero padded to the length L+M-1 (L, M are lengths of x(n) and h(n), respectively) before finding their DFTs.

PRE-SESSION QUIZ:

1. Multiplication of two DFT sequences in frequency domain is equal to _________________ of the sequences in time domain.

    a. Linear convolution
    b. Circular convolution
    c. Multiplication
    d. Addition

2. Let x(n) and y(n) be two sequences of length N each. Then circular convolution of x(n) and y(n) gives a sequence of length

    a. 2N-1
    b. 2N
    c. N
    d. N-1

3. Circular convolution can be applied when

    a. One signal is periodic
    b. Both signals are periodic
    c. Both signals are aperiodic
    d. Unconditionally.

PROCEDURE:

- Load the circular convolution.sce file in Scilab.
- Enter the values of the signal x(n) and h(n).
- Save the file.
- Go to Execute->Execute in Scilab or press Ctrl-E
- Compare the result with that of linear convolution.

POST-SESSION WORK:

1. Compute the circular convolution y[n] of the signals

    a. x[n] = (1/3)n for 0<n<6
       0 otherwise

$h[n] = 1$ for for $0<n<2$

0 otherwise

Compare the result with that of linear convolution