Assignment 4

Course: DSAA, Monsoon 2017 @IIITS

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I. Convolution

MATLAB CODES:

a) Definition

```
function [y] = myConvolution(x, h)
m = length(x);
n = length(h);
L = m + n - 1;
y = zeros(1, L);
xe = zeros(1, L);
he = zeros(1, L);
xe(1: m) = x;
he(1: n) = h;
for i = 1: L;
        y(i) = 0;
        for j = 1: i;
                y(i) = y(i) + he(j) * xe(i - (j - 1));
        end;
end;
return;
```

b) Matrix Method

```
function [p] = myTabularConvolution(x, h)
m = length(x);
n = length(h);
z = zeros(m + n - 1, n);
for i = 1: (m + n - 1)
        k = i;
        j = 1;
        if (k > m)
                r = k - m;
                k = k - r;
                j = j + r;
        end;
        while (k >= 1 && j <= n)
                z(i, j) = x(k);
                k = k - 1;
                j = j + 1;
        end;
end;
y = h.';
z
y
p = z * y;
p = p.';
```

II. Application

MATLAB CODES:

a. Sine signal

```
clc
clear  all
close  all
%%
t  =  0:  1:  6;
xt  =  sin(7  /  22  *  pi  *  t)
h  =    [0,  2,  -1,  3]
y = myConvolution(xt,  h)
z = myTabularConvolution(xt,  h)
a  = [0,  0,  1.6825,  0.9780,  1.8988,  1.0751,  -0.7363,  -1.8712,  -2.5967,  -0.8452];
plot(z,  '+--');
hold  on;
plot(y,  's-.');
hold  on;
plot(a,  'd:');
legend('Convolution', 'Matrix', 'Theoretical');
```

b. Complex Exponential Signal

```
clc
clear all
close all
%%
n = 0: 1: 7;
k = 1;
N = 8;
h = exp(-j * 2 * pi * n * k / N)
x = [-1, 1, -1, 1, -1, 1, -1, 1]
y = myConvolution(x, h)
z = myTabularConvolution(x, h)
a = [1, 0.2929 + 0.7071 i, -0.2929 + 0.2929 i, 1 + 0.4142 i, -
0.4142 i, 0.7071 - 0.2929 i, -0.7071 - 0.7071 i, 0, 1, -
0.2929 - 0.7071 i, 0.2929 - 0.2929 i, -1 - 0.4142 i, 0.4142 i, -
0.7071 + 0.2929 i, 0.7071 + 0.7071 i];
plot(real(y), '+--');
hold on;
plot(real(z), 's-');
hold on;
plot(real(a), 'd:');
legend('Convolution', 'Matrix', 'Theoretical');
figure;
plot(imag(y), '+--');
hold on;
plot(imag(z), 's-');
hold on;
plot(imag(a), 'd:');
legend('Convolution', 'Matrix', 'Theoretical');
```

RESULTS:

a) Sine signal

i) Using myConvolution Method:

```
xt =

         0    0.8413    0.9096    0.1423   -0.7557   -0.9595   -0.2817


h =

     0     2    -1     3


ans =

         0         0    1.6825    0.9780    1.8988    1.0751   -0.7363   -1.8712   -2.5967   -0.8452
```

ii) Using myTabularConvolution (Matrix) Method:

```
z =

         0         0         0         0
    0.8413         0         0         0
    0.9096    0.8413         0         0
    0.1423    0.9096    0.8413         0
   -0.7557    0.1423    0.9096    0.8413
   -0.9595   -0.7557    0.1423    0.9096
   -0.2817   -0.9595   -0.7557    0.1423
         0   -0.2817   -0.9595   -0.7557
         0         0   -0.2817   -0.9595
         0         0         0   -0.2817


y =

     0
     2
    -1
     3
```

```
ans =

         0         0    1.6825    0.9780    1.8988    1.0751   -0.7363   -1.8712   -2.5967   -0.8452
```

iii) By theoretical Method:

1) $x[n] = \sin[\frac{7}{22} * pi * n]$ $\quad n = 0, 1, 2, 3, \ldots, 6$

$x[n] = [\sin[\frac{7}{22} * pi * 0], \sin[\frac{7}{22} * pi * 1], \ldots, \sin[\frac{7}{22} * pi * 6]]$

$= [0, 0.8413, 0.9096, 0.1423, -0.7557, -0.9595, -0.2817]$

$h[n] = [0, 2, -1, 3]$

$y[0] = x[0]h[0] = 0$

$y[1] = x[0]h[1] + x[1]h[0] = 0 + 0 = 0$

$y[2] = x[0]h[2] + x[1]h[1] + x[2]h[0]$

$= 0 + 1.6825 + 0 = 1.6825$

$y[3] = x[0]h[3] + x[1]h[2] + x[2]h[1] + x[3]h[0]$

$= 0 + (-0.8413) + (1.8192) + 0 = 0.9780$

$y[4] = x[0]h[4] + x[1]h[3] + x[2]h[2] + x[3]h[1] + x[4]h[0] = 1.8988$

$y[5] = \sum_{k=0}^{5} x[k]h[k+5] = 1.0751$

$y[6] = \sum_{k=0}^{6} x[k]h[6-k] = -0.7363$

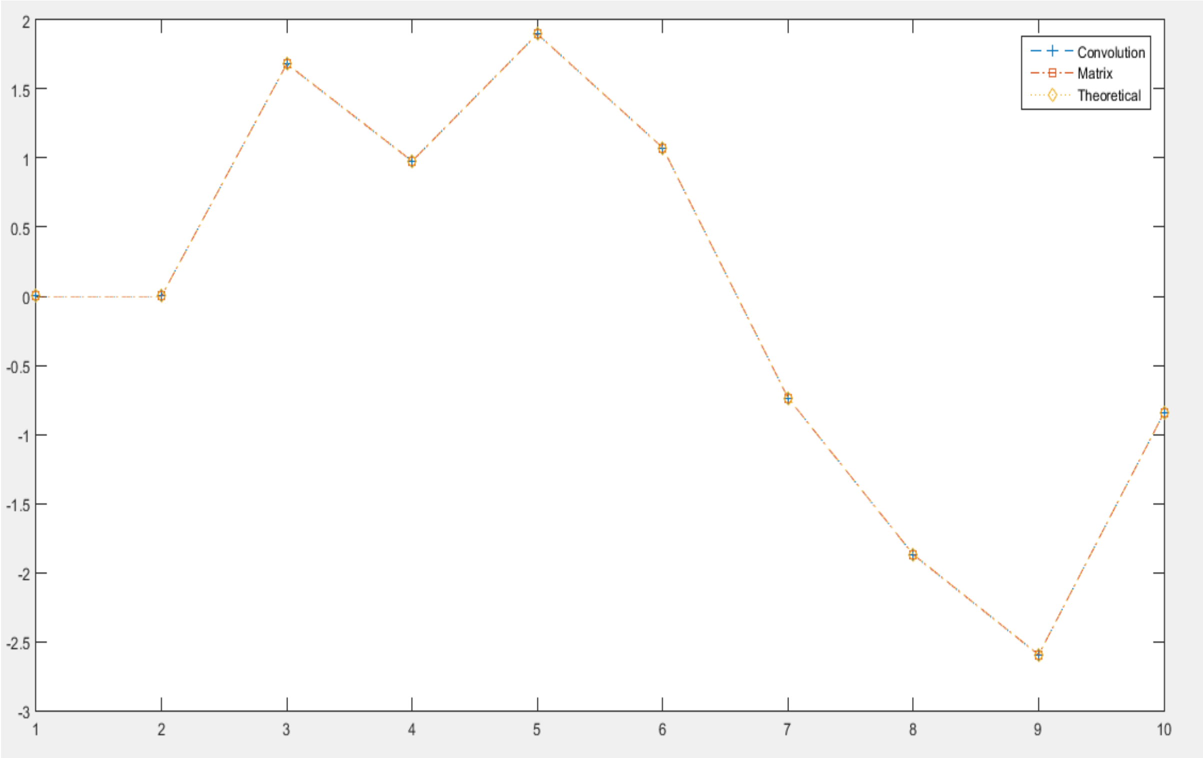
$y[7] = \sum_{k=0}^{7} x[k]h[7-k] = -1.8712$

$y[8] = \sum_{k=0}^{8} x[k]h[8-k] = -2.5967$

$y[9] = \sum_{k=0}^{9} x[k]h[9-k] = -0.8452$

$y[n] = [0, 0, 1.6825, 0.7780, 1.8988, 1.0751, -0.7363, -1.8712, -2.5967, -0.8452]$

iv) **Graphs showing that the signals obtained by all the three methods**



b) Complex Exponential Signal

i) Using myConvolution Method:

```
h =

  Columns 1 through 6

   1.0000 + 0.0000i   0.7071 - 0.7071i   0.0000 - 1.0000i  -0.7071 - 0.7071i  -1.0000 - 0.0000i  -0.7071 + 0.7071i

  Columns 7 through 8

  -0.0000 + 1.0000i   0.7071 + 0.7071i


x =

    -1     1    -1     1    -1     1    -1     1
```

```
ans =

  Columns 1 through 6

 -1.0000 + 0.0000i   0.2929 + 0.7071i  -0.2929 + 0.2929i   1.0000 + 0.4142i   0.0000 - 0.4142i   0.7071 - 0.2929i

  Columns 7 through 12

 -0.7071 - 0.7071i   0.0000 - 0.0000i   1.0000 + 0.0000i  -0.2929 - 0.7071i   0.2929 - 0.2929i  -1.0000 - 0.4142i

  Columns 13 through 15

 -0.0000 + 0.4142i  -0.7071 + 0.2929i   0.7071 + 0.7071i
```

ii) Using myTabularConvolution (Matrix) Method:

```
z =

    -1     0     0     0     0     0     0     0
     1    -1     0     0     0     0     0     0
    -1     1    -1     0     0     0     0     0
     1    -1     1    -1     0     0     0     0
    -1     1    -1     1    -1     0     0     0
     1    -1     1    -1     1    -1     0     0
    -1     1    -1     1    -1     1    -1     0
     1    -1     1    -1     1    -1     1    -1
     0     1    -1     1    -1     1    -1     1
     0     0     1    -1     1    -1     1    -1
     0     0     0     1    -1     1    -1     1
     0     0     0     0     1    -1     1    -1
     0     0     0     0     0     1    -1     1
     0     0     0     0     0     0     1    -1
     0     0     0     0     0     0     0     1
```

```
y =

   1.0000 + 0.0000i
   0.7071 - 0.7071i
   0.0000 - 1.0000i
  -0.7071 - 0.7071i
  -1.0000 - 0.0000i
  -0.7071 + 0.7071i
  -0.0000 + 1.0000i
   0.7071 + 0.7071i


ans =

  Columns 1 through 6

  -1.0000 + 0.0000i   0.2929 + 0.7071i  -0.2929 + 0.2929i   1.0000 + 0.4142i   0.0000 - 0.4142i   0.7071 - 0.2929i

  Columns 7 through 12

  -0.7071 - 0.7071i   0.0000 - 0.0000i   1.0000 + 0.0000i  -0.2929 - 0.7071i   0.2929 - 0.2929i  -1.0000 - 0.4142i

  Columns 13 through 15

  -0.0000 + 0.4142i  -0.7071 + 0.2929i   0.7071 + 0.7071i
```

iii) By Theoretical Method:

2)

$x[n] = [-1, 1, -1, 1, -1, 1, -1, 1]$, $k = 1, N = 8$

$h[n] = [1, 0.7071 - 0.7071i, -i, -0.7071 - 0.7071i,$
$-1, -0.7071 + 0.7071i, i, 0.7071 + 0.7071i]$

$y[0] = x[0]h[0] = -1$

$y[1] = x[0]h[1] + x[1]h[0] = 0.2929 + 0.7071i$

$y[2] = x[0]h[2] + x[1]h[1] + x[2]h[0]$
$= -0.2929 + 0.2929i$

$y[3] = \sum_{k=0}^{3} x[k]h[3-k] = 1 + 0.4142i$

$y[4] = \sum_{k=0}^{4} x[k]h[4-k] = -0.4142i$

$y[5] = \sum_{k=0}^{5} x[k]h[5-k] = 0.7071 - 0.2929i$

$y[6] = \sum_{k=0}^{6} x[k]h[6-k] = -0.7071 - 0.7071i$

$y[7] = \sum_{k=0}^{7} x[k]h[7-k] = 0$

$y[8] = \sum_{k=1}^{7} x[k]h[8-k] = 1$

$y[9] = \sum_{k=2}^{7} x[k]h[9-k] = -0.2929 - 0.7071i$

$y[10] = \sum_{k=3}^{7} x[k]h[10-k] = 0.2929 - 0.2929i$

$y[11] = \sum_{k=4}^{7} x[k]h[11-k] = -1 - 0.4142i$

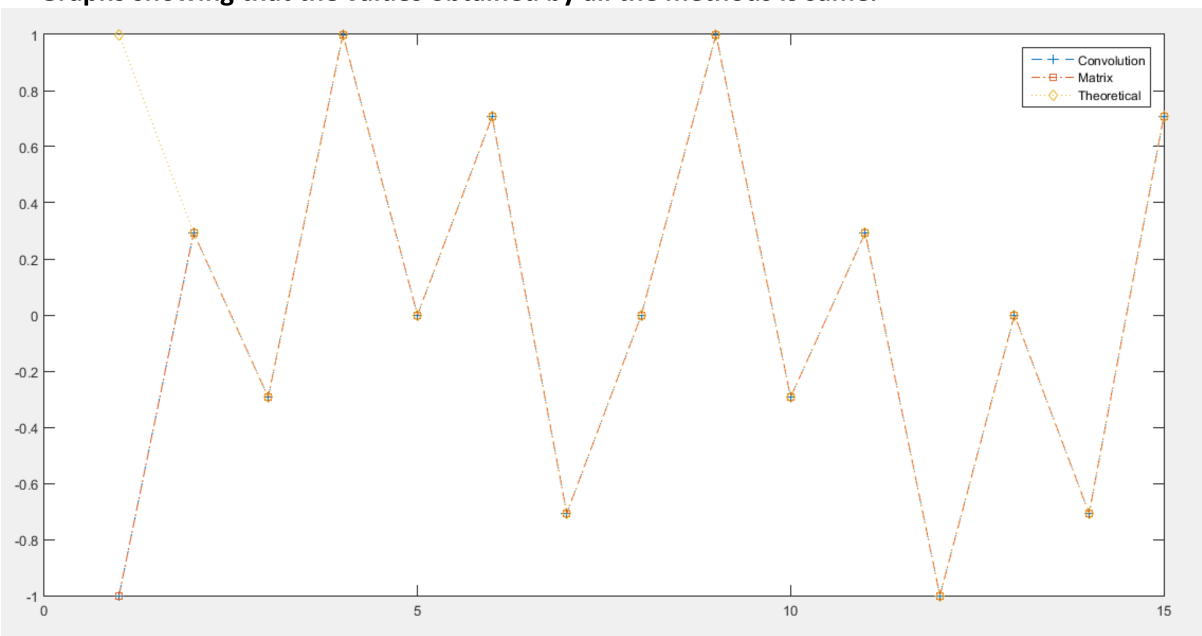
$y[12] = \sum_{k=5}^{7} x[k]h[12-k] = 0.4142i$

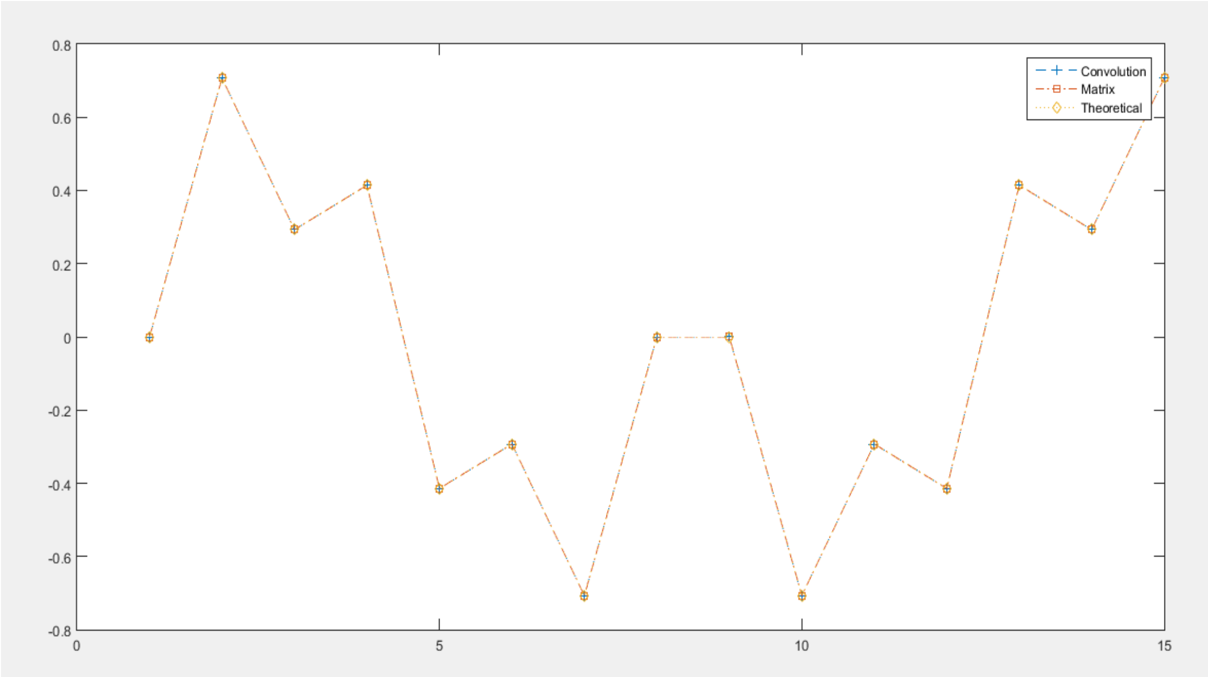
$y[13] = \sum_{k=6}^{7} x[k]h[13-k] = -0.7071 + 0.2929i$

$y[14] = \sum_{k=7}^{7} x[k]h[14-k] = 0.7071 + 0.7071i$

$y[n]$
$= [-1, 0.2929 + 0.7071i, -0.2929 + 0.2929i,$
$1 + 0.4142i, -0.4142i, 0.7071 - 0.2929i, -0.7071 - 0.7071i,$
$0, 1, -0.2929 - 0.7071i, 0.2929 - 0.2929i, -1 - 0.4142i,$
$0.4142i, -0.7071 + 0.2929i, 0.7071 + 0.7071i]$

iv) Graphs showing that the values obtained by all the methods is same.





DISCUSSION:

1. First, we create the functions for the convolution by using the conventional method and then by constructing a matrix which is to be multiplied with h[n] signal to get the required convoluted signal.
2. After constructing the functions for the both, we send the signals directly into the function by calling them through their programme. This is a part of the application of these functions.
3. We observe that the convoluted signal obtained from both the methods is the same.
4. In first function, we use the conventional formula to calculate the convoluted signal.
5. In second function, we build up a matrix with the number of input increasing per row in the matrix of order (m+n – 1) x (n) and then we multiply it with (n x 1) ordered matrix i.e. the h[n] signal in the form of a column matrix, to get the final convoluted signal in the form of a column matrix of order (m+n-1) x (1).
6. Since the values obtained from both the methods are equal, we also verify by calculating the convoluted signal theoretically and we notice that the convoluted signal obtained from the theoretical manner also matches with the convoluted signal obtained from the other two methods.
7. We have taken the assumption that k = 1 and N = 8 to get numerical values for the second application i.e. for the complex exponential function given.
8. From the graphs obtained from the 2 figures, we observe that the values obtained from all the three cases are equal as all the three plots overlap each other in the graph.
9. The two graphs in the second subproblem represent the real and imaginary parts of the obtained convoluted complex signal.

*****THANKS FOR READING*****