Signals and Systems MATLAB HW1
Deadline: 2021/3/30 before 23:59

The Convolution Sum

In this section, you will learn how to compute the convolution sum of two signals by using MATLAB.

1.Background

Suppose there are two finite-duration signals $x_1[n]$ and $x_2[n]$; now, there are two integers N_1 and N_2 so that $x_1[n]$=0 outside the interval $1 \le n \le N_1$, and $x_2[n]$=0 outside the interval $1 \le n \le N_2$.

The convolution sum of the two signals, denoted by $y[n]$, is written as

$$y[n] = \sum_{k=-\infty}^{\infty} x_1[k]x_2[n-k]. \tag{1}$$

To obtain the value using MATLAB, you may directly type the function just like

$$y = \boldsymbol{conv}(x_1, x_2) \tag{2}$$

where $x_1 = [x_1[1], x_1[2], \dots, x_1[N_1]]^T$, $x_2 = [x_2[1], x_2[2], \dots, x_2[N_2]]^T$ and the superscript *T* denotes the transpose operation.

Expecting for the direct computation of (1), there are some other methods to compute the convolution sum. For instance, it can be computed by following matrix form as

$$\begin{bmatrix} y[2] \\ \vdots \\ y[N_1+N_2] \end{bmatrix} = \begin{bmatrix} x_1[1] & 0 & \dots & 0 \\ x_1[2] & x_1[1] & \ddots & \vdots \\ \vdots & x_1[2] & \ddots & 0 \\ x_1[N_1] & \vdots & \ddots & x_1[1] \\ 0 & x_1[N_1] & \ddots & x_1[2] \\ \vdots & 0 & \ddots & \vdots \\ 0 & \dots & 0 & x_1[N_1] \end{bmatrix} \begin{bmatrix} x_2[1] \\ x_2[2] \\ \vdots \\ x_2[N_2] \end{bmatrix}. \tag{3}$$

Note: please notice the dimension of each matrix.

2.Questions:

Compose a MATLAB script (save as **myconv.m** file) to achieve the question I. to III.

I.Given two discrete signals are

$$x_1[n] = \begin{cases} n, & 1 \le n \le 5 \\ 10 - n, & 6 \le n \le 9 \\ 0, & elsewhere \end{cases}$$

and

$$x_2[n] = u[n-1] - u[n-5]$$

where u means the unit step function.

a.(10%)Use the MATLAB function **stem** to plot $x_1[n]$ vs n and $x_2[n]$ vs n.

b.(10%)Directly use the MATLAB function **conv** to compute equation (1) and use **stem** to plot the output $y[n]$ vs n.

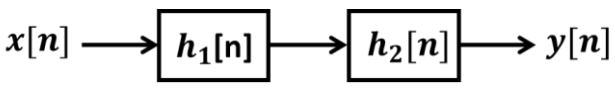
c.(20%)Create a MATLAB program by yourself to compute equation (1) by using equation (3) matrix form and use **stem** to plot the output $y[n]$ vs n. (You should verify whether the answer is the same as question b.)

II.(40%) Repeat question I. again, but $x_1[n]$ and $x_2[n]$ are changed to the following:

$$x_1[\mathrm{n}] = \begin{cases} 5^n u[n], & 1 \le n \le 3 \\ 0, & elsewhere \end{cases} ;$$

$$x_2[n] = \begin{cases} 2^n u[n-1], & 1 \le n \le 5 \\ 0, & elsewhere \end{cases} .$$

III.Consider the cascade of two discrete LTI systems as in the figure below,



where

$$h_1[n] = cos\left[\frac{\pi n}{4}\right](u[n] - u[n-9])$$

and

$$h_2[n] = a^n(u[n] - u[n-9])$$

and where the input is

$$x[n] = \delta[n] - a\delta[n-1],$$

where δ means the unit delta function and $a = 0.5$.

a.(10%)Use the MATLAB function **stem** to plot $h_1[n]$ vs n, $h_2[n]$ vs n, and, $x[n]$ vs n.

b.(10%)Directly use the MATLAB function **conv** to compute $y[n]$ and use **stem** to plot the output $y[n]$ vs n. Besides, is $y[n]$ the same as $h_1[n]$ or $h_2[n]$ for $0 \leq n \leq 8$? Please explain why.

Note: We expect that if executing your **myconv.m** file, there will be total 12 figures come out in order. (Question I. a. has 2 figures; question I. b. & I. c. has 1 figure respectively; question II. has 4 figures; question III. a. has 3 figures; question III. b. has 1 figure.)

3.CEIBA or NTU Cool Submission

- Please upload a compressed file (.zip or .rar), which includes your **m-file (**save as **myconv.m** file**)** and a **word file (**save as **report.doc** file**)**. Please show the plots mentioned above in the word file (report.doc) and give some explanation if needed.
- The compressed file name should be denoted as **ID_MATLAB1**.
  (ex: B09901xxx_MATLAB1)