Signals and Systems MATLAB HW1

Deadline: 2023/3/28 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 use the function **conv**:

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

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.

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

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

Note: please pay attention to the dimension of each matrix.

2. Questions:

Given two signals

$$x_1[n] = \begin{cases} n, & 1 \le n \le 20 \\ 40 - n, & 21 \le n \le 39 \\ 0, & elsewhere \end{cases}$$

$$x_2[n] = u[n-1] - u[n-11],$$

where u denotes the unit step function.

Please write a MATLAB script (saved as **myconv.m**) to implement problems (a) to (d).

(a) (15%) Use the MATLAB function **stem** to plot $x_1[n]$ vs n and $x_2[n]$ vs n.

(b) (15%) Use the MATLAB function **conv** directly 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 Problem (b).

(d) (50%) Repeat Problems (a) to (c) again, but $x_1[n]$ and $x_2[n]$ are changed to the following:

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

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

Note: We expect that executing your **myconv.m** file will output 8 figures in order.
(2 figures for Problem (a), 1 figure for Problem (b), 1 figure for Problem (c), and 4 figures for Problem (d))

3. NTU COOL Submission

- Please upload a compressed file (.zip), which includes your **m-file** (saved as **myconv.m**) and a **word file** (saved as **report.doc**). Please show the figures mentioned above in the word file (report.doc) and give some explanation if needed.
- The compressed file should be named as **ID_MATLAB1.zip**.
  (e.g., B10901xxx_MATLAB1.zip)